

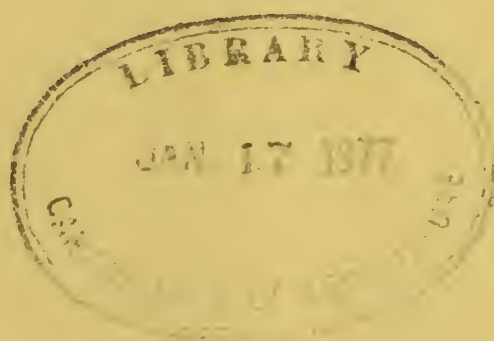
# RESEARCH BRANCH REPORT

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❧ 1975 ❧

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## RAPPORT DE LA DIRECTION DE LA RECHERCHE

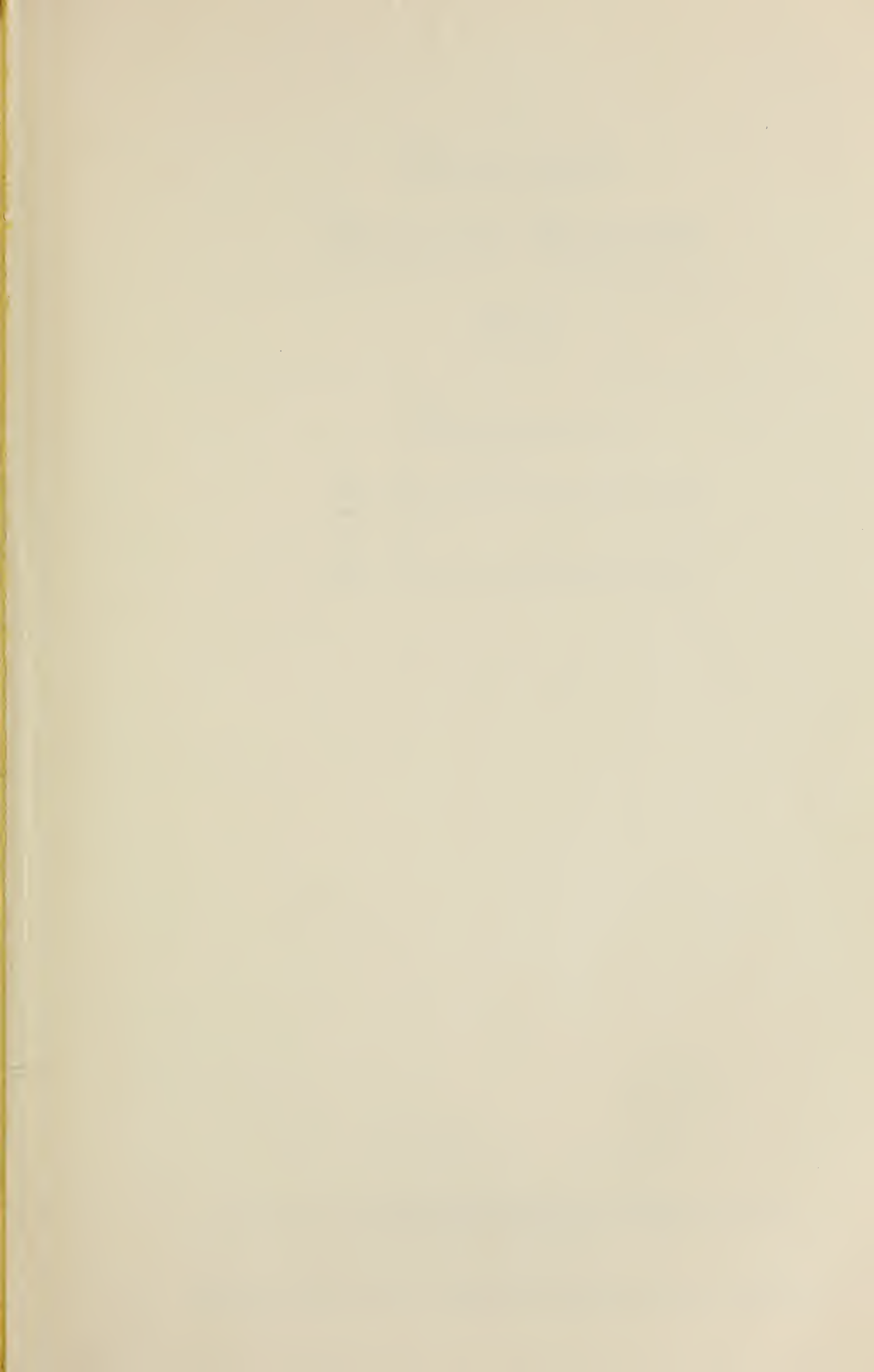


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# Research Branch Report

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1975

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## Rapport de la Direction de la recherche

CANADA DEPARTMENT OF AGRICULTURE

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MINISTÈRE DE L'AGRICULTURE DU CANADA

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Dr. B.B. Migicovsky



Dr. E.J. LeRoux



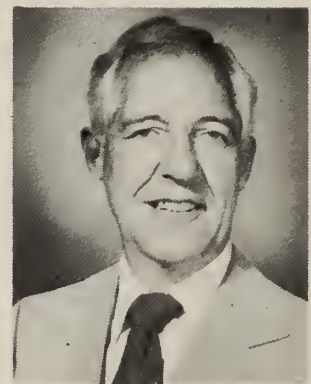
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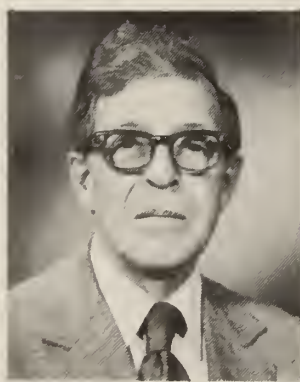
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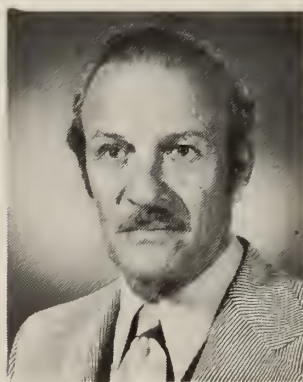
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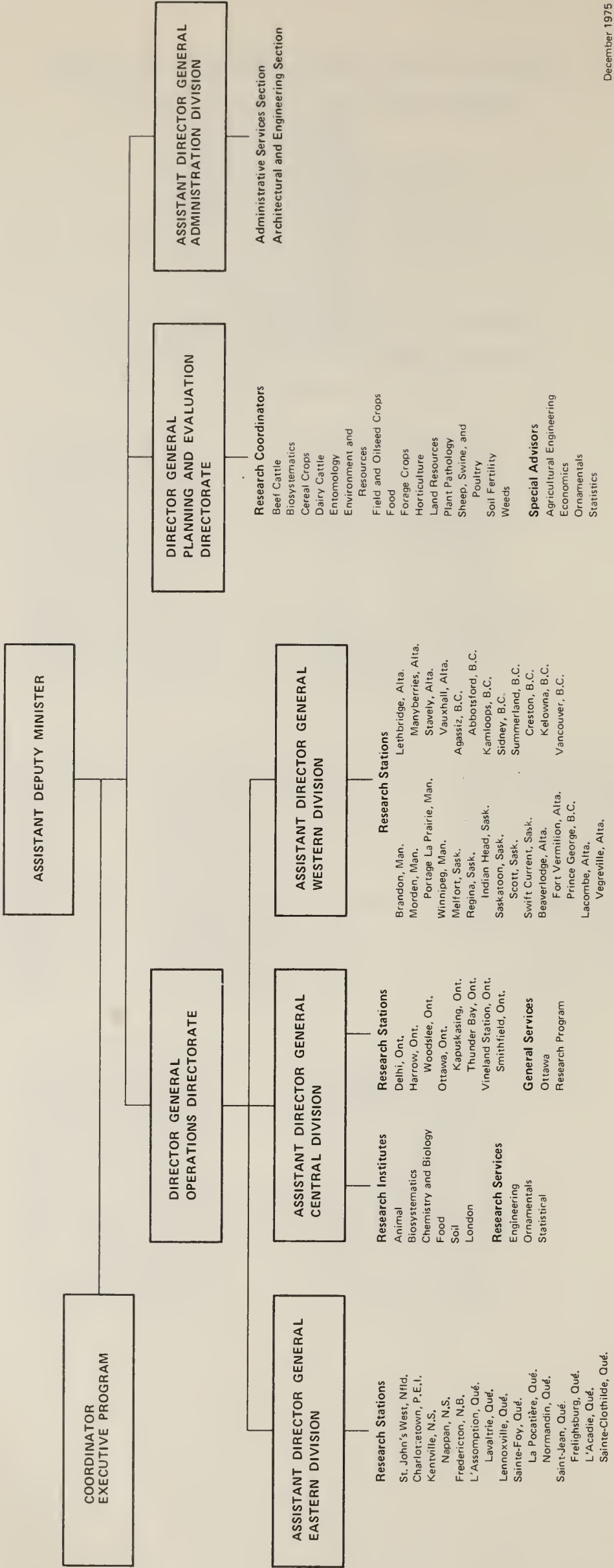
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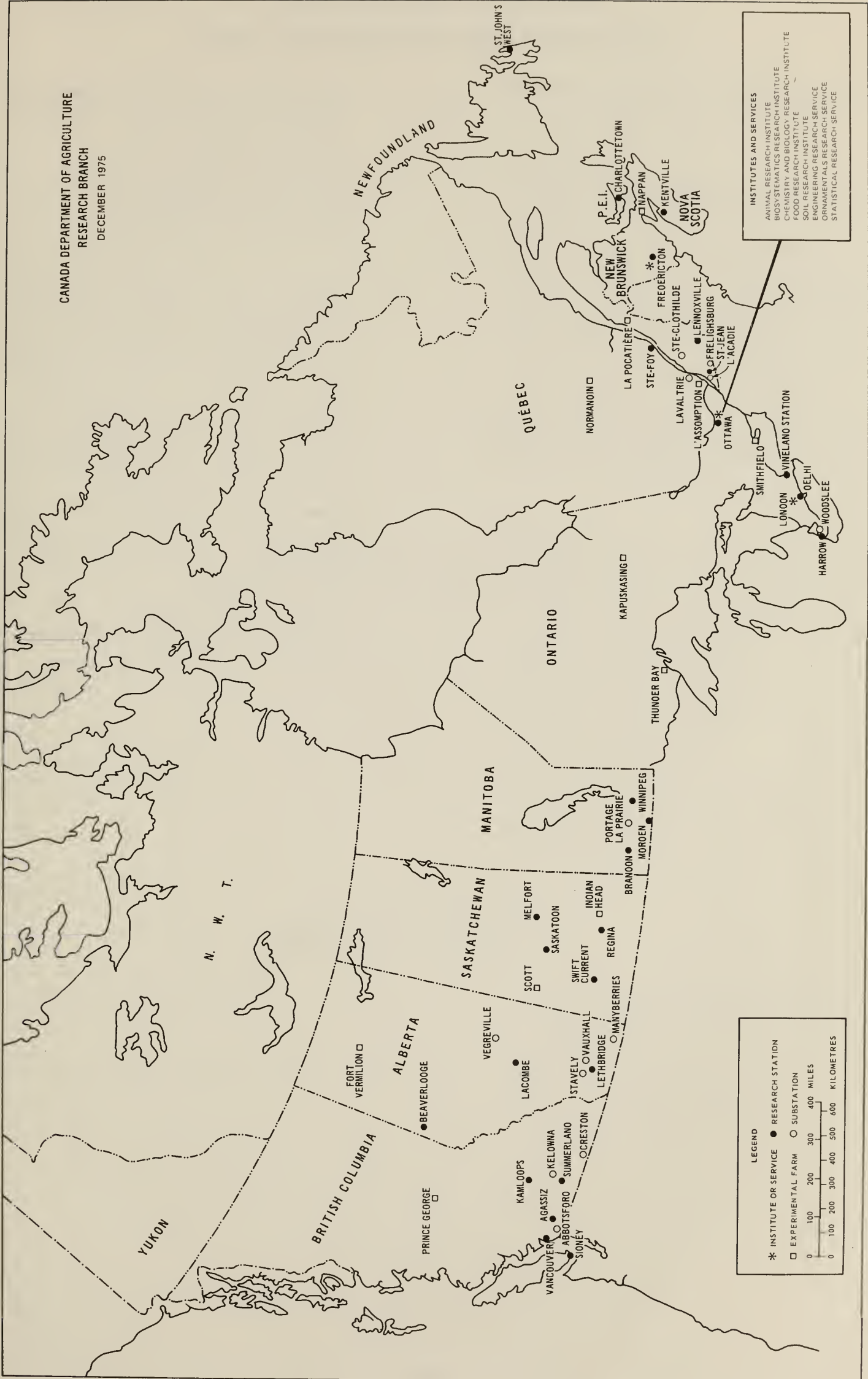
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CANADA DEPARTMENT OF AGRICULTURE  
RESEARCH BRANCH



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RESEARCH BRANCH  
DECEMBER 1975



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C. J. BISHOP, B.Sc., M.A., Ph.D., F.R.S.C., F.A.S.H.S.	Horticulture <i>Horticulture</i>
M. F. CLARKE, B.S.A., M.S.A., Ph.D.	Forage Crops <i>Plantes fourragères</i>
W. S. FERGUSON, B.S.A., M.Sc., Ph.D.	Soil Fertility <i>Fertilité des sols</i>
R. L. HALSTEAD, B.S.A., Ph.D.	Land Resources <i>Ressources de la terre</i>
C. D. MCKEEN, B.A., M.A., Ph.D.	Plant Pathology <i>Phytopathologie</i>
E. S. MERRITT, B.Sc. (Agr.), M.Sc., Ph.D.	Dairy Cattle <i>Bovins laitiers</i>
C. D. F. MILLER, B.S.A., M.S.A., Ph.D.	Biosystematics <i>Biosystématique</i>
H. V. MORLEY, B.Sc., Ph.D.	Environment and Resources <i>Environnement et ressources</i>
J. W. MORRISON, B.S.A., M.Sc., Ph.D.	Cereal Crops <i>Céréales</i>
W. J. PIGDEN, B.S.A., M.Sc., Ph.D.	Beef Cattle <i>Bovins de boucherie</i>
R. R. RIEL, B.S.A., M.Sc., Ph.D.	Food <i>Aliments</i>
W. J. SAIDAK, B.S.A., M.S., Ph.D.	Weeds <i>Malherbologie</i>
R. P. A. SIMS, B.Sc., Ph.D., F.C.I.C.	Field and Oilseed Crops <i>Grandes cultures et plantes oléagineuses</i>



**SPECIAL ADVISORS**  
**CONSEILLERS SPÉCIAUX**

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L. P. LEFKOVITCH, B.Sc.	Director, Statistical Research Service <i>Directeur, Service de la recherche statistique</i>
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**ADMINISTRATION DIVISION**  
**DIVISION DE L'ADMINISTRATION**

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## FOREWORD

The Research Branch Report for 1975 is a compilation of reports from the research establishments. This Report is part of a continuum of the progress made in research for agriculture by the Research Branch of Agriculture Canada. A companion report, prepared by the Planning and Evaluation Directorate, is also published each year and is prepared in terms of programs. The two reports indicate that our programs cover almost all research activities of significance to Canadian agriculture at local, regional, and national levels.

It is not readily apparent in this Report that the Branch cooperates actively with universities, provincial governments, and industry. During the past few years, through grants-in-aid, extramural research grants, contracts, and the New Crop Development Fund, as well as NRC and industrial research-assistance programs, our contacts and cooperative activity with institutions and organizations outside the Federal Government have expanded considerably. The Branch is continuing to encourage closer relationships among all groups working toward the solution of agricultural problems, because through cooperation results are more effective.

The Research Branch was reorganized in October 1975, creating an Operations Directorate, a Planning and Evaluation Directorate, and an Administration Division. The Operations Directorate consists of the Eastern Division, responsible for stations and

programs in the Atlantic Provinces and Quebec; the Central Division, concerned with the institutes, stations, and services in Ottawa and throughout Ontario; and the Western Division, responsible for stations and programs in Western Canada. The Planning and Evaluation Directorate is staffed with 15 Research Coordinators and is assisted by 4 Special Advisors from the Operations Directorate and other branches of the Department.

Dr. E. J. LeRoux, previously Assistant Director General (Planning and Coordination), became Director General, Operations Directorate. Dr. D. G. Hamilton, previously Assistant Director General (Eastern), was appointed Director General, Planning and Evaluation Directorate. Dr. J. J. Cartier, previously Research Coordinator (Entomology), became Assistant Director General, Eastern Division.

Dr. D. V. Fisher, Director, Research Station, Summerland, B.C., and Mr. L. S. Vickery, Director, Research Station, Delhi, Ont., retired in 1975. Dr. Fisher was succeeded by Dr. G. C. Russell, previously Director, Research Station, Harrow, Ont., who in turn was succeeded by Dr. J. M. Fulton, a senior Research Scientist at Harrow. Finally, Dr. J. G. Saha, a senior Research Scientist, Chemistry and Biology Research Institute, was appointed Director of that institute.

B. B. Migicovsky  
Assistant Deputy Minister

## AVANT-PROPOS

Le rapport de 1975 de la Direction de la recherche est constitué de l'ensemble des rapports de tous les établissements de recherches. Il fait le point des activités de recherches en agriculture menées par la Direction. Un rapport complémentaire sur les programmes, préparé par le Directeur de la planification et de l'évaluation, paraît également chaque année. Les deux rapports témoignent que les programmes de la Direction portent sur la presque totalité des domaines de recherches revêtant une importance pour l'agriculture canadienne aux échelons local, régional et national.

Il n'apparaît pas clairement dans le rapport que la Direction travaille en étroite collaboration avec les universités, les gouvernements provinciaux et le secteur industriel. Au cours des quelques dernières années, cette collaboration avec les établissements et organismes extérieurs et les contacts établis avec eux se sont considérablement intensifiés grâce à l'octroi de subventions, d'aide financière à la recherche extérieure et de contrats et au Fonds pour l'implantation de nouvelles cultures, ainsi qu'aux programmes d'aide à la recherche offerts par le C.N.R. et le secteur industriel. La Direction continue à favoriser le rapprochement entre les groupes oeuvrant à la solution des problèmes agricoles, car la coopération permet d'obtenir de meilleurs résultats.

En octobre 1975, la Direction de la recherche a fait l'objet d'une restructuration qui a amené la création du Directeur des opérations, du Directeur de la planification et de l'évaluation et de la Division de l'administration. Le Directeur des opérations comprend

la Division de l'Est, chargée des stations et programmes des provinces de l'Atlantique et du Québec, la Division centrale, de qui relèvent les instituts, stations et services d'Ottawa et de l'Ontario, et la Division de l'Ouest, qui s'occupe des stations et programmes de l'Ouest canadien. Le Directeur de la planification et de l'évaluation a un personnel de 15 coordonnateurs de recherche et bénéficie de l'aide de quatre conseillers spéciaux du Directeur des opérations et autres directions du ministère.

M. E. J. Leroux, auparavant directeur général adjoint de la Section de la planification et de la coordination, a été nommé directeur général du Directeur des opérations. M. D. G. Hamilton, auparavant directeur général adjoint de la Division de l'Est, est devenu directeur général du Directeur de la planification et de l'évaluation. M. J. J. Cartier, ancien coordonnateur de la recherche de la Section de l'entomologie, a été nommé directeur général adjoint de la Division de l'Est.

MM. D. V. Fisher et L. S. Vickery, directeurs des stations de recherches de Summerland (C.-B.) et de Delhi (Ont.) respectivement, ont pris leur retraite en 1975. M. G. C. Russell, ancien directeur de la Station de recherches de Harrow (Ont.) succède à M. Fisher et est lui-même remplacé par un des chercheurs scientifiques principaux de la Station, M. J. M. Fulton. Enfin, M. J. G. Saha, chercheur scientifique principal de l'Institut de recherche chimique et biologique, a été nommé directeur de cet institut.

Le Sous-ministre adjoint  
B. B. Migicovsky





# Research Station St. John's West, Newfoundland

## PROFESSIONAL STAFF

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

### Entomology Section

R. 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

### Agronomy Section

A. F. RAYMENT, B.Sc., M.Sc. Soil fertility

## INTRODUCTION

Research on potato wart disease, clubroot in turnip, the golden nematode, and economic insect control is the continuing responsibility of the Research Station at St. John's West. The Station's research program also includes experimental studies on vegetables and forages suitable for production on peat and mineral soils, drainage of peat soils, plant diseases, and plant nutrition.

This eleventh report covers results of research work conducted during 1975. Previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld., A1E 3Y3.

H. W. R. Chancey  
Director

### SOIL SCIENCE

#### Peat Soils

Because of high annual precipitation, intensive drainage with closely spaced, covered drains is necessary for vegetable production on local peat soils. When drains were back-filled with unhumified surface peat, permeability of the drain interface was fairly high, but after a period of cultivation rapid humification of the surface layer caused puddling and impeded drainage. In an effort to avoid puddling, tests were conducted with kiln dust from a cement plant to improve soil flocculation and drainage. The material used contained 8.3% water-soluble K and a fairly large amount of Ca.

In the greenhouse, applications of kiln dust and limestone were compared at rates of 5 000 to 15 000 kg/ha in combination with K at rates of 0, 166, and 332 kg/ha. The two materials showed no immediate difference in their influence on soil pH. With cultivated virgin peat, the effect of kiln dust on the mean hydraulic conductivity did not differ greatly from that of limestone, which showed a conductivity of  $6.81 \times 10^{-3}$  cm/s in cultures after 110 days. However, a cultivated, well decomposed peat under the same conditions had a conductivity of only  $5.28 \times 10^{-3}$  cm/s with limestone, but as much as  $7.71 \times 10^{-3}$  cm/s with kiln dust. Responses in conductivity appeared to be influenced by K supplied as fertilizer and in the kiln dust, but sharply declined where total K exceeded 830 kg/ha.

### PLANT SCIENCE

#### Forage Crops on Peat Soil

Chemical analyses of forage tissue taken from pastures in 1974 showed that the content of Cu and Mo increased as the season advanced. The high Mo content, 14.7 ppm, in Kentucky bluegrass samples taken in July and September verged on the level that would significantly interfere with assimilation of Cu by sheep. This might be associated with the declining lamb gains of the past two seasons, especially because the animals suffered more from scours in bluegrass pastures than in control pastures of reed canarygrass. The amount of Mo removed by bluegrass was about three times the annual application rate of 0.02 kg/ha, and possibly is related to residual effects of the carrot crop previously grown on the test area.

#### Field Crops

*Mineral soils.* When the rate of N applied before planting was increased from 224 to 336 kg/ha, field-seeded late cabbage cultivars Danish Ballhead and Houston Evergreen spaced at 36, 46, or 56 cm in the row did not give higher yields. However, yields at all plant spacings increased when N was applied as a split application of 224 kg before planting and 112 kg as a side-dressing. When plant spacing was increased from 36 to 56 cm, yields decreased.

*Weed control on peat soil.* Post-emergence applications of glyphosate at 1.12–5.60 kg active ingredient/ha were tested on land infested with reed canarygrass, Kentucky bluegrass, red clover, white clover, mouse-eared chickweed, and water foxtail. All rates

were equally efficient in controlling the weeds.

*Weed control on mineral soil.* Yields from plots of rutabaga cultivar Laurentian kept weed-free by hand for 5 wk after seeding were as high as those kept weed-free for most of the growing season. Marketable yields from plots kept weed-free for 3, 5, 7, 9, and 11 wk after seeding were 4.5, 62.0, 56.9, 51.3, and 53.3 t/ha, respectively. Weeding should not be delayed much later than 5 wk after seeding, if greatly reduced yields are to be avoided. Marketable yields from plots kept weed-free from 3, 5, 7, 9, and 11 wk after seeding until harvest at 16 wk were 61.2, 53.1, 38.1, 16.1, and 11.4 t/ha, respectively.

Similar trends were evident with transplanted late cabbages, cultivar Danish Ballhead, except that weeding could be delayed for about 7 wk after transplanting without excessive reduction in yield.

### Greenhouse Crops

At Happy Valley, Labrador, tests in 1974 and 1975 showed that satisfactory yields of greenhouse tomatoes were possible and that earliness in spring seeding was most important for producing ripe fruits. With seeding on May 1, 1974, the mean marketable yield per plant and percentage of ripe fruits were 3.7 kg and 29.6% for Vantage, and 3.6 kg and 33.7% for Ohio MR12 Pink Forcing. Seed set on April 15, 1975, produced mean marketable yields per plant and percentage of ripe fruits as follows: Vantage, 3.9 kg and 59.9%; Vendor, 3.5 kg and 60.7%; Tuckcross 533 Hybrid, 3.5 kg and 50.5%; and Michigan Forcing Hybrid, 3.7 kg and 52.0%.

At St. John's in 1975, seedings between January 30 and April 30 produced similar yields but later seedings produced lower ones. Yields of marketable ripe fruits of the variety Vantage seeded on January 30, March 1, March 31, April 30, May 30, June 29, July 29, and August 28 were 3.8, 3.9, 4.4, 4.0, 2.8, 2.2, 1.0, and 0.05 kg/plant, respectively. All plants were grown in fir-spruce sawdust with nutrient requirements supplied in water solution.

## ENTOMOLOGY

### Cabbage Maggot

In studies of control of the root maggot on rutabagas, five attractants were tested for effectiveness in controlling root maggot flies, all but Cabmaggottract (Zoecon Corporation, Calif.) for the first time.

At a density of 1 water-type trap/28 m<sup>2</sup>, Target rapeseed flour, allyl isothiocyanate, oriental mustard flour, and freeze-dried extract of Target FRI-71-19 (582) rapeseed flour (all supplied by the Food Research Institute, Ottawa) captured 231, 201, 197, and 288 root maggot flies/trap per season. Cabmaggottract in 3M Sectar yellow traps captured 120 root maggot flies at a density of 1 trap/14 m<sup>2</sup>. None of the attractants reduced populations of root maggot flies sufficiently to provide economic control.

### Golden Nematode

Studies on the effect of crop rotation on nematode populations and potato yields, started at Cupids in 1964, were concluded in 1975. Yields from monoculture plots were nearly 34% less than the average of those obtained from plots with 2-, 3-, and 4-yr rotations with grass or roots. Plot yields in 1975 were: monoculture, 30 kg; 2-yr rotation, 47 kg; 3-yr rotation, 51 kg; and 4-yr rotation, 47 kg.

Numbers of viable eggs of the golden nematode in cysts from the various plots were: grass monoculture, 0.8; potato monoculture, 120.5; 2-yr rotation, 42.5; 3-yr rotation, 15.8; 4-yr rotation, 26.3. Although the numbers of viable eggs varied widely, from 0.8 to 120.5, the total number of viable and dead eggs was approximately 1100 for each 25 cysts sampled.

## PLANT BREEDING AND PATHOLOGY

### Breeding Rutabagas Resistant to Clubroot

Samples of seed from a cross of York and Wilhelmsburger were distributed to growers in the Province and to other research stations. Reports indicate that yields and appearance of roots were acceptable, being similar to those of Laurentian or York. In a replicated trial at St. John's, yield was greater than that of either parent, but the purple color was less well developed than in York. Resistance to



clubroot was similar to that of Wilhelmsburger.

Seedlings of the European Clubroot Differential Series were raised in the greenhouse, in infested soil from the field test area. Coding was somewhat difficult because in some varieties only 50% of the plants became infected whereas in others infection was either 100% or 0%. These results may arise from lack of homozygosity in the differential hosts or from the presence of several races of the pathogen. Further tests will be required before the present system for describing races can be correlated with the suggested European one.

### Potato Breeding for Resistance to Wart and Golden Nematode

The wart-resistant selection N135-55 was named Mirton Pearl and released for commercial production early in 1975. Consistently good reports on its performance were received from commercial growers and no wart infection occurred.

In trials conducted throughout the Province, selection N344-10 bred from Sable × Mira again yielded well. Tubers were not as smooth as those grown in 1974 but were comparable to those of the control variety, Kennebec.

Selection N227L5, resulting from a cross of the wart-resistant variety Mira and the golden nematode – resistant variety Amelio, has been widely tested. Although resistance to both pests has been confirmed, yields have been generally unsatisfactory.

Greenhouse plantings included seedlings that originated from crosses made between wart-resistant andigena varieties at the International Potato Center, Peru. Plants generally matured extremely late and many failed to produce tubers. However, seedlings produced by hand pollination of parent plants with a bulked sample of pollen were superior in yield to seedlings obtained from naturally

occurring berries of the same parent plants. Such superiority lends support to the theory that most seed produced under natural conditions results from self-pollination and not from outcrossing.

### Infectivity and Germination in Potato Wart Disease

Last year's irrigation work with potatoes and *Synchytrium endobioticum* (Schilb.) Perc., in which a multi-modal infection curve was generated, was extended. It was found that for race 2, most wart was induced environmentally by irrigating to excess twice daily for 2 wk after planting. Tubers were dipped in various solutions of benomyl, thiabendazole, carbathiin, UNI 1049 (Uniroyal), BAS 3460 (BASF), BAS 3270 (BASF), thiophanate-methyl, Bay Dam 18654 (Chemagro), and triforine. At high concentrations, disease was reduced somewhat, but not consistently or to an economically significant extent. Races 2 and 8 were compared in the fungicide tests but no differences were apparent. The tests were interesting, especially the field tests, in that less infection occurred on the nontreated plants than on the treated ones. Fifty-five commercial tomato varieties were inoculated with races 2 and 8. Both races were equally effective in infecting all the tomato varieties.

Resting sporangia of *S. endobioticum* were incubated for up to 5 wk in plant extracts or soil leachates, at differential levels of osmotic pressure, surfactant, and pH. Little influence was found that could be detected repeatedly. Further work was carried out on exudates from sprouts. A rich ninhydrin-positive exudate was demonstrated in various potato cultivars as early as 1 h after the test started. Some qualitative differences were found between cultivars susceptible to race 2 and those susceptible to race 8, mainly among the more polar components of the chromatoplate.

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# Research Station

## Charlottetown, Prince Edward Island

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## INTRODUCTION

The Research Station at Charlottetown has Atlantic regional responsibility for research into the production of forages, cereals, tobacco, and certain 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.

Research at the Charlottetown Station resulted in the licensing of a new winter wheat variety, Lennox, which has improved winterhardiness and tolerance for snow mold. A method was developed to wean calves onto dry feed at 3 wk of age. This early weaning method and use of fermented colostrum together provide an economical system for starting dairy calves.

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. C1A 7M8.

L. B. MacLeod  
Director

## CEREALS AND PROTEIN CROPS

### Breeding and Testing

*Barley.* Nordal, a two-rowed barley variety from Denmark, produced more than other varieties under abnormally dry conditions in field plots at Charlottetown in 1975. Nordal also performed well before 1975, under more normal conditions of soil moisture. Diva and AB15-1, two-rowed types, excelled in provincial trials in 1974 and 1975. They have good resistance to lodging.

*Winter wheat.* Lennox, a variety with improved hardiness, was licensed. It out-yields Yorkstar, Genesee, and Talbot in years when winterkilling is a problem. Lennox has higher test weight and heavier kernel weight than other recommended varieties, is resistant to seed sprouting in the head, and is tolerant of snow mold, causal agent *Fusarium nivale* (Fr.) Ces.

*Spring wheat.* The selections MRO-1, MRO-2, and AW1-3-2-1 were superior to Opal in yield performance. In the Maritime-Quebec Cooperative Test, MRO-1 and MRO-2 yielded 150 and 130 kg/ha more than Opal. Both selections have resistance to powdery mildew, *Erysiphe graminis* DC. ex Mérat f. sp. *tritici* Marchal. The selection AW1-3-2-1 yielded 200 kg/ha more than Opal in the Maritime Cooperative Test. AW1-3-2-1 matures 2-4 days earlier, and is about 20 cm shorter, than Opal. Screening

for resistance to *E. graminis* and *Septoria avenae* Frank f. sp. *triticea* T. Johnson identified several selections with resistance.

*Winter rye.* This crop continued to give excellent grain yields, Kodiak and Puma yielding 4.5-5.0 t/ha. This year was the first time that damage from snow mold was severe. Kodiak and Puma expressed tolerance for the disease, but Kustro was damaged severely, with grain losses of 30-50%.

*Fababeans.* Data for the past 3 yr show that Herra, Diana, Minden, Herz Freza, and Ackerperle gave seed yields of 3670, 3640, 3489, 3317, and 2824 kg/ha and protein yields of 989, 962, 948, 881, and 785 kg/ha, respectively. Herz Freza matured 4 days earlier than Diana, which required 120 days. Minden, Herra, and Ackerperle matured 3, 9, and 13 days later, respectively, than Diana. Yields of fababeans have been inconsistent among years, differences varying up to 50% from the 3-yr average.

*Field peas.* Six varieties of field peas, two from the breeding program at Morden, Man., and four European introductions, yielded more than Century and Trapper. MP789 (Morden) produced the highest seed yield, 3788 kg/ha. The European introductions all had shorter vines and larger seeds than the Canadian varieties.



## Nutrition and Management

*Determination of  $\text{NH}_3$  in soil.* A method was developed for determining  $\text{NH}_3$  concentrations in soil. It involves pumping dilute acid through a cell that contains a gas-permeable membrane and determining the concentration of  $\text{NH}_4^+$  in the acid stream. The method is currently being used to study urea transformations in soils.

*Response of cereals to boron.* In field experiments conducted for 3 yr, additions of 1–2 ppm B resulted in 28–58% reductions in grain yield of wheat and barley. At 1 ppm added B, N applied at rates of 50–75 kg/ha had some beneficial effect in controlling B toxicity in barley.

*Least-cost implement sizes for tillage and seeding cereals.* A computer program was written in Fortran IV to determine the least-cost sizes of tractors and implements and the allocation of implements to one or two tractors, for assigned cultural practices and areas of cereal crops. Estimates of the costs of tractors, implements, labor, and the value of a late-planting penalty are provided by the program. Least-cost sizes of tractors and implements were determined for an example of 81 ha of cereals, given that half of the plowing was done the preceding autumn and that the soil was disced once and harrowed twice before seeding. The sizes are: three-bottom (41-cm) plow, 3.66-m disc, 4.27-m harrow, and 3.66-m seeder. The disc and harrow are assigned to a 29.8-kW tractor, and the plow and seeder to a 39.5-kW tractor. Costs for labor, tractors, implements, and late-planting penalty are \$10, \$25, \$17, and \$3/ha, respectively; total cost per hectare is \$55.

*Field pea – cereal plantings.* In harvested grains, protein content but not yield was higher when the proportion of field peas was increased in mixed plantings of field peas and cereals. The quality of peas was higher in mixtures than in pure plantings because leaf and pod diseases were reduced.

## Diseases and Insects

*Snow mold damage.* During the winter of 1974–75, more than 90% of the winter rye fields in Prince Edward Island were infected with *F. nivale* and severe damage from snow mold occurred. Damage from that infection was less in Nova Scotia.

*Common root rot of barley.* Early seeding, which reduces leaf diseases, did not reduce the severity of common root rot. Losses in yield from root rot were directly proportional to reductions in numbers of tillers.

*Barley yellow dwarf virus.* Progress was made in identifying cultivars of oats, wheat, and barley with tolerance for the barley yellow dwarf virus (BYDV) disease of cereals. The oat line PI186606 may be useful in future oat breeding work because it shows some tolerance for BYDV and some resistance to septoria disease.

*Control of pea moth in field peas.* Good control of the pea moth, *Laspeyresia nigricana* (Stephens), was obtained with carbofuran, methomyl, or dimethoate sprays, or with granular soil treatments of disulfoton, phorate, or carbofuran, but yields were not significantly increased. Such treatments would be beneficial if the peas were grown for seed.

## FORAGES

### Management and Nutrition

*Winter survival.* Literature was surveyed to determine the frequency of occurrence of winter injury among various crops in this century in Prince Edward Island. The frequency was 1 in 5 yr for clovers, 1 in 5 yr for alfalfa, 1 in 3 yr for winter wheat, 1 in 8 yr for winter rye, and 1 in 5 yr for strawberry plants. When the soil moisture level was increased from 50% to 100% of field capacity equivalent at above-freezing temperatures, Saranac alfalfa plants suffered a significant loss of cold tolerance. Much less cold damage to plants was observed when sufficient water was added at a subfreezing temperature to increase the soil moisture level to 116% of field capacity equivalent (comparable to a 2.4-cm rainfall in winter). Cold tolerance of forage crops grown in wet soil decreased, in the order Champ timothy, Leo birdsfoot trefoil, Tardus orchardgrass, Saranac alfalfa, Norlea perennial ryegrass, and Lakeland red clover. The adverse effect of high moisture content of soil on the survival of these plants, except timothy, was greater than the effect of an ice sheet 10 cm thick covering the soil for 2 mo.

*Harvest systems and nitrogen rates for timothy.* In a 3-yr study, Champ timothy



under a two-harvest system persisted well and produced dry matter (DM) yields from 3902 to 8348 kg/ha, depending on the rate of N applied. The DM yields increased as N rates were increased to 264 kg/ha per year (two applications of 132 kg). The low crude protein (CP) content, 9.3–13.8%, and in vitro digestibility of DM (IVD), 59.6%, resulted from advanced maturity of the timothy at both harvests. Under a three-harvest system the DM yields ranged from 3125 to 7214 kg/ha per year and increased as the N rate was increased to 300 kg/ha per year (three applications of 100 kg). The three-harvest system, with the first harvest at the early heading stage, reduced the persistence of timothy. Depending on N rate, CP contents were 12.8–19.9% and IVD was 68.9%. With a four-harvest system, CP contents were 15.2–22.4% and IVD was 71.1%. The DM yields were 2679–6313 kg/ha and increased as more N was applied up to 400 kg/ha per year (three applications of 133 kg). Timothy persisted well under the four-harvest system. The seasonal distribution of DM production was not altered much by the harvest systems and N rates, with 57–73% of the forage produced by July 1. Weeds quickly infested the plots when N was applied at 100 and 200 kg/ha per year. Under the two-harvest system, 48–72% of applied N was recovered, and under the three- and four-harvest systems 38–72% was recovered. Recovery of N was highest where N was applied at 200 and 300 kg/ha per year.

*Selection of machinery size for direct-cut forage harvesting systems.* The results obtained by simulating harvest with a computer suggest that a wide range of system capacities can provide a net margin (crop value less machinery and labor costs) within 5% of the maximum net margin. For direct-cut systems at Charlottetown, the ranges in capacities for handling wet matter were 5–15, 7–18, and 9–23 t/h for 20, 40, and 81 ha, respectively. Although the net margin did not change significantly within these ranges, the larger systems provided higher and more consistent year-to-year levels of energy and protein in the harvested forage, and lower yields, than the smaller systems. Economies of scale were found to exist for both machinery and labor without affecting forage yield or quality.

*Effect of foliar spray of molybdenum on its uptake.* A field experiment conducted on a fine sandy loam soil indicated that Mo

applied at 0.22 kg/ha as a foliar spray was effective in increasing the concentrations of Mo in alfalfa and red clover. The foliar spray did not increase the concentration in plant tissue beyond 10 ppm.

*Pure forage species vs a natural pasture sward for grazing.* When all fertilizer treatments were averaged, timothy produced a DM yield of 12.13 t/ha, which was 0.92, 1.57, and 2.57 t/ha more than the yields of a natural sward (Kentucky bluegrass, timothy, browntop, and white clover), brome grass, and reed canarygrass, respectively. No significant yield increase was obtained from annual treatments with N at more than 280 kg/ha. Treatments with N in early spring and on September 1 stimulated growth in all swards and increased production. Reed canarygrass was not as well grazed as the other swards during the lush growth period, but the herbage was used well after one mechanical clipping. Reed canarygrass and timothy survived the winter better than brome grass. Under rotational grazing management, volunteer Kentucky bluegrass and white clover infiltrated all swards; clover constituted from 13% to 45% of the stand by species.

*Whole-crop fababeans for silage.* In a 2-yr study, whole-crop fababeans, cultivar Diana, harvested at three maturities, produced low DM yields (1885–3131 kg/ha). Although the quality of fababean silages was good, fababeans show poor potential in Prince Edward Island as a silage crop compared with other annual forages.

*Corn management.* Two-year-average DM yields of silage corn were greatest immediately before the first fall frost. Within 10 days after the frost DM yields fell by 10%, and by 15% after 30 days. In vitro digestible DM yields were also greatest immediately before frost and were reduced by 15% and 18% in the same periods. Plant nutrient contents of N and K, as well as total N and K harvested, also declined progressively after frost, which indicates direct losses of plant nutrients from frosted plants.

Over 4 yr, population densities of 39 000 to 80 000 plants/ha had no significant effect on silage DM yields, although populations of less than 50 000 plants/ha had the lowest yields. Whole-plant DM contents were not affected significantly by population density, but the percentage DM content of the grain



component of silage from the denser populations was reduced significantly in 2 yr.

As the planting date for silage corn was delayed from mid-May to late June in a 4-yr experiment, the maturity of both the whole plants and the grain progressively lessened. Depending on the season, DM yields were greatest from either a mid- or late-May planting. Early plantings took from two to three times longer to emerge, thus diminishing the expected advantages of earlier planting.

*Effects of quack grass competition on corn silage yield.* Corn was planted in conditions of light or heavy infestation with quack grass (30% or 90% of unweeded control plot covered). When control of quack grass was delayed until 3 wk after the corn emerged, silage yield was 10% lower under the light infestation and 45% lower under the heavy infestation than were yields from plots that were hand-weeded all season. When control was delayed for 6 wk, yield reductions were 36% and 76% under light and heavy infestations, respectively. Weed control was necessary during the first 6 wk after emergence to obtain maximum yields.

*Fall vs spring application of glyphosate and Velpar.* Application of glyphosate at 1.12 and 2.24 kg ai/ha to quack grass in the four- to six-leaf stage in the fall of 1974 or spring of 1975 gave 85–95% control of quack grass, whereas application at 0.56 kg ai/ha at each time gave only 55% control. Results were based on visual ratings and rhizome dry weight recorded in the fall of 1975. Application of Velpar (DuPont) at 2.24, 4.48, and 6.72 kg ai/ha to quack grass at the same stage of development resulted in only 2.5%, 50%, and 45% control, respectively, for each rate applied in fall 1974; however, application in spring 1975 gave 85% control of quack grass at all three rates of treatment. Glyphosate can be used at any time of the year, whereas Velpar is most effective as a spring-applied herbicide.

## Nematodes and Insects

*Effect of nematode control on alfalfa.* Yield of alfalfa forage was 30%, 51%, 11%, and 25% higher from plots fumigated with methyl bromide than from nonfumigated plots in the 1st, 2nd, 3rd, and 4th yr after seeding, respectively. The increases were coincident with excellent initial control of the root-lesion nematode, *Pratylenchus penetrans*

(Cobb) Filipjev & Stekh., and very little reinfestation occurred. Nematode control by treatment with fenamiphos was good for 2 yr but declined thereafter. Fenamiphos treatment resulted in a 19% increase in forage yield in the 2nd yr and increases of less than 10% in the 3rd and 4th yr. Numbers of nematodes in fallow plots, although lower than in control plots at seeding, increased until they were similar to those in the control plots by the end of the 2nd yr. Following increased forage yield in the 2nd yr only. Infections of alfalfa roots caused by *Fusarium* spp. were positively correlated with nematode numbers during the first 2 yr of the study, but extensive infection of alfalfa roots occurred even in fumigated plots by the 3rd and 4th yr. Plant persistence was not affected by any of the treatments.

*Behavior of root-lesion nematodes.* During a very dry period in August 1975, *P. penetrans* migrated out of red clover roots into the soil. When moisture increased in late September, the nematodes appeared to reinvade the roots.

*Insect pests of forage legumes and grasses.* The bronzed cutworm, *Nephelodes minians* Guenée, appeared again in large numbers in the Tantramar Marsh in New Brunswick. Granulosis and polyhedrosis virus diseases, and a microsporidian disease, may have been responsible for the sudden reduction in the population before grasses were seriously damaged. The alfalfa blotch leafminer, *Agromyza frontella* (Rondani), was present in most alfalfa crops in the three Maritime Provinces, but serious damage was not reported. The European skipper, *Thymelicus lineola* (Ochsenheimer), was present in large numbers in Prince Edward Island and caused considerable damage to timothy in a number of fields. Sprays of trichlorfon, carbaryl, malathion, and *Bacillus thuringiensis* Berliner effectively reduced larval populations in field plots.

*European corn borer in field corn.* Granular carbofuran, fonofos, diazinon, fensulfothion, phorate, *B. thuringiensis*, or N-2596 (Stauffer) was applied once to field corn at the whorl stage, or the corn was sprayed twice with carbofuran, carbaryl, Pencap E (Pennwalt), or NRDC-143 (Chipman). The treatments reduced infestations of the European corn borer, *Ostrinia nubilalis* (Hübner),



significantly, but silage and grain yields were not increased.

## CATTLE

### Model of Milk Production Based on Timothy Silage

As a result of cooperative work among most of the Research Branch establishments in Eastern Canada, a five-part preliminary model of a dairy farm in which timothy silage is the sole forage has been completed. The five parts are: daily DM accumulation in timothy as a function of selected weather parameters and applied N; DM, energy, and protein put into storage as a function of harvest system capacity and type, and selected daily weather parameters; in-silo losses of DM, energy, and protein as a function of silage moisture content, type of silo, and silage treatment; conversion of silage and other feeds to milk, by means of an algorithm that indicates optimal level of milk production and optimal ration composition; and physical description, energy consumption, labor use, and costs associated with various systems of housing, feeding, milking, and manure disposal.

### Early Weaning of Dairy Calves

In studies comparing 2- to 5-wk weaning ages for Ayrshire and Holstein calves, 3 wk was found to be an acceptable age for weaning onto dry feed. Calves that were aggressive eaters could be weaned onto dry feed at 2 wk; however, some calves weaned at less than 3 wk did not adapt to dry feed and required additional milk feeding to survive. It was unnecessary to delay weaning until dry feed intake reached a fixed daily amount. Healthy calves, weaned abruptly at 3 wk, adapted quickly to dry feed with practically no setback.

Early-weaned calves consumed more of a coarsely rolled grain ration (0.67 kg/day) than of a pelleted ration (0.59 kg/day) and made better gains on the coarsely rolled ration (0.28 vs 0.20 kg/day), up to 5 wk of age. The inclusion of either plant or animal protein sources (soybean meal or fishmeal) in the starter ration fed up to 5 wk of age made little difference in feed intake (0.63 and 0.64 kg/day) or rate of gain (0.25 and 0.22 kg/day). Performance of calves fed fermented colostrum was essentially identical to that of calves started on whole milk. Weaning at 3

wk of age and the use of fermented colostrum provide an economical system for starting dairy calves.

## HORTICULTURAL CROPS

### Potato Nutrition and Management

*Fertilizers, plant spacings, and seed tuber sizes.* An unusually dry growing season resulted in low yields with small responses to fertilizer treatments. When Netted Gem potatoes were planted late, tuber set was reduced and the percentage of large tubers increased. With wider plant spacings, up to 56 cm, the percentage of large tubers increased. Spacings wider than 56 cm reduced total yields. Applications of urea and urea plus diammonium phosphate delayed plant emergence and early-season growth, but recovery of plants by mid-August resulted in final yields equal to those from plots treated with ammonium nitrate at similar rates of N application. High N rates caused a slight reduction in specific gravity of tubers. To measure the effects of seed tuber size on yield and size distribution of Netted Gems, 57-g sets were planted as 57-g whole tubers, halves of 113-g tubers, and quarters of 227-g tubers. As seed tuber size increased, the number of main stems per hill decreased from 3.9 to 2.8, yields of tubers weighing 50–170 g decreased, and yields of tubers weighing 170–570 g increased. The specific gravity of tubers decreased slightly as the size of seed tubers increased.

*Cultivar response to metribuzin.* Metribuzin was applied before emergence on the soil surface, soon after emergence on potato shoots 7.5 cm tall, or late on potato shoots 22.5 cm tall, at rates of 0.56, 0.84, and 1.12 kg ai/ha at each time of application, to Irish Cobbler, Kennebec, and Sebago potatoes. Yields of all varieties were excellent at all rates applied before and soon after emergence. The late treatment caused lower yields of all varieties at all rates of application; however, Irish Cobbler and Kennebec appeared more susceptible to yield reductions than did Sebago. Weed control was excellent at all rates and timings, except that wild buckwheat was only 50% controlled initially and subsequently became a problem at harvest.

## Potato Diseases

*Control of viruses.* More than 9000 serological tests were conducted during the summer at the Elite seed farm for potato viruses S (PVS) and X (PVX). Pre-elite stocks were found to be 2.7% infected with PVS, but no PVX was found in this class. In the Elite I and Elite II classes, less than 6% PVS and less than 2% PVX were found. On selected growers' farms, the Elite III seed of Kennebec and Sebago contained less than 7% PVS and less than 5% PVX.

*Spread of viruses S and X.* Replicated field trials were planted with virus-free seed of the varieties Kennebec, Sebago, or Green Mountain. No spread of PVS or PVX was found during the growing season in two tests by serological and plant indicator methods.

## Vegetable Nutrition and Management

*Effects of N, P, K, and lime on pea yields.* Broadcast applications of N, P, and K failed to affect the yields of green peas significantly in experiments conducted at three locations. Yields ranged from approximately 3700 to 5600 kg/ha and also were not affected by applications of lime at 400 kg/ha in the row with the seed. However, the growing season had considerably less rainfall than normal, and lack of sufficient moisture could have depressed yields at 11 locations.

*Manganese toxicity in carrots at high soil pH.* Carrots grown on a sphagnum peat soil showed a leaf disorder and reduced yields at soil pH levels of 7.8–8.1. These symptoms and reduced yields were attributed to toxicity caused by Mn concentrations greater than 332 ppm.

*Broccoli spacing trial.* Broccoli plants spaced at 30 × 30 cm produced more than those of equal plant density spaced at 90 × 10 cm. The cultivars Bravo and S & G No. 1 grown in the square planting plan produced 14.8 and 15.0 t/ha, respectively, at a single harvest. In comparison, the yields of the two cultivars were 6.9 and 9.6 t/ha, respectively, where the plant spacing was 90 × 10 cm.

## Vegetable Nematodes and Insects

*Nematodes in vegetables.* Twenty-five genera of nematodes were identified in carrot, pea, broccoli, rutabaga, Brussels sprouts, and

cauliflower. *P. penetrans* was the dominant plant-parasitic nematode, with the greatest number recovered from carrot soil.

*Bioactivity of new insecticides.* Bioassays for detecting residues of pesticides in plant tissue have shown that toxicants of all compounds tested to date (approximately 35 materials) are absorbed by rutabagas grown in treated soil. Comparative levels of toxicants varied greatly among compounds, particularly after plants had been in storage for varying periods of time. Toxicants of carbamate materials, such as carbofuran and propoxur, were high at first in the pulp of roots in storage (where high rates had been applied to the soil) but disappeared after 60–100 days. Toxicants of certain organophosphorus compounds, such as fenamiphos and isofenphos, were also concentrated in the pulp, but the toxic metabolites of these materials persisted at high levels for at least 100–150 days in roots in storage at 3 °C. Toxicants of all other organophosphorus compounds tested to date were concentrated in the peel of the roots and only small or trace amounts were found in the pulp. Materials considered to be most persistent in the soil, such as N-2596 (Stauffer), fonofos, trichloronat, and phoxim, were absorbed more slowly by plants and showed lower levels of toxicants at time of harvest. However, the toxicants present in roots in storage were more persistent and were detectable for 6 mo to 1 yr.

## TOBACCO

Three sources of N produced varying yields of flue-cured tobacco when applied at equal rates at two locations. Diammonium phosphate at 34 kg/ha produced higher yields but lower quality than ammonium nitrate at the same rate. Tobacco grown with the third source, potassium nitrate, showed evidence of N deficiency and yields were significantly lower. All three sources are suitable for tobacco production but vary in the amount of N supplied to the crop during the growing season. Correlation of yield and quality with applied N must be carried out separately for each source.



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# Research Station

## Kentville, Nova Scotia

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Toxicology

Transferred to Research Station, Vineland Station,  
Ont., April 1, 1975

A. C. COX, B.S.A., M.Sc., Ph.D.  
Resigned October 9, 1975

Nutritional physiology

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## INTRODUCTION

This publication summarizes the main research results of the Research Station at Kentville and the Experimental Farm at Nappan for 1975. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km (50 miles) north of Kentville, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool, humid climate, and Podzol soils.

On December 29 Dr. R. F. Bishop, Head of the Vegetables, Cereals, and Field Crops Section, retired after 37 years of service.

Copies of this chapter of the Research Branch Report and reprints of the listed publications are available on request from the Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5.

J. R. Wright  
Director

### BREEDING, NUTRITION, AND CULTURE OF CROPS

#### Lowbush Blueberries and Cranberries

*Lowbush blueberry fertilization.* In a greenhouse study, the addition of N, P, and S at the rate of 56 kg/ha singly or in combination to a sandy loam till of the Westbrook soil series produced changes in the growth of lowbush blueberry seedlings. N alone produced some undesirable effects such as late fall vegetative growth, whereas P had some beneficial effects such as increased production of flower buds.

When the same treatments were applied to clonally propagated plants of the same species grown on the same soil type the differences in growth were not as striking, but the fertilizer containing N, P, and S produced the best growth.

A correlation coefficient of 0.97 was found between the diameter and weight of the berries.

*Lowbush blueberry seed germination.* Seeds of the lowbush blueberry germinated well following storage in the berry at  $-23^{\circ}\text{C}$  or when cleaned and stored dry in paper envelopes at  $-23^{\circ}\text{C}$ ,  $-2^{\circ}\text{C}$ , or  $1^{\circ}\text{C}$ . When stored in the berry at  $-2^{\circ}\text{C}$  or at  $1^{\circ}\text{C}$ , the berries became moldy with a *Botrytis* species and germination was reduced considerably. The technique of storing seed dry at a reduced temperature will be of value to the lowbush blueberry breeder.

*Genetics of lowbush blueberry.* One diallel involving five parents and a second involving eight parents were evaluated for 3 yr each. In the five-parent diallel, the date of harvest, yield of ripe fruit, weight per berry, and area covered by one plant were evaluated. Of these, weight per berry had the greatest genetic and additive components of variation, whereas these components for yield were very low. In the eight-parent diallel the same variables were evaluated with the addition of berry color, plant vigor, and log number of berries. Weight per berry and berry color had large genetic and additive components, whereas yield of ripe fruit, plant vigor, and log number of berries had large environmental components of variation.

*Crop improvement of lowbush blueberry.* After 2 yr of growth in the field a planting of select clones yielded 1662 kg/ha in 1975. Other plantings produced 8083 and 14 032 kg/ha 4 and 6 yr after planting. Production from seedlings has been of the same order of magnitude. Yields from mature native stands are in the order of 2000 kg/ha. The establishment of select clones or seedlings or both makes it possible to implement a greater degree of management coupled with superior plant material resulting in increased and hopefully more consistent yields.

*Augusta lowbush blueberry.* The Augusta lowbush blueberry is the first clone of the lowbush blueberry to be named and released as a cultivar for commercial production. It is an early to midseason cultivar with large



attractive berries and is adapted to areas where lowbush blueberries are being cultivated.

*Oxygen levels and cranberry production.* The level of oxygen in the floodwater under the ice covering a large (8 ha) cranberry stand in the Annapolis Valley dropped to at least 4.0 ppm of O<sub>2</sub> during the winter of 1974–75. This may be one of the reasons for low yields in this area because an oxygen content below 6.0 ppm has caused killing of the meristematic tissues of vines in Massachusetts and resulted in marked reduction in yields.

## Strawberries

*Breeding.* The cultivar Bounty introduced in 1971 has performed well in the Atlantic Provinces and Quebec. Of the plants set in Nova Scotia for fruiting in 1975, 12.3% were Bounty. Redcoat with 38% and Gorella with 12.9% were the only cultivars out of 17 available ones that were more widely planted. In grower test plots of 1000 plants or more, selection 68-108 (Tioga × Guardsman S<sub>1</sub>) has performed well. A consumer acceptance trial conducted at a fresh-fruit outlet in Truro, N.S., indicated that 68-108 was highly satisfactory. Selection 72-9 (Bounty × 68-108) also showed much promise in test plots that fruited in 1974 and 1975.

*Plant spacing with Bounty.* Bounty was grown for 2 yr (1973 and 1974) in matted rows with plant spacings of two, four, and six plants/0.093 m<sup>2</sup> and noncontrolled spacing. In the first fruiting year yields were lowest from two plants/0.093 m<sup>2</sup> and yields of other spacings did not differ significantly. Second-year yields from the same plots were lowest from the noncontrolled spacing and did not differ significantly for other spacings.

The percentage of the marketable crop weighing 7 g or more per fruit ranged from 84.3% from the noncontrolled stand to 93% for two plants/0.093 m<sup>2</sup>. Seasonal mean fruit weight was not affected by treatments in 1973. In 1974 fruit from the noncontrolled spacing was significantly smaller than fruit from the other spacings. Optimum marketable yields were 46 629 kg/ha and a seasonal mean weight per fruit of 12 g was produced from a plant stand of six plants/0.093 m<sup>2</sup>.

*Boron nutrition in three strawberry cultivars.* The cultivars Redcoat, Midway, and K68-108 were grown in sand culture and

supplied with four levels of nutrient B interacted with three levels of nutrient P. Leaf B values of 2–5 ppm were associated with B deficiency symptoms in Redcoat and K68-108. Maximum vegetative growth of these cultivars occurred when leaf B ranged from 58 to 116 ppm, with nutrient B at 0.2 and 0.4 ppm, and nutrient P at 5 and 25 ppm. Midway exhibited maximum growth at leaf B values of 14–33 ppm with nutrient B at 0 ppm and nutrient P at 5 and 25 ppm. The higher levels of nutrient B were reflected in higher leaf B values and no significant P–B interactions were exhibited. Redcoat and K68-108 leaf B values are similar to those associated with maximum growth in rutabagas, sugar beets, barley, and several forages, whereas Midway was found to be very sensitive to B additions.

*Effects of growth regulators on runner plant production, yield, and fruit maturity of the strawberry.* Ethephon and succinic acid 2,2-dimethylhydrazide (SADH) were applied either singly or in combination to Redcoat in the greenhouse. A single ethephon application at 960 ppm significantly increased fruit yield and the percentage of fruit harvested in the first three picks compared with the control. Production of runner plants from ethephon-treated fruited plants was comparable to that of deflowered control plants. SADH had no beneficial effect on yield, time of maturity, or production of runner plants. In one field trial with Redcoat a single application of ethephon at 480 ppm combined with gibberellic acid (GA) at 50 ppm applied to flowered plants 2 wk after planting resulted in a production of runner plants that was comparable to the production from deflowered control plants. In a second field trial, a single application of ethephon at 960 ppm was applied to each of seven cultivars. Flowered plants of Redcoat, Bounty, Vibrant, Midway, and Totem that received this ethephon application produced as many runner plants as deflowered control plants. Flowered plants of Gorella and Raritan did not respond to this treatment.

## Red Raspberries

*Breeding.* Emphasis has been placed on winterhardiness, disease resistance, upright canes, productivity, and fruit firmness. Selections 69-4 (Fairview × Boyne), 70-11 (Southland × Boyne), and 70-15 (Fairview × Boyne) have been promising and placed

in replicated test plots in Nova Scotia and Prince Edward Island.

## Apples

*Shape of McIntosh fruit.* Fruit shape was influenced by position in the blossom cluster, rootstock, and strain and was correlated with the Mg content of leaf tissue. High Mg content of leaves was associated with large length-to-diameter (L:D) ratios of fruit. The effects of rootstock and strain were conditional; in years of short apples the L:D ratio of fruit approached a common small value regardless of rootstock or strain, whereas in years of more elongate apples the L:D ratio of fruit was more influenced by rootstock or strain. In general, large L:D ratios were associated with shallow stem cavities.

*Effect of hormone sprays on drop, firmness, and other responses.* In two experiments succinic acid 2,2-dimethylhydrazide (SADH) at low to moderate rates (62.5–1000 ppm, 0.93–4.32 kg/ha [0.82–3.84 lb/ac]) increased fruit firmness and decreased fruit drop of McIntosh apples in proportion to the amount applied. Split and single sprays that applied the same total amount of SADH were equally effective. The addition of Tween 20 at 0.025% (vol/vol) had no significant effect on response. None of the treatments affected cropping over three seasons nor fruit color or fruit size in the year of application. Fruit size in the year following application showed a threshold effect in that earlier dates and lower rates had no measurable effect.

## Forage and Vegetable Crops

*Cutting schedules for grass.* A study on a fine sandy loam at Charlottetown, P.E.I., indicated that alfalfa grown with timothy or brome grass produced high dry matter yields over a 3-yr period when the stands were harvested the first time June 23–25, followed by the second harvest in early August, and final harvest in late October after the killing frost. Under such management, crude protein (CP) concentrations were 15–17% in all harvests. The in vitro digestible dry matter (IVDDM) was 61–62% in the first harvest. In the second and third harvests the IVDDM ranged from 52 to 57%. Earlier harvesting of the first crop tended to reduce alfalfa in stands and thus lower the yields, particularly in the third year. Taking the first crop in early July reduced the concentrations of IVDDM

and CP, but the survival of both alfalfa and grass was good under such managements.

*Seeding fababeans in frozen ground.* Because fababeans require a long season to mature, methods of seeding fababeans in and on frozen soil were studied at the Experimental Farm at Nappan in 1973 and 1974. Broadcasting the seed on the frozen soil and rototilling it in was found to be a good method as was rototilling the frozen soil and seeding with a grain drill. Seeds did not germinate when they were merely broadcast on the surface of the soil.

*Yield and quality of cereal crops for forage.* Herta barley, Stormont oats, and Opal wheat were grown at the Experimental Farm, Nappan, for 3 yr and harvested for forage. The three cereals were harvested at the boot, milk, soft dough, and mature crop stages of growth. The green weight and dry weight of the crops were determined along with in vitro digestibility and crude protein content of the whole plants. Over the 3-yr period of this experiment the highest digestibility and crude protein content were found when the oats, wheat, and barley were harvested at the boot stage. The most digestible dry matter per hectare was obtained when Opal wheat was harvested at the soft dough and milk stages of growth. Herta barley produced the most digestible dry matter at the soft dough stage of growth, whereas Stormont oats produced the most digestible dry matter at the milk stage. In general Opal wheat produced the most digestible dry matter, followed by barley and oats. Wheat was generally lower in crude protein than either oats or barley.

*Nutrient requirements of cabbage on peat.* Fertilizer treatments for cabbage grown on sphagnum peat consisted of an N, a P, and a K series. Each nutrient was applied at four rates in combination with constant rates of the other two. Results indicated that N at 270 kg/ha, the highest rate used, may not have been adequate, whereas P and K at 80 and 150 kg/ha were. In the N, P, and K series the highest head weights coincided with midribs containing 2.06% N, 0.48% P, and 4.18% K respectively.

*Influence of iron and pH on yield and nutrient content of carrots on peat.* In two greenhouse experiments sphagnum peat adjusted to various pH levels was used to study the effect of various levels of Fe on the



growth of carrots. The Fe was added to the medium as sequesterine 330 chelate. Maximum carrot root and top tissue yields were obtained at soil pH 6.6 and 7.1. At soil pH 5.2 and 7.8 the yields were in the intermediate range. The yields were low at pH 4.3, 4.5, and 8.1 and at pH 8.4 the carrots did not grow. The chlorotic symptoms on carrot leaves and reduced yields were associated with 39–82 ppm Fe and > 332 ppm Mn in the leaf tissue and were likely due to Mn toxicity. Toxic levels of Mn in tissue were found even at soil pH 8.1 and were associated with reduced carrot yields. The leaf tissue concentrations of Fe and Mn decreased as the pH of soil increased; however, at pH 5.2, 7.8, and 8.1 the tissue Mn concentration increased. The added Fe had no effect on the Fe concentration, but decreased the Mn and Zn concentration of leaf tissue and increased carrot root yields. There was a significant interaction between added lime and Fe; the decrease in leaf tissue Mn concentration and increases in root yields with added Fe were much greater at pH 4.5 and 5.2 than at pH values of 6.6 and 7.8. The S concentration in the leaf tissue decreased with added Fe and lime. The leaf tissue Zn concentrations of 207–490 ppm and S concentrations of 0.32–0.63%, as found here, are considered to be high but not in the toxic range.

## Soils

*An enriched organic fertilizer.* An enriched organic fertilizer containing poultry manure, peat moss, superphosphate, *p*-formaldehyde, quick lime, and iron sulfate has been developed. When these ingredients were mixed there was little loss of ammonia. The material was stable in storage between –5 °C and 25 °C over a 6-wk period and it had a tolerable odor. The percentages of N, P, K, and Ca were 3.1, 2.5, 0.7, and 10.8 respectively on a dry weight basis and these could be varied by additions of the appropriate nutrient. The product had good pouring characteristics and its high organic content is advantageous in many applications.

## PROTECTION OF CROPS AGAINST PESTS

### Plant Pathology

*Temperature related to canker on lowbush blueberry.* Lesion development on lowbush blueberry (*Vaccinium angustifolium* Ait.) artificially inoculated with *Godronia cassandrae* P. f. *vaccinii* Groves was greater on plants grown at 15 °C days and 4.5 °C nights than on those grown at 21 °C days and 9.5 °C nights. Inactive lesions on plants from 21 °C days and 9.5 °C nights became active when the plants were exposed to cool autumn temperatures in an unheated greenhouse.

*Screening red raspberry for resistance to Botrytis cinerea Pers.* In 1975 two cultivars and five seedling selections of red raspberries of the Station were screened for resistance to decay caused by *Botrytis cinerea* Pers. Botrytis decay on the fruit was correlated to the firmness of the berries. Haida had the least decay, followed by K70-11, Festival, K70-25, K70-15, K71-13, and K71-16. Haida was the firmest and K71-16 the softest throughout all the tests.

*Decay control and firmness tests on red raspberries.* On a captan fungicide program, Matsqui had firmer berries, less decay, and lower yields when a single spray of SADH was applied 2 wk before the first harvest than when no sprays or sprays of SADH, CaCl<sub>2</sub>, or Folicote (wax) were applied in the pink green stage 1 wk before first harvest followed by a second application of each immediately following the first harvest.

*Tolerance for dodine in apple scab.* In 1974 the fungicide dodine failed to control apple scab, caused by *Venturia inaequalis* (Cke.) Wint., in several orchards in Nova Scotia. Isolates of the fungus obtained from these orchards were tested in culture media for tolerance for dodine. Several isolates were somewhat tolerant and two isolates showed a marked tolerance for dodine. Isolates from the same orchards varied in their tolerance for dodine.

*Apple replant.* In a greenhouse bioassay of orchard soils for replant disease of apples there was a greater response with apple seedlings to fumigation with chloropicrin in soils from areas of poor apple tree growth than in those from areas of good tree growth. With soil having a replant problem, Vorlex (Morton Chemicals Co. Ltd.) and ethylene

dibromide gave about the same response as chloropicrin. There was a lesser response with fensulfothion and no response with benomyl. In field tests on fumigating planting sites with chloropicrin in orchards suspected of having a replant problem, trees usually grew much better in fumigated than in nonfumigated sites. The response to fumigation appeared to coincide with the original tree site.

*Fungicidal control of cereal diseases.* In an experiment for the control of cereal diseases the fungicide treatments thiophanate + Calixin (BASF) or Benlate (DuPont) applied at growth stage 5 and thiophanate or Benlate + Manzate 200 (DuPont) at growth stage 10 were ineffective against mildew on Yorkstar winter wheat. Both treatments reduced mildew on Opal spring wheat by 50%. These fungicide treatments on Russian WW1000-1 and Kustro winter rye reduced the amount of septoria leaf infection by 10.4 and 31% respectively. The average reduction in plant height when Cycocel Extra (Cyanamid) was applied with the first fungicide treatment was 13.1 cm for WW1000-1, 2.9 cm for Yorkstar, 10.7 cm for Opal, and 2.2 cm for Kustro rye.

*Taphrina spp. on poplars.* Early in June of 1975 golden yellow enlargements of carpels on catkins of poplar caused by *Taphrina* spp. were much in evidence throughout Kings County. *Taphrina johansonii* Sadeb. was identified on *Populus grandidentata* Michx. for the first time in this province. *Taphrina rhizophora* Johanson was found on *Populus alba* L. and this is believed to be the first authentic record of this fungus in North America.

## Insect Pests

*Apple maggot.* The fecundity of apple maggot females was significantly greater ( $P < 0.05$ ) on apple than on black ceresin wax domes. Eggs laid per female in apples varied from 24.8 to 318.1 and in domes from 0.4 to 27.5. Mated females did not lay significantly more eggs than virgins and those confined in groups did not lay significantly more than those confined individually. These findings do not concur with those reported in the literature.

In apple orchards in Ontario, Quebec, and Nova Scotia yellow Sector Pull-down (3M Co.) traps prebaited with a mixture of HyCase protein hydrolysate, ammonium acetate, and adhesive trapped significantly

more *Rhagoletis pomonella* (Walsh) adults than did yellow Sector 1 traps prebaited as before or Pherocon<sup>TM</sup> 1CPY (Zoecon) traps baited with a solution of soy hydrolysate and ammonium acetate. The largest number of flies was caught with Sector Pull-down traps, and first capture was significantly earlier than with the others. Nontarget insects, of which ca. 95% were Diptera, accounted for ca. 70, 25, and 5% of all captures on Sector Pull-down, Pherocon, and Sector 1 traps respectively. The use of prebaited yellow traps of the pull-down design, obtained from Zoecon Corp., to time first spray and later applications resulted in fewer sprays than are presently recommended in orchards with low or moderate apple maggot populations.

*European red mite.* The numbers of male and female first-generation European red mites were recorded from 13 apple orchards representing widely different levels of mite infestation on four different varieties. The average percentage of males was 27.5. Statistically significant differences were found among orchards, varieties, observers, and their interactions. No relationship between sex ratio and population density was evident. The relationship between the distribution and cluster size was examined. As the population intensity increased, numbers and distribution tended to be more closely related to the number of leaves in a cluster.

Overwintering eggs of the European red mite were killed on McIntosh and Red Delicious apples by 4.5 h fumigation with ethylene dibromide (EDB). Constant concentrations of 8 mg EDB/litre at 14°C achieved 100% mortality, and absorption of the fumigant by the apples, the bins, and the chamber was determined so that the amount of fumigant for various size commercial loads could be calculated. Treatments increased scald on McIntosh, but reduced it on Red Delicious. Taste and other qualities of the fruit were not affected.

*Apple stinging bugs.* The amount of damage to apples caused by the bugs *Atractotomus mali* Meyer and *Campylomma verbasci* Meyer is largely related to the density of the bug population and to the apple variety. Bug numbers can be reliably measured by a hatching method and preventative insurance spraying can be avoided where indicated.



*Integrated control in Canadian orchards.* A practical integrated pest-control program is used commercially in Nova Scotia and in British Columbia apple orchards. The Nova Scotia program includes biotic controls of many species including mites, scales, aphids, and most Lepidoptera with supplementary selective chemical control of apple maggot and often also of codling moth. The British Columbia program includes biotic control of McDaniel spider mite with chemical control of most other pests. Progress integrating biotic controls with reduced use of chemical controls is being made on apple pests in Quebec and Ontario and on peach pests in Ontario.

*Growth disruptors on the winter moth.* The activity of two insect growth disruptors PH 60-38 and PH 60-40 (Philips-Duphar) was assessed against larvae of the winter moth in the laboratory and field. Larvae continued to feed on foliage treated with PH 60-38 and PH 60-40 until the ecdysis phase when death occurred, seemingly due to disruption in cuticle formation. Field tests with PH 60-40 indicated that concentrations of 165 ppm were effective for control. As measured by bioassay, using winter moth larvae, PH 60-40 was persistent for at least 28 days in the field.

## PESTICIDE RESIDUES

*Chlordane.* The incorporation of chlordane at a rate of 6.7 kg active ingredient/ha into a sandy loam soil (12% clay) resulted in residues in beets, carrots, parsnips, potatoes, and rutabagas of 0.03, 0.26, 0.24, 0.04, and 0.01 ppm respectively. In these crops grown in another loam soil (28% clay) the respective residues were 0.01, 0.07, 0.12, 0.15, and 0.01 ppm chlordane. The qualitative composition of the soil and crop residues as evaluated by the peak patterns of gas chromatograms did not change greatly during the 16-mo period following chlordane application.

*Organophosphorus and organochlorine residues.* Studies were conducted in 1972 with four organophosphorus insecticides, chlorpyrifos, leptophos, methidathion, and N-2596 and in 1973 with chlorpyrifos, leptophos, and methidathion and one organochlorine, heptachlor, to determine their residues in soils and tobacco plants. In 1972 all organophosphorus pesticides were detected

in the soil 3 mo after application, but none was detected in cured tobacco leaves. In 1973 ca. 68% of the leptophos applied in June was found in the soil in September, whereas only 20% of the chlorpyrifos and 2% of the methidathion were detected. Heptachlor was persistent in the soil and heptachlor epoxide, its conversion product, was detected in the soil in September but not in June. Gamma chlordane, an impurity in technical heptachlor, was also detected in the soil. In noncured tobacco chlorpyrifos and leptophos were detected in sand leaves but not in mid or top leaves. Methidathion was not found. Heptachlor, heptachlor epoxide, and  $\gamma$ -chlordane were found in sand, and mid and top leaves.

*Picloram.* When 4.48 kg/ha (2 ppm) of picloram as the potassium salt (Tordon 22K) was incorporated with soil to a depth of 15 cm, 1.86, 1.78, 1.32, 0.70, 0.28, 0.12, and 0.02 ppm were detected at 18, 63, 145, 337, 504, 690, and 843 days after application respectively. The growth of carrots, parsnips, potatoes, table beets, and rutabagas was inhibited when these crops were planted in the greenhouse in soil containing 1.32 ppm picloram that was collected 145 days after application. The year after application when soil sampled about 1 mo before planting contained 0.70 ppm picloram, the growth of sweet corn and oats was reduced by about 20%, but beans, parsnips, and Swiss chard did not grow at all. Picloram residue 1055 days after application was 2.5 ppb ( $10^{-9}$ ) as determined by a bioassay using bean as the indicator plant.

*Test for picloram.* A rapid, sensitive, and specific fluorescent test for picloram has been developed. A 36 N sulfuric acid solution is added to the dry residue of picloram in glass test tubes or quartz tubes, or on a white porcelain plate. Yellow fluorescence is observed under long wavelength UV radiation when the test is performed in glass test tubes but with greater sensitivity under short wavelength UV radiation when done on a white porcelain plate or in quartz tubes.

*ZR515 (Altosid).* The insect development inhibitor ZR515 (Altosid; Zoecon Corp.) was relatively stable in aqueous suspensions (1000 ppm) prepared from an emulsifiable concentrate and a microencapsulated formulation. At 4.5 °C the half-life of ZR515 from the emulsifiable concentrate was  $\sim$ 100 days



in salt water and ~35 days in fresh water, whereas at 20 °C the half-life was ~12 days in both fresh and salt water. Little degradation occurred in the encapsulated formulation after 132 days at 4.5 °C in salt and fresh water, whereas the half-life at 20 °C was ~35 days in fresh and salt water.

## STORAGE

### Effectiveness of Surfactants in Controlling Greening of Kennebec Potatoes After Cold Storage

Greening control tests were performed on Kennebec potato tubers after cold storage by using a comprehensive collection of Tween surfactants. When these materials were sprayed onto the surface of the potato, the relative effectiveness was directly related to the hydrophile-lipophile balance of the surfactant. It appeared beneficial to shorten the polyoxyethylene chain or to increase the proportion of fat in the molecule. The selection of the fatty component is probably influential because tristearate > trioleate > monostearate > monoleate > monopalmitate > monolaurate.

## FOOD TECHNOLOGY

### Shear Behavior of Wheat Gluten

The dynamic shear properties of commercial vital wheat gluten subjected to small-deformation oscillatory shear were investigated. Hydrated wheat gluten was found to be rheologically complex and in general required multiple linear regression analyses to adequately account for variation. Dynamic shear storage modulus was extremely sensitive to moisture content. Other parameters were affected to a lesser but significant amount by moisture level. Working caused an increase in the magnitude of both the storage and loss moduli, but did not alter the ratio of loss-to-storage modulus. Gluten exhibited a proportional increase in viscous response with increased oscillatory frequency. All findings appeared to be compatible with a published theory for the mechanism of the viscoelastic response of wheat gluten.

### Concentration of Maple Sap Using Reverse Osmosis

By using high rejection cellulose acetate membranes 27% of the water was removed by one pass through the system, 45% by two passes, and 57% by three passes. By this method the sucrose content of the sap was increased from 2.5 to 5.6%. From every 100 litres of sap 57 litres of water were removed, so that a lower capacity conventional evaporator could be used to complete the evaporation process. Conventional evaporation procedures require 3 litres of fuel oil per litre of syrup produced. By using reverse osmosis this energy requirement can be reduced by about 50%.

## ANIMAL SCIENCE

### Cattle

*Silages from grass, grass-legume mixture, and corn fed to steers with and without diethylstilbestrol.* Three silage crops were evaluated as the main source of nutrients for finishing beef steers in terms of the efficiency of animal gain per unit weight of crop harvested and per unit of land used to grow the crops. Silage was made from a mixture of grasses: 65% timothy (*Phleum pratense* L.), 10% couchgrass (*Agropyron repens* (L.) Beauv.), 10% bluegrass (*Poa pratensis* L.), 15% browntop (*Agrostis* spp.); a grass-legume mixture of 50% brome grass (*Bromus inermis* Leyss.) and 50% alfalfa (*Medicago sativa* L.); and corn (*Zea mays* L.). The three silages were fed to yearling Hereford steers for a period of 126 days. In addition to silage all steers received 1 kg of coarse ground barley per head per day and one-half of them were given 10 mg of diethylstilbestrol (DES) mixed in the barley. Dry matter percentage at harvest was 25.8 for grasses, 18.4 for grass-legume mixture, and 24.1 for corn. The loss from seepage, respiration, and fermentation during storage was 9.5, 15.3, and 0.1%. The average daily gains (ADG) for steers were 0.56 kg for grass, 0.89 kg for grass-legume, and 1.05 kg for corn. When DES was added the ADG increased to 0.74, 0.96, and 1.15 kg respectively. The calculated animal gains per hectare of each crop were 695, 1414, and 1415 kg for grass, grass-legume, and corn respectively. Higher grades of carcasses were obtained from steers fed corn silage than those fed grass-legume

silage, which were better than those from steers fed grass silage.

## Poultry

*Effects of the pellet binder "Lignosol FG" on the chicken's digestive system and general performance.* When the pellet binder "Lignosol FG" (calcium lignosulfate) was used to make up 2.5% of a broiler finisher diet it resulted in a reduction in feed efficiency and the caecal contents were darker in color than normal. A second experiment was conducted in which Lignosol FG was included in both the starter and finisher diets at 0, 2.5, 3.75, and 5.0% of the diets. By week 4, postmortem examinations disclosed that birds receiving the diet containing the pellet binder at all levels had enlarged caeca and the caecal contents were dark brown, shiny, tenacious, and gelatinous and continued so to slaughter age (7 wk). There was also an indication that increased feed consumption and body weights were associated with the higher levels of Lignosol FG in the diet. However, poorer feed conversion with the Lignosol FG supplemented diets offset any financial gain. As the higher levels of Lignosol FG resulted in an enlarged caeca with dark gelatinous, sticky contents, this provided the potential for contamination during the eviscerating process following slaughter.

*Flip-over syndrome.* Chickens exhibiting "flip-over" syndrome were found on necropsy to have a blood structure in the heart chamber. Histological studies showed that this structure is formed of erythrocytes, leucocytes, fibrin, and serum. Fibroblasts, collagen fibers, and thrombocyte agglutination were not observed. These observations indicated that the structures studied are postmortem blood clots.

*Hatchability of eggs.* Two experiments were conducted to determine the interrelated effects of genotype, storage time, and proximity of eggs during hatching on the hatchability of chicken eggs. It was concluded that hatchability was unaffected whether eggs were in contact or separated on the hatching tray regardless of genotype or egg storage time.

## Sheep

*Fat and protein levels for artificially reared lambs.* Two growth trials were conducted to determine an optimum level of fat in milk replacer and an optimum level of protein in

creep feed for artificially reared lambs. In experiment 1, milk replacers containing 31 or 36% fat (dry matter [DM] basis) were fed ad lib. to 58 lambs at 1 day of age. The protein was supplied by low-heat, spray-dried skim milk powder and Na caseinate and the fat from a mixture of 10% coconut oil and 90% tallow. A finely ground unpelleted creep feed with 20% protein, on a DM basis, was fed ad lib. The lambs consumed more of the 31% fat milk replacer and gained more live weight (228 vs. 254 g/day;  $P < 0.025$ ) to weaning at 25–30 days of age than did lambs fed the 36% fat formula. Weight gains to 10 wk of age were 190 and 170 g/day respectively ( $P < 0.10$ ). In experiment 2, 84 lambs were fed a 26% fat milk replacer ad lib. and creep feeds with 15, 20, or 25% protein (DM basis). The supplementary protein was supplied by herring meal and soybean meal. Weight gains of lambs to weaning at 24 days of age were similar on the three creep feeds. However, gains to 10 wk of age averaged 218, 235, and 244 g/day ( $P < 0.05$ ) on the 15, 20, and 25% protein diets respectively. One and 2 kg of DM were consumed for each gain of 1 kg in body weight to weaning and to 10 wk of age respectively. It was concluded that the milk replacer should contain 26–31% fat and the creep feed 20% protein or more for maximal performance of artificially reared lambs.

*Rapeseed as a protein and energy source in lamb milk replacers.* Dehulled low-erucic acid, low-glucosinolate full fat rapeseed (FFRS), processed with (ground) and without (unground) a colloid mill, was incorporated into milk replacers for lambs to provide 25% (FFRS-25) or 50% (FFRS-50) of the total dietary protein. When compared with an all-milk protein diet (FFRS-0), inclusion of the unground FFRS decreased the digestibilities of dry matter, N, and energy ( $P < 0.01$ ). The addition of FFRS to the milk replacer also decreased N retention ( $P < 0.01$ ), but did not affect average daily gains per unit of metabolic weight. The addition of the colloid milled FFRS to the milk replacers resulted in higher digestibilities of dry matter, N, and energy and better retention of N than when the unground FFRS was added. However, the colloid milled FFRS was not as digestible as the all-milk diet. Increasing the level of substitution with colloid milled FFRS from 25 to 50% produced a further decrease of about four



units in the digestion coefficients and of nine units in the retention of N expressed as a percentage of the intake. Serum cholesterol levels just prior to and 2 h after feeding were not affected by the dietary treatments. Histopathological examinations of liver biopsies at 22 days of age and of hearts and livers at market weight showed no detrimental effect on these organs from adding low-erucic acid, low-glucosinolate FFRS to milk replacers for lambs. On the basis of trials it was concluded that after colloid milling low-erucic acid, low-glucosinolate FFRS can replace from 25 to 50% of the milk protein and most of the fat in lamb milk replacers without significantly affecting animal performance.

## Swine

*Evaluation of crossbred sows.* Data from 726 male and 765 female pigs (364 litters) from 28 three-breed crosses obtained from

mating Poland China boars to gilts and sows from different two-breed crosses were analyzed. The 28 two-breed crosses were obtained from mating Yorkshire (Y), Landrace (Ld), Lacombe (Lc), Hampshire (H), Duroc (D), Berkshire (B), and Large Black (LB) sows to Ld, Lc, H, D, B, LB, and Tamworth (T) boars in an incomplete diallel mating design. The traits studied were age at slaughter (72 kg carcass weight), carcass backfat measurement, and an index combining both traits.

The youngest pigs to reach slaughter weight were those from LB × D sows (191.3 days) and the oldest were from T × D sows (211.6 days). The pigs with the least depth of backfat were those involving the Hampshire breed (mean 7.28 cm) and those involving the Large Black had the thickest backfat (mean 7.81 cm). In descending order, the five highest ranking crosses based on the index were those from H × Ld, H × Lc, LB × D, Lc × Ld, and H × Y sows.

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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
C. H. LAWRENCE, B.Sc., M.Sc.	Soil-borne pathogens

M. E. MACGILLIVRAY (Mrs.), B.A., M.Sc., D.Sc.	Insect ecology
A. R. MCKENZIE, B.Sc., M.Sc., Ph.D.	Soil-borne pathogens
G. C. MISENER, B.Sc., M.Sc., Ph.D.	Harvesting and storage engineering
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

A. D. L. GORRILL, B.S.A., M.Sc., Ph.D.	Calf and lamb nutrition
Resigned March 31, 1975	



## INTRODUCTION

The Research Station at Fredericton is the Canadian center for research on the potato crop. Emphasis is placed on breeding and genetics, pest management, soil and crop management, and harvesting and storage engineering. The Station is also the Atlantic center for research on animal nutrition, for studies on harvesting, storage, and utilization of cereal and forage crops for livestock feeding, and for environmental quality studies relating to the impact of nutrients and pesticides on water quality. The Station collaborates with other Branch establishments in evaluating new cultivars and selected management practices for New Brunswick.

This report presents a summary of significant research activities during 1975. Additional information may be obtained by writing to Research Station, Research Branch, Agriculture Canada, Box 20280, Fredericton, N.B. E3B 4Z7.

G. M. Weaver  
Director

### LIVESTOCK FEEDS AND ANIMAL NUTRITION

#### Buckwheat as a Food for Beef Cattle

The buckwheat grown in the Maritime Provinces is tartary buckwheat (*Fagopyrum tataricum* (L.) Gaertn.) and is not the same as the common buckwheat (*Fagopyrum sagittatum* Gilib.) grown in Western Canada. Tartary buckwheat has a smaller seed and is not as palatable. However, it is well adapted to the local acid soils and climatic conditions.

Although tartary buckwheat has been grown in the Maritimes and eaten by man and animals for nearly 300 yr, there are few data on its actual feeding value. A feeding trial with beef cattle and a digestibility trial with sheep showed that it has about 85% of the feeding value of barley. The buckwheat contained 9.8% crude protein on a dry matter (DM) basis, of which 53.5% was digestible by sheep.

Beef steers readily consumed up to 3.6 kg per head per day of pelleted whole buckwheat, but were reluctant to consume this amount of dry rolled buckwheat.

#### Protein Supplementation of Potato Rations

Feeding trials with beef cattle rations containing a high level of potatoes with corn silage have demonstrated the necessity of supplementing with preformed protein. Supplementation with soybean meal resulted in

0.12 kg more daily gain than rations supplemented with urea. The protein supplementation also resulted in a significant improvement in feed efficiency.

Sheep were fed rations similar to those used in the steer feeding trial to determine if the crude protein supplements were affecting energy digestibility. The energy digestibility of the total diet was higher ( $P < 0.05$ ) when the ration was supplemented with an adequate amount of soybean meal (78.1%) than when fed as the unsupplemented control (75.3%) or with a low level of urea (75.2%), but not significantly higher than with a high level of urea (76.2%) or a low level of soybean meal (76.2%). These differences in energy digestibilities at least partly explain why steers fed the diets adequately supplemented with protein gained faster.

#### Feeding Potato Processing Waste

Peeling waste from potato processing plants contains 9–11% NaOH (DM basis) and has a pH in excess of 12. Even when neutralized the high sodium content may limit the amount that can be fed. To simulate this material, pulped potatoes were mixed with 2.3% NaOH. Before feeding to sheep, the potato slurry was partly neutralized with acetic and propionic acids. The addition of various levels of the potato slurry up to 1805 g/day as a substitute for pulped fresh potatoes had no effect on the dry matter or crude protein digestibilities of the rations. It was concluded that sheep can be fed diets containing up to 3% sodium (DM basis), at least for short periods.

## Feed Potentials of Sawdust and Straw Mixed with Alkaline Potato Peel Refuse

Alkaline potato peel refuse and sawdust are potential dietary energy sources for ruminants. Before they become acceptable feedstuffs, the caustic properties of the potato peel refuse must be reduced and the digestibility of sawdust increased. Because treating low-quality forages such as straw with alkali improved its feed value, it was thought that mixing peel refuse with straw or sawdust would produce a useful feed. Digestibility of dry matter (DDM) was estimated by in vitro fermentation with rumen fluid and by *Trichoderma viride* Pers. carbohydrases. DDM of the mixtures was always less than that predicted by an additive linear model. The interaction of potato peel refuse with straw or sawdust apparently yields a complex with lower DDM than the original materials.

## Potato Silage

Many farmers would like to carry over surplus potatoes for fall feeding. A feasible way of doing this on most farms is to store them in the form of silage. Various mixtures of pulped potatoes and chopped hay or broiler house litter were ensiled in plastic bags. Mixtures containing 35–50% DM gave satisfactory fermentation as determined by odor and pH and were readily accepted by sheep.

## Effect of Dehydrated Alfalfa Pellets on Silage Intake by Dairy Cows

Feeding processed forages offers a method of increasing forage intake and total DM intake while reducing the dependence on imported grains. Direct cut and wilted timothy harvested at the early head and full bloom stages were ensiled and fed ad lib. to dairy cows in combination with 0, 4.5, and 9.0 kg/day of dehydrated alfalfa pellets (DAP). One kilogram of grain was fed for each 3.5 kg of milk produced. Wilted silage was consumed in larger amounts than direct cut silage irrespective of maturity at harvest. With the early harvested silages, 9.0 kg of DAP depressed silage DM intake. For the late harvested silage this depression occurred at the 9.0-kg DAP level with the direct cut silage and at both the 4.5- and 9.0-kg levels with the wilted material. The highest level of DAP supplementation was effective in increasing total DM intake by 26%. Milk yield

and milk composition were unaffected by the type of silage or level of DAP fed.

## Colostrum Preservation with Formalin or Yogurt Culture

Calves were reared on either whole milk, colostrum (including transition milk) treated with formalin (0.1% vol/wt), or colostrum fermented by a commercial yogurt culture. All diets were diluted with water to 0.47% N (wt/wt) and fed at 8% of body weight. The colostrum was stored for up to 3 wk at ambient temperatures up to 33°C before feeding. Formalin prevented mold growth, but the yogurt culture did not. Average weight gains were 3.7, 1.3, and 1.6 kg and amounts consumed were 77, 67, and 71 kg respectively, for the milk, formalin, and yogurt treatments during a 21-day period. Previous experiments with whole milk treated with formalin at 0.1% (vol/wt) showed no adverse effects on milk consumption or growth.

## Once-calved Beef Heifers

One way of increasing the national beef-calf crop without increasing the national cow herd is to obtain a calf from beef heifers destined for slaughter. Under many management systems beef heifers are 20–24 mo of age before slaughter so that breeding to produce a calf does not appreciably increase the time to market provided the calf is weaned early. In a trial with 30 heifers it was shown that the extra feed costs of producing a calf to be weaned at 1 day of age varied from \$20 to \$40. The feed costs of allowing the calf to nurse for 42 days to avoid the problem of feeding milk replacer amounted to \$35 and increased the time to slaughter of the heifers by 33 days. It was concluded that the concept is economically feasible.

## Evaluation of Loose Hay Stacker

In 1974 timothy hay with a DM content of 70–80% was harvested at an average rate of 6.5 tons/h with a one-ton loose hay stacker. In 1975 when the DM was 80–85% the rate fell to 3–4 tons/h because the drier hay had to be compressed more often. The combined annual costs of harvesting, storing, and feeding in 1974 were calculated at \$24.49, \$14.00, and \$10.64 per ton for quantities of 100, 200, and 300 tons respectively. Losses in storage were 8–10% of the DM; crude protein increased from 10.5 to 13.09%. All



1974 stacks showed signs of heating, but the 2.6% of the DM that was refused by heifers was mostly top spoilage.

Feeding trials with sheep indicated significant differences between the quality of the hay from stacks and mow-dried bales produced from the same original forage material. The DM consumed from bales was 1.68% of body weight and from stacks 1.36–1.65%. DM digestibility of hay from bales was 66% and from stacks 61.5–64.2%. The energy digestibility of hay from bales was 64.0% and from stacks 57.1–61.5%. N digestibility of hay from bales was 60.6% and from stacks 52.8–55.4%.

### Bird Control in Small Grains

Mesurool, a carbamate insecticide, was used during the past year to protect cereal plots from bird damage. The material provided excellent control when applied at 10 kg/ha. Oats treated at the dough stage produced 79 hl/ha vs. 41 hl/ha from the untreated blocks. The material acted as a repellent and no bird mortality was observed. At present the cost of the treatment is prohibitive for large-scale field use, but the method offers a practical means of protecting research plots. Further research is needed on rates and timing of application and residue levels.

## POTATO BREEDING

### Three Promising Potato Selections

Seedling F61025 successfully passed commercial chipping trials and will be proposed for licensing in 1976. This cultivar is similar to Irish Cobbler in early yield and comparable to Kennebec when harvested as a main crop. It is of high boiling and baking quality, moderately resistant to verticillium wilt and fusarium dry rot, and highly resistant to virus Y. Because of its midseason maturity and good yield, it has potential as a chipper in areas where harvest temperatures drop below critical levels before Kennebec has matured.

Seedling F67072 gave highest yields of marketable tubers for three successive years in Atlantic Regional Trials at 80 days after planting. It outyielded Irish Cobbler by 21% in 1975 trials. It possesses high specific gravity and good size, type, and skin. It is moderately resistant to common scab and wart and is immune to virus X. Stock is to be multiplied for possible introduction in 1977.

Another seedling, F69016, has proved superior to Netted Gem in French fry quality evaluation tests. It is of midseason maturity with a long-type tuber of high specific gravity, good table quality, and smooth appearance.

### Diploid Breeding

A mass selection program has been started using the primitive diploid South American cultivated species *Solanum phureja* Juz. & Buk. and *S. stenotomum* Juz. & Buk. Approximately 60% of this material produced tubers under New Brunswick field conditions. Advanced diploid selections are being screened for their ability to produce  $2n$  gametes. Several new diploid hybrids with relatively high frequencies of  $2n$  gametes have been identified.

### Use of Superior Andigena Clones in Variety Development

Long-day-adapted clones of Group Andigena potatoes judged to be superior on the basis of plant type, maturity, tuber set, tuber size, and boiling, baking, and chipping quality are being used in crosses with Group Tuberosum parents in the variety development program.

In 1975 over 1000 seedlings from seven crosses were evaluated as single hills. Some of the progeny showed good set and size. Evaluation of the crosses will be completed by testing random samples from the four superior crosses in 10-hill plantings. To date, nine Tuberosum and nine Andigena parents have been used in these crosses.

### Responses of Tuberosum-Andigena Hybrids to Environment

Four hybrids between Tuberosum and long-day-adapted Andigena and two cultivars, Warba and Kennebec, were planted in 10 field plots in New Brunswick, Quebec, Ontario, and Manitoba. Yield and yield components, number of stems, number of tubers per stem, and mean tuber weight were used to analyze the responses of Tuberosum-Andigena hybrids and cultivars to environmental influence. The hybrids showed a variation in stem number three to eight times greater than Kennebec. Kennebec, on the other hand, had a slightly greater environmental response for mean tuber weight than did the hybrids. This may result from the ability of the hybrid genotypes to increase



their stem number when conditions are favorable whereas Kennebec showed a greater ability to use the available resources for tuber bulking.

### Index Selection with Desired Gains

The problem of assigning relative economic weights to traits may limit the practical use of index selection in plant breeding. A solution to this difficulty is to specify desired gains of the traits that are sought in the breeding program. The secondary traits for which improvement is not important cannot be included in the indexes to assist selection. A method is suggested whereby any number of traits can be included to construct selection indexes if we specify desired gains for traits of economic importance and let the economic weights of the secondary traits be zero.

## POTATO PATHOLOGY

### Potatoes from Disease-indexed Stem Cuttings

Second-generation material from stem cuttings and greenhouse-grown, disease-indexed tubers (Avon, Katahdin, Kennebec, Keswick, Red Pontiac, Sebago, and F61026) has remained free from virus diseases and blackleg, pinkeye, and verticillium wilt. Stored tubers are being examined for continued freedom from other tuber-borne diseases, including silver scurf, black dot, phoma rot, and skin spot. This material will be used as nuclear stock and seed for experimental and commercial plots.

### Blackleg in Potatoes

In 1974 an experiment was started to determine if *Erwinia carotovora* var. *atroseptica* (L.R. Jones) Holland overwinters in the soil. The bacterium was incorporated directly in the soil or inoculated on Sebago tubers or stems in the soil. The bacterium was recovered from tubers and stems early in December, but was not reisolated from any replicate in May. When disease-indexed Sebago tubers were planted, no plants became infected and the daughter tubers did not become contaminated with blackleg.

Disease-indexed Sebago tubers were planted with the tubers in one block inoculated at planting with *E. atroseptica* (van Hall) Jennison and the other uninoculated. Eighteen percent of the inoculated sets

produced blackleg plants. No blackleg was observed in the uninoculated block nor was the bacterium recovered from the daughter tubers.

### Pycnidial Development on Potato by *Phoma exigua* var. *exigua* Desm.

Several experiments were conducted to study pycnidial formation, and viability and importance of *Phoma* conidia. Every stem of each plant was examined for pycnidial development and modified spore traps, which were changed weekly, were used to detect aerial movement of conidia. Tuber samples were bruised and stored, and subsequently examined for lesions and pycnidia.

Inoculated disease-indexed Kennebec tubers and infected and commercial Katahdin tubers produced small, slightly chlorotic plants that senesced early when compared with plants produced from noninoculated disease-indexed tubers. Disease-indexed Katahdin tubers were planted among commercial Katahdin in a field that had produced *Phoma*-infected tubers in 1974. Katahdin tubers with *Phoma* lesions from the same field were used as seed pieces in a nearby plot. Pycnidia were found only on six stems in the latter plot. Disease-indexed Kennebec tubers were inoculated with a *Phoma* isolate and planted in an inoculated soil. Prior to harvest three chemical top killers representing fast, medium, and slow kill were applied; the fourth treatment was natural senescence and frost. The type or rate of senescence to kill had no effect on pycnidial production and only one stem of one plant had pycnidia. A few conidia were isolated from the spore traps in the Kennebec plot during the last 2 wk in September.

### Isolation and Characterization of Poly (A)-associated RNA from Potato Sprout Tissue

In a preliminary study on the capacity of the potato for the generation of poly (A)-associated RNA and of procedures for its isolation, the RNA fraction of rapidly growing potato sprout tissue was extracted from sprout sections that had been exposed to either <sup>14</sup>C-labeling adenine or uracil. Chromatography of this material on methylated albumin kieselguhr (MAK) columns and characterization of its components by separation in polyacrylamide gels revealed a substantial degree of labeling in the ribosomal

RNA fraction. Incubation of the excised sprout tissue in the presence of  $^{14}\text{C}$ -labeled adenine and actinomycin D ( $5\ \mu\text{g/ml}$ ) showed a fivefold reduction in the amount of label incorporated into this fraction.

Although not readily detectable in the eluates of MAK columns, a radioactive component that moved in a zone intermediate between DNA and 28S RNA in 3% polyacrylamide gels was observed. Attempts to characterize it by its adsorption on nitrocellulose filters showed that up to 2% of the acid-insoluble fraction of RNA was retained on the filters. Sequential treatment of this fraction with pancreatic RNase and  $\text{T}_1$  RNase prior to binding on Millipore filters further reduced the level of labeled RNA bound to the filter by a factor of 10.

Elution of this RNase-treated fraction from the filter and subsequent electrophoresis in 7.5% gels after preliminary incubation with formamide and NaCl disclosed a small, highly mobile component that moved well in advance of the 4S marker and showed a high specific activity when labeled with  $^{32}\text{P}$ . A second, slower moving component that eluted in the 7–9S portion of the gel and showed a moderate degree of labeling was also found.

#### **Purine Metabolism and Spore Germination in *Phytophthora infestans***

Chromatographic analysis and autoradiographic studies of the end products that resulted when sporangia of the blight race 1.2.3.4 were incubated with 4 mM aqueous solutions of adenine and  $\text{N}^6$ -dimethyladenine riboside disclosed an almost identical pattern. The enhanced indirect germination observed in this particular race in response to treatment with various purines was a reflection of the capacity of the pathogen to transform these compounds and to convert them ultimately to a common active intermediate, hypoxanthine.

#### **Nucleotide Sequencing of Potato Spindle Tuber Viroid**

It has been shown that potato spindle tuber viroid (PSTV) ribonucleic acid isolated from infected plants of *Scopolia sinensis* Hemsl. exists in three forms. Form II purified by 10 and 20% polyacrylamide gel electrophoresis or with gel containing 6 M urea was used for sequencing studies. The RNA was digested with pancreatic ribonuclease A or

ribonuclease  $\text{T}_1$  enzymes, treated with bacterial alkaline phosphatase, and labeled with  $\gamma$ - $^{32}\text{P}$ ATP-polynucleotide kinase at 5' ends. The radioactive digest was separated by two-dimensional electrophoresis-homochromatography and fingerprinted. Each spot was numbered and eluted from the homochromatography plates. The material from each spot was partially digested with snake venom phosphodiesterase. The digests were separated by a two-dimensional procedure. From the characteristic mobility shifts of the sequential degradation products of the partial venom phosphodiesterase digest of the  $^{32}\text{P}$ -labeled oligonucleotides, the sequence was deduced. In some cases M values were used. The nucleotide sequence of ribonuclease A digest of some spots (in parentheses) is given below: AGC and GAC (1), GGC (2), GAU and AGU (3), GGU (4), GAAC and AAGC (1'), GAGC and GGAC (5), GAGU and GGAU (6), GAAGC and GAGAC (11), GGAGC (16, 18), GGAAAC (12), GGG-AAC and GGUAAC (12'), GGGAGC and GGUAGC (17), GGAAAUAU and GGG-AAUAU (23). This research was done in collaboration with Dr. S. A. Narang, National Research Council, Ottawa.

#### **Piperonyl Butoxide Inhibits Potato Spindle Tuber Viroid**

Piperonyl butoxide, a comparatively inert and nontoxic methylenedioxyphenyl derivative, was found to be a potent inhibitor of PSTV in *Scopolia sinensis* Hemsl. The application of piperonyl butoxide before inoculation prevented PSTV infection for 10 days whereas postinoculation treatments had only partial effect.

#### **Virus Spread in Potatoes**

In recent years there has been a large increase in the production of the cultivar Netted Gem. It is extremely susceptible to rugose mosaic (potato virus Y [PVY]) and potato leaf roll virus (PLRV) and so problems with these two aphid-transmitted viruses have been increasing. The practice of early harvest has been recommended for many years as a means of control. A close relationship has been shown between flights of the green peach aphid, *Myzus persicae* (Sulzer), and the spread of PVY and PLRV. In 1974 *M. persicae* flights commenced in late July and peaked sharply from August 14 to 26. Fifty percent of the season's spread of



PVY occurred by August 19 and of PLRV by August 25. Approximately 10% in both cases had occurred by August 5. These dates refer to foliage infections. Tuber infections have been reported to occur 5–10 days later.

## POTATO ENTOMOLOGY

### Aphid Populations and Incidence of Leaf Roll Virus

Over 60 greenhouses in New Brunswick were inspected for potato-infesting aphids in May and June. The green peach aphid was the most abundant species. Elimination of this source can greatly lessen the number of dispersal forms and potential virus carriers later in the season.

The results of 1975 disease readings on Florida-grown tubers from plants on which insect counts and disease readings were made during 1974 suggest:

- Transmission of leaf roll to healthy potatoes occurs mainly from the green peach aphids that fly in from late July through late September.

- A granular systemic insecticide used at planting will suppress aphids until late July, but is ineffective in preventing leaf roll spread by migrant viruliferous aphids.

- Growers in areas free from migrant aphids until late August usually have little, if any, leaf roll.

- Growers of Netted Gem along the Maine – New Brunswick border can expect to have leaf roll unless top killing is carried out soon after the appearance of winged green peach aphids in July or August.

- Large crop areas of Netted Gem infected with leaf roll are exerting stress on less susceptible varieties such as Katahdin.

- If Netted Gem continues to be grown, special attention must be given to regulating the quality of seed used for processing and table stock.

### Aphid Resistance in *Solanum*

The aphid acceptability of 79 seedlings and varieties of *Solanum tuberosum* L. was examined in the field. Of these, 13 were considerably less susceptible to aphid buildup and injury.

Five categories of plant response to aphids have been described from the study of approximately 1000 tapes of electronic read-out of the relationship between a probing aphid and its host plant: (1) very resistant,

where initial approach is characterized by test salivation and immediate rejection; (2) resistant, where test salivation is followed by brief ingestion and then rejection; (3) tolerant, where initial salivation is followed by ingestion and one or more aborts in the following 4 min; (4) susceptible, where salivation is followed by ingestion and no aborts, but rather frequent salivation surges; and (5) very susceptible, where salivation is followed by continuous ingestion. In future, these aphid response categories will be added to the descriptive compilations of candidate *S. tuberosum* seedlings.

## POTATO PHYSIOLOGY AND CROP MANAGEMENT

### Seed Handling, Planting Method, and Yield of Netted Gem Potatoes

Tuberization in transplants, in plants from sprouted seed, and in plants from unsprouted seed began 2, 3, and 4 wk following a common field planting date. The largest set occurred in plants from unsprouted seed and the lowest in plants from sprouted seed. Tuber dry weight production in transplants was superior to that from sprouted or unsprouted seed throughout the growing season. Differences in tuber dry weight production between plants from sprouted and unsprouted seed were obvious only early in the season. The pattern of tuber dry weight production was related to leaf area and canopy development early in the season. The relationship disappeared following the development of the full canopy.

### Carbon Dioxide Enrichment of Netted Gem Potatoes

Carbon dioxide enrichment (0.06%) either before or after bloom increased tuber dry weights significantly at harvest. Enrichment during the period of tuber bulking from bloom to harvest provided the greatest yield increase. Tuber set was slightly increased by carbon dioxide enrichment, but haulm dry weight and leaf area tended to decrease.

### Mulching Netted Gem Potatoes

Further studies on the management of plastic mulches on Netted Gem potatoes were conducted following a trial in 1974 in which no increase in yield resulted from mulching despite earlier emergence.



Yields from plants mulched with black polyethylene until harvest were lower than those from unmulched plants or from plants on which the mulch was removed at emergence. The magnitude of the yield decline increased with the time the mulch remained after emergence. The total number of tubers was not affected by mulch treatment. However, the number of marketable tubers decreased when the mulch remained on until harvest. Mulching promoted earlier emergence, but had no effect on yield.

### Seed Management for Earlier Emergence

The type of preplanting treatment of Netted Gem seed was shown to influence significantly the time from planting to emergence. Plants from seed in which the sprouting period was interrupted by a return to cold storage conditions for a week prior to completion of sprouting emerged earlier than those from other treatments. Seed pieces from seed sprouted prior to planting and from seed that was warmed for 2 days prior to planting emerged earlier than those from cold, unsprouted seed or seed that was planted whole regardless of preplanting treatment. However, these treatments had no effect on yield and suggest that early emergence per se is not a critical determinant of yield.

### Potato Planter Evaluation

A cooperative survey with the Research Station, Ottawa, of the potato plant stands in New Brunswick in 1973 indicated 32% misses that were nearly all due to planter operation and a resultant 10% decline in yield. This observation prompted an evaluation of the bulk storage hopper, the singulating and delivery wheel, and tools for opening and closing fertilizer and seed furrows of a picker-wheel type of planter. A laboratory study identified problem areas and guidelines for the development of an improved potato planter have been prepared.

### Cultivation Requirements of Potatoes

Cultivation did not increase the yield of Netted Gem grown on a well drained sandy loam soil during a 5-yr investigation. However, two to four cultivations in July increased yield on fine textured soils.

Weeds were controlled with a preemergence herbicide and cultivations were performed with a farm tractor equipped with

tool bar and cultivator teeth. With no cultivation about 5% of the crop was sunburned; one cultivation near early bloom reduced sunburn to a very low level.

## ENVIRONMENTAL QUALITY

### Ethylene Thiourea Analysis

Ethylene thiourea (ETU) is a decomposition product of the ethylenebisdithiocarbamate fungicides. The most widely used method for analysis of ETU involves extraction with ethanol and reaction of the crude extract with benzyl chloride. The resultant *S*-benzylethylene thiourea derivative is dissolved in chloroform and reacted with trifluoroacetic anhydride. The ensuing *N*-trifluoroacetyl-*S*-benzylethylene thiourea is determined by gas-liquid chromatography (GLC) (electron capture detector). However, the *N*-trifluoroacetyl derivative is extremely unstable and the method does not give consistent and complete recoveries. ETU has been converted to a stable *S*-meta-trifluoromethylbenzylethylene thiourea derivative by reaction with meta-trifluoromethylbenzyl chloride. This is followed by clean-up extraction and quantitative measurement by GLC (electron capture detector) at similar levels of detection to the *N*-tri-fluoroacetyl derivative.

### MesuroI Analysis

In collaboration with the Chemistry and Biology Research Institute a method was developed for the determination of MesuroI (Chemagro Corp.) and its oxidized analogues (sulfoxides, sulfones, and corresponding phenols). The method was used for determining residues in blueberries and oats.

### Pesticide Sulfoxides

As a result of a novel reaction discovered during work on trifluoroacetylation of MesuroI sulfoxide, a study was undertaken to explore the applicability of derivatizing (for GLC analysis) pesticides containing a sulfoxide moiety by treatment with trifluoroacetic anhydride. The reaction was applied to Dasanit (Bayer), Dasanit oxon, Metasystox-R, and the sulfoxides of Vitavax (Uniroyal), phorate, and Counter (Cyanamid). The structures of the various products were determined by infrared, nuclear magnetic resonance, and mass spectra, and their suitability for GLC analysis was investigated.

## PEST CONTROL IN FRUIT AND VEGETABLE CROPS

### Selective Control of Blueberry Insects

An insecticide has been identified that will control a variety of defoliating insects without hazard to blueberry pollinators. Trichlorfon (Dylox 80 SP; Chemagro Ltd.) applied at 1.1 kg active ingredient (ai)/ha gave excellent control (97%) of blueberry case beetle, blueberry spanworm, and larvae of two species of sawflies. Similar control of blueberry flea beetle larvae was obtained in tests carried out in 1974. Records of native and domestic bee activity before and after aerial applications on approximately 100 ha of blueberries at the peak of the bloom period showed no evidence of mortality or reduced activity.

### Bird Control in Blueberry Fields

Studies have continued with the carbamate insecticide Mesurol 75 WP (Chemagro Ltd.) as a repellent to birds in lowbush blueberry

fields. In a commercial field of approximately 4.5 ha that had been nearly abandoned because of previous bird depredation, significant protection of the crop was obtained with one aerial application at the rate of 2.2 kg ai/ha. Bird activity, particularly by robins, was greatly reduced within a day after treatment and remained at a low level throughout the subsequent period of study. Nineteen days after treatment 48% of the berries were lost from plots in this field as compared with 92% in a nearby untreated field. A significant part of the crop loss in both fields may have been due to natural drop of overripe berries, but methiocarb apparently reduced loss by about 50%.

### Quack Grass Control in Carrots

Preplant applications of glyphosate, paraquat, or amitrol-T 12 days before planting gave good control of quack grass and a 30-60% increase in the yield of carrots. There was still measurable residual control of quack grass in June of the following year.

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# Ferme expérimentale L'Assomption, Québec

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## INTRODUCTION

La Ferme expérimentale de L'Assomption vise à solutionner les problèmes qui surviennent dans la production des tabacs, plus particulièrement du tabac à cigare et à cigarette. En 1975, on a mis l'accent sur la mécanisation de la production du tabac à cigare et sur la protection du tabac. M. Glenn McLeod de l'Institut de recherches de London a complété son séjour d'un an en poursuivant des recherches sur la répression des vers gris et il est retourné à London. Les recherches conduites en équipes concernant la protection du tabac se poursuivent avec d'autres institutions.

Ce rapport décrit sommairement les résultats de nos essais conduits en 1975. Des exemplaires des rapports antérieurs ou des renseignements additionnels sont disponibles à la: Ferme expérimentale, Direction de la recherche, Agriculture Canada, Casier Postal 1070, L'Assomption, Québec, J0K 1G0.

P. P. Lukosevicius  
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## TABAC

### Tabac à cigare

*Études génétiques.* Dans la sélection du tabac à cigare, le plasma germinatif d'origines différentes peut être utilisé. A notre établissement, on se sert de variétés de tabac à cigare et à pipe provenant de différents pays. La connaissance des relations entre certains caractères à l'intérieur de chacun de ces deux types de tabac aide à la sélection de nouvelles lignées. Dans un essai au champ, 16 variétés de tabac à cigare et huit variétés de tabac à pipe ont été cultivées pendant 2 ans. Les données morphologiques, agronomiques et chimiques obtenues ont servi à établir les corrélations phénotypiques, génétiques et péristasiques. Parmi les corrélations des caractères morphologiques avec le rendement, la corrélation positive la plus élevée a été trouvée avec le nombre de jours à la floraison. La deuxième plus élevée le fut avec le nombre de feuilles et la troisième avec la hauteur après l'écimage. Par contre, le rendement a donné une corrélation négative avec l'indice de qualité. Avec les alcaloïdes totaux le rendement a montré une corrélation négative dans les deux types de tabac, tandis qu'avec le pourcentage de nicotine la même corrélation a été trouvée dans le tabac à cigare seulement. Dans les deux types de tabac les corrélations entre l'indice de qualité et les pourcentages de nicotine et d'alcaloïdes totaux furent positives.

*Séchage.* Les études sur le séchage commencées en 1974 se sont poursuivies en 1975.

Les plants entiers d'un cultivar et d'une lignée de tabac à cigare furent séchés dans un séchoir à un niveau de pente, recouvert de polythène, afin de déterminer les effets de la couleur du polythène sur la qualité du tabac séché. Les feuilles détachées des plants de deux cultivars et d'une lignée de tabac à cigare ont été séchées dans des séchoirs en vrac et des chambres de séchage afin de déterminer l'influence de différentes températures et humidités relatives sur la feuille séchée. Les résultats obtenus démontrent que (1) les plants entiers peuvent sécher aussi bien dans un séchoir recouvert de polythène noir que dans un séchoir conventionnel, cependant le tabac séché sous un polythène transparent s'est décoloré durant le séchage (2) une période de 7 à 8 jours est suffisante pour sécher des feuilles de tabac à cigare dans des séchoirs en vrac (En 1974, le tabac séché dans des séchoirs en vrac pendant 11 ou 12 jours a été aussi bien accepté par les fumeurs de cigares que celui séché conventionnellement.) (3) les conditions de séchage en vrac pourraient varier avec les variétés de tabac à cigare.

*Méthodes culturales.* Production de plants en pots de plastique. La récolte du tabac à cigare à des intervalles de quelque 10 jours permettrait l'utilisation d'un séchoir en vrac plusieurs fois pendant la période de récolte. Dans plusieurs cas, le nombre possible de séchages par séchoir serait déterminé par la première date de récolte. C'est pourquoi on a étudié les effets de deux méthodes de production de jeunes plants sur la hâtivité du tabac



à cigare. Les jeunes plants de trois variétés produits dans des pots de plastique (multi-pots) et dans le lit de la serre ont été transplantés au champ. Tous les plants étaient à peu près au même stade de développement au moment de la transplantation. Les plants provenant des pots de plastique ont été plus hâtifs au champ que ceux provenant du lit de la serre. Cependant ces plants furent plus courts et leurs feuilles plus petites et moins nombreuses. Les caractéristiques morphologiques n'ont pas été modifiées significativement par le diamètre et la couleur des pots ou par le type de serre utilisée pour la production de jeunes plants.

*Distance, écimage et stade.* Influence de la distance de plantation, du stade et de la hauteur d'écimage sur le tabac. Cette expérience se compose de trois distances de plantation, soit 30, 36 et 41 cm, de trois stades d'écimage, soit début floraison, 25% floraison et 50% floraison, et aussi de deux hauteurs d'écimage, soit haut et normal. On récolte chaque parcelle au stade de maturité physiologique.

Les données culturales de cette année nous indiquent que la distance de plantation n'a pas d'influence sur le nombre de feuilles, la longueur et la largeur des feuilles. Le stade d'écimage influence le nombre de feuilles, la longueur et la largeur des feuilles. La hauteur d'écimage affecte aussi le nombre de feuilles, leur largeur et leur longueur.

*Fertilisation.* Un essai a été réalisé en 1975 sur la fertilisation du tabac à cigare au champ dans le but d'obtenir des rendements et des revenus maximaux par l'application de taux progressifs d'azote, de phosphore et de potasse. Les résultats préliminaires indiquent que l'application de 101 kg/ha d'azote, 168 kg/ha de phosphore et 252 kg/ha de potasse a donné les meilleurs rendements et indices de revenu. Les données agronomiques démontrent que des niveaux progressifs d'azote ont donné des effets statistiquement significatifs sur la largeur et la longueur de la feuille.

## Tabac à cigarette

*Évaluation des cultivars.* En 1975, nous avons comparé la valeur agronomique de 14 cultivars. Quatre cultivars ont surclassé le témoin Delhi 34. Au point de vue du rendement, c'est Strain C-18 qui se classait au premier rang. Virginia 115 se classait immédiatement après Delhi 34. Au point de vue de

la qualité, aucun cultivar n'était supérieur au témoin, un seul soit Strain 73-M-49 obtenait le même indice de qualité. En ce qui concerne le revenu brut, quatre cultivars furent supérieurs au témoin, Strain C-18 se classant le premier. Le temps nécessaire pour parvenir à la floraison s'échelonne entre 64 jours (sept cultivars) et 68 jours (sept cultivars).

*L'effet de N, P et K sur le tabac.* Ce projet comporte l'essai de quatre niveaux d'azote, quatre niveaux de phosphore, quatre niveaux de potasse et deux types de sol. Les tendances sont les mêmes sur les deux types de sol, sauf qu'il faut beaucoup moins d'engrais sur un sol riche pour obtenir les mêmes résultats.

Avec l'application de fortes quantités d'azote, le rendement et le revenu s'accroissent mais la qualité diminue. L'application de fortes doses de phosphore diminue le rendement. Par contre, l'application de fortes doses de phosphore diminue le rendement. Cependant, l'application de phosphore augmente la maturité indépendamment de la quantité. L'effet de la potasse est inégal; parfois il accroît le rendement, parfois il le diminue, par contre, son effet est le même sur la qualité.

*Répression des drageons du tabac.* En 1975, nous avons modifié quelque peu l'expérience. Onze produits furent mis à l'essai afin de connaître leur pouvoir de répression sur les drageons du tabac. L'expérience comprenait aussi deux stades d'application. La méthode d'application manuelle fut abandonnée afin d'essayer un plus grand nombre de produits. Les produits n'ont pas été très efficaces.

Lorsqu'on compare le temps d'application, on constate qu'une application avant écimage est plus efficace qu'une après écimage. De tous les produits à l'essai, seulement deux assurèrent un contrôle des drageons supérieur à 60%. En général, les traitements ne semblent pas avoir eu d'influence négative sur le rendement et la qualité.

*Distance et écimage.* En 1975, c'était la deuxième année d'existence de ce projet. Celui-ci vise à trouver un stade d'écimage idéal et une distance de plantation sur le rang adéquate avec un espacement entre les rangs de 122 cm.

Les données recueillies jusqu'à présent ne permettent pas de confirmer la supériorité d'un traitement sur un autre. Le meilleur rendement et le meilleur revenu s'obtiennent lorsqu'on plante à 41 cm sur le rang. On

obtient la meilleure qualité lorsqu'on distance les plants de 61 cm sur le rang. Par contre, pour ce qui est du stade d'écimage, la prédominance est pour le début floraison; c'est à ce stade qu'on a eu le meilleur rendement et le meilleur revenu brut. Pour ce qui est de la meilleure qualité, c'est au stade bouton qu'on l'obtient.

Cette deuxième année nous laisse entrevoir des résultats intéressants dans le cas d'une plantation à 41 cm sur le rang et d'un écimage en début floraison.

*Tabac gris.* Des échantillons de sol et de tissu de plants de tabac gris ont été recueillis chez plusieurs producteurs pour être ensuite analysés. Tous les échantillons de tissu avaient une concentration de manganèse et de fer très élevée et le pH du sol était autour de 5.1.

Pour obtenir une croissance acceptable avec le tabac jaune par procédé hydroponique, on a modifié plusieurs solutions nutritives et ajusté le rapport ammoniacque-nitrate pour stabiliser le pH à 5.1 avant d'essayer d'obtenir l'effet gris sur le tabac jaune.

*Répression du chiendent.* Les méthodes culturales actuelles ont pour effet de ralentir la croissance de cette plante adventice. Aussi au moment de la récolte, la population de

cette mauvaise herbe équivaut à celle avant le labour.

Un essai d'un an nous apprend que des herbicides peuvent détruire 95% du chiendent. Le tabac des parcelles traitées avec des herbicides a atteint un rendement supérieur à celui des parcelles sarclées seulement.

*Répression des vers gris. Euxoa scandens* (Riley) qui jusqu'en 1974 se concentrait sur une seule ferme, s'est répandu dans toutes les zones tabacoles de notre région.

*Euxoa messoria* (Harris) a causé des dommages à la quasi-totalité des fermes à tabac à cigarette.

Lorsqu'aucune mesure de répression n'est prise, les vers gris détruisent 25% des plants de tabac. Les dommages réels que subit la plantation sont beaucoup plus élevés. Les larves se nourrissent de feuilles entières ou de portions de feuille. Les larves coupent les bourgeons terminaux et le plant développe alors des tiges supplémentaires. La maturité de ces nouveaux plants est retardée et le tabaculteur doit détruire les tiges excédentes.

Les effets calorifiques et photopériodiques ont des répercussions à des stades différents pour les deux espèces de noctuelles. Ainsi la durée de pré-pupaison d'*Euxoa messoria* (Harris) variera pour atteindre la période d'envol à la mi-août. Quant à *Euxoa scandens* (Riley) sa croissance se réglera pour hiberner au cinquième ou au sixième instar.

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## INTRODUCTION

La station est située dans la partie sud-est du Québec, région où l'on pratique surtout une agriculture mixte à base de productions animales. Le territoire, d'une topographie légèrement ondulée, reçoit environ 100 cm de précipitations par année, distribuées assez uniformément d'un mois à l'autre. Les cultures fourragères y croissent avantageusement sauf la luzerne qui éprouve du mal à survivre aux rigueurs de l'hiver.

La recherche qu'on y poursuit est conçue en fonction d'une telle agriculture. Elle porte principalement sur les productions animales, soit les bovins laitiers, les bovins de boucherie, les porcs et les moutons, cette dernière en collaboration avec la Ferme expérimentale de la Pocatière. Des recherches sont également dirigées vers les productions végétales, en particulier la régie des cultures fourragères et les conditions de sols qui les favorisent.

Ce rapport résume quelques expériences poursuivies en 1975. On peut obtenir de plus amples renseignements en écrivant à: Station de recherches, Agriculture Canada, Lennoxville, Québec, J1M 1Z3.

C. S. Bernard  
Directeur

## ZOOTECHNIE

### **Influence de l'âge au sevrage et de la nature des protéines dans le succédané du lait sur la croissance de génisses laitières**

Trente-six génisses Holstein croisées ont servi à étudier l'effet de deux âges au sevrage, soit 5 et 7 semaines, et de deux sortes de succédanés du lait sur la croissance de génisses de remplacement. Les génisses étaient âgées de 1 à 3 jours au début de l'expérience et pesaient alors en moyenne 40,7 kg. Un succédané du lait dosait 12% de gras et 22% de protéine provenant entièrement du lait; l'autre dosait 10% de gras et 22% de protéine dont 45% provenait du soja. Les génisses recevaient en plus une moulée dosant 20% de protéine. La consommation était limitée à 2,25 kg par jour. Elles avaient aussi accès à un foin de mil dosant 9,5% de protéine et à de l'eau.

Les génisses sevrées à 5 et 7 semaines consommaient respectivement 11,4 et 22,8 kg de succédané du lait. Pendant la période expérimentale totale de 16 semaines, le gain observé était presque identique, soit 0,71 kg pour celles sevrées à 5 semaines et 0,69 kg pour celles sevrées à 7 semaines.

A partir de l'âge de 3 semaines jusqu'aux deux âges de sevrage, la moitié des génisses recevaient un succédané du lait dont 45% de la protéine totale provenait du soja. Au cours des 3 semaines suivantes, l'addition de protéine de soja dans le succédané du lait a réduit le gain quotidien de 0,19 kg. Toutefois,

à l'âge de 16 semaines, on n'observait aucune différence significative entre les deux groupes. Le gain en poids vif par jour était respectivement de 0,69 kg et 0,70 kg pour les génisses au succédané du lait avec ou sans protéine végétale.

Il en ressort que les génisses sevrées à 5 semaines se comparent favorablement à celles sevrées à 7 semaines. Aussi, dans les succédanés du lait, on peut remplacer 45% des protéines provenant du lait par une protéine provenant de soja sans affecter la croissance des génisses.

### **Influence des poids de mise en marché sur la qualité des carcasses de bouvillons**

On a abattu 10 bouvillons croisés Maine-Anjou × Holstein, 8 Limousin × Holstein et 10 Holstein × Holstein à chacun des poids vifs de 454 kg, 544 kg et 635 kg. Tous ont reçu la même ration de croissance à partir du poids vif d'environ 300 kg jusqu'à environ 70 kg avant la mise en marché. Cette ration fournissait aux bêtes quotidiennement 1,8 kg de moulée à 18% de protéine, 3,6 kg de foin de qualité moyenne et de l'ensilage d'herbe ou de maïs pour achever d'assouvir l'appétit. La période de croissance était suivie d'une période de finition pendant laquelle les animaux consommaient, à volonté, de la moulée à 18% de protéine et 0,91 kg de foin quotidiennement.

L'efficacité alimentaire, qui était de 6,8 kg d'U.N.T./kg de gain, pour les bêtes abattues à 454 kg, diminuait à 8,3 kg pour celles qui

étaient abattues à 635 kg. Il n'y avait pas de différence significative entre les croisements par rapport à ce critère. Le gain journalier diminuait de la même façon au fur et à mesure que les bêtes augmentaient de poids vif; il passait de 782 à 722 g par jour lorsque le poids d'abattage allait de 454 à 635 kg.

Pendant la période de croissance, le croisement Maine-Anjou accusait un gain de 669 g par jour, soit seulement 15 g de plus que le Holstein × Holstein (654 g). Par contre, durant la période de finition, les croisés Maine-Anjou faisaient un gain journalier de 1177 g, soit 102 g de moins que les bouvillons de race Holstein (1279 g). Au cours de ces deux périodes, les croisés Limousin × Holstein se sont développés le moins vite, soit 634 g pendant la période de croissance et 1155 g pendant la finition.

Lors de l'abattage, le rendement des Holstein était de 54.8%, comparé à 56.0% pour les croisés Maine-Anjou et 56.9% pour les croisés Limousin. Ces différences étaient significatives. De même pour la surface de noix de côte, le croisement Limousin était significativement plus élevé que les autres, soit 77,4 cm<sup>2</sup> par rapport à 71,1 cm<sup>2</sup> pour le Maine-Anjou et 68,3 cm<sup>2</sup> pour le Holstein.

Aucun animal abattu à 454 kg n'a obtenu la catégorie «Canada A». Il y en a eu 28,59% dans la catégorie «B» et 71,43% dans la catégorie «C». C'est la race Holstein qui avait le plus de carcasses «B», soit 40%. A l'abattage à 544 kg, deux des huit carcasses du Limousin se sont classées «Canada A» et aucune des Maine-Anjou et des Holstein. Neuf des dix carcasses des Holstein se sont classées «Canada C». Enfin, lorsque l'abattage avait lieu à 635 kg, la distribution des carcasses aux catégories «A», «B» et «C» était de 50.0%, 37.5% et 12.5% pour les croisés Limousin, 30.0%, 90.0% et 10.0% pour les croisés Maine-Anjou et 37.5%, 37.5% et 25% pour la race Holstein. On constate donc que les carcasses montaient en catégorie au fur et à mesure qu'il y avait augmentation de poids d'abattage.

Les tests de dégustation ainsi que les lectures à l'appareil Warner-Brazler révélaient qu'à l'abattage à 454 kg la viande des Holstein était significativement supérieure aux autres; elle était plus savoureuse, plus tendre et plus juteuse. A l'abattage de 544 kg et 635 kg, il n'y avait plus de différence entre les groupes.

## Productivité de vaches croisées

Des vaches de boucherie provenant des croisements Charolais × Holstein (CHo), Charolais × Ayrshire (CA), Hereford × Holstein (HeHo) et Hereford × Ayrshire (HeA) pesaient, à leur deuxième vêlage, 520 kg, 468 kg, 469 kg et 413 kg respectivement. Leurs âges respectifs étaient alors de 38.0, 36.6, 37.3 et 35.7 mois. Elles avaient été saillies artificiellement soit par un taureau Chianina ou un taureau Simmental.

Les veaux des CHo pesaient, à la naissance et au sevrage à l'âge de 182 jours, 43,4 et 196,3 kg; ceux des CA, 42,9 et 194,1 kg; ceux des HeHo, 41,1 et 197,2 kg; et ceux des HeA, 37,0 et 184,6 kg. La différence en poids à la naissance était de 10.2% en faveur des veaux issus du Chianina. Au sevrage, la différence n'était que de 1.4% et n'était plus significative. Les veaux mâles étaient environ 10% plus pesant à la naissance que les veaux femelles. Cet écart s'est maintenu jusqu'au sevrage.

L'augmentation du poids vif de la vache durant l'allaitement ainsi que celui du veau durant les premiers mois d'allaitement sont des indices de production laitière de la mère. Pour toute la période d'allaitement, les vaches de chacun des croisements ont fait les gains suivants: CHo, 13 kg; CA, 24 kg; HeHo, -15 kg et HeA, -1 kg. Dans le même ordre, les veaux issus de ces vaches ont fait, durant les premiers 91 jours d'allaitement, des gains journaliers de 0,80, 0,83, 0,88 et 0,82 kg par jour.

## L'effet du stress et du niveau alimentaire au moment du sevrage sur quelques caractères de reproduction de la truie

On a distribué alléatoirement 177 truies, représentant cinq croisements, dans une expérience factorielle 2<sup>2</sup> pour étudier l'effet du stress et du niveau alimentaire, imposés au sevrage, sur l'intervalle post-partum et les caractères de reproduction. Le sevrage avait lieu 35 jours après la mise bas. Les truies étaient saillies à la première chaleur après le sevrage et abattues 30 jours après la saillie. Le stress consistait à placer les truies, par groupes de 10, dans des enclos à l'intérieur de la porcherie. Les non stressées étaient placées dans des enclos individuels dans la même porcherie. Les deux niveaux alimentaires étaient les suivants: les truies au «flushing» étaient nourries à volonté à partir du sevrage jusqu'au moment de la saillie tandis



que les autres continuaient à être nourries à raison de 2,7 kg de nourriture par jour.

Au moment de l'abattage on a constaté que le stress avait augmenté de 10% ( $P < 0.05$ ) le nombre de truies gestantes par rapport aux truies non stressées. Cependant, le stress ne changea en rien l'intervalle post-partum. Le niveau alimentaire favorisa le retour des truies en chaleurs après le sevrage: 61% des truies nourries à volonté ont eu des chaleurs dans les 7 jours suivant le sevrage, soit 9% de plus que celles nourries avec restriction. L'alimentation à volonté favorisa aussi le taux d'ovulation mais il fallait qu'il s'écoule au moins 6 jours avant que cette influence se fasse sentir. Le taux de mortalité embryonnaire était de 9% plus élevé chez les truies alimentées à volonté jusqu'à la saillie.

Les races impliquées dans les croisements n'ont eu aucune influence sur le comportement des truies, peu importe les traitements imposés.

#### **Mécanisme du développement folliculaire ovarien chez la brebis**

Le marquage à l'encre de chine nous a permis d'observer la destinée du plus gros ( $F^1$ ) et du second plus gros ( $F^2$ ) follicule après différents traitements.

Les  $F^1$  et les  $F^2$  du groupe témoin, marqués au 10<sup>e</sup> jour du cycle oestral sont tous (8/8) devenus atrésiques. Lorsque le marquage fut fait au 14<sup>e</sup> jour, seuls les  $F^1$  parmi les follicules marqués ont ovulé. La destruction des  $F^1$  accompagnée ou non d'une extirpation des corps jaunes a permis à certains  $F^2$  d'ovuler, tandis que l'enlèvement des corps jaunes a eu pour effet d'abaisser le nombre de  $F^1$  ovulés. Il semble donc que la destinée des  $F^1$  serait fonction du moment du cycle et que les  $F^1$  pourraient exercer une influence inhibitrice sur l'ovulation des  $F^2$ . De plus, l'enlèvement des corps jaunes a fait apparaître plusieurs follicules kystiques lutéinisés et a diminué le taux d'ovulation.

#### **L'influence de la saison d'agnelage sur l'intervalle post-partum des brebis et sur l'âge à la puberté de leurs agnelles**

Les brebis qui ont servi à cette expérience provenaient d'un troupeau sélectionné pour l'agnelage en tout temps de l'année. Après l'agnelage d'automne, dont la date moyenne fut le 8 novembre, l'intervalle entre le sevrage à 14 jours et la première saillie a été de 18.0 jours. Par contre, après l'agnelage du

printemps, le 14 mai, il fut de 87.1 jours. Les taux d'agnelage après sevrage d'automne et de printemps ont été de 76.6% et 89.3%, respectivement. Les brebis à leur troisième parité étaient plus prolifiques de 0.23 ( $P < 0.05$ ) agneaux par agnelage que celles à leur deuxième et nécessitaient 0.38 saillie de moins par agneau produit ( $P < 0.05$ ).

Parmi les agnelles issues des agnelages d'automne, 93.3% atteignaient la puberté à un âge moyen de 312.8 jours. De celles nées le printemps 57.1% atteignaient la puberté à un âge moyen de 201.8 jours. Les agnelles du printemps qui atteignirent la puberté à l'automne de leur année de naissance étaient significativement plus lourdes aux âges de 140, 168 et 196 jours que celles qui n'atteignirent pas la puberté à cette période.

### **PRODUCTIONS VÉGÉTALES**

#### **Effet de la densité de population et de la fumure sur la teneur en P et K des sols et sur la digestibilité et la composition chimique de trois hybrides de maïs**

Depuis 1971, on a étudié l'influence de la densité de population et de la fertilisation de trois hybrides de maïs de maturité différente sur la production d'ensilage. Les données concernant les rendements ont déjà fait l'objet du rapport 1972.

Les résultats d'analyses de sol indiquent qu'au cours de la période de 1971-1974, l'apport de 50 kg/ha de P a favorisé une accumulation rapide de cet élément dans le sol, tandis que 100 kg/ha de K étaient insuffisants pour maintenir le niveau de potassium dans le sol.

La fertilisation azotée a modifié la teneur des plants et des épis en  $N-NO_3$ , en P et en K de façon appréciable. Les teneurs moyennes des plants en  $N-NO_3$  lors de la récolte étaient de 0.05%, 0.09% et 0.14% selon que le sol recevait 0, 100 ou 200 kg/ha de N.

En 1972, une période sèche précédant la récolte a favorisé l'accumulation de  $N-NO_3$  jusqu'à un niveau de 0.23% dans les plants fertilisés à 200 kg/ha de N. Il convient de noter que, cette même année, la teneur des épis en  $N-NO_3$  était la plus faible que l'on ait observée de sorte que la teneur du plant entier était de 0.09%.

La teneur en P des épis diminuait avec l'augmentation des doses de N, ce phénomène étant relié au stade de maturité atteint selon les doses de N. De la même façon, le K



augmentait dans les plants et diminuait dans les épis.

La digestibilité du maïs a été influencée principalement par la saison de végétation, l'hybride et la densité de la population. En 1973, année où une infestation de brûlure du nord sévit, la digestibilité était de 60% comparativement à une variation de 68% à 70% pour les autres années. La digestibilité de l'hybride Dekalb XL était de 63.9% comparativement à 68.5% et 68.7% pour les hybrides Warwick SL 209 et Funk's G 4252. Il semblerait donc que le pourcentage de digestibilité ne soit pas associé à la précocité d'un hybride mais plutôt aux qualités intrinsèques de cet hybride. Enfin, la digestibilité moyenne du maïs à une densité de 44 000 plants/ha était de 69% comparativement à 66% pour les densités de 70 000 plants/ha et 124 000 plants/ha.

La teneur moyenne en protéine du maïs a varié, selon les saisons, de 6.6% à 7.7%. L'hybride Warwick SL 209 dosait en moyenne 6.8% comparativement à 7.3% pour les deux autres hybrides plus tardifs. Le maïs provenant de parcelles à population élevée dosait 6.8% de protéine tandis que celui provenant des parcelles de moins grandes densités de population en contenait de 7.2% à 7.4%.

### Contrôle des oiseaux causant des dommages aux cultures de maïs ensilage

L'étude entreprise en mai 1975 avait pour but de déterminer la diète estivale de cinq espèces d'oiseaux, d'évaluer leur nombre approximatif ainsi que leurs périodes d'activités destructrices du maïs ensilage, et de comparer certains moyens de contrôle.

Les analyses stomacales ont démontré deux périodes où ces espèces d'oiseaux endommageaient le plus les cultures de maïs: aux semences (du 10 au 19 mai) et avant les récoltes (du 12 août au 16 septembre).

Une première espèce responsable de ces dommages était le carouge à épaulettes (*Agelaius phoeniceus* Linnaeus). Il est granivore et insectivore. Aux semences, sa diète se composait de 19.4% de graines de maïs et avant les récoltes augmentait à 48.2%.

Le mainate bronzé (*Quiscalus quiscula* Linnaeus) est aussi granivore et insectivore. Aux semences, sa diète comportait 53% de graines de maïs. Avant les récoltes elle augmentait à 79% en maïs.

Le vacher à tête brune (*Molothrus ater* Boddaert), bien que granivore et insectivore, causait très peu de dommages aux cultures de maïs. Aux semences, il consommait 3.4% de graines de maïs et après cette période, il délaissait cette culture pour se nourrir dans les auge des animaux.

Le pigeon biset (*Columba livia* Gmelin), une espèce uniquement granivore, endommageait fortement les semis de maïs. Aux semences, 40% de sa diète se composait de maïs. Une fois cette période écoulée, le peu de maïs qu'il ingérait provenait des auge des animaux.

L'étourneau sansonnet (*Sturnus vulgaris* Linnaeus) est presque exclusivement insectivore et frugivore. Il ne causait pas de dommages aux cultures de maïs.

À l'époque des semences, les carouges à épaulettes, les mainates bronzés et les pigeons bisets envahissaient en grand nombre les champs de maïs. Nous trouvions aussi quelques vachers à tête brune. Du 12 août au 16 septembre, les carouges à épaulettes constituaient 95.5% des voiliers et les mainates bronzés 4.5%. Les pigeons bisets et les vachers à tête brune ne fréquentaient pas les champs de maïs à cette période.

Les champs les plus ravagés se situaient à proximité des cours d'eau et des perchoirs élevés.

Les dommages aux semences (4 témoins: 12,9 ha), évalués d'après le nombre de plants non germés en comparaison avec le nombre de graines semées, s'élevaient à 17.7%. Avant les récoltes, le comptage des dommages (4 témoins: 13,8 ha), effectué par la méthode de l'indice des dommages, totalisait 16.5%.

Aux semences, l'Avitrol 200 c'est-à-dire 4-aminopyridine (Avitrol Corp.) et Mesurol c'est-à-dire 4-(méthylthio)-3,5-xylylméthylcarbamate (Chemagro) et l'Av-Alarm (appareil qui émet des sons mécaniques) furent très efficaces. L'utilisation d'Avitrol 200 (1,12 kg de graines traitées à l'hectare répandues après le semis) a permis de réduire les dommages dans une proportion de 84%, comparativement à 53% pour le Mesurol (226,8 g de répulsif mélangé aux graines) et à 57% pour l'Av-Alarm.

À partir du 12 août (période avant les récoltes), l'Avitrol 200, en deux applications de 1,12 kg/ha et de 0,56 kg/ha, a réduit les dommages de 93%. L'Avitrol 200 et l'utilisation d'un canon ont permis une réduction des dommages de 80%. L'Av-Alarm et le canon

fonctionnant simultanément ont diminué les dégâts de 70%.

Ces expériences se poursuivront en 1976 pour préciser davantage les moyens de contrôle.

### Effet du pH et de l'humidité des sols sur la teneur en manganèse et en aluminium échangeable

Dans le cadre du programme de recherches sur les facteurs édaphiques influençant la productivité de la luzerne, nous avons mesuré le manganèse et l'aluminium échangeable de l'argile Ste-Rosalie et du sable St-Jude après avoir récolté six coupes de luzerne en serre. Nous avons soumis les sols à deux régimes hydriques: (1) Très humide: pourcentage d'humidité du sol variant du point de saturation à la capacité de rétention d'eau au champ (2) Optimal: pourcentage d'humidité du sol variant entre la capacité de rétention d'eau au champ et 70% de cette valeur. Le pH des sols avait été ajusté à 5.0, 6.5 et 7.5. De plus, on avait appliqué du manganèse aux doses suivantes: 0, 40 et 80 ppm et de l'aluminium à raison de 0, 20 et 40 ppm. Tous les facteurs, à tous les niveaux, ont été combinés factoriellement.

*Manganèse échangeable.* De tous les facteurs à l'étude, le pH du sol a été celui qui a le plus influencé la quantité de manganèse échangeable. En chaulant le sol au pH 7.5, on a diminué de dix fois la quantité de manganèse échangeable.

Évidemment, le Mn échangeable s'est accru avec les doses de Mn appliquées au sol et ceci même en sol chaulé. Cependant, la teneur en Mn échangeable du sol de pH 7.5 et traité avec 80 ppm de manganèse s'est révélée trois fois plus petite que celle du sol non chaulé et non fertilisé au manganèse.

Sur le loam Greensboro non chaulé, le Mn échangeable du sol a augmenté à mesure qu'on accroissait les doses d'aluminium (Al). A la dose d'aluminium la plus élevée, on a augmenté de trois fois le manganèse échangeable.

*Aluminium échangeable.* Nous avons extrait l'aluminium échangeable avec de l'acétate d'ammonium tamponné au pH 4.5.

Encore ici, le pH du sol s'est avéré le facteur qui a le plus influencé la quantité d'aluminium présente dans le sol. On en a enregistré, en moyenne, 152 ppm, 76 ppm et 56 ppm quand le sol avait été ajusté aux pH de 5.0, 6.5 et 7.5 respectivement. Les régimes hydriques expérimentés n'ont pas eu d'effet sur la quantité d'aluminium retrouvé dans les sols.

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## INTRODUCTION

Les équipes de recherche à Sainte-Foy, La Pocatière et Normandin sont de plus en plus appréciées à tous les niveaux d'influence. En plus de leur travail régulier plusieurs chercheurs de cette station participent à l'enseignement universitaire et technique.

Nous déplorons le décès accidentel de notre valeureux technicien en réfrigération monsieur Maurice Tardif. Son excellent travail depuis le début de la Station fait en sorte que le vide créé sera difficile à combler.

Ce rapport présente un résumé de certains des résultats expérimentaux obtenus durant 1975. Pour des comptes rendus plus détaillés, veuillez vous adresser à: Station de recherches, Agriculture Canada, 2560 Chemin Gomin, Sainte-Foy, Québec. G1V 2J3.

Le Directeur  
S. J. Bourget

## LES PLANTES

### Les céréales

Plusieurs lignées et variétés d'avoine, d'orge et de blé venant de l'Amérique du Nord et de l'Europe ont été évaluées à la Pocatière, à Normandin et dans les Maritimes. La variété Alma continue de se classer très bien et son aire d'adaptation semble être la province de Québec au complet. On a, de plus, fait la multiplication de la semence pour les essais coopératifs de l'Est.

*Mauvaises herbes.* On a conduit une expérience ayant pour but d'étudier la concurrence de quatre mauvaises herbes annuelles sur le blé et l'avoine. L'hypothèse émise est que l'effet des mauvaises herbes annuelles sur le rendement des céréales est fonction de la biomasse totale indépendamment des espèces présentes dans les populations. Les résultats préliminaires en serres et au champ indiquent que la forte densité des mauvaises herbes est le facteur important indépendamment des espèces de mauvaises herbes. A faible densité, le chou gras et l'ortie royale semblent avoir un effet sur le rendement des céréales, ce qui n'est pas vrai pour la renouée liseron et le tabouret des champs. A faible densité, il semble également que le chou gras et l'ortie royale exercent un haut pouvoir compétitif lorsqu'ils sont semés en mélanges bispécifiques avec le tabouret des champs et la renouée liseron. L'absence de compétition de la part de la renouée liseron est due principalement à l'effet de l'insecte *Gastrophysa polygoni* L. qui se nourrit des feuilles de cette espèce. L'effet des dates de semis sur

le rendement des céréales n'a pas été influencé par les mauvaises herbes puisque nous avons observé des rendements plus faibles sur les semis tardifs, même si les populations de mauvaises herbes étaient beaucoup moins importantes.

On a également étudié les différences, quant aux effets, de quatre produits herbicides sur l'évolution, la diversité et la biomasse des populations de mauvaises herbes. Les résultats montrent peu de différences floristiques sauf pour le traitement au Kilmor (Green Cross) où la diversité est très faible. Les différences majeures se situent au niveau de la contribution de chaque espèce à la biomasse totale. Par contre, la biomasse totale montre peu de variation entre les traitements herbicides. Ceci est vrai pour les parcelles semées en avoine et celles non semées. L'effet de l'avoine sur les mauvaises herbes, indépendamment des produits herbicides, montre une réduction sensible du chiendent et de la sétaire glauque par rapport aux parcelles non semées. De plus, l'effet des différents herbicides sur le rendement de l'avoine n'apparaît pas significatif sauf avec le traitement au HOE 23408 (Hoechst) où une forte toxicité a été observée.

*Désinfection des semences.* On a déterminé l'efficacité de quinze fongicides systémiques et non systémiques à réprimer les maladies transmises par la semence des céréales et principalement les charbons. Pour la deuxième année consécutive on a noté une influence importante des conditions environnantes, des méthodes d'inoculation ainsi que de la profondeur du semis sur le développement de la maladie dans les parcelles témoins et

sur l'efficacité pratique de certaines formulations chimiques. Ainsi, le charbon s'est mieux développé à St-Hyacinthe, là où le semis était plus hâtif et plus profond. Parmi les formulations chimiques à l'essai, la TF 3262 B (Chipman), au taux de 2,1 ml/l s'est avérée la plus efficace à contrôler tous les charbons, tout en n'affectant pas le pourcentage de germination, le taux d'émergence et le rendement des parcelles. Les formulations d'Uniroyal étaient toutes efficaces au taux recommandé.

**Septoriose.** On a effectué des traitements de fongicides, à différents stades de croissance des trois cultivars Garry, Alma et Dorval. Le rendement des variétés résistantes telles Garry et Alma n'a pas été influencé. Cependant, les traitements au semis et à la fin du tallage ont amélioré légèrement le rendement du cultivar Dorval beaucoup plus sensible. De tels résultats s'expliquent étant donné que la septoriose n'a pas été abondante au cours des deux dernières années. L'application de deux traitements en végétation ne s'est donc pas avérée rentable dans de telles conditions.

**Nanisme.** Le dispositif de semis en butte a été jugé environ trois fois plus efficace que le semis en rang pour effectuer la dernière sélection de résistance au BYDV (*barley yellow dwarf virus*). Avec ce dispositif il a été possible d'évaluer environ 8000 lignées d'orge et d'avoine. Dans une expérience avec inoculations hebdomadaires de BYDV, il a été démontré que l'orge et l'avoine peuvent subir des pertes de l'ordre de 25% à 33% sans montrer de symptômes typiques, si les pucerons vecteurs de BYDV infestent la plante après une date critique.

**Helminthosporiose.** Une étude a été entreprise afin de déterminer l'importance de cette maladie de l'orge dans l'est du Canada. L'inoculation artificielle de l'organisme à six cultivars d'orge augmentait considérablement les symptômes, diminuait le rendement ainsi que le poids au 1000 grains. La maladie était inexistante dans les parcelles traitées au manèbe à un taux plus élevé que la dose économique. Un autre essai effectué à St-Hyacinthe, depuis deux ans, sur le développement de la même maladie au niveau des racines a démontré que cette phase de l'helminthosporiose a été d'une importance médiocre étant donné que le système racinaire des cultivars d'orge à l'essai était très légèrement nécrosé.

**Amélioration.** On a réalisé 187 croisements d'avoine et 167 croisements d'orge en 1975, en ayant comme objectif global de rencontrer les besoins de l'est du Canada. Nous avons pu bénéficier d'accommodations en Nouvelle-Zélande pour l'avoine et en Californie pour l'orge afin de réaliser des multiplications d'hiver. On a pu ainsi faire un essai de rendement de quelque 1200 lignées d'avoine en F<sub>6</sub> et F<sub>7</sub> en plus de permettre une sélection pour la grosseur du grain, le poids de 1000 grains, la hauteur, la maturité et la verse. Pour ce qui est de l'orge la multiplication d'hiver de 5400 buttes a produit environ 800 lignées en préobservation. Les travaux d'amélioration précédents et les nombreux autres essais effectués en 1975 nous permettent d'être optimistes dans les nombreuses lignées fort prometteuses d'avoine et d'orge.

### La luzerne

**Amélioration.** Le projet sur l'amélioration de la luzerne pour l'est du Canada en est maintenant à sa quatrième année d'opération. Sept plantes de chacune des neuf meilleures familles issues parmi 80 obtenues de croisements réciproques entre WL-303 × Iroquois ont donné 63 F<sub>2</sub>. Les buts recherchés dans ce travail sont d'évaluer les 63 nouvelles familles obtenues par croisement multiple pour le rendement en matière sèche et leur réaction au nématode *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. La population de 55 plantes nommées SQ provenant de huit champs de cultivar Saranac dans huit comtés différents et qui ont survécu à l'hiver rigoureux de 1973-1974, ont été bouturées et transplantées à La Pocatière et à divers endroits de la région de Québec pour la production de semence. Ayant pu faire établir la SQ1 en Nouvelle-Zélande afin de produire de la semence F<sub>2</sub>, nous espérons obtenir d'ici le printemps 1976 suffisamment de semence pour évaluer cette sélection en parcelle à travers toute la province.

**Inoculants.** Une méthode rapide et peu laborieuse a été mise au point pour sélectionner des souches de *Rhizobium meliloti* symbiotiquement supérieures. Il s'agit de mesurer la consommation des deux paramètres oxygène et mannitol par unité de protéine cellulaire au cours de la phase exponentielle de croissance, de même que la production totale d'acide.

En collaboration avec la Division des produits et marchés, nous avons mené une



enquête nationale sur la qualité des inoculants des légumineuses. Les résultats indiquent à quel niveau les problèmes de perte de la qualité se situent et nous avons fait des recommandations spécifiques à cet effet. De plus, nous avons étudié le comportement des meilleures souches de *Rhizobium meliloti* sélectionnées dans notre laboratoire à travers les régions agricoles du Québec. Ces souches ont une grande capacité d'adaptation aux conditions de sol et de climat, sauf dans la région de l'Abitibi-Témiscamingue où les réponses à l'inoculation furent moins bonnes qu'espéré. Ailleurs dans la province l'utilisation de souches efficaces avec une bonne méthodologie d'application a donné de très bons résultats.

**Maladies.** L'inventaire s'est poursuivi tout en améliorant l'intensité et les méthodes d'échantillonnage. Les maladies du feuillage les plus fréquemment rencontrées ont été la tige noire (*Phoma medicaginis* Malbr. & Roum.) et la tache leptosphaerulinienne (*Leptosphaerulina briosiana* (Poll.) Graham & Luttrell). D'autres maladies ont aussi été observées mais moins fréquemment; ce sont la tache stemphyllienne (*Stemphylium botryosum* Walbr.), le mildiou (*Peronospora trifoliorum* de Bary) et la tache commune (*Pseudopeziza medicaginis* (Lib.) Sacc.). Cette dernière maladie a été considérablement moins importante cette année que par les années passées. D'autres parts, la mineuse virgule (*Agromyza frontella* Rondani) qui s'était déjà manifestée l'an dernier a été observée cette année en très grande abondance et semble causer des dégâts considérables.

### Le trèfle rouge

Les cultivars de trèfle rouge Hungaropoli, Dollard et Altaswede soumis à l'inoculation par le *Stemphylium sarcinaeforme* (Cav.) Wiltshire et à différents régimes de coupes révèlent que la tache zonée réduit le rendement de 8% à 12% lorsque les coupes sont faites à 50% de floraison ou à un stade plus avancé. Le cultivar Dollard, bien que moins affecté par la tache zonée, donne un rendement inférieur à Hungaropoli. Des rendements de l'ordre de 12 t/ha ont été obtenus dans ces essais, ce qui est de beaucoup supérieur aux rendements moyens à la ferme. Les différences significatives obtenues indiquent qu'il y a possibilité d'augmenter considérablement le rendement à la ferme

par une régie appropriée de la culture, par le choix adéquat du cultivar et par la pratique d'une coupe hâtive afin de réduire les pertes dues à la tache zonée. Les résultats de ces essais indiquent également la possibilité d'amélioration des cultivars de trèfle rouge, puisque le cult. Hungaropoli donne un rendement supérieur au cult. Dollard qui possède une plus grande tolérance à l'infection de la tache zonée.

### Le mil

**Amélioration.** La pépinière de 6000 plants établie à St-Augustin nous a permis de sélectionner 1800 plants à la récolte de la première coupe, plants qui sont actuellement analysés pour leur contenu en protéines et leur digestibilité afin de retenir environ 500 plants supérieurs. On a établi une pépinière de 4500 plants cet été à La Pocatière.

**Hespérie européenne.** Le virus étudié en 1974 par Smirnoff, McNeil, Comeau et Letendre, a causé une diminution notable de population au Lac St-Jean et le potentiel de ce virus comme agent préventif contre les épidémies d'hespérie a été démontré à l'aide d'arrosages aériens. Le virus persiste dans l'environnement et peut apporter une protection durable quoique le niveau de protection obtenu reste à réévaluer dans les années à venir. L'innocuité de ce virus envers les abeilles et plusieurs autres organismes vivants a été démontrée.

### Le brome

Suivant des observations faites aux champs et en parcelles, le brome est affecté gravement par une tache foliaire causée par *Dreschlera bromi* (Died.) Shoem. Des essais préliminaires ont aidé à mettre au point une technique d'inoculation du pathogène qui permettra de déterminer l'importance de cette maladie sur le rendement et la qualité du fourrage.

### La tolérance au froid

Nous avons amorcé un projet multidisciplinaire sur la survivance de la luzerne à l'hiver. Pour la réalisation de ce projet on fait appel à 14 spécialistes de la station. Les travaux se poursuivent sur quatre sites dont deux dans la région de Montréal et deux dans la région de Québec. Une étude complète des sols à chaque site, incluant un relevé des principaux nématodes, a été faite. On a établi le protocole expérimental en tenant compte des avis du



Dr P. Jui du Service de la recherche statistique à Ottawa.

*Échantillonnage.* A l'aide d'une foreuse tubulaire mise au point ici, on prélève des échantillons dans des luzernières l'hiver et on les transporte en serres pour étudier la croissance des plants de luzerne. Il nous est ainsi possible d'étudier l'intensité des dégâts et prévoir ainsi les conditions de récolte l'été suivant.

*Photographie aérienne.* Afin d'accumuler une banque de photos aériennes qui nous permettront d'évaluer les dommages aux récoltes de luzerne durant l'hiver, sept vols ont eu lieu au printemps et à l'automne depuis 2 ans. Treize sites dans les régions de Montréal, Sherbrooke et Québec ont été couverts. De tous les sites couverts en 1974, un seul s'est prêté à l'évaluation des dommages, soit celui de St-Thuribe, près de Québec. Dans la région de Montréal, la glace et la neige avaient entièrement disparues au moment de la prise des photos en avril, rendant difficile la comparaison avec l'état de la végétation au mois de mai ou juin. Dans la région de Québec, l'épaisse couche de neige visible sur les photos a protégé les luzernières contre le gel. Les photos prises en mars et en avril démontrent qu'il est difficile de relier l'état de la couverture du sol (neige, glace, eau) avec la reprise de la végétation en mai et en juin. Cependant, dans plusieurs cas, les photos nous renseignent sur l'état du drainage de surface des sols, sur l'emplacement des drains souterrains et sur l'état de la végétation.

*Protéines.* Une étude de la compressibilité et de l'expansibilité des couches phospholipidiques du blé d'hiver sur une surface d'eau a démontré que le cycle était beaucoup plus réversible pour la variété Kharkov que pour Champlain. Cela nous indique que les phospholipides de la variété résistante Kharkov sont mieux adaptés pour résister au dommage physique de la membrane. Une expérience similaire faite sur la surface d'une solution aqueuse de protéines de Kharkov nous a donné des cycles compressibilité-expansibilité complètement réversibles; cela indique une interaction probable entre les fractions protéines et lipides de Kharkov ce qui accroît la résistance de la membrane.

*Lipides.* Les résultats avec l'incorporation de  $^{33}\text{P}$  dans les lipides des racines de luzerne

suggèrent que les différences variétales observées au niveau du phosphore lipidique de la luzerne endurcie sont principalement le résultat de taux différents dans la dégradation des phospholipides au cours de l'endurcissement. Cependant la synthèse *de novo* des phospholipides, surtout la phosphatidylcholine, semble également jouer un rôle dans l'endurcissement. Durant ce dernier, la teneur en acide linoléique augmente fortement aux dépens de l'acide linolénique, aussi bien chez la variété rustique Kharkov que chez la variété tendre Champlain. Cette différence variétale en résistance à la gelée ne peut donc s'expliquer en terme d'insaturation des acides gras. Le fractionnement subcellulaire de racines de blé a montré que la forte stimulation de l'incorporation de  $^{33}\text{P}$  dans les lipides, observée précédemment au cours de l'endurcissement, se fait surtout au niveau des microsomes.

## LES SOLS

### Productivité

*Conductivité hydraulique.* Des mesures de conductivité hydraulique saturée ( $K$ ) ont été faites sur des échantillons intacts de sols du bas du fleuve et du Lac St-Jean ainsi que sur deux podzols à fragipan développés dans des dépôts glaciaires des Laurentides et des Appalaches. Pour le premier groupe de sols les valeurs de  $K$  ont varié de 1 à 85 cm/h, ce qui nous fait conclure que ces sols sont relativement perméables malgré leur forte teneur en argile. Pour les fragipans, la conductivité hydraulique saturée décroît avec la profondeur dans les deux profils principalement à cause de l'augmentation de la densité apparente qui passe de 0,7 à 2,0 g/cm<sup>3</sup>. Cependant, à densité égale, les valeurs de  $K$  sont toujours plus élevées dans le sol des Laurentides qui a une texture plus grossière. Elles varient de 120 à 25 cm/h. Ces différences proviennent du mouvement et de la réorganisation de particules fines dans les pores et les plans de fracture. Dans le profil appalachien, la porosité vésiculaire est élevée et ne contribue plus à la transmission de l'eau. Dans ce sol, un horizon d'éluviation secondaire à conductivité élevée s'est développé au sommet du fragipan par suite d'un accroissement abrupt de la densité à ce niveau et de l'écoulement latéral des eaux de percolation.

## FERME EXPÉRIMENTALE NORMANDIN

### Les plantes fourragères

*Graminées en semis pur ou en mélange.* La fléole Climax, le brome Saratoga et leur association respective avec soit la luzerne Saranac, soit le trèfle rouge Lakeland, ont été exploités durant 3 ans sous un régime de deux fauches annuelles. La fléole a fourni le meilleur rendement, 6284 kg/ha, suivie du brome, 5878 kg/ha. L'association de ces graminées à la luzerne a été supérieure (5500 kg/ha) à celle du trèfle rouge (4870 kg/ha); cependant, la contribution au rendement des graminées a été plus élevée avec cette dernière légumineuse. Sur une moyenne de deux coupes durant 2 ans, la teneur en protéine du mélange brome-luzerne a atteint 16.5%, celle de la fléole avec luzerne ou trèfle rouge a été de 16.3%, alors que la fléole et le brome en semis pur ont accusé une teneur respective de 10.4% et 11.7%. Le contenu en fibres brutes a été le plus faible dans les mélanges à base de trèfle rouge, soit environ 50%, alors qu'il s'est établi à un peu plus de 60% dans les mélanges à base de luzerne et dans les graminées pures.

*Entreposage du foin.* Du foin mélangé a été pressé sous forme de grosses balles rondes pesant entre 800 et 1000 kg et laissées au champ durant des périodes allant de 1 à 4 semaines. Pour une meilleure conservation, la teneur en humidité au pressage ne doit pas dépasser 22% et, dans ces conditions, les pertes de feuilles et autres résidus ont été d'environ 8 kg par balle. Les pertes sur le pourtour ont révélé que ces balles sont passablement résistantes à l'infiltration de l'eau de pluie; cependant, un long séjour au champ a démontré que l'aire d'entreposage doit être bien drainée pour minimiser les moisissures par contact avec le sol. A l'alimentation, les pertes ont varié de 6% à 15% quand les balles ont été servies dans une mangeoire ou au champ. Les difficultés de manipulation, associées aux pertes de foin qui augmentent avec le nombre de ballots, sont des facteurs à considérer dans le choix du système.

### Les petits fruits et légumes

*Rusticité des framboisiers.* Les cultivars E604, C.2-522, M544 et 25-563, en provenance de Beaverlodge, Alb., ont été comparés avec la variété Boyne durant 5 années

*Matière organique.* L'influence de la texture et de la matière organique sur les propriétés d'échange cationique des 17 plus importants sols à grande culture du Québec a été déterminée en utilisant les horizons de labour Ap. La capacité d'échange cationique (C.E.C.) a varié de 10,6 à 42,6 meq/100 g sol dont 40% a été attribué au carbone et 32% à l'argile. Les équations de régression simple et multiple ont démontré que le carbone était relié surtout à l'acidité échangeable, alors que l'argile augmentait les bases échangeables. Les C.E.C. de la matière organique et de l'argile ont été calculées respectivement à 161 meq/100 g de matière organique et à 29 meq/100 g d'argile.

*NPK.* Dans le but de déterminer la réponse des plantes à différentes applications d'engrais chimiques, des études se sont poursuivies dans la région du Lac St-Jean, sur sol argileux. Deux variétés d'avoine, Alma et Yamaska, deux variétés d'orge, Conquest et Bonanza et la féverole de variété Herz Freya ont été utilisées. L'azote est l'élément le plus susceptible d'apporter des augmentations importantes de rendements. Certaines des variétés ont toutefois très peu répondu à des apports d'azote. Des applications de phosphore à la féverole ont amené une hausse de 5% des rendements alors que l'azote et le potassium ont eu un effet négligeable.

*Poussière d'amiante.* Des applications à doses élevées de poussières d'amiante (correspondant à 400 kg MgO/ha) en serres à un podzol humo-ferrique de la série Leeds n'ont pas eu d'influence sur la productivité du sol telle qu'évaluée par les cultures de luzerne, d'avoine et de pommes de terre. Dans le milieu naturel, la pollution du sol par les poussières minières réduit la microflore totale du sol. Elle abaisse les populations de champignons et de bactéries obligatoirement hétérotrophes à l'avantage des bactéries autotrophes qui sont favorisées. Les comptages effectués dans les sols lors des essais en serre (pour la culture des pommes de terre) ont indiqué que le nombre total des bactéries reste constant, mais que les bactéries facultativement hétérotrophes et autotrophes augmentent en nombre.



dans le but d'évaluer leur résistance à la dessiccation par le froid. Les observations recueillies ont démontré que la lignée 25-563 est la plus rustique de l'essai, accusant le plus faible taux de dessèchement des tiges et la meilleure production de fruits; ses tiges sont cependant retombantes et exigent tuteurage mais son fruit est le plus sucré des cultivars testés.

*Régie des fraisières.* On a planté les variétés Redcoat, Veestar et Guardsman durant 3 années successives soit sur billon, soit à plat (méthode conventionnelle). Les trois plantations ont donné les mêmes résultats et tendances, en ce sens que la production de fruits a été significativement plus élevée (5490 kg/ha) selon la méthode conventionnelle que sur billon (4781 kg/ha). Par ailleurs, les fruits étaient un peu plus lourds dans la plantation à plat. Sans égard à la façon culturale, Veestar a produit plus que les autres variétés dans les trois plantations, soit un peu plus de 6000 kg/ha.

#### Les oléagineuses

*Évaluation du genre Brassica.* Sur les 10 lignées à l'essai du groupe *B. campestris*, quatre ont produit plus de grain que les variétés Span, Torch et Echo. Les lignées R-500 et CZY3-1804 ont manifesté un bon potentiel de rendement.

Dans le groupe *B. napus*, la variété Tower a obtenu la meilleure production des 14 variétés et lignées à l'essai, mais avec une légère marge par rapport à S72-292, S71-864 et Target.

*Évaluation du tournesol.* Les dix variétés et lignées à l'essai ont produit une moyenne de 19.1 q/ha de grain d'une teneur en huile s'établissant à 34.87%, ce qui équivaut à 666 q/ha d'huile végétale. Le plus haut rendement de grain a été obtenu de la variété Krasnodarets, alors que Saliut avait la meilleure teneur en huile, soit 42.4%.

#### Études sur le genre *Vicia*

*Imbibition au froid.* De la semence de la variété de gourgane Windsor a été soumise au froid (1°C) durant 43 h et comparée à un autre lot de semence imbibée, dans les mêmes conditions, dans une solution contenant 0%, 0.5%, 1%, 1.5% et 2% de sucre. Après imbibition, l'augmentation du poids des grains a été en moyenne de 74.7%, comparativement à 3.2% pour le témoin soumis au froid seulement. Le meilleur

rendement (3475 kg/ha) a été obtenu du témoin, alors que les semences imbibées ont produit en moyenne 2972 kg/ha.

*Ensilage de la féverole.* La féverole Ackerperle et l'orge Conquest ensemencées, aux taux respectifs de 135 et 95 kg/ha, avec un semoir de grande culture en alternant deux rangs de l'une et l'autre espèce ont produit 14 132 kg/ha d'ensilage à 35% de matière sèche, comparativement à 6619 kg/ha obtenus d'une monoculture de féverole semée au taux de 135 kg/ha.

## FERME EXPÉRIMENTALE LA POCATIÈRE

### Les céréales

*Relation entre le BYDV et le NPK sur l'avoine.* On a étudié les effets du NPK (nitrogen, phosphorus, potassium) sur différents cultivars d'avoine infestés durant la croissance par des pucerons porteurs de BYDV pour déterminer les effets bénéfiques des fertilisants sur le BYDV. On a constaté que les effets néfastes du BYDV dépendent de la date d'infestation. Plus les infestations étaient hâtives, plus le BYDV était dévastateur.

Les apports de N et K n'ont pas apporté de correctif au BYDV. On a constaté une interaction négative entre P et le BYDV. Même les apports élevés de P n'ont pas enrayé la diminution du rendement et la qualité du grain.

*Régie.* Sur l'argile Kamouraska, le temps et le mode de préparation du sol ont influencé la distribution de la grosseur des agrégats. Ainsi, le sol labouré et hersé à l'automne avait 7% d'agrégats de plus de 8 cm, comparé à 24% pour le sol labouré à l'automne et disqué au printemps et 51% pour le sol labouré et disqué au printemps. Les types d'instruments ont aussi exercé une influence sur la grosseur des agrégats. Ainsi, la herse à dents a produit 9% d'agrégats de plus de 8 cm, la herse à disques, 29% et le rotoculteur, 41%.

La préparation complète du sol à l'automne et l'utilisation de la herse à disques ont diminué la prêle mais ont augmenté la renouée liseron.

Sur l'argile Kamouraska, les rendements d'orge ont été similaires sur le sol totalement préparé à l'automne et sur celui préparé au



printemps. Cependant, sur le loam graveleux St-André, le rendement a été plus élevé lorsque le travail du sol a été fait au printemps. Néanmoins, la préparation complète du sol à l'automne a permis de semer plus tôt au printemps. Le passage de la herse à disques suivie d'une herse à niveler sur les deux types de sol a donné les meilleurs rendements.

### Les plantes fourragères

*Régie du semis.* On a étudié l'influence de deux périodes de semis sur l'implantation de la luzerne. Mai était la première et août, la deuxième période. La date de semis la plus près de la mi-mai a produit le meilleur rendement. Avec le semis du mois d'août, la date la plus hâtive a toujours été la plus productive.

Le mil et la luzerne, ensemencés purs, en association ou en mélange, ont démontré une influence marquée de la luzerne sur le rendement des diverses associations. L'association de deux rangs de mil et deux rangs de luzerne alternés a surclassé les rendements obtenus par ordre décroissant avec les modes suivants: la luzerne semée en rangs, un rang de mil et un rang de luzerne alternés, le semis à la volée, le mélange mil-luzerne semé à la volée, le mil en rangs et le mil semé à la volée.

Le semis du brome et de la luzerne sans labour, précédé d'un désherbage au glyphosate, a produit des rendements supérieurs à ceux effectués avec labour. Le trèfle rouge, semé au mois d'août, n'a pas produit un rendement satisfaisant, malgré la destruction de la végétation déjà établie.

*Régie de coupe.* Le trèfle rouge a réagi différemment selon les périodes de coupe. Les combinaisons de coupes les plus avantageuses pour trois cultivars ont été les suivantes: coupe du premier juin et coupes subséquentes à tous les 40 jours; coupes du 15 et du 30 juin, avec intervalles de 50 jours entre les coupes et coupe du 15 juillet et tous les 40 jours par la suite. Cependant, la coupe du 30 juillet et à tous les 40 jours par la suite a été plus efficace pour le cultivar Dollard, de même qu'à tous les 30 jours, pour les cultivars Hungaropoli et Lakeland. Le rendement du cultivar Hungaropoli a été excellent et, dans la plupart des cas, supérieur à celui de Dollard et Lakeland.

### Les pommes de terre

*Contrôle de la nappe phréatique.* On a étudié les effets du contrôle de la nappe phréatique à 0,5, 0,8 et 1,2 m de la surface sur le loam argileux de l'Anse. La nappe phréatique, maintenue à 0,8 m de la surface, a produit les meilleurs rendements totaux. Des six cultivars à l'étude, Irish Cobbler et Kennebec ont donné des meilleurs rendements à 1,2 m. Les cultivars hâtifs Norland, Irish Cobbler et Keswick ont produit des rendements aussi élevés sur les témoins (nappe phréatique naturelle) que sur la nappe contrôlée. Les cultivars tardifs Katahdin et Montagne Verte ont été plus productifs avec une nappe variant entre 0,8 et 1,2 m de profondeur. La nappe phréatique naturelle du sol de l'Anse variait de 20 cm à 40 cm depuis mai-juin à septembre-octobre.

*Effets résiduels de P et K.* On a étudié les effets de l'application N, P et K seuls et en mélange sur deux types de sol: le loam argileux de l'Anse et le loam graveleux St-André. Ces deux sols étaient moyennement riches en P et K, avec une teneur en matière organique de 8% à 10% et de 4% à 5% respectivement. Comparé à N seul, une application de P et K seuls ou en mélange ont augmenté les rendements de 10% à 15%. Ainsi, une application de N ( $\text{NH}_4\text{NO}_3$ ) a donné un rendement équivalant 85% à 90% de celui obtenu avec l'engrais complet NPK. Un dosage de 88 kg/ha de N a produit un rendement total optimal.

*Dates de semis.* A cause de son contenu élevé en eau et de sa teneur en matière organique, le loam argileux de l'Anse présente des problèmes spéciaux de production pour la pomme de terre. Ainsi, un semis hâtif ne présente aucun avantage sur ce type de sol. Les rendements totaux ont été plus élevés avec un semis hâtif (fin de mai).

*Les défanants.* L'emploi d'un adjuvant (*control*) avec les défanants tels que le diquat et le dinoseb a augmenté leur efficacité. Le dinoseb, en particulier, a été quasi inefficace sans huile. Le diquat a produit 87% de dessiccation des fanes avec l'huile et seulement 76% sans huile. L'huile appliquée dix jours avant le défanant a donné des résultats légèrement supérieurs à l'huile appliquée en mélange avec le défanant.

On a constaté que les cultivars réagissent différemment à l'action des défanants.

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## INTRODUCTION

La Station de recherches de Saint-Jean se spécialise dans les domaines des productions fruitières et légumières. Ses efforts visent présentement à résoudre les problèmes économiques inhérents à la production de la pomme et, d'autre part, à augmenter la rentabilité des cultures maraîchères en sols organiques tout en prévenant, le plus possible, l'affaissement de ces sols.

Ce rapport contient des résultats sommaires de nos recherches. On peut cependant obtenir des exemplaires des publications mentionnées à la fin de ce rapport ainsi que des renseignements supplémentaires directement de la part des chercheurs en adressant sa demande à: Station de recherches, Agriculture Canada, Casier postal 457, Saint-Jean, Québec J3B 6Z8.

J. J. Jasmin

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## POMME

### Régie des pommeraies

*Boutures de racines.* On a expérimenté avec succès la multiplication des porte-greffes *Malus robusta* 5, O-3, M.7, M.9 et M.26 par boutures des racines dans un milieu de croissance composé en parties égales de perlite et de vermiculite. Plantés en couches froides au début de mai, les plants ont repris à un taux à peu près aussi élevé qu'en serre, soit plus de 80%.

### Génétique

*Évaluation de cultivars.* Les lignées à lambourdes entrent en production plus rapidement que les McIntosh standards. Parmi les lignées McIntosh à lambourdes, Morspur et MacSpur viennent en tête au point de vue de la précocité suivies successivement par Dewarspur, Starkspur, et Lussierspur.

*Évaluation de porte-greffes.* Dans des essais préliminaires, le porte-greffe O-3 s'est avéré plus précoce que M.26 lorsque greffé avec les cultivars MacSpur, Redspur et Summerred. Le rendement des arbres sur O-3 a été supérieur à celui de ces mêmes arbres sur M.26.

### Entomologie

*Lutte intégrée.* Après accumulation de données saisonnières, il a été possible d'établir des corrélations entre le piégeage à l'aide de phéromones sexuelles de synthèse et les dommages causés par les cinq lépidoptères suivants: la pyrale de la pomme, *Laspeyresia pomonella* (L.); la petite pyrale de la pomme, *Grapholitha prunivora* (Walsh); la tordeuse

du pommier, *Archips argyrospilus* (Wlk.); la tordeuse à bandes rouges, *Argyrotaenia velutinana* Wlk.) et la tordeuse à bandes obliques, *Choristoneura rosaceana* (Harr.).

*La punaise terne.* Les conditions de chaleur et de sécheresse en mai 1975 semblent avoir favorisé les infestations de la punaise terne, *Lygus lineolaris* (P. de B.), sur les bourgeons à fruits des pommiers, tout particulièrement chez les cultivars à lambourdes où près de 30% des fleurs ont avorté. Les insecticides chlorpyrifos, méthidathion et oxamyl, appliqués après la chute des pétales et de nouveau au premier traitement de couverture, se sont montrés aussi efficaces que le DDT contre cet insecte.

*Vers du fruit vert.* Le complexe des vers du fruit vert dans les pommeraies du Québec comprend au moins deux espèces, *Orthosia hibisci* Gn. et *Amphipyra pyramidoides* Gn. En 1975, l'espèce *O. hibisci* comptait pour plus de 90% de tous les spécimens collectionnés car, en même temps que ces ravageurs, on trouvait des arpeuteuses du tilleul, *Eranis tiliaria* (Harr.), des larves brunâtres du groupe *Eupsilia tristigmata* Grt. et des larves de la spongieuse, *Porthetria dispar* (L.). Dans certains vergers de Hemmingford, cette dernière espèce était prédominante.

### Phytopathologie

*Tavelure du pommier.* Ces dernières années, différentes méthodes ont été mises à l'essai pour la répression de la tavelure du pommier, *Venturia inaequalis* (Cke.). On a pu ainsi évaluer les avantages et les désavantages de chacune de ces méthodes et la moins

coûteuse demeure l'emploi de variétés résistantes à la maladie. Sous ce rapport, nous avons évalué 400 semis résistants qui fructifiaient pour la première fois cette année. L'emploi, en début de saison, du captafol en une seule dose massive s'est avéré aussi efficace que la dodine en doses régulières. Les fongicides systémiques bénomyle et méthylthiophanate ainsi que les préparations comprenant bénomyle et captane ou bénomyle et mancozèbe ont assuré une bonne protection des arbres.

## FRAISE

### Génétique

*Évaluation de cultivars.* A la suite de plusieurs années d'expérimentation, nous suggérons le remplacement du cultivar hâtif Earlidawn par Veestar et du cultivar tardif Redcoat par Bounty. Redcoat représente 80% des fraisiers présentement cultivés au Québec mais nos travaux ont démontré des augmentations de rendements de plus de 10% avec Veestar et de plus de 35% avec Bounty. Dans les deux cas, la qualité des fruits a été supérieure à celle des témoins Earlidawn et Redcoat.

### Entomologie

*Écologie.* L'étude de la faune des fraisières s'est poursuivie au cours de 1975. Le ver fil de fer *Agriotes mancus* (Say) a infesté environ 10% des plants d'une nouvelle fraisière établie sur un retour de prairie mal préparé. Cette espèce s'ajoute donc à la liste des ravageurs susceptibles de causer des pertes réelles à la culture des fraises au Québec.

*Répression.* Les produits Pencap E (Ciba-Geigy Canada Ltd.), carbofuran, DDT, chlorpyrifos, azinphos-méthyl, tétrachlorvinphos et malathion, appliqués avant et au début de la floraison des fraisiers Redcoat, se sont avérés très efficaces en même temps contre l'anthronome, *Anthonomus signatus* (Say), et la punaise terne, *Lygus lineolaris* (P. de B.). Le taux de répression contre ces deux ravageurs a été au moins de 93%.

### Phytopathologie

*Blanc du fraisier.* A la fin d'une série d'essais de fongicides visant à la répression du blanc du fraisier, *Sphaerotheca humuli* (DC.) Burr., on a établi qu'il n'était pas

économique d'effectuer des traitements spécifiques contre cette maladie. Même chez les cultivars les plus sensibles comme Earlidawn, les traitements n'ont pas augmenté de façon significative les rendements.

## FRAMBOISE

### Entomologie

*Écologie.* L'étude de la faune entomologique a démontré que le taux de mortalité hivernale chez l'anneleur *Oberea bimaculata* (Oliv.) était de 50% au cours de la première année de son cycle évolutif de 2 ans. Les plus importants dégâts observés dans les framboisières sont sans contredit occasionnés par la punaise terne, *Lygus lineolaris* (P. de B.), dont les piqûres sur les fruits provoquent l'affaissement et la décoloration des drupéoles; jusqu'à 30% des framboises ont été avariées de cette façon en 1975.

### Phytopathologie

*Blanc du framboisier.* Des essais de répression du blanc du framboisier ont démontré qu'il n'était pas avantageux d'appliquer des traitements spécifiques contre cette maladie. Les mildioucides n'ont pas contribué à augmenter les rendements d'une façon significative même chez les cultivars aussi sensibles que Carnival.

## BLEUET EN CORYMBE

### Régie et évaluation de cultivars

*Établissement des plantations.* Depuis 1972, on a établi plusieurs plantations de bleuets en corymbe à différents endroits dans le sud-ouest du Québec pour sélectionner les cultivars les plus prometteurs et pour mettre au point des systèmes de paillis et des programmes d'irrigation et de nutrition. Jusqu'à présent, le cultivar Blueray donne les meilleurs rendements mais la croissance des plants accuse d'importantes variations ce qui semble indiquer que les conditions du sud-ouest du Québec seraient marginales pour cette culture.



## MAÏS

### Génétique

*Sélection.* Sous des conditions d'infestation naturelle et artificielle de la pyrale du maïs, *Ostrinia nubilalis* (Hbn.), 14 lignées se sont montrées très résistantes à cet insecte. Le matériel provenait en grande partie des stations de recherches de Harrow et d'Ottawa. Sous des conditions d'infestation artificielle, quatre cultivars se sont montrés résistants au pathogène *Fusarium roseum* Lk. Ce matériel résistant est également hâtif et possède un bon potentiel de production.

*Résistance à la pyrale.* La production de variétés synthétiques se poursuit en été à L'Acadie et en hiver en Floride, dans le but de hâter les cycles et de procéder à la sélection récurrente. Les méthodes de croisement au hasard sont également employées dans le but de briser les linkages non désirables avant de commencer les sélections récurrentes.

### Entomologie

*Production de masses d'oeufs.* A la suite d'élevages de la pyrale du maïs sur diète synthétique, nous avons obtenu 85 000 masses d'oeufs qui ont permis d'infester artificiellement nos parcelles et qui ont également servi à d'autres projets de recherches en cours, notamment, à la Station de Harrow et à l'Université de Guelph.

*Répression.* Dans la lutte contre les larves de la pyrale, les insecticides granulaires appliqués dans le cornet de la plante semblent avoir une meilleure rémanence et assurer une meilleure protection que ces mêmes produits employés en pulvérisation. Chlorpyrifos est en tête des insecticides contre cet insecte, aussi bien sur le maïs frais que sur le maïs de transformation.

## CHOU

### Génétique

*Croisements interspécifiques.* Dans le but d'obtenir un taux élevé de résistance aux différentes races de la hernie du chou, *Plasmodiophora brassicae* Wor., on a procédé à des croisements interspécifiques entre le chou, *Brassica oleracea* L., et la navette, *Brassica napus* L. On a dû à cette fin créer chez le chou, à l'aide de la colchicine, des diploïdes et des autotétraploïdes. Nous avons

obtenu de ces croisements des plantes à 28 chromosomes (génome ACC) et d'autres à 37 chromosomes (génome ACCC). Par autofécondation, la production de  $F_2$  a été facile chez les plants à 37 chromosomes mais impossible chez ceux à 28 chromosomes qui ont alors été recroisés avec le chou.

*Étude génétique.* La résistance à la race 6 de la hernie, présente dans Badger Shipper et dans 8-41, est produite par des gènes additifs, donc le degré de résistance peut être accumulé même si la sensibilité à la maladie est partiellement dominante.

## CAROTTE

### Fertilité des sols

*Réaction aux fumures.* Des applications de N, P et K à différents taux et sur cinq sites différents ont révélé que les sols qui ont reçu précédemment les fumures recommandées pour des productions commerciales de carottes peuvent produire une récolte maximale sans aucun apport subséquent. Les sols vierges ou qui n'avaient pas reçu de fumures adéquates dans le passé ont produit une récolte maximale après certaines applications moyennes de P et de K mais en aucun cas en 1975 l'apport de N n'a augmenté les rendements.

### Mini-carottes

*Variétés.* Les cultivars les plus intéressants, en sols organiques, sont Foram, Mini Cor, Little Finger, Baby Finger et Amca. Les cultivars qui s'étaient avérés intéressants les années passées ont réagi différemment aux conditions climatiques très chaudes et sèches de 1975 en produisant, en général, des racines beaucoup trop longues. Ce même phénomène a été commun chez les producteurs de carottes et de mini-carottes en sols organiques.

En sol sablonneux et en loam sableux, Little Finger se classe en tête des rendements tandis que Mini Cor et Douce Amsterdam se classent au deuxième rang et Amsterdam ABK, au dernier rang. Les rendements sont également très élevés à condition d'avoir une forte densité de plants à l'hectare.

*Mécanisation de l'arrachage.* Des essais conduits avec la récolteuse Scott Viner (FMC) et la récolteuse S.A.M. de Hollande (avec et sans modifications) ont démontré la nécessité d'intensifier la recherche en ce

domaine car ces machines ne permettent pas présentement de récolter économiquement les mini-carottes. Un rendement approchant 35 t/ha de produit vendable est nécessaire pour rentabiliser cette culture en vue de la transformation. La densité de nos semis permet d'atteindre ces rendements mais il faudrait être réellement en mesure d'en mécaniser l'arrachage.

## Protection

*Malherbologie.* Le linuron, herbicide très efficace et employé couramment par les maraîchers, a un effet de rémanence assez prononcé et des analyses de sol, effectuées un an après des applications normales de ce produit, ont indiqué des concentrations de 20% à 28% des résidus détectables immédiatement après application.

Des études de métabolisme du métobromuron et du chlorbromuron en utilisant le  $^{14}\text{C}$  comme indicateur radioactif ont démontré que l'ordre de tolérance au chlorbromuron était coriandre > carotte > tomate > moutarde et que la quantité d'herbicide retrouvée dans le feuillage après une absorption par les racines était dans le même ordre que la tolérance. La tomate métabolise 28% du chlorbromuron dans les feuilles, la carotte 25%, la moutarde 18% et la coriandre 17%. Le métobromuron a un ordre de tolérance semblable mais son métabolisme dans la plante est bien différent, ayant un taux de 11% chez la coriandre et 58% chez la tomate.

L'humidité à la surface des sols organiques a un effet marqué sur l'activité du linuron appliqué en pré-émergence. Au fur et à mesure que l'humidité décroît de 200% (humide) à 50% (sec), l'efficacité du linuron vis-à-vis des mauvaises herbes décroît de 50%. La grosseur des particules de terre noire a également un effet sur l'activité toxique de cet herbicide.

*Entomologie.* Les essais de répression effectués contre le charançon de la carotte, *Listronotus oregonensis* (Lec.), dans un champ infesté ont montré que le carbofuran appliqué sous forme granulaire dans le sillon lors du semis, à raison de 2 kg/ha, a assuré une bonne protection contre l'insecte. Le taux d'infestation dans les parcelles témoins a été de 89%.

*Phytopathologie.* La rémanence des nématocides en sols organiques semble très faible. Le D-D (Shell Canada Ltd.), la chloropicrine

et le Vorlex (Morton Chemical Co.), appliqués en 1974 contre *Meloidogyne hapla* (Chitwood), avaient alors donné de bons résultats. Dans ces mêmes parcelles ensemencées en carottes en 1975, on a constaté sauf dans celles traitées au D-D en 1974, une réinfestation de nématodes puisque le taux de nodosité atteignait 80% et que la qualité de la récolte a été sévèrement compromise.

## OIGNONS

### Génétique

*Variétés.* Le cultivar étalon Autumn Spice sera maintenant remplacé dans nos parcelles par Canada Maple qui chaque année donne de très bons rendements et dont les qualités d'entreposage sont difficilement surpassables. Northern Oak, Super Elite, Bronze Age, Spartan Banner, Harvestmore, Gladiator, Trapp No 6, G. Lake et Ontario L. sont aussi de bonnes variétés à forte production.

### Physiologie

*Germination et survie des plantules.* L'imbibition des semences d'oignon dans l'eau à 2°C durant 2 semaines est aussi efficace que l'imbibition dans l'eau chaude ou dans une solution de carbowax (polysaccharide) causant une osmose renversée. Ces méthodes permettent à la graine d'oignon de germer à 80% en 2 jours à 10°C alors que celles non soumises à l'imbibition prennent de 8 à 10 jours. Canada Maple et Northern Oak fournissent un plus fort pourcentage de plantules que Autumn Spice lorsqu'ils sont soumis à ces traitements avant d'être semés en plein champ. Cette technique semble augmenter les rendements et permettre une germination plus uniforme.

## GESTION DES SOLS ORGANIQUES

### Affaissement des sols organiques

*Oxydation biologique.* Tel qu'observé durant l'été 1975, le taux de décomposition des sols organiques varie suivant le site, le degré d'humidité, la température du sol et certains autres facteurs. Des mesures du bioxyde de carbone libéré par ces sols durant la saison indiquent des taux de 600 à 750 kg de C/ha en forêt contre des taux de 450 à 700 kg de C/ha en pleins champs. Plus la densité



apparente est basse, plus le taux de décomposition, mesuré en perte de C, est élevé.

*Facteurs hydrologiques.* La sécheresse et la température chaude de 1975 ont fait descendre le plan d'eau à plus de 130 cm dans certains cas. Des mesures d'humidité à différents paliers serviront de points de comparaison avec les relevés des années subséquentes. Nous avons démontré cette année que le taux de germination de la carotte est réduit si le plan d'eau est maintenu à plus de 30 cm. De plus les rendements d'oignons sont diminués si les plants sont inondés avant d'avoir atteint leur troisième

feuille. Il est important que ces sols aient un potentiel de drainage de plus de 5 cm/24 heures afin de pouvoir éviter les inondations locales au printemps.

*Influence des façons culturales.* Différentes façons culturales font présentement l'objet d'études pour évaluer leur action sur l'affaissement de ces sols. Il faudra plusieurs années avant de pouvoir mesurer le taux d'affaissement selon les différents traitements mais il est intéressant de signaler que les meilleurs rendements de carottes ont été obtenus là où le sol a été labouré à l'automne et disqué au printemps, alors que les producteurs préfèrent un labour de printemps.

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# Research Station Delhi, Ontario

## PROFESSIONAL STAFF

L. S. VICKERY, B.S.A., M.S., F.A.I.C. Director

### Tobacco

H. H. CHENG, B.Sc., M.Sc., Ph.D.	Entomology
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F. H. WHITE, B.Sc., M.Sc.	Genetics and plant breeding
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### Departure

L. S. VICKERY, B.S.A., M.S., F.A.I.C. Director  
Retired December 1975

## EXTENSION SERVICES<sup>1</sup>

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

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<sup>1</sup> Provided by Ontario Ministry of Agriculture and Food.

## INTRODUCTION

Programs at this Research Station concern flue-cured tobacco production, with emphasis on the improvement of quality from the standpoint of health. Research on nutrition, on control of insects, diseases, and nematodes, and on crop management have resulted in improved practices for the crop. Cultivars with complete resistance to black root rot have been produced in the plant breeding program, and a new haploidy program is under way. Health-oriented research, performed in cooperation with the Canada Department of Health and Welfare and various universities, was enhanced by construction of new laboratory facilities in 1975.

At the end of 1975 Mr. L. S. Vickery retired after 39 years of service, the last 26 years as Officer-in-charge and Director. During that time he made many valuable contributions to the tobacco industry in Canada and other countries.

This report summarizes the most important research results from the Research Station in 1975. Further information may be obtained by directing enquiries to individual scientists at the following address: Research Station, Research Branch, Agriculture Canada, Delhi, Ont. N4B 2W9.

E. K. Walker  
Director

## SOIL SCIENCE

### Soil pH

Soil samples were taken weekly for 3 yr from loamy sands at four locations in southern Ontario. From the end of May until the middle of August, the pH level dropped by 0.4–1.0 unit in soil within the tobacco rows, then by mid-October it increased to about 5.6, almost the same level as in the spring. The pH level decreased only in 1 yr in samples taken between rows of tobacco and under the rye grown in the 2-yr rotation.

### Nematocides

Application of the fumigant nematocides Telone, Telone C, Vorlex, and chloropicrin increased the levels of N ( $\text{NH}_4^+ + \text{NO}_3^-$ ) in unfertilized soil. This effect of Telone C and chloropicrin on mineralization lasted for 30 days but that of Telone and Vorlex for only 23 days after application. The nonfumigant nematocides oxamyl and triazophos had no effect on levels of N as  $\text{NH}_4^+$  and  $\text{NO}_3^-$ .

## PLANT SCIENCE

### Height of Topping

Yields of tobacco increased progressively as plants were topped to a height of 12, 15, or 18 leaves. Untopped tobacco yielded more

than tobacco topped to 12 leaves. An increase in topping height resulted in a lower level of total alkaloids in leaves and cigarette smoke; untopped tobacco was lower in total alkaloids than any topped tobacco. In plants topped at the low height, lamina weight tended to increase and reducing sugars to decrease. Total particulate matter (TPM) content of cigarette smoke was unaffected by the height of topping but was lowest in untopped tobacco.

### Ripening Agents

Applications of ethephon had variable effects on maturation of leaves depending on the rate of application, leaf maturity, and ambient temperature. The product had little effect when ambient temperatures were low or when leaves were immature. The effect increased as the application rate increased at temperatures above 20°C, if leaves were mature or overmature.

Tobacco leaves matured earlier when sprayed with dicamba at rates of 0.14 to 0.56 kg ai/ha. Sprays contained Tween 20 and were applied immediately after topping. The response of leaves was more gradual to dicamba than to ethephon, but more complete, in that all leaves were affected. The results indicated that other times and rates of application might be more effective.



## Culture for Whole-plant Harvest

Cultivars grown in dense populations (60 800 plants/ha) revealed wide differences in alkaloid levels, yield, susceptibility to leaf drop of bottom leaves on maturation, and maturity. Compared with high-alkaloid selections, the standard varieties Delhi 34 and Virginia 115 were high in yield and low in total alkaloid levels. The standard varieties were similar in yield and alkaloid level to  $F_1$  hybrids from yellow-mutant parentage. The  $F_1$  hybrids showed less susceptibility to leaf drop, a more yellow habit of growth, more uniform maturity of the various stalk positions, and earlier maturity than other cultivars.

## Harvesting and Curing of Whole Plants

Development of a system for harvesting, curing, and handling whole plants continued in cooperation with the Engineering Research Service. Various mounted and tractor-drawn forage harvesters, alternative transport systems, collection and curing facilities, and techniques for cured leaves were compared.

## PLANT PHYSIOLOGY

### DDT

Under controlled conditions, DDT uptake by tobacco decreased as the proportion of soil was increased in a sand-soil mixture. This was attributed to the higher content of organic matter in the growth medium from the added soil. The positive correlation of DDT and organic matter in soil fractions was highly significant.

A survey of DDT on 32 farms in Ontario showed a continued decline between 1971 and 1974. In 1971, the average DDT content of flue-cured tobacco lamina was 1.24 ppm. By 1974, this value had decreased to 0.60 ppm. Foreign markets required DDT levels in tobacco to be less than 0.1 ppm; however, by 1975 the acceptable level of DDT in export tobacco was increased by 7.5 ppm.

### Vertical Temperature Gradients in the Tobacco Greenhouse

Initial growth of tobacco seedlings occurs within a very small vertical zone, between 2.5 cm above and 2.5 cm below the soil surface. Unheated greenhouses depend entirely upon solar radiation for adequate heating. A black

soil surface (muck) that receives solar energy can have fairly high surface temperatures. In preliminary observations, surface soil temperatures up to 40°C were common. Although the air temperature occasionally decreased to near freezing during the night, in the critical zone it was moderated by heat lost from the soil, and average temperatures remained between 10° and 35°C. Air temperatures at 15 cm above the surface averaged between 5° and 25°C.

## Smoke Quality of Cured Whole-plant Tobacco

Cigarettes made from close-planted, chopped whole-plant (CP) tobacco in the ground form delivered considerably lower mainstream nicotine levels as the plant population increased. Mainstream tar levels were unaffected by the density of the plant population. The tar-to-nicotine (T:N) ratio in smoke decreased as the crop fertilizer level increased, and was lower from plants topped at 12 rather than 18 leaves when grown at the high fertility level. Three tobacco sheets were made from combinations of CP tobacco stalk, stem, and lamina (97 157 plants/ha) as well as from conventional tobacco midrib and lamina fines, by a specially devised cast-sheeting process. Mainstream TPM and nicotine levels were lower from blended cigarettes made with tobacco sheet with the highest content of CP tobacco than from those made with the two other tobacco sheets. Short-term biological testing, involving sebaceous gland suppression and epidermal hyperplasia in mice, suggested that the smoke condensate from tobacco sheet was less biologically active than the standard commercial tobacco blend and the Kentucky 1R1 reference cigarette.

## GENETICS AND PLANT BREEDING

### Evaluation of New Varieties

New varieties from several countries have been evaluated to determine their usefulness for tobacco production in Ontario. Two varieties, Speight G41 and Coker 347, were above average in yield and most agronomic characteristics, although both flowered 5 to 7 days later than Delhi 34. Speight G41 also tended to produce cherry-red tobacco. The introductions Coker 354, N.C. 88, Speight

G140, and Va. 770 were undesirable with respect to yield, quality, and tolerance for black root rot.

### Total Alkaloid Relationships in Tobacco Varieties

Multivariety tests were conducted for 3 yr to evaluate agronomic, chemical, and physical characteristics. Simple correlation analyses showed that the level of total alkaloids in the leaf lamina was positively associated with the following characteristics: grade index; lamina weight; ratings for color, body, and texture; quality index; and buyers' rating. Correlations involving grade index, lamina weight, quality index, and buyers' rating were usually highly significant. However, the percentage of total alkaloids was negatively correlated with filling value, days to flowering, leaf number, and percentage of reducing sugars. Occasionally, among the nine tests conducted, correlations were opposite to the above, although they were usually not significant. This was particularly the case for data on yield and days to flowering.

### Induced Mutations and Selections

Mutations were induced in Delhi 34 and Strain 205 by treatment of seeds with ethyl methane sulfonate and irradiation with gamma rays. Nine mutant homozygous lines from Delhi 34 and three from Strain 205 were evaluated at the M<sub>7</sub> generation for agronomic, physical, and chemical characteristics. Three mutant lines from Delhi 34, that is, M15, M26, and M91, were found to possess potential for eventual release as varieties. Levels of alkaloid were increased from 2.7 to 4.8% and from 0.88 to 1.7% in Delhi 34 and Strain 205, respectively. Selection against ground suckers in Delhi 34 was partly successful because the character is controlled polygenically.

## PLANT PATHOLOGY

### Black Root Rot

The chlorogenic acid content of tobacco leaves of cultivars grown in soil infested with *Thielaviopsis basicola* (Berk. & Br.) Ferr. was higher than in leaves of the same cultivars grown in disease-free soil. Increases were 260% in White Mammoth, 340% in Hicks Broadleaf, and 150% in Delhi 34.

When soil was fumigated with chloropicrin at 11.23, 22.46, or 33.69 litres/ha or with Telone C at 89.84, 112.30, or 134.76 litres/ha, the dry weight of tobacco plants more than doubled and root lesions were reduced by 20 to 60%, depending on the fumigant rate. Application of Lignasan (hydrochloric acid salt of benomyl) at 500 and 1000 ppm or of Banrot at 1000 ppm in the planting water significantly increased tobacco vigor without reducing the number of root lesions.

### Damping-off

Treatment of tobacco seedlings in the greenhouse with benomyl at 60 g and captan at 120 g ai/100 m<sup>2</sup>, applied either separately or together, controlled both *Rhizoctonia solani* Kühn and *Pythium ultimum* Trow. The treatment had no undesirable effects.

### Pole Rot

Preharvest spraying of tobacco with 100 ppm of either quintozone or 37% formaldehyde in water to control pole rot had no adverse effect on quality of smoke and no residual effect on the cured leaf. Use of twine treated with dichloran (Oxford Yarn Ltd.) reduced the severity of pole rot by 40%. In culture, the growth of *Rhizopus arrhizus* Fischer, the main cause of pole rot of flue-cured tobacco in Ontario, was suppressed better by SN 4310 than by dichloran.

## ENTOMOLOGY

### Cutworms

Field investigations at Delhi indicated that cutworm infestations in tobacco fields were moderate in 1975. Of the cutworm larvae collected from the field each year, an average of 96% were the darksided cutworm, 2% were the striped cutworm, and 0.5% were the dingy cutworm.

In a field test, only FMC 33297 and leptophos were significantly more effective than the insecticides recommended for cutworm control in a crop of tobacco after transplanting.

### Control of Aphids, Hornworms, and Suckers

Aphid infestations were more severe in 1975 than they have been for many years in the tobacco-growing area of Ontario. Of 10 insecticides tested, only pirimicarb and



oxydemeton-methyl were superior to the insecticides recommended at present.

Each of eight insecticides tested controlled larvae of the tomato hornworm, and they were equally effective.

To reduce the cost of tobacco production, the effects of combinations of insecticides and

sucker control agents for control of aphids, hornworms, and suckers on tobacco were examined. Data indicated that these chemicals are compatible without losing their efficacy, and they were not toxic to the tobacco plants.

## MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Banrot	Mallinchrodt Chemical Works
FMC 33297	FMC of Canada Ltd.
Lignasan	DuPont of Canada Ltd.
SN 43410	Nor-Am Agricultural Products Ltd.
Telone	Dow Chemical of Canada Ltd.
Telone C	Dow Chemical of Canada Ltd.
Tween 20	ICI United States Inc.
Vorlex	Nor-Am Agricultural Products Ltd.

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# Research Station Harrow, Ontario

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 Retired December 30, 1975  
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 Summerland, B.C., April 3, 1975  
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## INTRODUCTION

The Research Station at Harrow is located in southwestern Ontario, where favorable climatic conditions support an intensive and diversified agricultural industry. Our research programs are designed to improve yield, quality, and efficiency of crop production for the economic, environmental, and social requirements of the population. Crops under study include field and greenhouse vegetables, tree fruits, corn, soybeans, white beans, and winter wheat. Crop improvement is achieved in various ways including breeding new varieties with superior characteristics; improving insect, disease, and weed control practices; and improving soil and crop management practices.

This report summarizes the more significant research activities in 1975. Requests for further information or reprints of publications should be addressed to: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

J. M. Fulton  
Director

### FIELD CROPS

#### Cereal Viruses

Wheat spindle streak mosaic virus affected an average of 38% of plants in Essex, Kent, and Lambton counties. Two hundred disease-free plants were selected from F<sub>2</sub> plants derived from crosses between a resistant variety and several susceptible commercial varieties. Twenty-five wheat-rye hybrid lines were selected for resistance to the disease.

#### Corn

*Breeding.* Production rights to a Harrow corn hybrid involving Harrow inbreds was granted to a commercial company for marketing under the name Hyland HL2520. This hybrid yields 5% higher than comparable control hybrids do, has superior standability, and is suitable for growing in the 3100 heat-unit area.

*Depth of plowing.* Plowing 10 or 20 cm deep produced a higher yield of corn than plowing 30 cm deep on Brookston clay soil during 1968–74. In practice, there is a mechanical limitation to plowing at 10 cm. However, the yields obtained indicated that the current practice of plowing 10–15 cm deep is satisfactory. Fall plowing on this soil produced consistently higher yields of corn than spring plowing.

*Insects.* Oviposition by a bivoltine strain of the European corn borer on field corn was light in 1974. Control of either one brood or both broods did not significantly increase the yield. This differed from 1973, when control

of both broods or just the second brood increased the yield significantly, and in some instances highly significantly.

Populations of the northern corn rootworm were greater in 1975 than in the preceding 2 yr, and damage was more severe. The yield of the corn hybrid Pioneer 3909 was reduced 28% by a larval density of 13.4/plant. Adults of the western corn rootworm were found in Essex, Kent, and Lambton counties.

*Leaf spot.* Data on the inheritance of a leaf spot, characterized by the sudden appearance of numerous water-soaked lesions, which rapidly become necrotic, indicate that this condition is controlled by a dominant gene. One or more modifying genes also appear to be involved.

*Nitrogen.* Downward movement of NO<sub>3</sub>-N in sandy soil, which was unexpectedly slow in 1973, was demonstrated to depend largely on the amount of rainfall. Any holdback caused by biological activity was negligible and was not considered to be a factor in the lag. Continued use of N fertilizer at 336 kg/ha reduced the pH of the soil in 5 yr from 6.4 to 4.6, seriously upsetting corn growth.

*Potassium.* Rapid experimental depletion of soil K from 1971 to 1974 by corn harvested for fodder has shown that the current fertilizer recommendations for this crop in Ontario are too low. On coarse textured soils more K is being removed by the crop than is provided by the fertilizer, and the result is rapid depletion of K in the soil.



*Root and stalk rot.* The rates of growth of the ear shoot and ear of five hybrids were related to the order of their susceptibility to stalk rot; this is considered to reflect differences in plant growth pattern that could reinforce a breeder's estimate of the behavior of cultivars toward stalk rot fungi.

*Weed control.* Excellent control of velvetleaf in corn has been obtained with dicamba, applied either before or after emergence. The weedy grass fall panicum was previously thought to germinate late in the spring; however, in the Weed Identification Garden it germinated at the same time as other weedy grass species.

## Soybeans

*Breeding.* Harcor, a new cultivar developed at the Station, was licensed and released to seed growers in 1975. In 11 tests in southwestern Ontario during 1972-75, Harcor matured 3 days later than Harosoy 63, but produced a 15% higher yield.

*Pathology.* Surveys indicate that race 6 is now the prevalent pathotype of *Phytophthora megasperma* Drechsl. var. *sojae* Hildebrand in Ontario. In 1974 and 1975, in a field at the Woodslee Substation infested with race 6, cultivars were shown to differ widely in their field tolerance for the fungus. Harosoy 63 had a 56% stand loss compared with only 17% for Harcor.

*Physiology.* In a field experiment where light levels were varied by means of reflectors and shades, the yield of soybeans responded to light level. In another test on various experimental lines, leaf photosynthetic rates were correlated with bean yields. Yield seems responsive to alterations in photosynthetic rate, and therefore high rates of photosynthesis are an important factor in the development of new cultivars.

*Potassium fertilization.* Estimates of the threshold level of soil K required to sustain soybean yields have been obtained. On coarse textured soil the currently accepted levels appear to be minimal for optimum soybean growth. On soil having a medium level of K, yields were increased 28% by the addition of K.

*Tile drainage.* Soybean yield in 1975 responded to close spacing between tile drains, in a manner similar to the effect of spacing on corn in previous years. The three

closest spacings of 6.1, 9.1, and 12.2 m between laterals resulted in soybean yields of 3844, 3648, and 3011 kg/ha. The two widest spacings of 21.3 and 24.4 m between the drains produced yields of only 2809 and 2883 kg/ha.

*Weed control.* Effective control of Canada thistle with applications of glyphosate before planting in spring depends on the early and uniform emergence of independent shoots. Management practices that promote this type of development should be used in conjunction with applications of glyphosate early enough to permit soybean planting at the proper date.

Substantial injury to soybeans was produced by dicamba applied at 0.56 g/ha. This confirms the observation that it is essential to prevent dicamba drift from adjacent cornfields.

The herbicide metribuzin effectively degrades within 4 mo of application to Brookston clay loam. Therefore winter wheat, which is sensitive to metribuzin injury, may be safely planted in the fall following soybeans.

## Breeding of White Beans

In 16 tests over 4 yr, two advanced selections of white beans produced yields 26-35% higher than those of Sanilac. They mature 9-15 days later than Sanilac does and are adapted to the higher heat-unit areas of southwestern Ontario. These selections are resistant to strains 1 and 15 of bean common mosaic and to the alpha, beta, and gamma races of anthracnose, *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. When cooking-quality evaluations by processors in Canada and the U.K. have been completed, one or both of these high-yielding selections will be considered for release to producers in Canada.

## HORTICULTURAL CROPS

### Field Vegetables

#### Control of Insects on Asparagus

Adults of the asparagus beetle were susceptible to many contact insecticides. Current recommendations are valid and allow for differences in toxicity, but the cost of insecticides for one spraying ranges from \$3.70 to \$14.80/ha.

## Growth and Development of Baby Carrots

Only those varieties of baby carrots with an optimal radial-to-longitudinal rate of growth produced carrots of maximum individual weight and the highest yield at harvest. An example of such a variety is Amsterdam Minicor.

## Control of Weeds in Broccoli, Brussels Sprouts, and Cauliflower

Activated charcoal, spread in a 5-cm band at 400 kg/ha over the seed row, prevented injury by metribuzin applied at 0.56 kg/ha to these crops for weed control.

## Control of Cabbage Insects by Pathogens

Laboratory tests showed that the microsporidian *Nosema necatrix* Kramer readily infects larvae of the cabbage looper, usually killing any that have ingested 25 or more spores. The microsporidian was almost as effective as the nuclear polyhedrosis virus in controlling the looper on late cabbage in a field plot test.

## Sweet Corn

*Oviposition of the European corn borer.* Laboratory work showed that 72% of female corn borers laid eggs the night after mating, 19% the next night, and the rest within 1 wk. After they had been confined to prevent mating, the females that mated when exposed to males began to decline in numbers after 5 days and only 40% mated after 7 days; those that mated produced fewer fertile eggs than usual. This shows that unseasonal cold or windy weather, which prevents flights, would have to be very prolonged to have a marked effect on field egg laying. The yellow band that forms at the base of the ovarioles after egg laying formed in 37% of the females in 1 day, but took more than 6 days to form in 15% of the females. It thus indicates only the minimum number of females that have laid eggs in a field sample.

*Insect control by pathogens.* Preliminary studies on microsporidian parasites of the corn borer showed that about half of the larvae infected with the pathogen died and infection influenced the development and vigor of the survivors. Infection by microsporidia (probably *Nosema* spp.) was prevalent in a laboratory culture of the corn borer, and infected adults were collected in a light trap.

When spores of a microsporidian were applied to field plots, up to 66% of corn borer larvae became infected.

## Cucumbers

*Aphid control.* Melon aphids on pickling cucumbers were effectively controlled by pirimicarb, malathion, or endosulfan sprays applied at weekly intervals. Carbofuran, Counter (Cyanamid of Canada), and Dacamox (Diamond Shamrock) applied as granules at planting time were systemic insecticides that gave season-long control of aphids.

*Weed control.* Chloramben alone, or in combination with bensulide or naptalam, gave excellent weed control. Combinations of dinitramine with naptalam or dinoseb with naptalam gave almost equally effective control.

## Control of Pepper Insects

Five treatments were compared for control of pepper insects, mainly the European corn borer. Outstanding control was provided by carbofuran granules side-dressed 3 wk before the flight of the second-generation moths.

## Control of Potato Insects

The efficacy of insecticide-silica mixtures depended on the brand of silica, the number and population density of pest species, and the cultivar of potato. Mixtures were applied as water emulsions; those containing either phosmet or pirimiphos-methyl and silica, with 30 ppm of insecticide and 270 ppm of silica, were as effective as 100 ppm of insecticide. A mixture of 600 ppm carbaryl and 5400 ppm Arogen 500 (J. M. Huber Corp.) reduced larval populations of the Colorado potato beetle by 66% and increased the yield of Irish Cobbler 18-fold at high beetle and low aphid densities. At low beetle and high aphid densities, 1000 ppm of carbaryl and various mixtures of carbaryl and Arogen 500 increased aphids twofold, reduced coccinellid predators by one-third, and reduced yield of Irish Cobbler and Sebago cultivars by 12%. At medium beetle and low aphid densities, a mixture of 500 ppm pirimiphos-methyl and 4500 ppm Zeolex 100 (J. M. Huber Corp.) increased the yield of Irish Cobbler twofold and of Sebago threefold.



## Tomatoes

*Depth of plowing.* During 1968–74, no method of plowing was better on the average for tomato yield on clay soil than the conventional one of plowing 20 cm deep in the fall. Plowing more than 20 cm deep was more suitable for tomatoes only in seasons with optimum precipitation, and was less satisfactory over the period of investigation. Fall plowing was also better than spring plowing for tomato yields, which averaged 5.97 t/ha higher for the 7-yr period. In addition, fall plowing was essential for adequate survival of transplants.

*Early blight.* On arrival in Canada from Georgia, transplants of processing cultivars were shown to be heavily infested with latent early blight (*Alternaria solani* Sorauer) and other fungi. Advancing the standard fungicide control schedules to control these infections and applying fungicides as the weather dictated to control incipient secondary infections proved superior to standard calendar programs.

*Fusarium foot and root rot.* The fungus *Fusarium oxysporum* Schlecht. is distinct from *F. oxysporum* f. sp. *lycopersici* (Sacc.) Snyder & Hansen in host range and symptoms. Of 7 *Lycopersicon* spp. and 89 greenhouse and field cultivars, only four species showed resistance to *F. oxysporum* f. sp. *lycopersici* in screening tests; all material of the species *L. esculentum* Mill. was susceptible. Root lesions were induced in several processing cultivars by inoculation, though no other symptoms appeared; it is possible that this almost symptomless material constitutes a reservoir for infestation in greenhouse crops. The disease is more severe when tomatoes are planted in cool soils; potted plants were more severely affected at 18°C than at 24°C.

*Insects.* Good control of *Glischrochilus quadrisignatus* (Say), a nitidulid beetle that infests damaged processing tomatoes, was obtained in hampers of tomatoes from mid-to late August when ultra-low-volume malathion (95% technical) was applied once to empty hampers in either mid-July or early August. Only moderate control was obtained in September when low temperatures made malathion less effective.

*Low-temperature germination.* Tomato and corn seeds from seed lots in which most of the seeds germinate quickly at optimum

temperatures (high vigor) also germinate more readily at low temperatures (10°C) than seeds with low vigor. Thus, to understand low-temperature germination it is essential to know how seeds acquire vigor. Preliminary results have indicated that factors other than genetic ones appear to have a substantial effect on seed vigor and should be more completely identified.

*Methods of growing transplants.* In 1975, the cultivars Fireball, Starshot, Springset, and Campbell 27 were seeded early (March 20) and grown in flats of soil, first at 50, then at 10 plants/flat. Early yields were 24.2, 23.5, 22.5, and 18.8 t/ha, which exceeded early yields from the same cultivars seeded later (April 1) in peat pots, by 5.6, 8.3, 11.2, and 11.7 t/ha, respectively. In the 4-yr trial, combined early yields from the four cultivars seeded early exceeded those from the later seeding by an average of 16.1 t/ha. Early produce from early seeding should bring financial returns that more than compensate for the increased labor and heating costs.

*Nematodes.* In studies with the southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, the systemic nematocide oxamyl significantly reduced root galling on tomato when applied as a soil drench before planting followed by two foliar applications after planting. However, it was ineffective when applied as a foliar spray to transplants before planting followed by two foliar applications after planting. Tomato yield from the plots drenched with oxamyl was superior to that from control plots, but not as high as the yield from plots treated with D-D Soil Fumigant (Shell Canada), even though root galling in the D-D plots was equal to or more severe than that in the plots treated with oxamyl. When oxamyl and D-D were used in combination, root galling was equal to or less than that in the plots drenched with oxamyl, and yield was equal to or higher than that obtained with D-D alone. Additional work is required to determine if this combination treatment has any economic advantage over use of D-D alone.

*Weed control.* For effective weed control and high crop yields, EPTC or trifluralin should be incorporated in soil before planting to eliminate the grass weeds. This treatment should be followed before emergence by an application of metobromuron, which has been particularly effective in controlling



common ragweed as well as other broad-leaved weeds. None of the 26 herbicides that were incorporated before planting adversely affected N-fixing nodulation in snap beans.

## Greenhouse Vegetables

### Cucumbers

*Powdery mildew.* Because chinomethionate has been deregistered and powdery mildew, *Sphaerotheca fuliginea* (Schlecht. ex. Fr.) Poll., is tolerant of benomyl, work on other control measures has been intensified as an adjunct to the cucumber breeding program. A hyperparasitic fungus, *Cicinnobolus cesatii* de Bary, has been isolated and is being manipulated as a potential biological control agent, both in the greenhouse and in the field.

*Sulfur, an essential plant nutrient.* Symptoms of S deficiency and toxicity in greenhouse cucumbers and tomatoes were produced experimentally in sand culture. The main morphological effect was a general depression in growth and fruit production. An S content of less than 0.25% in any plant tissue and a general chlorosis of all foliage were associated with only the most severe deficiency.

*Variety introduction.* The F<sub>1</sub> hybrid seedless cucumber HG70.72, developed at Harrow, was named Harlton and released through the Canadian Seed Trade Association. It is now under test by growers and seedsmen on a worldwide basis. Harlton was bred to meet the need for a medium-sized cucumber suited to small families. Its chief distinguishing feature is its intermediate length (25–38 cm), with more than one-half of its fruits 30–35 cm long. Also, it does not have the wasteful stem end (long neck) that typifies most European seedless cultivars. Harlton has good shelf life, being slow to yellow, shrivel, or become pitted.

*Variety test.* A search among existing cultivars for a seeded cucumber that combines the high yielding capacity of Burpee Hybrid with the desired dark green quality of High Mark II has been unsuccessful. Of the 40 cultivars tested over 3 yr, none possesses all the desired characteristics.

### Tomatoes

*Fertilizer schedule.* A newly revised single schedule has been developed and published as a guide to weekly application of fertilizer for tomatoes and cucumbers. Slight adjustments in timing and concentration of applications make it suitable for various crops, varieties, rates of growth, and other variable factors of crop production. The schedule is intended only as a guide, to be used preferably in conjunction with information from soil and tissue tests.

*Hydroponics.* A small hydroponics unit was established, based on the simple English model proposed by A. J. Cooper. Two cultivars, Vendor and MR13, showed satisfactory growth and production. Early growth was more rapid than that of plants growing in soil or other rooting media, but fruit set, size, quality, and flavor were precisely the same, contrary to claims in advertising literature.

*Leafminer ecology.* Four out of 10 species of parasites of the vegetable leafminer were present both outdoors and in greenhouses, indicating that biological control may be possible by managing the parasite complex. The most abundant species was *Opius dimidiatus* (Ashmead).

*Pesticide residues.* Residues of the fungicide mancozeb and its degradation product ethylene thiourea were monitored after experimental spraying at 14-day intervals. The residues that remained on tomato fruits after four sprayings were within the legal tolerance levels, but any additional applications increased the residues beyond this limit.

## Tree Fruits

### Performance of Apricot Varieties

Data were obtained on 11 named varieties in the Harrow collection. Only five were judged to have possible commercial value: Rakowski, Viceroy, Veecot, Goldcot, and Sunglo. Varieties that were judged to have no commercial value included Toovey, Southwick, Suphany, Stepnyak, J. L. Budd, Steede, Stella, Morden 604, Alfred, and Farmingdale. The performance of 22 Harrow selections was compared with performance of two from Prosser, Wash.; two from South Haven, Mich.; two from Summerland, B.C.; five from New Brunswick, N.J.; and eight from the

Horticultural Research Institute of Ontario, Vineland, Ont. The most promising of the Harrow selections were H6305042 (ripening July 13), HW401 (July 13), H6506088 (July 29), and HW405 (August 1). None of the selections from Michigan, Washington, or British Columbia were promising. The best of the New Jersey selections was NJA7 (July 22), and the best of the Vineland selections was V60011 (July 20).

## Peaches

**Bacterial spot.** In the peach cultivar Olinda, *Xanthomonas pruni* (E.F.Sm.) Dowson was successfully controlled with oxytetracycline-HCl applied at 100 ppm in three differently timed schedules, each ending 3 wk before harvest. A weekly spraying of the bactericide starting at petal fall resulted in fruit infection of 2%, which was significantly lower than the level of 20% in untreated trees or trees that were sprayed with a foliar nutrient (1% solution of 20:20:20 NPK); spraying on a weekly schedule from the time of shuck-split and a 10-day-interval schedule each resulted in 4% fruit infection. Corresponding levels of foliage infection and defoliation in July were 40, 51, and 48% for the spraying schedules, compared with 60% in untreated trees and those sprayed with foliar nutrient. These results are similar to those of 1974 in the cultivar Velvet.

**Canker resistance.** One-year-old seedlings of eight peach rootstocks were inoculated in April 1974 by placing actively growing mycelial plugs of *Leucostoma cincta* (Fr.) Höhn. beneath bark flaps made with a sterile scalpel. Excellent results were obtained from bark flap inoculation of the canker pathogen but no infection occurred when sterile agar medium was used. The downward progression of canker in 1974, the additional progression in 1975, and the total progression from the time of inoculation to June 1975 were measured. Each measurement revealed significant differences in rates of canker progression among the rootstock varieties, but total progress over the 14-mo period was the best means of separating the varieties according to their resistance to canker. It was possible to place the eight varieties into three classes of resistance: moderately resistant, Bailey, Sinung Chui Mi, and Tzim Pee Tao; moderately susceptible, Harrow Blood, Chui Lum Tao, and Siberian C; and susceptible,

Elberta and Yeh Hsiemtung Tao. No highly resistant rootstocks were found.

**Crown gall.** In an experiment on the biological control of crown gall, *Agrobacterium radiobacter* Smith & Townsend var. *tumefaciens* Conn., in a peach nursery, germinated peach seeds were treated with a suspension of the bacterium *A. radiobacter* Beijerinck & van Delden *radiobacter* Conn. Biotype 2 (Australian bacteriocin-producer strain). When nursery stocks were taken out of the ground 2 yr later, 15% of the 5000 trees grown from untreated seeds had crown gall but the 4000 trees grown from treated seeds were free from it.

**Flower bud hardiness.** The rates of deacclimation and reacclimation of peach flower buds at controlled temperatures were studied in two moderately hardy varieties, Madison and Redhaven, and one moderately tender one, Loring. Samples were collected and tested in February when buds were dormant, in March when buds were just beginning to grow, and in April when buds were quite enlarged but still closed. In February, during the first 24 h of deacclimation at 10°C, bud hardiness decreased rapidly by about 4–5°C when measured by  $T_{50}$  (temperature required to kill half of the buds). During the next 24 h at 10°C, flower buds lost another 2–3°C of hardiness, regardless of the cultivars studied. During the first 24 h of reacclimation at –10°C the buds regained about 3°C of hardiness, but in the next 24 h of reacclimation they regained less than 1°C. A similar pattern was obtained in March for each variety. In April, when the buds were quite enlarged, the pattern of deacclimation and reacclimation among cultivars changed. Loring showed a much greater response to the environments of deacclimation (10°C) and reacclimation (–10°C) than did Madison or Redhaven, in that it was substantially less bud hardy than the other two. In February, the temperatures required to kill half of the flower buds of Madison, Redhaven, and Loring were –24.5°, –25.9°, and –23.9°C, respectively. In April, the corresponding temperatures were –20.5°, –20.0°, and –17.9°C. The stage of development of peach flower buds also had an important influence on their ability to deacclimate and reacclimate.

**Nematodes.** Root samples from an 8-yr-old planting of Babygold 5 peach on six different



rootstocks were extracted to test for the root-lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. The rootstocks fell into three classes on the basis of nematode population levels; Harrow Blood and Bailey supported the lowest population levels, Veteran and Rutgers Red Leaf showed intermediate levels, and Halford and especially Siberian C were the most suitable hosts.

**Peach X-disease.** Surveys showed an increase in the spread of peach X-disease in Essex County. Infected trees of the chokecherry, *Prunus virginiana* L., the known weed host of the pathogen (a mycoplasma-like organism), were usually present near affected orchards. Injection of roots with 40–60 mg oxytetracycline-HCl per tree in the fall of 1974 resulted in remission of symptoms during 1975.

Three species of leafhoppers known to transmit X-disease were identified and monitored near Ruthven, Ont., where the disease occurred in peaches and chokecherries. In order of both abundance and duration of flight period they were *Paraphlepsius irroratus* (Say), *Scaphytopius acutus* (Say), and *Colladonus clitellarius* (Say). *C. clitellarius* was confined to a woodlot area with chokecherries.

**Pruning systems.** Significantly higher concentrations of sprayed captan and azinphos-methyl were found on trees pruned to a modified oblique fan configuration (MOF) and a modified canted oblique fan configuration (MCOF) than on trees pruned according to the standard open center system (SOC). Under the MOF and MCOF systems 36–47% of the pesticide was lost by spray drift, whereas 67–71% was lost under the SOC system. The results suggest that less pesticide may be required to control insects and diseases, without loss of efficacy, in orchards pruned according to the MOF or MCOF system.

**Rootstock hardiness.** Seedlings of 10 rootstock varieties were subjected to controlled freezing to  $-10^{\circ}$ ,  $-13^{\circ}$ , and  $-16^{\circ}\text{C}$  in January, 1975. Regrowth tests were the basis for assessing relative hardiness. All seedling rootstocks were killed at  $-16^{\circ}\text{C}$ , some survived at  $-13^{\circ}\text{C}$ , and more survived at  $-10^{\circ}\text{C}$ . The unfrozen controls made good growth. At  $-10^{\circ}\text{C}$ , rootstock varieties differed significantly in hardiness. The hardiest were seedlings of Chui Lum Tao, Siberian C, and

Bailey, and the tenderest were H661511, H661502, and Elberta. The remaining four varieties, Yeh Hsiemtung Tao, Sinung Chui Mi, Tzim Pee Tao, and Y327 were intermediate in hardiness. Survival based on an overall visual rating of regrowth was closely and significantly correlated with number of shoots ( $r = 0.753$ ), vigor of shoots ( $r = 0.982$ ), abundance of new roots ( $r = 0.936$ ), and visible injury to the tap roots ( $r = 0.818$ ). The methods used for controlled freezing and assessment of injury were effective in screening peach rootstocks for cold hardiness.

**Tree density and irrigation.** In the 1st yr of commercial production, the yield response of Harken on Siberian C rootstocks was influenced more by tree density than by irrigation. Trees at close ( $3.1 \times 6.1$  m) and intermediate ( $4.6 \times 6.1$  m) spacings outyielded those at conventional ( $6.1 \times 6.1$  m) spacing by 70 and 43%, respectively. Trees in plots irrigated to maintain 25% available soil moisture (ASM) outyielded those in unirrigated plots by 20%, but trees in plots held at 50% ASM outyielded unirrigated controls by only 9%. The best combination treatment was close spacing plus irrigation to maintain 25% ASM. Trees that received this treatment outyielded the unirrigated ones at conventional spacings by 110%.

**Weed control.** Granular simazine provided safe, effective weed control for newly planted peach trees and nursery seedlings. Spray drift of the postemergence herbicide glyphosate onto foliage of lower laterals of young trees caused injury throughout the tree as a result of translocation.

## Pears

**Breeding.** One pear selection, HW603, was placed in advance trials held on the Station and with growers. HW603 ripens in early August and appears to be suited to the early fresh market. It is superior in fruit quality to the fresh market cultivars Giffard and Clapp's Favorite, and is equal in resistance to fire blight to Kieffer, which is grown in Ontario without risk of fire blight.

**Fire blight.** This disease, caused by *Erwinia amylovora* (Burr.) Winsl. *et al.*, was more severe in 1975 than in 1974. Foliar applications of streptomycin after periods of rainfall between blossoming and 30 days before harvest resulted in a 23-fold reduction of



twig blight. The epiphytic population of *E. amylovora* was monitored weekly throughout the growing season; the bacteria were detected before they actively infected the host, and they could not be found after the host tissues matured.

*Rootstocks.* Trees on several clonal dwarfing rootstocks of Old Home × Farmingdale and hardy quince have been produced for Station and grower trials beginning in 1976. Eight more dwarfing rootstock clones have been introduced from South Africa; two of these were found to be virus-infected and are receiving heat treatment.

*Winterhardiness.* The temperature that induced xylem injury in the commercial cultivars Bartlett, Anjou, and Bosc was found to be closely associated with the freezing point of a supercooled water fraction in the xylem. This in turn was closely related to the average annual minimum temperature at the northern limits of pear production. The supercooling point of xylem water appears to be a major limitation to pear production in northern climates. Some potential for varietal improvement in winterhardiness was revealed. The variety Moe survived to temperatures that would allow production in some northern areas of Ontario where apples but not pears survive.

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# Research Station Ottawa, Ontario

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## Horticultural Crops

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## Experimental Farm, Thunder Bay, Ont.

W. B. TOWILL, B.S.A.	Superintendent; Crop management and evaluation
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## Departures

L. M. CASSERLY, B.A., B.S.A., M.Sc. Retired February 1975	Corn
D. R. GIBSON, B.Sc. (Agr.) Retired December 1975	Corn and soybeans
V. A. HELSON, B.A., M.A. Retired September 1975	Environmental physiology
D. P. HOLMES, B.Sc., Ph.D. Resigned August 1975	Growth analysis
W. C. JAMES, B.Sc., Ph.D. Resigned November 1975	Surveys and methodology

L. H. LYALL, B.S.A., M.S.  
Retired November 1975  
R. W. MARTIN  
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Assistant Director  
  
Administrative Officer

*Experimental Farm, Smithfield, Ont.  
Transferred administratively to Vineland Station, Ont., April 1975*

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## INTRODUCTION

The research program of the Research Station at Ottawa is concerned with the development of improved cultivars of cereals, corn, soybeans, and forages, the protection of these crops from diseases and insects, and the discovery of new information that will support these activities.

Three scientists working in the Station were honored during the year for their contributions to science and agriculture. Dr. W. R. Childers was presented with the Canadian Seed Trade Association's Man of the Year Award for his outstanding contributions to grass breeding. Dr. V. D. Burrows was awarded the Grindley Medal by the Agricultural Institute of Canada for his singular contribution to agriculture, the development of the high-protein oat cultivar Hinoat. Dr. J. T. Slykhuis was elected to Fellowship in the Royal Society of Canada.

In April the administration of the Experimental Farm at Smithfield, Ont., was transferred to the Research Station at Vineland, where closer associations in the horticultural program will be possible. Retirements and resignations during the year resulted in the loss of a number of professional staff who have contributed greatly to research programs in the past. The retirements of Mr. L. H. Lyall, Assistant Director, and Mr. R. W. Martin, Administrative Officer, brought to a close distinguished careers from which all research programs have benefited significantly.

This report summarizes some of the more important research results from the Station in 1975. Further information can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

F. K. Kristjansson  
Director

## CEREAL CROPS

### Wheat

*Breeding.* Yield trials of 32  $F_1$  winter wheat hybrids showed some to be equal to the best cultivars but none superior. However, these hybrids yielded 32% more than their male-fertile parents (pollen restorers), which indicates the need to breed restorer lines with better local adaptation and higher yield potential.

Tests of many conventional winter wheat lines showed that none were superior to our very successful release Fredrick. Line 8077 B92-1, which showed promise, is being reselected for better pastry quality, but the winterhardy line O-18-3 has been discarded because of susceptibility to lodging.

Breeding for feed-quality spring wheat is concentrated on the cross Opal  $\times$  Pitic 62. Selection Cal.15 outyielded both parents during 3 yr of testing in Ontario and is being considered for release.

*Physiology.* The development of tolerance for freezing in cereals and woody trees is directly associated with an increase in the total membranous material in the cell.

Completely functional mitochondria were isolated from rye cells killed by slow freezing. The maintenance of functional integrity is contingent upon the speed of isolation from the dead cells. Therefore, mitochondria frozen in situ do not share the sensitivity of other cellular membrane elements to freezing stress and cannot be directly responsible for freezing damage to plant cells.

*Virology.* Experiments were conducted to correlate the presence of individual soil organisms with infection of wheat by wheat spindle streak mosaic virus. These, and tests with pure cultures of fungi, show that the virus is transmitted from soil to wheat only in the presence of a zoospore-producing fungus, *Polymyxa graminis* Ledingham. Naturally infectious soil stored dry or moist in a greenhouse was still infectious after 10 yr, but not after 11 yr. After wheat plants have become infected in soil at 15°C, exposure to temperatures fluctuating near freezing for about 10 days increases the number of plants that develop symptoms when the plants are again grown at 10°C.

## Oats

**Breeding.** Areas planted with the Ottawa Research Station cultivars Scott, the highest-yielding feed oat in Ontario, and Hinoat, the highest-protein food oat (grown mainly under contract in Saskatchewan), were increased in 1975. The dual-purpose forage- and grain-type oat OA123-81 was evaluated, at a farm scale, by the Forage Foothills Association of Alberta under the financial auspices of the New Crop Development Fund.

Good progress was made in high-yielding, daylength-insensitive (DI) strains that combine early maturity, lodging resistance, large seed with thin hull, and resistance to diseases such as barley yellow dwarf virus and smut. Some advanced strains in the program have displayed moderate to high yield and wide adaptability in Canada and the USA, whereas many new but genetically stable strains yielded significantly more grain than Scott at Ottawa in 1975. Hinoat may soon be replaced by higher-yielding DI strains with a high protein content, such as strain 0428.

The new dominant dwarfing gene in the cultivar Harmon, which was discovered by R. I. H. McKenzie of the Research Station at Winnipeg, has been successfully transferred by backcrossing to 49 standard cultivars and strains of oats. In most instances, the dwarfing effect was too severe and yield losses occurred because the panicle failed to emerge completely from the boot and the bottom florets were sterile. Use of very tall recurrent parents, or treatment of the dwarf plants at the flag-leaf stage with 50 ppm of gibberellic acid, partly or completely overcame the problem of flower emergence.

**Quality.** Significant relationships were detected between lipid content and total fatty acid composition of seed from *Avena sativa* L. As lipid content increased, the proportions of palmitic and linoleic acid decreased and that of oleic acid increased. The relative proportions of acyl lipid classes were also affected. High-oil strains had a greater proportion of triglyceride and a lower proportion of phospholipid. The potential exists for increasing the metabolizable energy of this crop by more than 10%, by breeding cultivars for higher lipid content. However, the greater amounts of free fatty acid found in seed of high-oil strains may cause some difficulties with storage stability.

**Diseases.** Three types of response by cultivars to development of septoria disease (*Septoria avenae* Frank f. sp. *avenae*) were obtained in the growth room. Most cultivars, such as Garry and Scott, were quite susceptible to development of septoria leaf blotch and black stem. A few, such as Dorval and CI8424, were susceptible when inoculated after the fourth leaf had developed but resistant to black stem when inoculated by the fourth-leaf stage. The cultivar CI8175 showed considerable resistance to development of both leaf and stem symptoms.

A cooperative field test at Kapuskasing showed that oat cultivars that developed symptoms of leaf blotch and gray speck responded with yield increases to applications of manganese to the foliage. However, cultivars that showed no symptoms gave no yield increases. Growth room studies indicated that both leaf blotch and gray speck symptoms developed when oats were grown in liquid cultures at low concentrations of manganese.

## Barley

**Breeding.** Vanier barley, released by this Station in 1972, continues to be the top-yielding cultivar in Ontario Regional Tests. New strains OB123-28 and OB123-34 possess resistance to smut, mildew, and scald, combined with high yield.

When 24 barley cultivars were grown at four diverse geographical locations in Canada, the expression of aleurone color varied with cultivar and climate. In a cool, moist region (Beaverlodge, Alta.) the expression of blue was faint, whereas in a dry, warm climate (Lethbridge, Alta.) the blue was intensified. Classification by seed color was aided by treatment of the seed with a 1% HCl solution, which did not alter the color of yellow kernels but turned blue kernels pink.

An experiment was conducted in which the cultivars Brock and Fergus were planted at four dates spaced at weekly intervals into soil maintained at three moisture levels, to study the influence of the two variables on yield and chemical components. Early seeding under high soil moisture levels maximized the grain yields and ash content. The same conditions maximized protein yields, although higher protein contents were obtained from plots with lower moisture levels; grain fiber and  $\beta$ -glucan contents were also decreased.



*Winterhardiness.* Ascorbic acid analyses of vernalized seedlings were correlated with winterhardiness. In vitro freezing tests conducted in cooperation with the Technical University, Weihenstephan, Germany, showed that electric impedance of decapitated seedlings is a reliable and fast measure of winter injury.

*Diseases.* Only limited information was obtained on the influence of mixtures of barley and oats on development of spot blotch caused by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, because disease levels in two separate tests were low; however, certain combinations of barley and oats outyielded pure stands. Spot blotch developed well on barley in the field when it was inoculated with spores grown on sterilized straw, but not when inoculated with several other types of inocula. Yields were reduced by approximately 10% by the heaviest infection. In the growth room, spore inocula were grown on several types of media; the severity of infection was not affected by the medium, but the types of lesions produced varied considerably between isolates and cultivars.

## CROP LOSS ASSESSMENT

### Methodology

*Determination of yield loss of processing peas from fusarium root rot.* A method was developed to estimate loss of yield in processing peas from fusarium root rot, caused by *Fusarium solani* (Mart.) App. & Wr. and related species. Estimates based on the percentage of moderately and severely affected plants were obtained by employing two yield loss conversion factors, 0.35 and 0.58, determined from experimental and growers' field data from the past 3 yr. The general formula for determination of yield loss is as follows: % yield loss = (% moderately infected plants  $\times$  0.35) + (% severely affected plants  $\times$  0.58). Based on this method, the average losses in selected fields in Nova Scotia, Prince Edward Island, Quebec, and Ontario were 8.8, 39.3, 41.3, and 5.5% during 1975. A field plot experiment with 30 pea cultivars at Ottawa in 1975 confirmed the validity of the conversion factor for average yield loss in the severely infected plants.

*Determination of alfalfa yield loss from two foliage diseases.* A simple method was

developed to estimate alfalfa yield loss from common (*Pseudopeziza* sp.) and stemphylium leaf spots. The method involves counting the leaves from 50 main stems per field and determining the percentage of defoliation. This percentage is then multiplied by a factor of 0.5 to estimate yield loss, because the ratio of leaf to stem (by weight) in alfalfa is about 1:1 during the usual time of harvest. The above method significantly correlated with J. G. Horsfall's original method (1930) described for stemphylium leaf spot of clover, and was applied to 34 alfalfa fields in nine counties of eastern Ontario. Yield losses in these fields ranged from 0.76 to 8.4%, with an average of 3.29%. Common and stemphylium leaf spots most frequently occur together on the same plant, and the loss value is an estimate for both.

*Remote sensing.* Optical density signatures were developed from infrared (IR) aerial photographs of potato plots infected with late blight, caused by *Phytophthora infestans* (Mont.) de Bary. Density signatures were developed by plotting the various relative densities that occurred on film of the various plots against their frequency of occurrence. Slight differences between optical density signatures of plots with different spray schedules were detectable before the corresponding differences in infection levels became visually apparent. The technique of density signature development allowed consistent and quantitative differences to be recorded.

The blue-, green-, and red-sensitive layers of a visible-color aerial photograph of crops in the Hensall area were reproduced as optical separations in black and white. When these were combined with a monochrome IR aerial photograph of the same scene, contrast and feature discrimination were improved.

*Potato late blight.* Results from 14 field experiments with potatoes infected with *P. infestans* were used to study the relative importance of positive and negative interference in plots sprayed with fungicide. In a field experiment, the loss in yield associated with a fungicide schedule may be overestimated (positive interference) if the adjacent plots have more disease, or underestimated (negative interference) if they have less disease. An epidemic in some plots resulted in positive interference in fungicide-sprayed plots in the same experiment, despite the application of five protectant sprays. Negative interference occurred in sprayed plots



adjacent to plots with no disease, and the negative interference was of greater magnitude than the positive interference. The representational errors between treatments attributable to interference were equal to or greater than the corresponding experimental errors.

## Surveys

**Bacterial blight of field beans.** In 1975, two high-intensity production areas of white beans were aerially photographed with IR color film. These areas, near Chatham and Hensall, Ont., contain Select, Foundation, and Commercial bean fields. In the Hensall area, 55 Commercial and Foundation bean fields were aerially photographed and ground surveyed for bacterial blight; 21 fields were infected. In the Chatham area, 24 fields were aerially photographed and ground surveyed, and two fields were infected. Positive isolates were obtained from infected material. Field percentages of blight will be determined by the drum scanner technique. For the 1974 crop, results of photointerpretation followed by drum scanning showed that 0.2% of the crop was infected in the Chatham area, but blight was too limited to determine in the Hensall area.

**Ergot.** In wheat shipments inspected at terminal elevators in 1974, the incidence of ergot declined in both durum and common wheat, reflecting the decrease in field levels noted since 1973. In the field, ergot levels continued to decline in 1975 but distribution changed, indicating a return to rather high levels in the traditional problem area of southeastern Saskatchewan.

**Barley diseases.** A survey of 25 fields of barley and mixed grains in southwestern Ontario in mid-June showed that infection from *Pythium* spp. was present but was causing little damage. Tests gave positive results in 18 out of 24 fields, and *P. aristosporum* Vanterpool and *P. arrhenomanes* Drechsl. were the most prevalent species isolated. A survey of the same fields in mid-July showed that spot blotch (*C. sativus*) was the most prevalent foliage disease, being found in all fields. Observations indicated that spot blotch inoculum was abundant and could come from plants growing from infected seed, plant debris, and infected crown tissue.

**New diseases.** Plant pathogens reported for the first time in Canada include two foliar diseases of buckwheat; *Verticillium nigrescens* Pethybr. in field-grown tobacco; squash mosaic virus detected in muskmelon seed; seed-borne pea mosaic virus in field peas from Manitoba; and new, aggressive forms of smut fungi attacking six-row barley.

## CYTOGENETICS

### Cereal Species

The karyotype of the perennial and cross-pollinating tetraploid ( $2n = 4x = 28$ ) oat species *Avena macrostachya* Balansa was characterized by overall symmetry and the absence of acrocentric chromosomes. Autotetraploidy was indicated by an average of four quadrivalents per pollen mother cell at first metaphase, most of which were zigzags or chains. This, together with a negligible frequency of univalents, minimized aneuploidy in the progeny.

Somatic chromosomes of barley were differentially stained by a modified schedule of Giemsa, and primary trisomics were used successfully to relate some of the linkage groups to the corresponding Giemsa karyotype. Somatic divisions in the barley cultivar Vanier have been partly synchronized at mitotic metaphase by appropriate treatment with 5-amino-uracil.

Somatic association of metaphase chromosomes has been examined in the fababean cultivar Diana and the rye cultivar Prolific. Irrespective of the method of pretreatment, no somatic association was found in the fababean. The distribution of the rye chromosomes was random after cold pretreatment but a highly significant association of the SAT chromosomes resulted after pretreatment with colchicine.

### Bromegrass

A fertile, meiotically regular, tetraploid cytotype ( $2n = 4x = 28$ ) of *Bromus inermis* Leyss. was discovered among introductions from the USSR. Hexaploids derived from crosses to the octoploid cytotype of *B. inermis* ( $2n = 8x = 56$ ) tended to behave as autotriploids at meiotic metaphase. Colchicine-induced octoploids produced from the tetraploid cytotype contained four chromosomes with large satellites and four with



small satellites, whereas the octoploid cytotype contained four large and two small satellites.

Pentaploid hybrids ( $2n = 5x = 35$ ) were produced from *B. variegatus* Bieb. ( $2n = 14$ )  $\times$  *B. inermis* ( $2n = 56$ ) as a possible bridge to produce tetraploid cytotypes from the octoploid. The genome of *B. variegatus* was shown to be differentiated from the A genome of *B. inermis*, based on chromosome pairing in an interspecific hybrid with an autotetraploid carrier of the A genome, *B. erectus* Huds. ( $2n = 4x = 28$ ).

### Experimental Haploidy

**Tobacco.** Haploids of *Nicotiana tabacum* L., cultivar Delhi 34, were routinely produced by anther culture methods. A haploid sucker-free plant was successfully doubled and many seeds were obtained for field trials. Haploid leaf explants cultured on media with a high ratio of cytokinin to auxin regenerated large numbers of shoots.

**Brassica spp.** The production of homozygous diploid embryoids in anthers of *B. campestris* L., cultivar Torch, was continued. Embryoids were produced in less than 1% of the cultured anthers from cultivars of *B. napus* L. and *B. oleracea* L.

**Flax.** Twelve lines of cultivar Rocket-4, selected for high haplo-diplo twinning, yielded 5% or more haplo-diplo twins. Advanced Breeder's lines from Morden were screened and doubled haploids produced from the few twins that occurred.

Explants of mature haploid (cultivar Rocket-4) and diploid (cultivar Redwood 65) plants were induced to undergo multiple shoot formation in the presence of benzyladenine.

For mutagenesis in haploids, haploid plants of Rocket-4-2 were treated with diethyl sulfate (DS). After three cycles of treatment, 27% of the haploid clones contained color chimeras; boll set of 0.9% was obtained from haploid  $\times$  diploid crosses and the chromosome number varied in the  $F_1$  plants between  $2n = 16$  and  $2n = 46$ . Among the doubled progeny of the mutagen-treated haploids, two seedlings were resistant to race 371 of flax rust. Tissue culturing was conducive to rust development and sterile conditions persisted after DS treatments.

**Wheat.** Previous results obtained by anther culture of cultivar Pitic 62 were repeated, and

attempts have been made to improve the frequency of haploids.

Various wheat cultivars were crossed with cytotypes of *Hordeum bulbosum* L. and more than 100 embryos were cultured, but no haploids have been found thus far. Crosses between alloplasmic wheat (*Aegilops caudata* L. cytoplasm + wheat nucleus) and the wheat cultivar Salmon yielded 27% haploids. This method has been discontinued because of difficulties in eliminating from the progeny the *A. caudata* cytoplasm that induces male sterility.

## ENTOMOLOGY

### Insect Population Dynamics

**Alfalfa weevil.** Graphic and components analysis of a series of life tables has identified the fungus *Entomophthora phytonomi* Arthur as the key factor in regimenting populations of the alfalfa weevil, *Hypera postica* (Gyllenhal), in southern Ontario. During 1975, a natural epizootic of the pathogen killed 94–99% of the larvae in five study plots. Evidence of fungal activity was detected in 30 counties.

A biometrically oriented sampling plan has been developed for estimating numbers of cocoons in fields of alfalfa, and for assessing the activity of natural control agents while the weevils are at this stage. The plan provides for samples from foliage and ground litter. For samples from foliage, where two-thirds of the cocoons are found, the most appropriate unit is a bouquet of six stems: for typical weevil densities, estimates with acceptable precision may be obtained from 25 bouquets taken at random from within a field. For litter samples, the appropriate unit is 232 cm<sup>2</sup>; acceptable precision may be obtained from 20 such units taken at random. Total cost for a combined sample is 3.9 man-hours.

**Cereal leaf beetle.** Survey and life table data in 1975 showed that *Tetrastichus julis* (Walker), a European larval endoparasite of the cereal leaf beetle, *Oulema melanopus* (Linnaeus), has become established throughout Ontario. Dissections of host larvae showed that rates of attack in 10 counties varied from 15 to 92% and declined from west to east. Dispersal into Ontario is the result of extensive colonization of the parasitoid in Michigan and other parts of the U.S.

midwest during 1970–71. Its success and unexpectedly rapid spread across the Province may be attributable to different cropping practices and better synchronization with its host than in the USA.

Time–temperature data obtained under controlled conditions showed that rates of development for the immature stages of the beetle increased with temperatures up to 30°C and then reached a plateau. Survival was highest for eggs at 12° to 32°C and for larvae and pupae at 10° to 28°C. The insect failed to complete development at 6° and 34°C.

### Honey Bees

*Behavior.* An airborne swarm of bees is led to a new homesite by worker bees releasing Nassanoff pheromone. However, the swarm flies to the homesite only if accompanied by a queen, whose presence is perceived by the workers through her release of queen pheromones. By use of mixtures of artificial pheromones, airborne swarms can be attracted to preselected locations and into empty hives.

Introduction of extracts of queens or equivalent amounts of synthetic queen pheromone partly inhibited rearing of queens in colonies after the previous ones had been removed. However, during the swarming season, continuous treatment with pheromones was ineffective and did not prevent swarming.

*Disease.* Contrary to published reports, the addition of nonanoic, lauric, myristic, palmitic, or behenic acid (each 5% by weight) to solid food cakes fed to overwintering colonies did not inhibit the development of American foulbrood disease (AFB) in the spring. Spore counts were highest in honey extracted from combs and pollen trapped at hive entrances, and lowest in scrapings from the walls of contaminated hive boxes. Intermediate numbers of spores were found in washed beeswax.

Ethylene oxide (12% by weight in liquid Freon 12) sterilized AFB-contaminated combs when used at the rate of 1 kg/1.2 m<sup>3</sup> of chamber. However, the effectiveness of this treatment could only be determined by bacteriological culture.

## FORAGE CROPS

### Grasses

*Orchardgrass.* About 8200 kg of the cultivar Juno were seeded in Manitoba, for both grass and seed production. This cultivar of orchardgrass has been recommended for the interlake district of that Province, and 3000 kg of Foundation and 204 kg of Breeder seed are available. Seed increase and forage production of the cultivar Kay were continued. Rust resistance of the cultivar Rideau was further improved. The strain Bumper was selected for higher seed yield and had excellent forage quality.

*Timothy.* Breeder seed (270 kg) of the timothy cultivar Basho was produced for testing. Further testing and selfing were carried out for production of a tall, wide-leaved new strain. Excellent tall plants were identified but wide differences were still observed between segregates; an attempt is being made to fix the tall characteristic and to increase digestibility. Twelve promising clones were selected for use in developing an early timothy.

*Bromegrass.* Tempo, the new bromegrass with high seed yield, was well established in the spring of 1975. Its forage yield was very similar to yields of Saratoga and Baylor and hence represents a significant improvement in bromegrass production.

### Alfalfa

In a group of 81 selections, chosen in 1974 for freedom from foliar and crown diseases and superior vigor, leaf content varied from 44 to 65%. Protein content of whole plants varied from 19.5 to 29.2%, indicating the feasibility of improving this trait by selection. A correlation of  $r = 0.57$  between leaf and protein contents of whole plants suggested that, for rapid improvement, simultaneous selection for high leaf and protein contents should be carried out.

Among the 33 parent clones of the cultivars Angus and Algonquin, 18 were found to have satisfactory resistance to the northern root-knot nematode, *Meloidogyne hapla* Chitwood, and eight were resistant to the root-lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. A pool of germ plasm with resistance to these nematodes is being formed.



*Breeding methods.* About 45 kg of Breeder seed of BW9 (named Chapais) have been produced. The new breeding method of allelic selection, now under investigation, promises to be effective in improving the forage yield of alfalfa. Four synthetics developed during the first attempt to use this method were superior to the control cultivars Iroquois, Saranac, and Vernal, in the 1975 trial. This superiority asserted itself despite the rather low heterozygosity and gene frequency of their two parental populations. Very simple and quite rapid, the method is designed to make better use of hybrid vigor. Based on the theory of multiple alleles, it maximizes heterozygosity and at the same time increases the frequency of superior alleles.

## Corn

*Breeding.* The experimental hybrid OX519 qualified for licensing in the 1975 Ontario Corn Committee tests. Seed production rights have been allotted and seed should be available in 1977. This hybrid is a single cross that requires about 2650 heat units to mature. One of the inbreds is Flint, the first such developed and used in a hybrid released from the Ottawa program that qualified for inclusion in the Ontario Recommended List.

Testing of earlier-maturing combinations continued in Eastern and Western Canada. In Alberta and Manitoba Corn Committee tests, five hybrids reached physiological maturity and produced acceptable grain yields (4.3–7.1 t/ha). In tests in the Atlantic Provinces, three of these and seven other hybrids performed well enough to warrant further testing.

The main emphasis in the breeding program continues to be placed on improving the stalk quality of established inbreds. In the Ottawa nursery in 1975, 274 backcross-derived lines involving six inbreds and two sources of superior stalk quality were top-crossed to provide seed for general combining tests in 1976. The Florida winter nurseries were used to advance two other groups of eight and six lines through generations  $S_2$  and  $S_3$  and  $BC_1$  and  $BC_2$ , respectively.

General combining ability was tested in 45 lines developed from synthetic No. 6, with resistance to the corn borer; 12 of these lines were selected for further study.

*Agronomic practices.* Losses of grain corn resulting from machine harvesting decreased

in 1975 from 14 to 4% from the first to the fourth date of planting. Total yields generally were much higher for the later planting dates, so that the actual amount of grain lost remained almost constant. The order of both grain yields and harvest losses was reversed from that of previous years because of unusual weather conditions.

Two hybrids with similar performance for silage production, grown at up to 50 000 plants/ha, responded differentially at higher population densities. One gave maximum yields at 60 000 and the other at 86 000 plants/ha. Corn hybrids for use as silage should be tested over a range of densities to determine the most productive population.

Sunflower appeared the most promising of various crops grown with corn to improve silage yield or quality, or both. Three cultivars of sunflower grew compatibly with corn and greatly increased total yield. A study of the silage quality is in progress.

## Soybeans

*Breeding.* For the 2nd yr, the Ottawa line O73-15 (proposed name: Maple Arrow) outyielded currently recommended cultivars of similar maturity in the Ontario Soybean Variety Trial for 2500–2700 heat unit areas, it has been recommended for licensing. In addition to its high yield potential, this line has improved lodging resistance, seed quality, and oil content. Yield trials of selected pure lines from Ottawa and available licensed cultivars were sent to 10 cooperating research establishments in the Prairie Provinces and Eastern Canada. A number of lines showed rather wide regional adaptability for grain yield and maturity.

The program to develop soybean cultivars of very early maturity was considerably expanded by the establishment of a breeding nursery and yield trials at Brandon, Man. In addition to numerous single-plant selections, a number of advanced lines were identified that possessed the yield potential and plant height of the cultivar Altona, but matured 1 to 2 wk earlier.

The whole collection of available germ plasm with early maturity was grown at Ottawa from two dates of planting. Strains unaffected by planting date and those that matured very early, did not shatter, or bore their pods well off the ground were identified.

*Agronomy.* Cultural experiments showed that in 1975 soybean yields were not affected

by kinds or rates of bacterial inoculant, rates of nitrogen application, or seed size. Yields were consequently greater at a row width of 45 cm than at the standard row spacing of 90 cm.

### Pathology

In tests dealing with temperature for the growth of *Phytophthora megasperma* Drechsl., it was found that optimum temperature is 25°C for the fungus on solid pea media, and 20–22°C for mycelial mats in liquid pea broth. Both media supported little or no growth at 5° and 35°C.

Screening tests for resistance of alfalfa to *Phytophthora* root rot were carried out under controlled conditions. The most resistant cultivars tested thus far were WL-318, Thor, and Saranac-AR; Maris Phoenix, Saranac, and Algonquin were the most susceptible. Disease-resistant plants from the cultivars screened were repotted for further study, along with additional cultivars for screening.

Soil temperature experiments were carried out at constant temperatures of 5°, 10°, 15°, 20°, and 25°C. Low temperatures of 5° and 10°C appeared to favor the disease more than the high temperatures, with least disease at 25°C. The dry weight per plant of diseased plants was much lower than that of the healthy plants at the same temperature.

Various replacement solutions were tested to find a method of producing abundant zoospores; it was determined that a 1:1 soil extract made with distilled water and a 1:1 soil extract made with deionized water gave the highest zoospore production. It was also shown that sterilization greatly reduced the number of zoospores produced in all the replacement solutions tested. The most suitable environmental factors such as the medium, temperature, and specific period of time for the best production of zoospores were determined. With this information, an important aspect of root rot of alfalfa, the chemotaxis of *P. megasperma* zoospores toward the primary roots of alfalfa, is being reinvestigated.

### Introductions

Promising introductions identified in small-plot trials in 1975 were a *Medicago falcata* L. from Germany, a *M. × varia* Martyn from Bulgaria, and a *M. sativa* L. from Hungary; all outyielded the controls, Iroquois and Saranac, in the first cut. A

previously untested species, *M. glomerata* Balkin, from France gave higher yields than the above controls. A tall, vigorous, and palatable milkvetch, *Astragalus glycyphyllos* L., from Czechoslovakia considerably outyielded the alfalfa controls in forage production. Two introductions of timothy, *Phleum pratense* L., from the Netherlands and England, outyielded the control, Champ; an orchardgrass, *Dactylis glomerata* L., from the USSR gave a higher forage yield than the control, Kay, and a brome grass, *Bromus inermis* Leyss., from Czechoslovakia and one from Hungary gave higher forage yields than the control, Redpatch. A previously untested species, *B. carinatus* Hooker & Arnott, from England compared favorably with the orchardgrass controls in forage production and could prove to be of value as a grass for hay and late pasture.

An increase block of a new introduction of cicer milkvetch, *A. cicer* L., yielded 370 kg/ha of Breeder seed.

During a survey of old meadows in eastern Ontario, 190 alfalfa ecotypes were collected during the season for the alfalfa breeding program at Ottawa.

## HORTICULTURAL CROPS

### Potatoes

*Breeding and testing.* In 1975, the temporary licenses of the potato cultivars Onaway and Abnaki were renewed for a 2nd and 3rd yr respectively. Fredericton-bred early potato seedling F.61025 will be recommended for licensing by the Ontario and Atlantic Regional committees as the cultivar Alma. In addition, the Fredericton-bred maincrop potato seedling F61051 will also be recommended for licensing by the Ontario Committee as the cultivar Nipigon. It is especially well adapted to northwestern Ontario. Guelph-bred potato seedling G.6549-7 is being increased from virus-free stock for possible release in 1977. It is medium-early and is rated very good in both table and processing quality. Some progeny of true seeds from crosses made at the University of Guelph are reported to be quite adaptable to conditions at the Asian Vegetable Research and Development Center in Taiwan.



## PLANT GENE RESOURCES

### Information

Descriptions for almost 1500 stocks of barley, tomato, and alfalfa have been obtained to date. Computer listings containing the information obtained on the stocks described will be available in early 1976.

### Conservation

Over 7400 stocks are stored at present under controlled temperature and humidity. They represent accessions from the Canadian wild oat gene pool, CN accessions already described by plant breeders, plant gene resources accessions introduced from other countries, and Canadian cultivars (old and new).

### Exchanges

The Plant Gene Resources Office is increasingly regarded as the national agency for conducting exchanges of germ plasm (seed and other plant parts). In 1975, it handled for the Research Branch large exchanges of material with the USSR and with the People's Republic of China. It obtained genetic material for individuals at Agriculture Canada research stations and at other institutions.

## EXPERIMENTAL FARM, KAPUSKASING, ONT.

### Effects of Soil Amendments on Barley and Mixed Forage

*Keystone barley.* In the 1st yr of experiment, grain yield of barley increased significantly with applications of N up to 120 kg/ha, but applications of various forms of manure and wood by-products had no effect. In the 2nd yr, an interaction between effects of N and manure indicated that at the restricted level of N, good grain yields were obtained from the pure manure treatments without wood by-products. However, with the maximum N level (160 kg/ha), grain yields were similar except for those from the pure shaving treatment, which were lower. Maturity was delayed up to 5 days when no N was applied.

*Mixture of timothy and reed canarygrass.* In the 1st yr, there was no effect of manure or wood by-products on dry matter (DM) yields; however, there was a significant effect

of N up to 180 kg/ha. In 1975, an interaction of N and manure showed that when liquid manure was used, optimum DM yields were obtained with N at 60 kg/ha, whereas when the pure semi-solid manure or no manure was applied, N was required at 120 kg/ha for optimum yields; with semi-solid manure mixed with shavings or sawdust, N was needed at 180 kg/ha; and with pure shavings N was needed at 240 kg/ha. At these levels all DM yields were similar. Soil bulk density and compaction (measured with a penetrometer) were not significantly affected by any of the treatments.

## EXPERIMENTAL FARM, THUNDER BAY, ONT.

### Forage Management

*Comparison of species sown singly and in mixture for hay.* On sandy loam soils containing adequate levels of P and K, grass species can significantly increase their seasonal productivity when fertilized with N at 84 kg/ha in the early spring and after the first hay cut. Thus, under a two-cut harvest system, yields of Saratoga brome grass, Rise reed canarygrass, and Fawn tall fescue were increased by approximately 28%. Saratoga brome grass and Rise reed canarygrass excelled as early pasture, producing on the average one-third more forage than Fawn tall fescue by mid-June. Saratoga brome grass was superior in aftermath yield, followed by Rise reed canarygrass and, lastly, Fawn tall fescue. Species differed significantly in total productivity for the season; Saratoga brome grass yielded 6908 kg/ha, compared with 6371 kg/ha for Rise reed canarygrass, and 4506 kg/ha for Fawn tall fescue. When Saratoga brome grass or Rise reed canarygrass were blended with birdsfoot trefoil and treated with identical inputs of N, total seasonal productivity failed to increase. Higher DM yields were obtained from Fawn tall fescue grown in mixture with trefoil.

*Control of grasses in establishment of alfalfa and trefoil.* Application of granular dalapon broadcast at rates of 2.24, 4.48, and 6.72 kg/ha on volunteer reed canarygrass averaging 12.7 cm in height failed to provide acceptable control of the grass in new stands of alfalfa and trefoil. By contrast, dalapon as a wettable powder sprayed on actively growing plants at rates of 4.48, 9.69, and 13.45

kg/ha provided good control. The grass population was reduced proportionally, with a maximum of 90% control recorded at the high rate of application. Paraquat at 0.56 and 1.12 kg/ha, applied in early September, gave satisfactory control of grass the following year; however, it also suppressed the growth of legumes by 35% early in the growing season.

## Horticultural Crops

*Potato evaluation.* F.61051, a medium-maturing and vigorously growing seedling bred and selected at Fredericton, has demonstrated exceptionally high yield potential at Thunder Bay, outyielding Kennebec by an average of 13.0% over the past 3 yr of the test. Results from station and grower trials support the licensing of F.61051 in 1976.

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# Research Station

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## INTRODUCTION

On April 1, 1975, the Smithfield Experimental Farm was administratively united with this Research Station. This union facilitates integration of expertise in research on production, management, and protection of fruits and vegetables.

Progress in developing and implementing pest management programs continued. Methods for control of arthropod pests on apples, peaches, and carrots were studied. An early-warning system based on accumulated biological and weather data is under development.

All vineyards growing the cultivar de Chaunac (Seibel 9549) in the Niagara region were surveyed. Almost 20% contained vines infected with tomato ringspot virus. Severely infected vines yield 95% less than do noninfected vines.

A chemical method that permits simultaneous measurement of benomyl and its degradation product methyl-2-benzimidazole carbamate was developed. This method shows that benomyl degrades at different rates in various solvents.

The tomato variety Quinte, developed at the Smithfield Experimental Farm, was released in 1975. It is a high-yielding, midseason variety with resistance to *Verticillium* spp. and good processing qualities.

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, Ont. L0R 2E0.

A. J. McGinnis  
Director

## PESTICIDES

### Application

*Biological relationship of droplet density.* The number of droplets of carbaryl sprayed per unit area and consequently the rate of exposure of larvae to carbaryl residues were varied, and the effects on newly hatched larvae of the oriental fruit moth were assessed in the laboratory. Newly hatched larvae traveled 0.68 mm/s and contacted droplet residues in direct proportion to droplet density, measured as number of droplets per square centimetre. They crawled at least 5 h without nourishment. When larvae were exposed continuously to droplet patterns containing carbaryl, the time required to reach a convulsive state was inversely related to droplet density and percentage area covered with droplets. On a high-density pattern, few contacts were needed to cause intoxication. With either continuous or short-term exposure, the minimum interval to the convulsive state was 20–30 min. These results indicate that a deposit of at least 35 droplets/cm<sup>2</sup> is required to prevent newly hatched larvae from invading developing peaches.

### Chemistry

*Rapid, simultaneous spectrophotometric determination of benomyl and methyl-2-benzimidazole carbamate (MBC).* Maximum absorbances of solutions containing benomyl and its degradation product MBC occur at 294 nm (*A*) and 286 nm (*B*) and can be measured with a UV spectrophotometer. Standard curves relating the ratio *A/B* to the percentage of intact benomyl remaining in solution are first established for various solvents. With the appropriate standard curve, the ratio of benomyl to MBC in a particular solution can be determined from the absorbances at the two wave lengths. The total quantity of benomyl and MBC in the solvent solution is then determined by adding butylisocyanate, which quantitatively converts MBC to benomyl. The absorbance is again measured at 294 nm, and the quantity of benomyl present is determined from a second standard curve. Benomyl thus formed is stable for extended periods in most organic solvents except alcohols. Of the solvents tested, benomyl degraded slowest in chloroform and fastest in dioxane.



## Fungicide Residues

*Captafol residues on semidwarf apple trees.* A single application of Difolatan 4.8F (Chevron) controlled early-season apple scab adequately for 4 wk. During this period wood residues declined from just over  $125 \mu\text{g}/\text{cm}^2$  to near  $80 \mu\text{g}/\text{cm}^2$ , and cluster-leaf residues declined from  $6.4 \mu\text{g}/\text{cm}^2$  to about  $1 \mu\text{g}/\text{cm}^2$ . During the succeeding 4 wk, wood residues fell to between 27 and  $54 \mu\text{g}/\text{cm}^2$ , and young leaves acquired redistributed deposits of about  $0.1 \mu\text{g}/\text{cm}^2$ . The protection of leaves and fruit against scab during this second period was inadequate. Although captafol was redistributed by rainwater, other environmental factors appear to affect the rate of dissipation. At harvest, residues ranged from 2 to  $36 \mu\text{g}/\text{cm}^2$  on wood and up to  $0.18 \mu\text{g}/\text{cm}^2$  on leaves, but only  $0.0062 \mu\text{g}/\text{g}$  was found in whole apples, with the peel containing the highest residues.

## INSECTS AND MITES

### Ecology and Pest Management

*Pest management in apple orchards.* In 1975 four applications of either phosmet at 2.3 kg/ha or azinphos-methyl at 1 kg/ha adequately controlled most apple pests. San Jose and oystershell scales appear to be increasing in some orchards, and control measures may soon be necessary. Spring-feeding tortricid larvae and plant bugs were present, but control measures were not necessary. Populations of leafminer flies were high in most orchards, and extensive mining in the leaves was evident. Pest-monitoring techniques developed and used in orchards with standard numbers of trees were tested in a high-density orchard containing 500 dwarf trees per hectare. Generally, the management program was adequate, but modifications may be necessary to control early-season indirect pests. Total insect damage in the monitored block, which received four applications of phosmet at 2.3 kg/ha, was 1.9%; it was 1.7% in the block that received eight applications of phosmet at 1.4 kg/ha, according to the growers' schedule.

*Pest management in peach orchards.* In 1975 sprays were applied 7–10 days earlier than in 1974. Three monitored orchards that were managed with a reduced spray program in 1974 suffered damage from San Jose scale and received a dormant oil spray in 1975.

The oil spray controlled the scale problem without allowing any increase in mite populations. Not more than one acaricide application in monitored orchards was needed.

*Monitoring carrot rust fly.* The amount of pesticide used in carrot fields was again substantially reduced by monitoring adults of the carrot rust fly and timing sprays accordingly. In 1974, only one or two sprays were needed on four carrot plantings instead of the three to seven usually applied during the same period. Injury in these plots from carrot rust fly averaged 3.8%. In 1975, after monitoring four commercial plantings of 1.6–4 ha, not more than three sprays were applied and less than 2.5% (trace to light) injury occurred. By using suitable monitoring techniques, personnel from the University of Guelph controlled foliar diseases in these same plantings with a significantly reduced number of fungicide applications.

*Computerized warning system for pest management.* Weather conditions and data on insects trapped in neglected and commercial orchards in Ontario were transmitted by Telex to a central computer at the Research Station, Vineland Station. Summaries were provided twice weekly throughout the growing season to scientists and extension horticulturists in the Vineland, Georgian Bay, and Simcoe areas. The information was used to base decisions on need for pesticide application. From the data currently in the bank, predictive models that permit advance warning of problem populations are being developed.

*Effect of pesticides and timing of sprays on predacious mites.* The sprays tested were similar to those that the pest management program for apples in Ontario recommends for controlling "special" pests. In the test orchard phytoseiid mites, mainly *Amblyseius fallacis* (Garman), and the stimaeid *Zetzellia mali* (Ewing) were abundant, whereas phytophagous mites such as the European red mite, *Panonychus ulmi* (Koch), were scarce. Difolatan applied April 28, 2% dormant oil applied May 5, dodine applied May 30, and a prebloom spray of azinphos-methyl applied May 30 were generally nontoxic to both predator species. When applied as calyx sprays on May 28, azinphos-methyl, phosmet, and diazinon were least toxic to phytoseiids. Tetrachlorvinphos, phosalone, and especially dimethoate were most toxic. In



contrast, all these compounds were relatively nontoxic to *Zetzellia* spp. Phosalone applied at second cover (June 18), and diazinon and endosulfan applied at third cover (July 11) killed many phytoseiids. Endosulfan was also toxic to *Zetzellia* spp. Despite high kills of phytoseiids with some treatments, predator-to-prey ratios were favorable for biological control, and peak numbers of pest mites were less than 0.2 mobile stage per leaf with all treatments.

### Chemical Control

*Evaluation of new acaricides.* Eight new acaricides provided excellent to satisfactory control of the European red mite under both laboratory and field conditions. In order of effectiveness they were: Vendex (Shell), PP199 (Chipman), R28627 (Stauffer), AC85258 (Cyanamid), ZR856 (Zoecon), benzoximate (Citrazon; Ciba-Geigy), GC5126 (Gulf Oil), and TF5081 (Chipman). In laboratory tests, Vendex, R28627, PP199, and benzoximate were relatively nontoxic to the predator *Amblyseius fallacis*.

## NEMATODES

### Host-Parasite Relationships

*Effect of temperature and soil moisture on severity of damage from root-lesion nematode.* Controlled experiments showed that plants of flue-cured tobacco, cultivar Virginia 115, infested with *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. required less moisture each day than uninfested plants. Nematodes decreased plant growth 60% on Vineland loam whether moisture was kept low or high and on Fox sand when moisture was kept high; growth was decreased only 37% on Fox sand when moisture was kept low. Plants were also grown in infested and uninfested Fox loamy sand when moisture was maintained near field capacity. Growth of infested plants was reduced 36% at 13°C but only 12% at 23°C. These results confirm the general field observation that *P. penetrans* causes more damage to flue-cured tobacco when springs are cool and wet than when they are warmer and drier.

*Histology and histochemistry of root-lesion development.* Some discoloration of feeder and secondary roots of alfalfa, red clover, and birdsfoot trefoil occurred within 48 h of inoculation with *P. penetrans*; after 4 wk the

epidermis, cortical parenchyma, and endodermis were extensively discolored. Histochemical tests indicated that a cyanogenic glycoside and certain polyphenols and aldehydes were present in lesioned alfalfa roots.

*Oat-cyst nematode.* A Kitchener-Waterloo population of the oat-cyst nematode (OCN), *Heterodera avenae* Wr., was identified as pathotype C by using the differential group of 24 cereal varieties designated by the European OCN group. Currently, 19 pathotypes of OCN have been identified internationally, but C is the one most common in Europe, Great Britain, and Scandinavia. It is also the one for which sources of resistance are known in both barley and oats in Europe.

*Population densities and crop response.* Barley and tobacco seedlings were grown in the laboratory in soil inoculated with *P. penetrans* in 13 densities ranging from 0 to 400 nematodes per gram of soil. For barley, up to 3 nematodes per gram of soil caused no loss of growth, and this density represents its tolerance limit. Regardless of nematode numbers, yield was not decreased below 50%. The shoot-to-root ratio remained constant at 1 for up to 50 nematodes per gram of soil but increased to 2.5 at 400/g. The results also indicated that tolerance of barley for *P. penetrans* increases with age. For tobacco, the tolerance limit was 0.2–0.3/g for all seedlings regardless of age. The minimum yield, however, was tenfold greater when seedlings were 3–5 wk old at inoculation than when they were 1 wk old.

*Effects of nematocides on relative populations in soil and root.* Most of the *P. penetrans* associated with flue-cured tobacco were in the soil during the first half of the growing season. By mid-August at least 50% of the nematodes were in the roots, but they moved back to the soil toward the end of the season when roots became senescent. This pattern was altered, however, when nematocides were used. The systemic nematocide oxamyl, *S*-methyl-1-(dimethylcarbamoyl)-*N*-[(methylcarbamoyl)oxy]thioformimidate, prevented buildup of the population in the roots. The fumigant nematocide Telone (Dow; 1,3-dichloropropene and related chlorinated hydrocarbons) had little effect on the overall ratio between the soil and root phases of the population during the growing season,



whereas Vorlex (Morton; 80% 1,3-dichloropropene and related chlorinated hydrocarbons and 20% methylisothiocyanate) prevented normal buildup in the roots during the second half of the growing season. Total numbers of root-lesion nematodes in the roots rather than population densities, in conjunction with soil population densities, provide a good measure of nematocide efficacy. These measurements are also good indicators of nematode response to different types of nematocides and provide information on the general action of nematocides. The results indicate that removing infested roots from the field after harvest is of little value as a control measure because by then most nematodes have already returned to the soil.

## PLANT DISEASES

### Fruit Virology

*Tomato ringspot virus.* Strains of tomato ringspot virus isolated from peach, apricot, and grape have components containing two nucleic acids that are separable by equilibrium centrifugation in CsCl. Preliminary results indicate that both nucleic acids are required to initiate infection. The nucleic acids of the apricot and peach isolates are separable by polyacrylamide-gel electrophoresis, but the nucleic acids of the grape isolates are not readily separable unless treated with formamide. Estimated molecular weight of the nucleic acids from a peach isolate was 2.5 daltons, and that from a grape isolate was 2.6 daltons, as determined by polyacrylamide-gel electrophoresis. Digests of these isolates contained a single protein with a molecular weight estimated at 61 000.

*Superior fruit stock program.* The repository for virus-tested material now contains 299 selections of fruit trees. Cultivars and rootstocks of most commercially important *Malus* and *Prunus* lines and some ornamentals are included. Of these, 131 have been indexed on five or more indicators, and 64 have been confirmed true-to-name. Also included in the program are 38 raspberry and 39 strawberry cultivars.

*Virus diseases of grapes.* A survey of all vineyards growing the cultivar de Chaunac (Seibel 9549) in the Niagara Peninsula (644 ha; 1591 ac) showed that 19.5% of them were infected by tomato ringspot virus

(TomRSV). The number of infected vines in each vineyard varied from 1 to 200. Yield of severely infected vines is reduced by as much as 95%. Tobacco ringspot virus (TobRSV) alone or with TomRSV was also detected in some infected vines. Cultivars de Chaunac and Chelois (Seibel 16878) were the most susceptible to TomRSV of 32 cultivars tested. TomRSV, TobRSV, or both were isolated from all samples of roots and leaves of dandelion, *Taraxacum officinale* Weber, taken near infected vines.

The undescribed virus isolated from the grape cultivar Joannes-Seyve 26-205 was separated by centrifugation into three components with sedimentation values ( $s_{20w}$ ) of 50 S, 88 S, and 112 S. Analysis of RNA preparations by polyacrylamide-gel electrophoresis revealed two predominant RNA species. Equilibrium density-gradient centrifugation in CsCl showed that the smaller RNA (RNA-2) is only present in the 88 S component, and the larger one (RNA-1) only in the 112 S component. Preparations of RNA-1 and RNA-2 were either not infectious or produced very small numbers of lesions on *Chenopodium quinoa* Willd. Mixtures of RNA-1 and RNA-2, however, were highly infectious.

### Fruit Mycology

*Injury to peach trees from salt.* Severe dieback of peach trees in winter along a heavily traveled highway was associated with frequent application of sodium chloride as a deicing agent. Similar injury and comparable sodium residues in dead shoots were induced experimentally by dipping dormant peach shoots into NaCl solutions greater than 1.5 M and then incubating the shoots at 1°C and 95% relative humidity for 3 days. The two species of *Leucostoma* that cause peach canker were commonly associated with injured shoots. Salt injury predisposes the tissue to infection by *Leucostoma* spp.; once trees are infected, the normal consequences of canker incidence, decreased yield, and shorter lifespan occur.

### Vegetable Virology

*Flexuous, rod-shaped virus isolated from carrots.* Particle length, general properties, and vector relationships suggest that the virus isolated from field-grown carrots, *Daucus carota* L. var. *sativa*, with premature leaf chlorosis and spotting is a member of the



potato Y virus group. It appears to be distinct, however, from local isolates of celery mosaic virus and a British isolate of parsnip mosaic virus. At harvest, carrots inoculated as seedlings with this virus weighed approximately 30% less than did those that were not inoculated.

### Vegetable Mycology

*Spinach root rot.* *Fusarium oxysporum* Schlecht. isolated from spinach, *Spinacia oleracea* L., caused root rot and was highly pathogenic to spinach seeded between June 1 and August 15. The *Fusarium* population was high in the top 10 cm of soils that had grown spinach continuously for many years. It was not recovered from these same soils at a depth of 40 cm. All commercially available cultivars tested in 1975 were susceptible to this organism except Harris Hybrid 621, which showed some tolerance.

## EXPERIMENTAL FARM, SMITHFIELD, ONT.

### Fruits

*Evaluation of apples for cider.* Scab-resistant cultivars and selections were tested for properties important in cider production. These apples contained 0.4–0.8% acid, 0.04–0.08% tannin, and 9.0–12.0% soluble solids, intermediate values that are similar to those for McIntosh. The general quality of cider made from these cultivars was acceptable. It had mild flavor, low to medium “sharpness,” and pale or light-yellow color.

*Effects of herbicides in mature orchards.* Five annual applications of simazine at 4.4 kg/ha, terbacil at 4.4 kg/ha, or dichlobenil at 8.8 kg/ha completely controlled undergrowth and increased terminal growth and trunk circumference. Cumulative yields with the three herbicides increased by 33, 28, and 18%, respectively. Analysis of foliage where herbicides were used showed that nitrogen, phosphorus, and magnesium levels increased and potassium levels decreased.

*Ethephon residue in McIntosh apples.* Ethephon breakdown in McIntosh fruit during storage was measured by gas chromatography. Ethephon disappeared at the same rate whether the apples had been stored at room temperature or at 1°C, or had just been harvested from the tree. Breakdown was rapid for the first 17 days but decreased to a

much slower rate after 30 days. Lack of color response under cool conditions in the orchard, therefore, is not caused by depressed breakdown of ethephon.

*Aid for apple harvesting and pruning.* Efficiency of harvesting and pruning a hedge-row orchard was increased considerably with a platform designed by the Engineering Research Service. Using the platform to harvest a hedge 4.3 m high, one man can pick 164 kg of apples an hour compared with 115 kg/h when using ladders. Most efficient operation was obtained with a crew of ten: five on the platform, four on the ground, and one driving the tractor. Pruning rates were increased by 35% with the platform. The platform was used most efficiently with four pruners on the platform using hand loppers and electric circular pruning saws.

*Apple tree walls.* A mature McIntosh orchard with rows spaced 5.5 m apart in both directions was pruned to form solid hedge-rows 2.7 m wide and 4.3 m high running east-west. The proportion of fancy-grade fruit was the same on both sides of the hedge. Much of the fruit harvested from the lower half of the wall was undercolored due to shading. A June application of daminozide plus ethephon increased the proportion of fancy fruit lower on the hedge by reducing vegetation to allow better light penetration.

*Effects of insecticides on predators of apple maggot.* Crickets, earwigs, centipedes, sowbugs, and millipedes, which are effective predators of apple maggot pupae, were common in orchards kept free from insecticides and acaricides. Carabid and staphylinid beetles were also occasionally found. Populations of these predators were lower in long-abandoned or wild stands of apples, and no predators were found in orchards where insecticide had last been applied in 1969. Trees, soil cover, and spray programs could not be modified sufficiently to attract these predators in sprayed orchards.

*Artificial propagation of parasites.* Oviposition and hatching of *Itopectis conquisitor* (Say) on an artificial host are no longer problems since determining that food of parental females needs vitamin enrichment and that the encapsulated food should be at pH 6.5 with an osmotic pressure equivalent to a freezing point of -1°C. Under aseptic conditions larvae can be developed to maturity on the larval diet established previously



by using a specially developed technique for respiration and capsule ventilation. A suitable environment for pupation and emergence remains to be developed.

## Vegetables

*Tomato breeding.* The selection ST-19, released in 1975 and named Quinte, is a high-yielding, high-quality, midseason variety combining the crimson gene *og<sup>c</sup>* with resistance to *Verticillium* spp. Its juice and whole-packed product are excellent. The variety is smooth, peels easily, and has a shallow core.

The line ST-23, a high-yielding, fresh-market type, is as early as New Yorker, but its fruit are 25% larger. ST-23 contains the gene *og<sup>c</sup>*. It is free from blotch and yellow top

and has better fruit storage on the vine, better foliage cover, and less internal structure than other early varieties.

*Plant populations for cole crops.* Cauliflower crops with populations of 60 000 plants/ha matured 4 days earlier and produced more marketable heads than crops with the standard population of 30 000 plants/ha. Further increases in population markedly reduced total yields.

*Weed control in pumpkin.* On a sandy loam soil bensulide at 2.2 kg/ha applied before planting or A-820 (Amchem) at 1.1 kg/ha applied before planting plus chloramben 5.4E at 3.3 kg/ha applied before plants emerge gave excellent control of weeds for the full season. In two of nine varieties stands were reduced when bensulide was used to control weeds.

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# Animal Research Institute

## Ottawa, Ontario

### PROFESSIONAL STAFF

#### Administration

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D. A. LEGER, B.Sc.	A/Assistant to the Director
D. B. SNYDER, B.Sc.	A/Resources Advisor
G. B. MATTHEWS	Chief, Administration and Resources
G. T. SPURR, B.A.	Administrative Officer, Accounts
M. W. MOSLEY (Mrs.)	A/Administrative Officer, Personnel

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K. G. HILSON, <sup>1</sup> B.Sc., M.Sc.	Computer programming
G. P. KAVANAGH	Systems and programming
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G. A. LODGE,<sup>7</sup> B.Sc., Ph.D.

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Protein synthesis

## **Poultry Breeding Program**

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Biochemical genetics

K. G. HOLLANDS, B.A., B.S.A., M.S.A.

Biochemical genetics

W. E. LENTZ, B.Sc., M.Sc., Ph.D.

Statistical genetics

## **Poultry Nutrition Program**

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J. D. CIPERA, Ing., M.S.A., Ph.D.	Eggshell formation
R. M. G. HAMILTON, B.Sc., M.Sc., Ph.D.	Eggshell formation and quality

## **Reproductive Physiology**

L. AINSWORTH, B.Sc., M.Sc., Ph.D.	Program Chairman; Steroid hormones and reproduction
A. J. HACKETT, D.V.M., M.Sc., Ph.D.	Reproductive and light physiology
W. G. HUNSAKER, B.S.A., M.S.A., Ph.D.	Environmental and light physiology
G. A. LANGFORD, <sup>8</sup> B.Sc., M.Sc., Ph.D.	Male reproductive physiology
G. J. MARCUS, <sup>9</sup> B.A., Ph.D.	Developmental physiology: ovary, embryo, uterus
H. A. ROBERTSON, B.Sc., Ph.D., C. Chem., F.R.I.C., F.R.S.E.	Hormones and reproduction
C. P. W. TSANG, B.Sc., M.Sc., Ph.D.	Metabolism and assay of steroid hormones
F. A. VANDENHEUVEL, B.Sc., M.Sc., Ph.D., D.I.C., F.C.I.C.	Identification and assay of steroid metabolites

## **Pesticide Residues Program**

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M. H. AKHTAR, <sup>6</sup> B.Sc., M.Sc., Ph.D.	Pesticide synthesis and analyses

## **Pollution Program**

N. K. PATNI, B.Ch.E., M.S., Ph.D.	Program Chairman; Waste utilization and pollution abatement
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## **Departure**

K. J. JENKINS, B.Sc., M.Sc., Ph.D. Transferred to Environmental Management Service, Environment Canada, Ottawa, February 1975	Program Chairman, trace mineral nutrition program; Trace mineral metabolism
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## VISITING SCIENTISTS

L. J. KOŁODZIEJ, M.Sc. (Agr.), D. Agr. Cent. Inst. Poultry Res. Dev. Poznan, Poland	Poultry breeding, geese
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*DeKalb AgResearch Inc. postdoctorate fellow*

A. J. McALLISTER, B.Sc., M.S., Ph.D.	Quantitative genetics and animal breeding
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*National Research Council postdoctorate fellows*

R. S. BUSH, B.S.A., M.Sc., Ph.D., 1974-76	Rumen microbiology and metabolism
J. P. CHESNAIS, B.Sc., M.S., Ph.D., 1974-76	Dairy cattle breeding, statistical genetics
J. N. B. SHRESTHA, B.V.Sc. & A.H., M.S., Ph.D., 1975-76	Quantitative sheep genetics

*Graduate student*

J. A. CARNEGIE, B.Sc.	Reproductive physiology
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<sup>1</sup>Seconded from Data Processing Division, Finance and Administration Branch.

<sup>2</sup>Seconded from Departmental Library, Finance and Administration Branch.

<sup>3</sup>On transfer of work at North Carolina State University, Raleigh, N.C., July 1974 to July 1975.

<sup>4</sup>Appointed June 1975.

<sup>5</sup>Appointed March 1975.

<sup>6</sup>Appointed July 1975.

<sup>7</sup>On transfer of work at Meat Research Institute, Agricultural Research Council, Langford, Bristol, England, July 1975 to July 1976.

<sup>8</sup>Appointed January 1975.

<sup>9</sup>Appointed February 1975.

## INTRODUCTION

Dr. Ed Lister was appointed to the position of Deputy Director, to assist the Director in developing and coordinating the research programs of the Institute. Dr. Frantz Vandenheuvel was honored by the Ottawa Biological and Biochemical Society for his contribution to lipid chemistry.

During the year, the development of some of the multidisciplinary research program teams was completed when six scientists joined the professional staff. Experimental work has thus been strengthened and diversified in some areas. In reproductive physiology, work on the collection, maturation, and fertilization of ovarian oocytes has started with a view to the collection and storage of embryos for transplantation. The reproductive physiology group also began studies into male reproductive physiology, including problems of long-term storage of sheep spermatozoa to permit wider use of artificial insemination in that species. The magnesium status of lactating dairy cows fed various roughage mixtures is being investigated as part of the dairy cattle nutrition program, which has been broadened to include macrominerals. Scientists working on pesticide residues in animal tissues commenced studies on organophosphorus insecticides, attempting to establish the metabolic pathways of the insecticides in livestock. Trace mineral nutritionists started experiments on the value of chelating agents and chelated trace minerals to improve the economics of supplementation with trace minerals.

On September 11, 1975, the Chinese ambassador to Canada, members of the ambassadorial staff, and a senior delegation from the Republic of China visited the Institute's specialized facilities for animal research at the Greenbelt Farm.

This chapter of the Research Branch Report records only the highlights of our accomplishments in 1975; more detailed information can be obtained from the publications listed at the end of the report. Reprints of the research publications and copies of this report are available on request from Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe  
Director

### RAPESEED OIL NUTRITION

#### Cardiopathogenicity in Pigs Fed Diets Containing Rapeseed Oils

Two separate feeding experiments with Yorkshire boars compared the incidence of myocardial lesions from diets containing corn and soybean oils to those containing rapeseed oils low (1%) and high (22–24%) in erucic acid (EA). In the first experiment, conducted for 16 wk, the incidence of myocardial lesions from all dietary treatments was low, but in the second experiment, which lasted 24 wk, it was higher. Contrary to results from experiments with rats, rapeseed oil did not significantly ( $P < 0.05$ ) increase the incidence of myocardial lesions in the boars.

Analyses of cardiac fat from boars fed diets containing 20% by weight of either corn oil or rapeseed oil (23% EA) for 8 wk showed that only small amounts of EA

accumulate compared with amounts observed in rats fed the same rapeseed oil. The relative concentration of the other fatty acids was also influenced by diet, but to a lesser degree in pigs than in rats.

#### Nutritional and Pathological Effects of Rapeseed Oils on Rats

It was established that feeding rapeseed oil (23% EA) for up to 4 wk to 6-wk-old male rats maintained at 4°C does not cause mortality. Mortality had been reported previously by other investigators, and attributed to high lipidosis in the rats fed rapeseed oil. In this study, pronounced lipidosis was observed but without mortality.

Previous studies have demonstrated that the triglycerides of rapeseed oil are cardiopathogenic. To eliminate the possibility that EA alone may be responsible for the lesion-producing properties of these oils, the following diets were tested: lard, lard to which 5.6%



free EA was added, lard containing 5.6% EA (lard rendered from the back and belly fat of pigs fed a high EA rapeseed oil), and Span rapeseed oil (4.8% EA). In three separate experiments, only Span rapeseed oil increased the incidence of myocardial lesions. It was concluded that EA per se at a level of 5% was not cardiopathogenic.

A large number of feeding experiments were carried out to test for myocardial lesions in male rats, using the same oils and experimental conditions and large numbers of animals per diet. This made it possible to conduct a detailed statistical study, which will assist other investigators in the design and interpretation of similar experiments.

## DAIRY CATTLE BREEDING

### Evaluation of Selection and Crossbreeding

Two pure lines of dairy cattle are being established, one Holstein (H) and the other synthetic (A), consisting mainly of Canadian Ayrshire genes with the addition of Brown Swiss, Norwegian Red, and Finnish Ayrshire genes. A crossbred line (C) from the two pure lines is being developed to evaluate heterosis on the basis of protein production, longevity, and reproductive performance. Research Branch establishments at Lethbridge, Alta., Charlottetown, P.E.I., Lennoxville, Que., and Normandin, Que., are cooperating in the project. The inventory at all five stations at the end of 1975 showed 514 H, 332 A, and 7 C mature females; 389 H, 262 A, and 97 C young stock; and 36 H, 33 A, and 17 C bulls.

### Pilot Selection with Mice

Selection has been continued for 11 generations in each of two populations of mice (P and Q) that had different origins. Selection is based on the nursing ability of the mother (*m*) in one line (M), the mature weight of the offspring (*w*) in a second line (W), and performance (combination of the two traits) in a third line (B). An unselected control line has been maintained in each population. The selected lines continued to show genetic gains in *m* as measured by 42-day weight. Relative to the performance of the control line, the genetic gains for *m* in lines M, W, and B increased from 6 to 11%, 15 to 18%, and 6 to 12% respectively, and gains for *w* increased from 5 to 10%, 33 to 35%, and 28 to 29%. Performance of crosses from these lines will

be examined to test genetic hypotheses fundamental to the current crossbreeding experiment in dairy cattle.

## DAIRY CATTLE NUTRITION

### Alfalfa Silage for Lactating Dairy Cows

Alfalfa, cut at the bud stage and treated with formic acid at approximately 4 kg/t wet weight, was ensiled in tower silos either with, or without, corn and cob meal at 30% on a dry weight basis. Three groups of five cows each were used in a changeover experiment to test feed intake and milk and milk fat production from cows fed various rations ad lib. The dietary treatments were (1) ensiled alfalfa and corn and cob meal; (2) ensiled alfalfa with 30% corn and cob meal added at feeding time; and (3) mixed roughage consisting of corn silage, wilted grass silage, and hay with a 22% protein dairy concentrate fed at the rate of 1 kg/4 kg milk production. During treatments 1 and 2, cows were fed the necessary vitamins and minerals mixed with 1 kg of ground corn. Each ration was fed to each group of cows for 42 days, with a 7-day changeover period between treatments.

No significant differences were noted in daily dry matter intake (15.5, 16.6, and 15.0 kg/day for treatments 1, 2, and 3, respectively), milk yield (18.4, 18.7, and 17.8 kg/day), milk fat content (3.6, 3.4, and 3.6%), or daily milk fat yield (654, 641, and 648 g). Feed conversion to milk and milk fat appeared to be more efficient during treatment 1 than during treatment 2 (0.84 vs. 0.89 kg feed/kg milk, and 23.7 vs. 25.9 g feed/g milk fat), which is in agreement with previously published reports on ensiled complete feeds. Although feed intake and milk production were lower during treatment 3, the efficiency of feed conversion to milk and milk fat was quite similar to that from treatment 1 (0.84 kg feed/kg milk and 21.6 g feed/g milk fat).

The experiment indicates that ensiled feed mixtures may be successfully fed to lactating dairy cows, and that performance on a fairly simple ration based on alfalfa silage and corn and cob meal can be as good as that obtained on a more complex one that uses a roughage mixture and expensive dairy concentrate.

### Fababean as a Protein Source

The fababean (*Vicia faba*) cultivar Ackerperle was grown for 2 yr consecutively, to evaluate its potential as a supplemental



source of high-protein forage for dairy cattle. Problems were encountered with the crop, mainly because of poor growth and weed encroachment. In the 1st yr, less than 5 t/ha of dry matter were harvested and in the 2nd yr, less than half that amount. The crop was harvested at two stages of maturity and ensiled. The forage ensiled when the pods were full contained 17.9% protein and the later-cut forage contained only 14.7%. When fababeans were fed as the only source of forage, milk production was 17.9 kg/day, and it increased to 18.8 kg/day when corn silage made up half of the forage dry matter. Corresponding forage intakes were 9.7 and 10.0 kg/day. The stage of maturity at harvest did not significantly affect either intake or milk production.

The problems found in growing the crop and the fact that it was not a particularly good source of protein or energy led to the conclusion that this plant is a poor choice as a forage crop in eastern Ontario.

### **Performance of Dairy Cattle Fed Urea**

Fifteen cows were fed a 29.4% protein concentrate for 4 wk and then received concentrates containing 9.8% protein (no urea), 18.6% protein (2.6% urea), or 26.7% protein (5.2% urea). Feeding urea caused elevated rumen ammonia levels but did not affect rumen volatile fatty acids. Rumen bacterial urease and DNA decreased during the course of the experiment. Plasma urea levels decreased in all groups but remained highest in the urea-fed cows. Plasma amino acid concentrations decreased for lysine, isoleucine, histidine, and valine but concentrations of all other amino acids remained unchanged.

Milk production decreased most rapidly in cows fed the concentrate highest in urea, but these animals produced a higher percentage of milk protein. Total milk protein yield was similar for all three groups. Concentrate intake was lowest for the cows fed the high urea level but their silage intake was highest. Total nitrogen intake was greatest for the urea-fed group; however, nitrogen excretion exceeded intake in cows on the low-protein diet but intake exceeded excretion in those on urea-containing diets. All animals lost body weight during the first 5 wk on experiment. It was concluded that urea feeding under these conditions was of no benefit to lactating cows.

### **Double-low Rapeseed Meal Fed to Lactating Dairy Cows**

One of the varieties of low erucic acid – low glucosinolate rapeseed meal (RSM) was tested at levels of 0, 11, 22, and 34% in a dairy concentrate, replacing soybean meal. Palatability, dry matter digestibility, and thyroid function were not significantly affected by a level of 22% in the concentrate, but at this level both milk yield and nitrogen digestibility were reduced. Processing difficulties with this new variety of rapeseed resulted in a meal with a high residual oil content and a brown discoloration, indicative of changes in proteins and carbohydrates. The reduced nitrogen digestibility may have resulted largely from processing effects or from the high fiber content of RSM rations.

### **Metabolism of Rumen Microorganisms**

The effect of ammonia concentration on the metabolism of rumen microorganisms in continuous cultures was investigated. Rumen microorganisms were obtained from a lactating cow fed a ration composed of 30% each of cellulose, cerulose, and cornstarch, with about 5% urea and 6% of a complex mineral mixture. In continuous cultures fed the same diet, ammonia was provided as  $\text{NH}_4\text{Cl}$ .

When ammonia concentration was decreased to less than 0.5 mM, glutamine synthetase activity was induced and activity increased 10-fold. When ammonia concentration was again increased, this enzyme activity decreased. Glutamic dehydrogenase, asparagine synthetase, and glutamic-oxalacetate transaminase showed no consistent responses to changes in ammonia concentration. The amino acid concentration in culture media decreased to low levels ( $< 20$  nmol/ml) when  $\text{NH}_4^+$  decreased to 0.1 mM or less. When  $\text{NH}_4^+$  was again increased in concentration, alanine showed a 10-fold increase. The production of volatile fatty acids was not greatly changed by decreased ammonia concentration.

Separate experiments with cell-free extracts from rumen bacteria demonstrated the presence of glutamate synthase. This enzyme, in conjunction with glutamine synthetase, provides a pathway for glutamate synthesis when ammonia concentrations are low, and may be of major importance in amino acid synthesis under conditions of restricted nitrogen intake.



## BEEF CATTLE NUTRITION

### Economic Systems of Beef Production in the Northern Claybelt

Year-round confinement of Shorthorn cows and their spring-born Shorthorn × Limousin calves was compared with systems of winter confinement and summer pasture at Kapuskasing, Ont. Five groups of cows were confined during the winter. Grass silage treated with formic acid (FA) was fed to all groups at the rate of 1.7 kg dry matter/100 kg initial liveweight during pregnancy and ad lib. during lactation in confinement. During the summer, one group of cows and their calves remained confined and the dams received FA-treated grass silage ad lib. The other four groups of cows and calves were assigned to four pasture treatments. Calves from all five groups were weaned in early October.

Despite the liveweight loss attributed to the conceptus and early lactation in confinement, all groups of cows made winter gains ranging from 0.08 to 0.16 kg/head per day. During summer the average daily weight changes (ADWC) of the confined cows and their calves were -0.07 and +0.84 kg, respectively. For those on unrenovated-unrotated, unrenovated-rotated, renovated-unrotated, and renovated-rotated pasture the ADWC of cows were 0.15, 0.28, 0.07, and 0.18 kg and for their calves 0.94, 0.99, 0.92, and 0.99 kg, respectively. All groups of cows appeared to be too fat at weaning time, indicating that the winter feed allowance could be reduced. The results also indicated that calves nursing their dams on pasture made better gains than those nursing under confinement, even though pastures became infested with armyworms. Because of this, grazing animals were removed from pasture for 4 wk and fed ad lib. with FA-treated grass silage until the pastures recovered.

Confined Shorthorn × Limousin calves, weaned in the fall and full-fed with FA-treated grass silage plus barley at 0.68 kg/head per day, made an ADWC of 0.84 kg. All were marketed at 278 days after weaning and all were graded Canada A. Similar calves, wintered on ad lib. grass silage plus barley at 0.68 kg/head per day and finished on pasture plus supplemental feeding of grain at 4.5 kg/head per day during the last 21 days before marketing, made an ADWC of 0.60 kg. Marketed at 359 days after

weaning, they were graded 42.8% A, 42.8% B, and 14.4% C. Their gain and carcass grade were undoubtedly adversely affected by the severe damage to pasture by armyworms during midsummer.

### Synchronization of Estrus and Breeding of Beef Cows

Prostaglandin  $F_{2\alpha}$  tromethamine salt (30 mg) followed in 48 h by estradiol benzoate (400  $\mu$ g) was used to synchronize estrus in 92 beef cows at Kapuskasing, Ont. Forty-three animals exhibited estrus within 11 days and were bred. Of these 43 animals, 20 were pregnant to the first service, 14 to a second service, and 1 to a third service. The 49 animals that did not exhibit estrus received a second treatment 11 days later and 48 were in estrus within the next 6 days. Of these, 25 became pregnant to the first service and 11 to the second service; 13 failed to conceive. When results from both treatments are combined, 45 out of the 91 cows synchronized (49%) conceived to the first service and 71 (78%) conceived to all services. Of the 71 control animals that were not treated and were allowed to run with bulls, 56 (79%) became pregnant. The combination drug treatment for synchronizing estrus and breeding in beef cattle therefore did not adversely affect overall reproductive performance.

## TRACE MINERAL NUTRITION

### Manganese Deficiency and Reproduction

Radioactive manganese was injected intravenously into ewes fed a corn silage diet; the Graafian follicle and corpus luteum cyclic were the target cells. A higher concentration of the radioactive and stable manganese was recorded in the corpus luteum cyclic on the 11th day of the estrus cycle than on the 4th day. Levels were far lower in the immature follicle and corpus luteum spurium. Manganese therefore appears to be of physiological significance in the reproductive performance of the ewe.

### Metabolism of Vitamin E in Ruminants

Corn silage was analyzed and found to contain a higher proportion of  $\gamma$ -tocopherol than did grass silage or hay. In sheep, because of a higher rate of excretion of  $\gamma$ -tocopherol than of  $\alpha$ - or  $\beta$ -tocopherols,

animals fed corn silage were more susceptible to vitamin E deficiency, and consequently to nutritional muscular dystrophy (NMD), than those fed grass silage or hay. Calves born to dams fed a diet low in selenium and vitamin E showed a high incidence of NMD, whereas NMD was not apparent when the dams were fed a low-selenium diet that contained an optimal concentration of vitamin E.

### **Chelates**

Cows fed a grass silage diet consumed more of a mineral-vitamin supplement, offered free choice, than cows fed a hay diet. There was also a marked increase in consumption during the summer, mainly by animals offered chelated trace minerals. The hematocrit values of cows provided with either chelated or inorganic forms of trace minerals were higher than values of those that received no trace minerals.

## **SHEEP PRODUCTION**

### **Data Processing in an Accelerated Breeding Program**

A data base was designed for the multidisciplinary research program on intensive sheep production at the Institute. Superimposed experiments on new techniques in the program are conducted to maximize research efficiency and increase the productivity of sheep in a long-term selection experiment involving specialized sire and dam strains kept in confinement. Inventory control and scheduling of weighing, measuring, accelerated breeding, and management operations are routine features to be built into the sheep information processing system.

### **Controlled Breeding**

Data from breedings in May and September, 1974, and January and May, 1975, were analyzed. Fertility at first service was 38, 29, 17, and 12% in ewes synchronized for estrus and bred by artificial insemination (AI) with unextended or extended fresh semen collected by artificial vagina or electro-ejaculation, compared with 26, 32, 44, and 60% in synchronized ewes bred by natural mating. The combined fertility for both groups to all services was 40, 50, 50, and 51% respectively. Injection of pregnant mares' serum gonadotrophin, at the time of removal of vaginal

sponges impregnated with fluorogestron acetate, significantly increased prolificacy but not fertility. The dam strains produced more lambs per lambing than the sire strain. Cyclic activity was induced in ewes maintained under three different light regimens, even during the normal anestrous state. Administration of prostaglandin  $F_{2\alpha}$  or dexamethasone with or without estradiol benzoate failed to induce parturition.

Routine procedures for collecting, handling, storing, and preserving ram spermatozoa for AI are being developed. It was found possible to collect routinely three to five ejaculations of semen (2–5 ml) during 10–15 min for freezing experiments. Preliminary results indicate that the volume of ejaculate and spermatozoa concentration do not decrease significantly in 10 successive ejaculations, which suggests the feasibility of collecting large volumes from desirable superior rams. The fertilizing capacities of fresh and frozen spermatozoa from the same rams were compared at breeding time in September 1975, by inseminating groups of estrus-synchronized ewes. Of 58 ewes that received fresh spermatozoa, 45 (78%) were diagnosed pregnant, compared with 35 (52%) of 67 ewes that received frozen spermatozoa. Pregnancy diagnosis was based on the level of progesterone in plasma samples collected 18 days after breeding.

### **Intensive Rearing of Lambs**

The standard lamb milk replacer (MR) used at the Institute contains 24% fat (in the dry powder), half of which is supplied by coconut oil. When coconut oil in the MR was replaced by rapeseed oil, average daily gains (ADG) were markedly reduced (238 vs. 181 g) despite slightly greater consumption (7.29 vs. 7.32 kg MR/lamb weaned).

Lambs weaned at 21 days of age lost 0.7 kg during the 1st week after weaning, whereas lambs weaned at 28 days just maintained their weaning weight. Subsequent growth to 70 days of age was continuous and slightly greater in lambs weaned at 28 days. The overall effect of the setback and subsequent growth was that lambs weaned at 28 days averaged 1.2 kg heavier by 70 days of age.

In postweaning experiments, a ration providing 20–30% of the dietary protein in the form of urea reduced ADG by 30–40 g



during the short growing period from weaning at 21 days to the end of test (for selection purposes) at 70 days of age. Gains tended to improve slightly when hay in the diet was reduced from 20 to 8%, when soybean meal was replaced by linseed meal, and when access to the preweaning creep ration was provided with the regular diet.

## SWINE NUTRITION

### Artificial Rearing of Neonatal Piglets

To compare the ability of two immunoglobulin sources to confer passive disease immunity, immunoglobins derived from bovine or porcine serum were added to a milk replacer and fed to colostrum-deprived piglets weaned at birth and reared in a nonisolated environment. The immunoglobins were administered at two levels, 10 or 15 g/kg body weight (BW) on day 1 followed by 2 or 5 g/kg BW on days 2–10 inclusive. The 15–5 level of administration offered no advantage in terms of survival over the 10–2 level. Survival to 3 wk of age of piglets that received bovine and porcine immunoglobins was 62 and 72% respectively. Piglets that received the bovine preparation displayed a higher and more persistent incidence of scouring than those that received the porcine preparation.

### Piglet Composition

Piglet composition at birth averaged 81.7% moisture, 11.5% crude protein ( $N \times 6.25$ ), 0.8% ether extract, and 2.9% nitrogen-free extract (NFE). By 96 h of age, the percentages of moisture and NFE decreased to 75.6 and 1.9 respectively, whereas the percentages of crude protein and ether extract increased to 13.8 and 5.8 respectively. The increase in body fat (ether extract) that occurs at a time of high energy demand may indicate that the piglet has a limited ability to use sow's milk fat as a source of energy.

### Short-term Nutritional Stress during Gestation

Sows were fed either 0.45 or 2.27 kg of a gestation ration each day from day 100 of gestation to farrowing, followed by ad lib. feeding from farrowing until weaning at 5 wk. Sows that received 0.45 kg/day lost an average of 8.5 kg before farrowing and gained 3.9 kg during lactation, whereas those

on 2.27 kg/day gained 13.8 kg before farrowing and lost 10.5 kg during lactation. There were no differences between groups in total litter size, number of pigs born alive, birth weight, number of pigs weaned, or weaning weight.

### Age at Puberty in Gilts

Three levels of fat (0, 10, and 20%) and three of purified soybean protein (0, 3, and 6%) were added to a basal corn-soybean type of diet (11% crude protein) in a  $3 \times 3$  factorial experiment to determine the effect of dietary energy and protein on age at puberty. Fifty-four 4-mo-old Yorkshire gilts were individually penned and limit-fed in each of three experiments. Preliminary results from the first two experiments, with 97 gilts, showed an average age at puberty of 166 days. There appeared to be no marked dietary effects other than a slight delay of 6 days in puberal age for gilts fed diets containing 10% added fat. Increased body weights at puberty reflected the influence of increased energy and protein content in the diets, resulting in improved efficiency of feed conversion.

### Cellular Growth of Various Tissues in Swine

A study was undertaken to measure changes in cell numbers (hyperplasia) and size (hypertrophy) in various tissues of pigs from birth to an age of 50 days. Over the 50 days, total body weight increased 7- to 8-fold; weights of the brain, liver, kidney, lung, heart, and gastrocnemius muscle increased 2, 8, 4.5, 4.4, 6, and 12.5 times, respectively. Total DNA in these organs increased 2, 8, 4, 5, 5.5, and 8 times, respectively, and the ratios of protein to DNA changed from 40 to 53, 37 to 66, 12 to 21, 11 to 14, 31 to 45, and 36 to 120. Results indicated that although hyperplasia was most active up to 30 days of age, hypertrophy was active throughout the full period; its rate differed, however, between the organs examined. Growth of the brain was age-dependent but for other organs it appeared to be more closely related to total body weight.

## POULTRY NUTRITION

### Insoluble Grit

Access to insoluble grit during the stages of rearing (0–20 wk) or laying (21–72 wk), or both, had little effect on the productivity and efficiency of 10 laying-hen genotypes housed on wire floors and fed mash diets.

### Phosphorus Requirement of Laying Hens

Eleven strains or strain crosses were fed 0.40, 0.45, 0.50, or 0.55% of available phosphorus in a laying diet. After 51 wk of laying, phosphorus level had no significant effect on egg production, feed intake, or feed efficiency but had a small significant and variable effect on specific gravity of eggs. Although egg production and specific gravity differed between strains, there were no interactions between diet and strain.

### Factors Affecting Eggshell Quality

Eight strains or strain crosses reared to 20 wk on diets containing 0.85 or 0.51% calcium showed no differences in growth or serum calcium levels. Mortality was greater and the increase in serum calcium, associated with the onset of lay, occurred earlier in the birds fed the 0.51% Ca diet. During the first 30 wk of laying, birds reared on the 0.51% Ca diet had lower egg production, feed efficiency, and egg specific gravity and higher mortality when fed a 2.25% Ca laying diet than when fed 3.25% Ca. Birds reared on the 0.51% Ca diet did not differ from birds reared on 0.85% Ca when both groups received 3.25% Ca in the laying diet.

Based on the hen's natural ability to select particles of different sizes, nine strains of hens were allowed to choose the "time" of calcium intake by supplementing a 2.1% Ca laying mash diet with coarse limestone grit. All strains tended to lay eggs of higher specific gravity than control birds fed a 3.1% Ca all-mash diet in which the limestone was pulverized.

It was found that the specific gravity of eggs laid in the afternoon was higher because their shells were thicker and more massive in relation to egg size. The length of time spent in the shell gland and storage conditions of the eggs before specific gravity was measured had no effects.

## Metabolizable Energy

The apparent metabolizable energy (AME) value of a diet increased in a curvilinear manner as feed intake increased; consequently, the low palatability of certain assay diets lowered the observed AME values. This effect has complicated the development of indirect procedures for estimating available feed energy. A bioassay for true metabolizable energy (TME) was developed and tested. It is simple, rapid, and inexpensive when compared with conventional AME assays. An important advantage is that TME values do not vary with changes in feed intake. The TME values of feedstuffs measured with roosters, laying hens, broiler hens, and turkeys exhibit only slight differences. Equations were developed to predict the TME value of barley from the crude fiber content or bulk density.

### Growth Restriction of Broiler Breeder Stock

Two strains of meat-type pullets were raised from 6 to 20 wk on whole wheat or a 1:1 mixture of whole rye and wheat, fed free choice and supplemented with vitamins and minerals in the drinking water and calcium phosphate free choice. Pullets ate less feed and had lower body weights at 20 wk than control birds fed Ottawa chick grower ration on a skip-a-day regime. Mortality was higher among grain-fed birds, being highest for those fed wheat. Sexual maturity (days to 50% production) was 4 and 10 days later in pullets fed wheat or wheat and rye than in those under the skip-a-day regime.

Three experiments were conducted to assess the feasibility of depressing voluntary feed intake by the use of feed additives. Glycine at levels up to 30 g/kg of diet depressed feed intake to as low as 81% of the control level; the effect was greatest at 0–2 wk but was not significant at 4–8 wk of age. A series of sulfate salts was assayed for toxicity and for effect on voluntary feed intake of chicks 2–4 wk old; feed intake was negatively correlated with dietary levels of ammonium, potassium, or sodium sulfates but was not substantially reduced by calcium or magnesium sulfates up to the highest level, 50 g sulfate/kg diet.

Meat-type pullets were fed a diet with a low sodium content (90 ppm) from 20 to 28 wk of age, to delay sexual maturity. Egg production reached 35% before declining to



5% as birds lost body weight. This response was different from that reported by others for White Leghorn pullets.

### Biological Availability of Amino Acids

A bioassay with chicks was developed to estimate the available lysine in cereal grains. The available lysine of 13 cultivars of Canadian wheat ranged within 30% of the mean value of 3.1 mg/g.

## POULTRY BREEDING

### Genetic Resistance to Marek's Disease

Effectiveness of cell-associated (C-HVT) and lyophilized (L-HVT) turkey herpesvirus vaccines against Marek's disease (MD) was compared in nine strains of Leghorns (a total of more than 11 000 females). Mortality in six strains that had been under selection for high egg production and related traits was low throughout the observation period (273 days), and there were no significant differences between mortality of groups vaccinated with C-HVT and L-HVT. However, in two out of the three unselected control strains tested, C-HVT protected the birds better than L-HVT.

The response of chickens to challenge with the MD tumor transplant JMV was further studied, in cooperation with the Animal Diseases Research Institute. The number of cells of the low chicken passage tumor transplant JMV-L that would kill 50% of a challenged population of day-old chicks ( $LD_{50}$ ) ranged from approximately 10 000 cells for Ottawa Strain 4 to 50 cells for Cornell Strain S; it was not affected by the presence of maternal antibody against MD. Resistance to JMV-L increased greatly as the chickens grew older. By comparison, the high chicken passage tumor transplant JMV-H was highly lethal to day-old chicks of all four strains tested and estimates of  $LD_{50}$  were less than 20 cells. In cooperation with the University of Alberta, the involvement of the *B* blood group system in resistance to MD was investigated. The results strongly indicated the association of allele  $B^{21}$  with resistance to MD, but also suggested that additional mechanisms of resistance to the disease must exist.

### Egg Composition

Genetics of egg composition was studied in collaboration with the University of Guelph. Heritability estimates for egg composition traits such as the weight or percentage solids of yolk or albumen were high, and no antagonistic genetic relationships were found between weight and quality traits of egg components. Selection for high egg production and large egg size has increased the percentage of solids in the egg contents, contrary to what was expected. Differences in egg composition between strains were found to be consistent from 34 to 54 wk of age of the hens.

### Degenerative Myopathy in Turkeys

To commence studies on the development and inheritance of degenerative myopathy (green muscle disease), a sample of 12 male and 58 female turkeys was obtained from a commercial flock of 1-yr-old Small White turkeys (Wrolstad strain) known to be affected. Birds were selected by visual examination and palpation of the breasts so that half of the sample would be affected. However, results of later necropsies showed that none of the males were affected by the disease. In the females the disease was initially characterized by green lesions in the deep pectoral muscle, but by 2 yr of age most of the lesions had disappeared. Observations at necropsy suggested that as the bird ages, the green muscle lesions are resorbed and this results in disappearance of various amounts of the muscle.

### Goose Production under Intensive Management

A pilot study was conducted on some aspects of management necessary for the development of a breeding program for geese in confinement. Results suggested that a slow (15 min every 2 wk) increase in daylength resulted in a higher rate of egg production earlier in the laying period than production under a constant regimen of light (10 h) or under normal outdoor conditions. Trapnesting appeared to delay broodiness, in that birds so treated maintained a higher rate of production longer than birds that were free to enter and leave the nesting boxes.

## REPRODUCTIVE PHYSIOLOGY

### Hormones in Body Fluids and Tissues

**Steroid identification.** The development of new microscale reactions and syntheses of commercially unavailable steroids provided complementary data for steroid identification, particularly with respect to characterization of corticosteroids.

**Hormones in body fluids and tissues during pregnancy.** A study of  $17\beta$ -hydroxysteroid dehydrogenase activity in erythrocytes of sheep in late pregnancy has established that estrone ( $E_1$ ) is actively converted mainly to estradiol- $17\beta$  ( $E_2\beta$ ), but there is no significant change in enzyme activity in relation to parturition. These data suggest that red blood cells may play a role in the regulation of the relative concentrations of  $E_1$  and  $E_2\beta$  in the maternal circulation.

The plasma profile of estrone sulfate ( $E_1S$ ) has been determined in each of six sheep throughout gestation. The  $E_1S$  was first detected ( $> 100$  pg/ml) in plasma at 40–50 days after conception. Although individual variations were evident, the levels increased gradually to a plateau (range 1–3 ng/ml) between 110 and 140 days of gestation and then rose sharply to a peak (range 9.6–47 ng/ml) at the time of parturition (146 days). A rapid decline to undetectable levels occurred within 15 h after parturition. It has been established that  $E_1S$  is the predominant estrogenic component in the fetal fluids of the cow and the sheep during pregnancy.  $E_1S$  (expressed as estrone equivalents) was first detected ( $> 40$  pg/ml) in the allantoic fluid of both species around the time when vascular attachment between the embryo and uterine caruncles was evident, that is, day 31 in the ewe (122 pg/ml) and days 30–36 in the cow (88 pg/ml). The concentration of  $E_1S$  then rose to a peak, which occurred at 45 days in the ewe (15 ng/ml) and at 120 days in the cow (450 ng/ml). This rise was associated with increased vascularization of the attachment sites. The levels dropped to a low point at 60 days in the ewe (2 ng/ml) and at 170 days in the cow (50 ng/ml) and then rose to a plateau, which was maintained until parturition.

Further studies on placental lactogens, carried out in collaboration with the University of Manitoba, have established that ovine placental lactogen (OPL) can be detected in placental membranes at 25 days of gestation.

A highly purified preparation ( $1000\times$  purification) of OPL has been shown to promote growth and to stimulate casein synthesis in vitro when incubated with mammary gland slices. A placental lactogenic hormone has been detected in fetal tissues and fluids of the pregnant cow.

### Biorhythms in Sheep

Further evaluation of biorhythmic patterns in a group of five sheep entrained to a regimen of 12 h light and 12 h dark have demonstrated the presence of body temperature rhythms with periods of approximately 24, 12, and 8 h. There was also evidence of a long-term, low-frequency temperature rhythm with a periodicity longer than the 3-wk duration of the experiment. Marked differences were apparent between animals in the time at which the maximum daily temperature occurred (phase relationship) and in the magnitude of the daily variation in temperature. In general, there was a high correlation between vaginal and jugular temperatures recorded simultaneously. Analyses of eating, drinking, walking, and resting activities for biorhythmic patterns are not yet complete. Experiments are in progress to establish the periodicity and phase relationships of the above parameters in the absence of the entraining agent.

### Factors Involved in the Ovulation Process in Swine

In a study in collaboration with Macdonald College of McGill University and the University of Western Ontario, prepuberal gilts were treated with pregnant mares' serum gonadotrophin and human chorionic gonadotrophin to induce ovulation. It was established that intramuscular injection of indomethacin, an inhibitor of prostaglandin synthesis, at various time intervals before the predicted time of ovulation effectively inhibits normal ovulation. Also, most of the oocytes removed from follicles of animals treated with indomethacin were found to have undergone normal nuclear maturation, as judged by completion of the first meiotic division with extrusion of the first polar body and the formation of the second metaphase plate. These data provide further evidence that prostaglandins are involved in the process of follicle rupture, and suggest that prostaglandins do not play a role in oocyte maturation.



## Postpartum Ovarian Activity in Cattle

In collaboration with the University of Guelph, it has been established that the median time to the first postpartum ovulation in a group of 70 dairy cows was 19 days. Behavioral estrus was observed at the first ovulation in 45% of the animals, which suggests that a functional corpus luteum is not essential for occurrence of estrus.

## PESTICIDE RESIDUES

### Methoxychlor

The metabolism of methoxychlor in poultry is being studied with the use of ring-labeled  $^{14}\text{C}$ -methoxychlor. To produce residues in eggs, laying hens were fed a diet containing 100 ppm methoxychlor. The data accumulated permit postulation that metabolism of methoxychlor in the hen proceeds via demethylation, resulting in metabolites that are readily eliminated in the excreta. A small amount of excretion takes place through the egg. Low concentrations of residues that remained in tissues and organs from the hens after they had been returned to a noncontaminated diet for a period of 7 days indicate a high metabolic rate and thus a low persistency. Positive identification of all metabolites is continuing. They have been tentatively identified as mono- and di-hydroxylated compounds that are similar to those produced in vitro from methoxychlor by an enzyme in chicken liver microsomes.

### Lindane

In cooperation with the Chemistry and Biology Research Institute, the metabolism of lindane has been studied in vitro. An enzyme, probably a dehydrogenase, which rapidly metabolizes the insecticide, was shown to be present in the soluble fraction of chicken liver homogenates. In total 17 possible metabolites have been positively identified. The data seem to indicate that the metabolic pathway for lindane in the chicken is similar to that in the pheasant, rabbit, rat, and mouse. Positive identification of metabolites continues.

### Atrazine

In a cooperative project with the Chemistry and Biology Research Institute, the metabolism of atrazine has been studied in laying hens fed 100 ppm atrazine in their

diet. Neither atrazine nor its metabolites were detected in eggs. However, unchanged atrazine and three metabolites were detected in excreta. Some residues continued to appear in excreta up to the 4th day after the hens had been returned to a noncontaminated diet. This indicated a possible buildup of residues in various organs and tissues. In this respect, analysis of organs and tissues removed from the hens after they had been returned to a noncontaminated diet for a period of 7 days revealed a considerable residue (39 ppm) of atrazine in abdominal fat, as well as detectable levels of two metabolites. In addition, three metabolites were detected and identified in 9 out of 10 organs and tissues analyzed. The liver and kidneys, normally active sites of metabolism, contained the greatest concentrations of residues of metabolites, and the gizzard, intestine, heart, lung, oviduct, and leg and breast muscles had detectable quantities. The combined data permit postulation that metabolism of atrazine in the chicken proceeds mainly by partial N-dealkylation accompanied by hydrolysis. The study is being continued with the preparation of ring-labeled  $^{14}\text{C}$ -atrazine, to be used as a tracer to assist in the identification of metabolites and the enzyme or enzymes responsible for metabolism.

### Tetrachlorvinphos and Trichlorfon

Investigations were started on the metabolism of the organophosphate insecticides tetrachlorvinphos and trichlorfon in farm animals and poultry. Pure tetrachlorvinphos and 9 out of 11 possible metabolites have been synthesized and spectroscopic and other data obtained, to assist with positive identification of metabolites in future animal studies.

## POLLUTION

### Pollutant Transport to Subsurface and Surface Water

A study began at the Institute's Greenbelt Farm to determine pollutant transport to subsurface tile drainage water resulting from the use of livestock manures for cropping, and to surface stream water from manures and fertilizers used in an integrated farm operation. The study is a part of Agriculture Canada's contribution to the Great Lakes Water Quality Agreement, and is in support

of the Agricultural Watershed Studies (Task C) of the International Joint Commission's International Reference Group on Great Lakes Pollution from Land Use Activities. The Laboratory Services section of the Environmental Protection Service, Environment Canada, conducted bacteriological studies on water, manure, and soil samples for the research.

Selected water samples were tested for temperature, pH, dissolved oxygen, specific conductivity, nitrogen (total Kjeldahl, ammonia, and nitrate), total phosphorus (filtered and unfiltered), potassium, solids (total, suspended, and volatile suspended), coliforms (total and fecal), fecal streptococci, and heterotrophic bacteria (standard plate counts) at 20° and 35°C. A few samples were also tested for other bacteria and pesticides. Limited data from the 1st yr of the study indicated no significant impairment of stream water quality caused by cropping operations, although transport of pollutants tended to increase after heavy rainfall. Wide variation in the bacterial content of liquid manure was observed. After liquid manure had been

plowed down, bacterial numbers were observed to decrease rapidly as soil depth increased from 5–10 cm to 25–46 cm. With passage of time after manure had been plowed down, total coliform numbers tended to increase but fecal coliform and fecal streptococcus numbers tended to decrease, and standard plate counts tended to remain static or increase slightly in soils.

### Rate and Time of Manure Application

As a part of a cooperative research project with the Engineering Research Service, Soil Research Institute, and Environment Canada, a preliminary assessment was completed on the effects on soil, water, and corn crop resulting from different rates and times of application of liquid manure from dairy cattle in test plots at the Central Experimental Farm. Erosion was found to be responsible for most of the loss of nitrogen and phosphorus in surface runoff caused by rainfall. Other results indicated that spreading of manure in winter resulted in greater loss of nutrients in spring than manure spreading at other times.

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# Biosystematics Research Institute

## Ottawa, Ontario

### PROFESSIONAL STAFF

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M. B. TRUDEL	Administrative Officer
M. KHAN (Mrs.), B.Sc., M.L.S.	Librarian, Botany
J. CURREN (Mrs.), B.A., B.L.S.	Librarian, Entomology
J. E. H. MARTIN	Head, National Identification Service

### Cultivated Crops

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M. E. BARKWORTH (Miss), B.Sc., M.Ed., Ph.D.	Gramineae, <i>Poa</i>
W. G. DORE, B.A., M.Sc., Ph.D.	Gramineae, <i>Bromus</i>
R. J. MOORE, B.A., M.A., Ph.D.	<i>Buddleia</i> , <i>Caragana</i> , <i>Medicago</i>
E. SMALL, B.A., B.Sc., M.Sc., Ph.D.	<i>Cannabis</i> , <i>Daucus</i>

### Noxious and Native Plants

G. A. MULLIGAN, B.Sc.	Head of Section; Weeds, Cruciferae
I. J. BASSETT, B.A.	Anemophilous groups, palynology
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W. J. CODY, B.A.	Curator of Vascular Plant Herbarium; Flora of continental Northwest Territories, ferns
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L. A. KELTON, B.S.A., M.Sc., Ph.D.

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Nematoda: Hoplolaimidae,  
Tylenchorhynchidae,  
Aphelenchoidea  
Homoptera: Cicadellidae;  
Hemiptera: Corixidae  
Hemiptera: Miridae, Anthocoridae  
Diptera: Chironomidae  
Homoptera: Aphidoidea,  
Coccoidea, Psyllidae, Collembola,  
Psocoptera, Thysanoptera

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Coleoptera: Elateridae  
Coleoptera: Staphylinidae,  
Alieculidae  
Arachnida: Araneida, Opiliones  
Siphonaptera  
Arachnida: Acarina  
Coleoptera: aquatic families,  
Staphylinidae  
Arachnida: Acarina

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Nycteribiidae  
Ceratopogonidae  
Lonchaeidae, Chamaemyiidae  
Lauxaniidae, Calliphoridae  
Tabanidae, Diptera larvae  
Syrphidae, Scatophagidae  
Tachinidae, Culicidae

**Experimental Taxonomy**

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J. R. BYERS, B.S.A., M.Sc., Ph.D.

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Head of Section; Hematology,  
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Physiology, electron microscopy  
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Physiology, chemotaxonomy  
Morphology, systematics of  
Hemiptera  
Physiology, histochemistry  
Genetics

## Hymenoptera

J. R. BARRON, B.Sc., M.Sc., Ph.D.	Head of Section; Ichneumonidae, Braconidae: Trogostidae
C. C. LOAN, B.A., M.S., Ph.D.	Ichneumonidae, Braconidae: Euphorinae
L. MASNER, B.Sc., M.Sc., Ph.D.	Proctotrupoidea, Bethyloidea, Evanioidea, Sphecoidea
W. R. M. MASON, B.Sc., Ph.D.	Braconidae
O. PECK, <sup>1</sup> B.Sc., M.Sc., Ph.D.	Chalcidoidea
G. S. WALLEY, <sup>1</sup> B.S.A., M.S.	Ichneumonidae
C. M. YOSHIMOTO, <sup>2</sup> B.A., M.Sc., Ph.D.	Chalcidoidea, Cynipoidea

## Lepidoptera and Trichoptera

W. C. MCGUFFIN, <sup>2</sup> B.A., M.A., Ph.D.	Head of Section; Lepidoptera: Geometridae
S. A. ALLYSON (Miss), B.Sc.	Lepidoptera: larvae
J. D. LAFONTAINE, B.A.	Lepidoptera: Noctuidae
E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C.	Lepidoptera: Pyralidae
A. MUTUURA, B.Sc., Ph.D.	Lepidoptera: Pyralidae, Tortricidae
F. SCHMID, Lic. ès. Sc. Nat., D. ès Sc. Nat.	Trichoptera

## Biodegrading Fungi

D. J. S. BARR, B.Sc., M.Sc., Ph.D.	Head of Section; Phycomycetes
R. ARNOLD (Mrs.), B.A., M.Sc.	Pyrenomycetes on woody plants
J. H. GINNS, B.S., M.S., Ph.D.	Curator of National Collection of Fungus Cultures; Wood-inhabiting Hymenomycetes
S. J. HUGHES, B.Sc., M.Sc., D.Sc., F.L.S., F.R.S.C.	Fungi Imperfecti, Hyphomycetes
R. MACRAE (Miss), <sup>1</sup> B.A., M.Sc., Ph.D.	Polyporaceae, Tremellales, Hydnaceae
M. K. NOBLES (Miss), <sup>1</sup> B.A., M.A., Ph.D., F.R.S.C.	Wood-inhabiting Hyphomycetes
L. K. WERESUB (Miss), B.A., M.A., Ph.D.	Thelephoraceae and Hydnaceae

## Plant Disease Fungi

J. A. PARMELEE, B.Sc., M.A., Ph.D.	Head of Section; Uredinales and other parasitic fungi
J. D. BISSETT, B.Sc., Ph.D.	Coelomycetes
I. L. CONNERS, <sup>1</sup> B.A., M.A.	Preparation of catalogue to genera of fungi
M. P. CORLETT, B.A., M.A., Ph.D.	Pyrenomycetes
M. E. ELLIOTT (Miss), B.A.	Curator of Mycological Herbarium; Discomycetes
D. B. O. SAVILE, <sup>1</sup> B.S.A., M.Sc., Ph.D., F.R.S.C.	Uredinales
R. A. SHOEMAKER, B.S.A., M.S.A., Ph.D.	Pyrenomycetes



## Departures

D. W. MALLOCH, B.A., M.A., Ph.D.

Resigned August 1975

K. A. PIROZYNSKI, B.Sc., M.Sc., D.P.P., Ph.D.

Resigned May 1975

L. Y. WU (Miss), B.S., M.S., Ph.D.

Retired August 1975

Agaricales

Pyrenomycetes including

Fungi Imperfecti

Nematoda: Criconematidae,

Paratylenchidae

## VISITING SCIENTISTS

G. A. BRADLEY, B.S.A., M.S., Ph.D.

Environment Canada

Hymenopterous parasites

*National Research Council postdoctorate fellow*

P. G. FONTANA, L.Sc. Biol., B.Sc., M.Sc., Ph.D.

Cytotaxonomy

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<sup>1</sup>Honorary Research Associate.

<sup>2</sup>Seconded from Environment Canada.

## INTRODUCTION

The Biosystematics Research Institute provides a National Identification Service for Canada on fungi, vascular plants, insects, arachnids, and nematodes. To meet this responsibility, the Institute conducts research on various aspects of biosystematics and maintains custody of the National Mycological Herbarium, the Agriculture Canada Vascular Plant Herbarium, and the Canadian National Collections of Insects, Arachnids, and Nematodes.

During the past several years, the research staff has strongly emphasized the production of identification manuals for the Canadian flora and fauna.

In the spring of 1975, the Parks Branch of the Department of Indian and Northern Affairs arranged for the Institute to conduct a floral and faunal survey of St. Lawrence Islands National Park.

During 1975 two mycologists resigned from the Institute; Dr. D. W. Malloch accepted a professorship at the University of Toronto, and Dr. K. A. Pirozynski assumed a position with the National Museums of Canada. Dr. L. Y. Wu of our nematology group retired in August. Dr. D. R. Oliver stepped down as Head of the Aquatic Biology, Hemiptera, and Nematology Section and was succeeded by Mr. R. H. Mulvey. Dr. J. A. Parmelee was appointed Head of the Plant Disease Fungi Section.

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

D. F. Hardwick  
Director

## IDENTIFICATIONS, COLLECTIONS, AND SURVEYS

### National Identification Service

Material received for identification this year amounted to 1804 shipments containing 131 650 specimens. Principal users of the service were Environment Canada (62 235 specimens, 47%), Agriculture Canada (27 070 specimens, 21%), Canadian universities (10 195 specimens, 7%), and foreign countries (21 190 specimens, 16%). Other federal and provincial departments and private users submitted 10 885 specimens. The number of specimens from the Mackenzie River pipeline survey continued to decrease; nevertheless, the Institute received substantial amounts of material associated with environmental problems. More than 167 000 specimens of nematodes, arthropods, plants, and fungi were identified and returned. Several students encountering these problems were assisted in making identifications.

Weather conditions favorable for the growth of fungi in late summer accounted for

the large numbers brought in for identification this year. Some 850 collections of mushrooms were identified for 353 members of the general public. Twenty-nine individual requests for assistance on mushroom identifications were received from the Poison Control Centre at the Children's Hospital.

The accompanying tables show the number of specimens identified, their sources, and the distribution within the group.

### Collection Development

The holdings of Institute collections increased by some 300 000 specimens of nematodes, arthropods, plants, and fungi during the year. Major contributions were made by 45 officers of the Institute collecting in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Northwest Territories, Texas, and Vermont. Accessions included 216 000 specimens of arthropods, 1730 collections of plants, and 1436 collections of fungi. Important among these were some 75 000 eriophyid mites from Ontario; 20 000 Coleoptera with emphasis on rare beetles; 26 000 mites from British Columbia; 10 000 Hemiptera, including Anthocoridae



**Number of vascular plants identified,  
Nov. 1, 1974 – Oct. 31, 1975**

<b>Canada</b>	
Agriculture Canada	12 172
Environment Canada	4 382
Other federal departments	878
Provincial departments	985
Universities	3 591
Private inquiries	1 993
<b>USA</b>	324
<b>Other countries</b>	116
<b>Total</b>	<b>24 441</b>

and plant bugs, from the Prairie Provinces and British Columbia; 8000 leafhoppers and spittlebugs from boreal Ontario; 2500 nematodes from Ontario; and 19 000 pieces of amber from the open-pit coal mines of Alberta. Donations of specimens to the collections totaled some 84 200 specimens, and purchases amounted to 34 900 specimens. Material lent to 217 institutions around the world amounted to 60 000 specimens: 51 000 specimens of arthropods, 8750 specimens of plants, and 576 mycological specimens and cultures. Material incorporated into the collections totaled 268 850 specimens of arthropods, 4140 specimens of fungi, and 374 collections of cultures. Some 1005 fungus cultures have been successfully lyophilized for long-term preservation.

**Institute Visitors**

The collections and expertise at the Institute attracted approximately 100 visitors, including delegations from China and the USSR and scientists from Canada, the United States, Australia, Czechoslovakia, England, Finland, Hawaii, Holland, Japan, Korea, Poland, and Switzerland. Notable visitors included Dr. S. G. Mjuge of the Helminth Laboratory, Moscow, USSR; Dr. J. W. Carmichael of the University of Alberta, who studied the mycological collections and compiled literature references; Mr. H. Vlug of Wageningen, Holland, who consulted with specialists and studied the Proctotrupidae

collection; Mr. R. Wharton of the University of California, Berkeley, who discussed a problem in his thesis on Braconidae and studied the collection; Dr. John Smart of the University of Cambridge, who presented a seminar and discussed research on Simuliidae; Dr. J. Wisniewski of Poznan, Poland, who discussed mites associated with bark beetles; and Professor Tosiyo Yasuda and Mr. Hiroshi Yamanaka of Japan, who spent several months in the Institute studying Lepidoptera.

**St. Lawrence Islands National Park  
Survey**

In the spring of 1975 the Parks Branch of Indian and Northern Affairs arranged for the Institute to conduct a floral and faunal survey of the St. Lawrence Islands National Park. This survey was a pilot project designed to develop a suitable approach for conducting other surveys in national parks. The data will be used to compile a resource list of flora and fauna in Canadian parks and to test a data-banking system under development at present at the Institute. The St. Lawrence Islands National Park was chosen for the test survey because it is biologically unique in Canada and close to the Institute at Ottawa.

The Park comprises 18 islands and approximately 80 islets in the Thousand Islands chain; the headquarters and park area are located at Mallorytown Landing. The area is predominantly Precambrian, but sedimentary limestone occurs at the eastern and western borders. The Park provides many habitats, from abandoned farmland on the larger islands to mixed forest on the smaller islands. Several ponds on Grenadier Island and the marshy shorelands of many of the other islands provide good aquatic collecting. Some southern trees such as shagbark hickory, white oak, and pitch pine grow here, as well as maple, red oak, beech, red and white pines, hemlock, and cedar. Many new records of Canadian flora and fauna will be established from the partial collection made to date in this survey.

Approximately 60 specialists from the Institute visited the area, collecting specimens in their fields of interest; however, most of the collection was obtained by technicians and students using various traps and collecting by hand. The present collection comprises 50 000 – 75 000 specimens of arthropods;

Number of insects, arachnids, and nematodes identified, Nov. 1, 1974 – Oct. 31, 1975

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonaptera	Other insects	Acarina	Other arthropods	Araneida	Nematoda	Total
Canada													
Agriculture Canada	476	4 901	76	2 792	1 685	1 266	—	329	258	—	1 251	2 914	15 948
Environment Canada	2 198	41 861	165	3 836	3 010	378	—	10 781	2 080	1	4	9 466	73 780
Other federal departments	1 582	6 467	1 101	11	2 095	73	—	560	72	—	1	—	10 962
Provincial departments	583	1 008	97	105	242	168	10	136	899	5	3	—	3 256
Industry	57	38	2	—	1	8	—	—	4	—	1	—	111
Universities	1 243	5 662	50	22	1 505	35	—	167	572	4	2 074	405	11 739
Private inquiries	846	616	170	516	246	269	1	97	49	93	3	1	2 907
USA													
Government departments	697	829	—	—	75	94	—	—	184	—	—	—	1 879
Universities	652	1 178	2 029	5 888	197	37	836	—	544	—	463	—	11 824
Private inquiries	287	11	—	—	2 273	30	—	2	—	—	—	—	2 603
Industry	—	—	—	—	—	3	—	—	—	—	—	—	3
Other countries	3 133	457	11	95	191	33	—	6	17	—	—	—	3 943
Total	11 754	63 028	3 701	13 265	11 520	2 394	847	12 078	4 679	103	3 800	12 786	139 955



Number of mycological collections and cultures identified, Nov. 1, 1974 – Oct. 31, 1975

	Agaricales		Aphyllorphorales		Coelomyces		Discomycetes		Erysiphales		Hyphomycetes		Phycomycetes		Pyrenomycetes & misc. Ascomycetes		Rusts and smuts		Other		Total	
	Coll.*Cult. †	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.	Coll.Cult.
Canada																						
Agriculture Canada	1	—	2	—	41	9	—	—	2	—	18	53	108	86	37	8	3	—	1	2	213	158
Environment Canada	2	—	1	3	2	—	1	—	2	—	—	6	—	8	2	—	1	—	—	—	11	17
Other federal departments	391	—	212	—	43	—	42	—	22	—	34	4	2	—	82	—	46	—	23	—	897	4
Provincial departments	97	—	41	1	3	—	15	—	—	—	1	—	1	—	7	—	—	—	9	—	174	1
Universities	14	—	1	—	—	—	2	—	3	—	13	12	2	2	5	—	1	—	4	—	45	14
General public	854	—	14	—	1	—	1	—	1	—	8	—	—	—	9	—	5	—	2	—	895	—
Poison Control Centre, Children's Hospital	27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	29	—
USA																						
Government departments	—	—	62	—	—	—	—	—	—	—	5	1	—	—	4	—	1	—	—	1	72	2
Universities	—	—	—	5	5	—	—	—	—	—	8	7	—	—	2	2	—	—	—	—	15	14
Other	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Other countries	—	—	—	3	—	—	3	—	—	—	2	—	—	—	2	1	2	—	—	—	9	4
Total	1 386	—	333	12	95	9	64	—	30	—	89	83	113	96	150	11	59	—	41	3	2 360	214
Combined total	1 386	—	345	—	104	—	64	—	30	—	172	—	209	—	161	—	59	—	44	—	2 574	—

\* The term collection is used to designate a sample of a fungus population. The sample consists of an indefinite number of individuals, ranging from a few in larger fungi to several thousands in microfungi. The term collection is used in contradistinction to specimen, which in zoology and phanerogamic botany is the equivalent of an individual.

† The term culture denotes a living fungus population aseptically cultivated on various substrates under different conditions, usually to obtain identifiable structures or different states in the life cycle.

1500 mycological collections; and 3100 specimens of vascular plants. The collections of vascular plants and mycological specimens and cultures were identified, and final reports have been written. A report on the forest types and ecological zones of the Park was also prepared. A preliminary report on the arthropods has been written, and identification of most of this collection will be completed early in 1976 for the final report. All collections were coded, and ecological data and other information are being transcribed for computer input. The pilot project on data banking can be expanded to cover other collections in the Institute, if it proves successful.

The survey, although not complete, has generally been considered worthwhile. It has provided the Parks Branch and the Institute with new data on an interesting undisturbed region of Canada.

### Identification Aids

*Insects and Arachnids of Canada.* This faunal series is designed to permit the non-taxonomic biologist to identify various arthropod entities. No contributions have been published, but substantial progress was made on 16 studies. Work on the *Fleas of Canada, Alaska, and Greenland* has continued; 78 illustrations were completed for a total of 251 since the project was initiated, and nearly all distributional maps have been completed. Descriptions and illustrations of the sac spiders, Clubionidae, were completed for inclusion in the *Hunting Spiders of Canada*. A manuscript on the flat bugs of Canada is nearly completed. Specimens of lace bugs were obtained and studied in preparation for a faunal work. Studies on the plant bugs of the Prairies and the Anthocoridae of Canada were continued, and both projects are nearing completion. As part of a faunal work on the Chironomidae, larval diagnoses of 46 genera of Orthocladinae were completed, and distributional records have been updated. The text describing the genera of Canadian biting midges is about three-quarters completed. Portions of the text for *Blow Flies of Canada* and *Syrphinae of Canada* have been completed. *The Mosquitoes of Canada*, a handbook for the identification of the larvae and adults of the 71 species occurring in Canada, is nearing completion. Each species is described and illustrated. Several new characters are used in

identifying the females, and a new system of identification based on abdominal chaetotaxy, augmented by conventional characters, is introduced for the larvae of the genus *Aedes*. A review of the Canadian genera and species of spittlebugs was completed, and a new subfamilial classification has been devised. Most of the text and many of the illustrations for a work on the 188 genera of Canadian aphids have been completed. Distributional data for a contribution on the Elateridae of Canada and Alaska continued to accumulate. Research on one suborder of caddisflies and part of a second has been completed in preparation for a faunal work on the genera of Canadian caddisflies. A study on the orthopteroid insects of Canada was initiated at McGill University, Montreal, Que., under a negotiated contract; a literature search is in progress, and preparation of illustrations is on schedule; one new species of grasshopper has been discovered on the Magdalen Islands.

*Fungi Canadenses.* Thirty numbers were published since the last annual report. They describe 12 Ascomycetes, 8 Basidiomycetes, and 10 Fungi Imperfecti. Contributions to this series at present total 80, and 10 treatments are now in press. The Basidiomycetes described are Uredinales, the rusts. Five species belong to the genus *Puccinia* and are limited to the host *Viola*. They include one new species, *P. glacieri* Savile, on *V. glabella* Nutt. and one new subspecies, *P. violae* ssp. *americana* Savile, on *Viola* spp. A second rust, *P. ornatula* Holw., on *Viola glabella* is recognized on teliospore characters illustrated by line drawings. The Fungi Imperfecti treated include four species of *Sporidesmium* found on decaying deciduous and coniferous trees. One little-known epiparasite in Canada is *Eleutheromyces subulatus* (Tode ex Fr.) Fckl. This pycnidial-forming 'Imperfect' was reported from Ontario and Quebec on mushrooms, polypores, and *Xylaria* spp. Another fungus epiparasite, *Calonectria decora* (Wallr.) Sacc., on the host fungus *Mas-saria* was described, as well as such plant leaf parasites as *Apiosporina* spp., which cause witches' broom on serviceberry or Saskatoon bushes, the mildew *Erysiphe graminis* DC. ex Mérat on cereals and grasses, and twig parasites like *Diaporthe alleghaniensis* R.H. Arnold on yellow birch.

*Plant-parasitic nematodes.* A key to the genera of plant-parasitic nematodes of



Canada and over 60 labeled plates of photographs illustrating the identifying features were completed. A new genus of cyst-forming nematodes and several genera of plant-parasitic nematodes not previously reported from Canada are included. Portions of the introduction, a general discussion of morphology and parasitic behavior, and a glossary of nematological terms have also been completed.

*Common Weeds of Canada.* This handbook was finished during the year and published by McClelland and Stewart Ltd., Toronto. It contains colored illustrations and short, bilingual descriptions of 117 of the most common weeds of Canada.

*Cutworm Moths.* A handbook of the cutworm moths of Ontario and Quebec was completed during the year and is now being edited. Over 600 species are treated, and most are illustrated by color photographs.

## SECTIONAL RESEARCH

### Biodegrading Fungi

*Basidiomycetes.* A comprehensive account of *Merulius*, an economically important genus of fungi causing wood decay, has been completed; nearly 400 names were treated and 20 species recognized. Studies of sclerotia established that this vegetative character can be used for distinguishing species of *Leucogyrophana*. Sclerotia morphology may also be suitable for distinguishing species of *Typhula*, a genus of pathogens that attacks grasses and cereals. Studies of *Leucogyrophana* and *Coniophora* are progressing toward the objective of completing generic revisions. Cytological characters, scanning electron microscopy, and serology, in addition to conventional morphology, are being used in taxonomic studies of Basidiomycetes.

*Ascomycetes and Fungi Imperfecti.* One of the most confused families of Ascomycetes, the Capnodiaceae, was revised by segregating the genera into six families. The revision was accomplished by establishing pleomorphy and correlating hyphal morphology, conidial states, and perfect states. Studies on *Rosellinia*, *Xylaria*, and *Hypoxylon* are continuing. Host and geographic distributions in Canada are being established, and generic revisions are being undertaken.

*Lower fungi.* A joint study with J. T. Slykhuis, of the Research Station, Ottawa, of wheat spindle streak mosaic, an economically important disease of winter wheat in Ontario, has shown that the causal virus is transmitted by a zoosporic fungus, *Polymyxa graminis* Ledingham. The fungus is abundant in Ontario soils on wheat and has also been found on couchgrass. In tests to identify possible hosts, it grew on barley, winter rye, and *Bromus tectorum* L. A fungus morphologically similar to *P. graminis*, *Ligniera junci* (Schwartz) Maire & Tison, was found for the first time in Canada. It occurred on lamb's-quarters and redroot pigweed in Ontario; in tests to determine possible hosts, it grew on spinach but not on wheat or other Gramineae. Studies of the ultrastructure of fungal zoospores are continuing.

*Other activities.* A hypothesis was developed to explain the origin of land plants through symbiosis from semiaquatic ancestral green algae and aquatic fungi; the present-day mycorrhizal associations, many of which are essential for growth of healthy plants, result from coevolution between fungi and plants. A study in which morphological characters of rust fungi are interpreted in terms of environmental problems showed that substantial modification of their classification is required. An analysis of Article 59 of the *Botanical Code of Nomenclature* was advanced; revision of this basic rule, which has an overwhelming influence on mycological nomenclature, is much needed. Cooperative projects with other establishments include: carrot rusty root disease, Research Station, Vineland Station; chalkbrood disease of honey bee larva, alfalfa decline, and root rot of cereals caused by *Pythium* spp., Research Station, Ottawa; and turf and forage diseases under snow, Research Station, Saskatoon.

### Plant Disease Fungi

*Taxonomy.* A taxonomic monograph of *Ophiobolus*, which contains 33 species that parasitize grasses and many herbaceous plants, was completed. The number of Canadian species recognized increased from 11 to 17, and three new species were described. A study of the Erysiphales, or mildews, of Ontario is continuing. Six genera and approximately 25 species are involved. Mildews are obligate parasites on cultivated and native



plants. Canadian species of the genus *Didymella* were examined and compared. Species of *Didymella* comprise some important and some minor parasites of legumes, raspberries, and grasses. A joint study of *Venturia inaequalis* (Cke.) Wint., which causes apple scab, was undertaken with Dr. R. G. Ross, Research Station, Kentville, N.S. Its purpose is to elucidate the morphology of the scab lesions of the conidial state (*Spilocaea pomi* Fr.) that developed under various fungicide spray programs. A study of the species of *Ciborinia* that occur in Canada was continued; type specimens of six species were critically examined. A description of a new species of *Lambertella* on the common barberry, *Berberis vulgaris* L., has been prepared. A symposium paper outlining the evolution and biogeography of Saxifragaceae was published. Chronological sequence was indicated by their association with the rusts, Uredinales.

*Other activities.* A study initiated at the University of Calgary provided background for two manuscripts that deal with how the environment influences the distribution and community structure of fungi in alpine soils. The fluctuating environmental conditions that caused the most severe stress on fungal communities were soil temperature, moisture, and available phosphorus. Extreme environmental changes placed conflicting demands on the efficiency and adaptability of the fungi. Dominant species in communities at the most exposed alpine sites were evidently genetically diverse enough to adapt to extreme environmental changes. In contrast, in soils where the environment was relatively stable, the dominant species were genetically specialized for the limiting dimensions that were widely distributed in the local environment.

### **Aquatic Biology, Hemiptera, and Nematology**

*Aquatic insects.* A paper on the distribution of the midges of Char Lake, Cornwallis Island, N.W.T., was completed, and descriptions of two new species are included. A revision of the *bicinctus* group of the midge genus *Cricotopus* was initiated. This group is considered a possible species complex. A review of the host-parasite relationship between midges and water mites was completed.

*Hemiptera.* Work on the Anthocoridae, which are predacious on aphids, mites, and other arthropods, was completed. Three papers containing descriptions of seven new species, new records of European species in Canada, and clarification of the taxonomic status of several genera and species were produced. The leafhopper genus *Oncopsis* was revised; 34 of its 44 Nearctic species are new to science. Six genera of North American spittlebugs were reviewed. Three new genera were described, and three others were recognized for the first time in the Nearctic region; 14 species were recognized as new.

*Nematology.* Illustrated keys and descriptions of plant-parasitic genera of the Mackenzie River system and the genera and species of Mermithidae that are parasitic on insects are being prepared. Male characters of mermithids, particularly spicule size and structure, are being emphasized for the first time in their systematics. Labial structure of the heads of males of the root-knot nematode and of the root-lesion nematode, as well as the perineum of cyst-forming species, were resolved by scanning electron microscope. They are being investigated as aids in taxonomy and identification of indigenous species. The regulatory functions of a previously undescribed valvular apparatus and nerve endings at the anterior end of a stunt nematode were studied by electron microscopy. The information obtained helps to clarify the mechanisms and sequence of feeding in plant-parasitic nematodes.

*Collaboration with other agencies.* Institute scientists supervised the work of a successful Ph.D. candidate, Dr. A. Soptonis; another student, Ms. P. Pehtla, who is engaged in systematic and biological studies of host-parasite research of midges and water mites at Carleton University; and a postdoctorate fellow, Dr. V. McCauley, who completed work on the morphological changes between instars of chironomid larvae. The Institute cooperated with Environment Canada in studying the taxonomy of aquatic insects and nematodes of the Mackenzie and Porcupine river systems. The Institute also collaborated with the research stations at Harrow and Vineland Station and with institutes in England and Holland concerning taxonomy and classification of cyst-forming nematodes, morphology and taxonomy of root-knot nematodes, and variation in populations of root-lesion nematodes.



## Coleoptera, Siphonaptera, and Arachnida

*Arachnida.* A review of generic concepts of the Tarsocheylidae and their systematic relationships to other families of prostigmatic mites was published; a radical transfer of this group, previously placed with the Heterocheylidae, to a position in the Heterostigmata was proposed. One comment was published and another submitted supporting an application by Russian acarologists to settle a nomenclatural problem for two genera of eriophyid mites. A systematic and phylogenetic revision of the generic and family concepts of Tarsonemidae from a world standpoint was nearly completed. Research leading to a guide to the eriophyid mites of fruit trees in Canada was expanded to include a detailed study of the fauna of cherry orchards in British Columbia. Research on the eriophyid fauna of pine trees was modified to lead initially to a preliminary guide to all species in North America. Manuscripts dealing with water mites of the family Pionidae were completed. They describe two new taxa in the superfamily Arrenuroidea and associations of larvae of parasitic water mites with their insect hosts. A taxonomic review of the spider genus *Philodromus* in North America was completed. It treats the seven groups of species and illustrates, maps the distribution of, and describes the 12 species of the *aureolus* group; five specific names were placed in synonymy. The North American species of Clubionidae were reclassified into conventional species groups, two new species from Eastern Canada were described, and one new synonym was proposed. A new species of the crab spider genus *Misumenops* was described. The life histories of nine species of hunting spiders were described. Emphasis was placed on the biotic factors that permit their coexistence within a single habitat.

*Coleoptera.* Considerable progress was made toward the completion of a monograph of the Sphaeridiinae, a large subfamily of Hydrophylidae. The monograph treats almost all the genera and species. A revision of the New World genera of the hydrophylid tribe Omicrini was completed and published. Work was begun on the staphylinid subfamily Xantholininae; three genera and 12 species are treated to date. Six papers were published or submitted toward a revision of the staphylinid subfamily Tachyporinae. They treated the genera *Coproporus*, *Cilea*,

*Sepedophilus*, and *Euconosoma* and included descriptions of 46 species; 17 of these were new to science. Substantial progress was made toward the completion of a revision of the North American species of the genus *Tachyporus*. A revision of the New World Coryphiini of the Staphilinidae was initiated, and all available material was borrowed for study. Work was nearly completed on a study of the Western Canadian species of the click beetle genus *Athous*, including a key to the 43 Nearctic species. Specimens resembling North American species of Elateridae contained in the collection of the British Museum (Natural History) were studied. Work is continuing on the scolytid genus *Pityophthorus*. Descriptions, distributional data, and biological information were compiled for 134 species, including 33 that are new to science; 41 new synonyms have been recognized. Over 3800 specimens from the collection of Dr. S. Wood were examined, and complete data on all specimens were recorded. Two preliminary papers designating lectotypes, describing new species, and indicating new synonymy were prepared. A short paper describing the relationship between several rare species of Trogositidae and Scolytidae was completed.

*Collaboration with other agencies.* Institute scientists supervised the work of two graduate students, Ms. P. Pehtla and Mr. P. Wanson, of Carleton University, who were studying the systematics and biology of parasitengone mites associated with insects in Eastern Canada. A systematic revision of the North American species of *Hydaticus*, a genus of predacious diving beetles, by Mr. R. Roughley, a student at the University of Guelph, was also supervised by an Institute scientist. An intensive, 2-wk course on agricultural acarology at the Ohio State University, Columbus, and a one-term course in biogeography at Carleton University were presented by two Institute scientists.

## Diptera

*Diptera Manual.* Much was accomplished this year toward producing the manual of the families and genera of North American Diptera. Twenty-four complete manuscripts and two partial manuscripts were received. A total of 72 family sections and two introductory chapters are now on hand. Substantial progress was also made on several other family sections. Some 272 inked drawings



were completed, and 81 final penciled figures were prepared. A total of 1706 inked drawings for this book are now completed. About three-fourths of the text is written, and about four-fifths of the illustrations are finished. A list of the morphological terminology to be used in the manual has been prepared. This list forms the basis for the section on morphology and for the glossary, and will be used as a guide in standardizing the morphological terminology throughout the family sections. The Scientific Editing Unit of the Research Branch of Agriculture Canada has assigned an editor to the manual, who is actively working on the chapters on hand.

**Fossils.** The number of pieces of Canadian amber collected in Alberta this year totaled 20 000. Some 37 000 pieces were polished for study, and 17 000 of them were microscopically examined for fossil insects. Examination revealed 363 new insect inclusions, which brings the number of fossil insects from Canadian amber cataloged in the Canadian National Collection to 1946. A description of *Plecia myersi* Peterson, the oldest fossilized march fly known, was published.

**Biting flies.** A study of the genus *Brachypogon*, not previously known from Canada, was completed, and one new species is included. Progress was made on a study of the Canadian species of *Ceratopogon*. A paper describing the immature stages of eight species of Tabanidae is in press, and progress has been made on descriptions of immatures of several western species. The rearing of two distinct larvae has proved that presumed variants of *Hybomitra typhus* (Whitney) are actually two separate species.

**Parasites.** A new sarcophagid fly parasitic on cicadas was described. The female locates the host by its song. Because only male cicadas sing, the male is most frequently parasitized.

**Other research.** A paper describing the larvae of a species of *Hylemya* and two species of Chloropidae associated with injury to cultivated brome grass in Alberta is in press. Another well-illustrated work with keys, descriptions, and brief biological notes on the larvae of 45 families of Diptera associated with trees in North America is in press. The description of the first known North American larva of the Canaceidae from salt-marsh algal beds was completed. A

paper analyzing the systematic position of the genus *Omomyia* and transferring the genus from the Thyreophoridae to the Richardiidae was completed. The family of skipper flies, the Piophilidae, was redefined to include bird's-nest dwellers, the Nettiophilinae, and necrophilous flies of the Thyreophorinae. A paper containing keys to the 25 world genera and all described species was completed. Included are two new genera from Canada and six new species. A paper describing one new genus and species of Phoridae from North America is in press. A paper on the Micropezidae of Canada and Alaska was also completed. It provides keys and illustrations to the four genera and 16 species of the area and describes four new Canadian species.

### Experimental Taxonomy

**Systematics of the Tingidae.** The external morphological characters of nymphal stages are being studied in an effort to distinguish all of the more than 60 species known for Canada. The research is aimed at providing a basis for preparing a faunal work to the Tingidae of Canada.

**Biosystematics of Euxoa.** Emphasis on studies of the biology and physiology of taxonomically difficult species complexes in this important genus of cutworms continued, and research was extended into promising new areas. The life histories of 36 species were studied. Differences in the extent of development of the egg for overwintering, the type of diapause involved, and the occurrence and duration of the aestival period of the prepupal stage were found. Many species have different mechanisms for water conservation, and small differences in the rates of larval development that contribute to the isolation of closely related species.

Three species in the complex containing *Euxoa altera* McDunnough, *E. annir* (Strecker), and *E. vulpina* (Smith) were hybridized in the laboratory. Viable F<sub>1</sub> hybrids from all combinations of crosses were produced, but evidence of genetic incompatibility in the case of the *annir-vulpina* cross was found. The appearance of the larva and adult of these two species is particularly distinctive, as are certain aspects of physiology and ecology.

Premating mechanisms of behavior that isolate the species were studied in the laboratory and the field. Males were released, and



caged females were used to recapture them. The test reveals the specificity of sex pheromones. Little cross attractancy was found among the three closely related species *Euxoa campestris* (Grote), *E. declarata* (Walker), and *E. rockburnei* Hardwick, and the study is continuing with tests of hybrid males from these species against both the hybrid and parental females.

A cytogenetic analysis of *Euxoa* spp. is proceeding well, after the development of an improved air-drying technique for applying Giemsa stain. The procedure allows increased resolution of the meiotic divisions in both sexes and is particularly valuable in studying synapsis in experimental hybrids. It provides evidence of the type and frequency of structural rearrangements of chromosomes in the process of riation and speciation. A complex pattern of variation has been found in *E. messoria* (Harris). It is caused by the occurrence of mitotically unstable supernumerary (B) chromosomes that show no obvious homology with any member of the standard chromosome complement.

Hemocytological distinctions based on the passive form of one class of cells, the plasmatocytes, were identified among species of the *declarata* group, *E. campestris*, *E. declarata*, and *E. rockburnei*. The fundamental basis for these distinctions in Lepidoptera was clarified in a study of the origin and multiplication of the different classes of hemocytes. Two classes, the granular hemocytes and spherule cells, originate in the embryo and multiply by mitosis in the circulating blood. Two others, prohemocytes and oenocytoids, originate in special hemopoietic organs in the insect thorax and are released intermittently into the blood. The prohemocytes transform directly to plasmatocytes in the organs or in the blood, and these cells maintain a relatively specific form in their passive state in circulation.

## Hymenoptera

*Braconidae*. In cooperation with the Research Station, Saskatoon, braconid parasites of *Lygus* bugs were surveyed in Western Canada. One species only, *Peristenus pallipes* (Curtis), was reared from mass collections, and its percentage parasitism was generally low. As a result biocontrol attempts are planned by the Research Station, Saskatoon, with suitable European species of *Peristenus*. A new Nearctic species of *Apanteles* reared

from a geometrid moth on Oregon grape was described. A revision of the genus *Dyscoletes* was completed.

*Ichneumonidae*. A revision of the Nearctic species of *Euceros*, secondary parasites of Lepidoptera and sawflies, was completed. It included a study of head capsules of the primary *Euceros* hosts. A revision of Nearctic species of *Phytodietus*, parasites of caterpillars, is nearing completion. It comprises about 32 species including 22 that are new. A new genus of Pimplini from Jamaica was described. A compilation of parasites of forest Lepidoptera in Canada that represent the subfamily Ichneumoninae was completed.

*Chalcidoidea*. The following new taxa were described: a new genus of Trichogrammatidae, based on an egg parasite of a brossolid banana pest in Ecuador; a new genus and species of Spalanginae from the intertidal zone of Mexico; a new species of Pteromalinae associated with the meadow jumping mouse; and two new Nearctic species of *Mestocharis*. All Nearctic species and one Japanese species of the genus *Di cladocerus*, which includes parasites of the larch casebearer, were revised.

*Proctotrupoidea*. A critical review of most world genera of Scelionidae, which are parasites of eggs of Orthoptera and Hemiptera, was made. It includes diagnoses, synonymies, and discussion of higher classification. A revision of the New World species of Ismarinae, hyperparasites of Dryinidae, was completed. Of the 21 species described, 16 are new to science. The Nearctic species of *Iphitrachelus* were revised. Diapriids associated with army ants were reviewed, including habits, adaptations, and relationships; a new genus and two new species were described. A key to the 42 genera of Inostemmatinae, including 21 that are new, was completed. Most are parasites of gall midges. The Nearctic tribe Gryonini of the Scelionidae, which are parasites of eggs of Heteroptera, was revised. It consists of four genera and 28 species.

## Lepidoptera and Trichoptera

*Lepidoptera*. Fascicle 13.2 of *The Moths of America North of Mexico* was completed. It deals with the Pyraustini, a tribe of pyralid moths. Types and other specimens of Pyraustinae were studied at the British Museum



(Natural History). Revisional studies of several pyraustine groups were continued.

Preliminary work on the classification of Canadian archipine leafrollers was done. Studies of the higher classification of Microlepidoptera continued, as did revisionary work on conifer pests of the genus *Dioryctria*.

In continuing work on the larvae of the pyralid moths, a paper on larvae of the genus *Loxostege* was published and another on larvae of the genus *Tetralopha* has been submitted for publication. Work on the relationships of two genera of the subfamily Macrothecinae is progressing. A study of the genera *Tallula* and *Jocara* is scheduled for completion before the end of May. A comprehensive revision of the larvae of the Pyraustinae has been initiated.

The manuscript for Part III of *Guide to the Geometridae*, which treats the Boarmiini, the Bistonini, and the Melanolophiini, is ready for final typing. A preliminary draft of Part IV of the Guide, which deals with another section of the Ennominae, is partially completed.

Analyses of 20 species groups in the genus *Euxoa* were completed. Those in which new species are being described include the *misturata*, *perexcellens*, *camalpa*, and *aequalis* groups. A key to species groups is nearing completion.

*Trichoptera*. Work on the Oriental caddisflies has been suspended until a contribution to the *Canadian Faunal Series* describing the genera of Canadian caddisflies is completed.

### Cultivated Crops

A main achievement this year was the completion of the taxonomic monograph of the genus *Avena*. The monograph is an account on the classification, evolution, distribution, and identification of 28 wild and cultivated species of oats and naturally occurring interspecific hybrids. It is a summary of about 2000 names that have been proposed for various taxa. The new approach used to elucidate the taxonomy and the various new numerical taxonomic and computer techniques developed increase the importance of this long-awaited book; the last monograph by Malzew (1930) is badly out-of-date. Progress was made in our attempts to devise automatic schemes for identifying oat cultivars; one is based on infrared spectroscopy, the other on seed

morphology. A taxonomic study of the tribe Triticeae was initiated.

A biosystematic study of the species of *Poa* L. (bluegrasses, meadowgrasses) growing in Canada was initiated. A tentative list of characters and their character states has been prepared for use in revising the genus.

A review of taxonomic studies of the genera of grasses on Canada's range and pasture lands was started. This review will enable us to obtain a more accurate picture of the grasses growing in Canada and their distribution.

The brome-grasses can be segregated into four well-defined groups that some authors consider as separate genera. The most conservative classification segregates the 28 Canadian species into *Ceratochloa* (3), *Zerna* (11), *Bromus* proper (10), and *Forasaccus* (4). Much infraspecific variation is exhibited in species that are freely exogamic. For example, cultivars of *Z. inermis* (Leysser) Lindman selected for agronomic qualities show little uniformity in morphological features.

The biosystematic survey of the genus containing the alfalfas, *Medicago*, was continued with a study of the morphology and cytology of living plants of both perennial and annual species. The status of the perennial taxa has been evaluated, and tentative dispositions have been made.

A manuscript on the taxonomy of *Cannabis* was completed. Six articles were published in 1975, and three are due to be published in 1976. Aid on forensic-taxonomic problems was provided to the Departments of Justice and Health and Welfare and to the R.C.M.P.

Material representing all growth stages of 200 wild and 300 cultivated populations of carrot was collected and preserved. The vegetative material was assessed, and morphological analysis of flowering and fruiting collections is progressing. After the data have been obtained, numerical taxonomic analysis can be started.

### Noxious and Native Plants

*Weed biology*. Biological studies were published on five species of weeds: wild mustard; common ragweed; perennial ragweed, *Ambrosia psilostachya* DC.; Canada thistle; and bracken. Descriptions, accounts of variation, and characters diagnostic for identification were included. A key for identifying



the species of *Sinapis*, *Brassica*, and *Raphanus* naturalized in Canada was given.

*Taxonomy.* *The Grasses of Ontario* is nearing completion and will soon be submitted for publication. Identification keys for 73 genera and 226 species are provided. Over 120 infraspecific taxa are distinguished, and attention is drawn to the six genera and 34 species found only in cultivation. The applications of all specific names are reassessed.

A paper containing a key and a discussion of the cytotaxonomy of four species of *Draba* that are invariably confused with one another was published. The characteristics of sterile, artificial, first-generation hybrids between

three of the species, *D. crassifolia* Graham ( $n = 20$ ), *D. albertina* Greene ( $n = 12$ ), and *D. stenoloba* Ledebour ( $n = 20$ ), were presented and analyzed.

Taxonomic studies of three annual species of *Urtica*, which are nettles, and one species of *Hesperocnide* were completed. Information on pollen morphology and chromosome numbers was included.

*Airborne pollen studies.* *An Atlas of Airborne Pollen Grains of Canada*, including a chapter on airborne fungus spores, was submitted for publication. Descriptions of 143 species are included. *Canadian Havens from Hay Fever* was revised and submitted for publication.

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## INTRODUCTION

The Chemistry and Biology Research Institute is engaged in research on winter survival of plants and seed dormancy; reduction of plant diseases by investigation of host-parasite interactions of viruses, mycoplasmas, and fungi with related crop plants; improvement of crop plants through genetic modification of plant cells; analytical methodology to determine the persistence, degradation, and translocation of pesticides; methodology for determining inorganic and organic toxic chemicals in soils, crops, and foods; and application of crop-weather data to agriculture.

The services provided by the Institute to other Research Branch establishments include facilities for a wide range of chemical analyses, from fiber determinations to the identification of microgram quantities of chemicals by computerized gas chromatography and mass spectrometry; electron microscopy facilities; and the processing, interpretation, and application of meteorological data to agricultural problems.

During the year a critical review of the Institute's research and service activities was completed. Five senior scientists were asked to advise the Director and to provide scientific leadership to the research programs. Section heads were appointed to increase the efficiency and management of our resources. Goals were set for each scientist in order to achieve those of the Institute.

Dr. J. W. Rouatt, Assistant Director, retired after 36 yr and Mrs. G. Botten, Administrative Officer, after 30 yr of dedicated service.

This report summarizes only the highlights of our achievements in 1975. More detailed information can be obtained from the publications listed at the end of the report. Reprints of the research publications and copies of this report are available from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. G. Saha  
Director

## AGRICULTURAL MICROBIOLOGY

### Sterols in the Control and Survival of *Fusarium oxysporum*

Sterols form an integral part of cell membranes and are essential to the existence and survival of the plant pathogen *Fusarium oxysporum* Schlecht. The key rate-limiting enzyme, hydroxymethylglutaryl-CoA reductase (HMGCoA), in the biosynthetic pathway of sterols in this organism was found to exist as three isoforms, which were separated electrophoretically from the cytoplasmic fraction of the cells. The molecular weight of one of the isoforms was determined to be 11 200. Its dissociation constant with HMGCoA as substrate was  $K_m = 2.1 \times 10^{-5}$  M.

The enzyme was inhibited by a complex entity identified as a lipoprotein. The lipid components in the complex included arachidonic, linoleic, oleic, and stearic acids, which inhibited the enzyme in proportion to their unsaturation. Saturated fatty acids and

the protein moiety of the lipoprotein complex were not inhibitory.

A number of synthesized lipid - amino acid conjugates demonstrated even greater inhibition of HMGCoA than the natural lipoprotein or the free unsaturated fatty acids. Linoleyl aspartate was about 40 times more inhibitory than linoleic acid and did not affect adversely the normal development of wheat seedlings in sand culture. Also, this compound reduced spore germination by *F. oxysporum* by half, indicating that it may have potential for control of the pathogen.

### Composition of Spores of *Fusarium* spp.

Because chitin is a unique component in cell walls of many fungi and inhibition of its synthesis was considered as a possible measure for controlling pathogenic fusaria, the composition of conidial and chlamydospore cell walls of *F. sulphureum* Schlecht. was determined. The major differences found in the composition of cell walls were in the amounts of glucose and *N*-acetylglucosamine (NAG). The conidial wall contained 18%

glucose and 14% NAG, whereas the chlamydospore wall contained 6% glucose and 21% NAG. These sugars are believed to form the two major structural polysaccharides  $\beta$ -1,3-glucan and chitin. The chitin contents of the conidia and chlamydospores were 12.5% and 19% respectively. The cell walls of both spores contained approximately 1% lipids, whereas the hyphal wall contained 6% lipids.

A method was developed for the large-scale production of chlamydospores from conidia of *F. sulphureum* in order to examine several metabolic processes separately with the aim of finding a weak point that could be used for control of this resistant propagule. A rather specific enzyme system (methyltransferase) that may be vital to membrane synthesis was found in *Fusarium* spp. The enzyme, which occurs in significant amounts in many fungi but is not present in most host plants, provides a potential for selective control of plant pathogenic fungi.

### Membrane Properties in *Fusarium oxysporum*

The effect of temperature changes on the growth of *Fusarium* spp. was observed, and the significant and critical effects on membrane structure and membrane-related metabolism (sterols, enzymes, fatty acids, and phospholipids) were determined. The vital significance of membranes in the survival of these pathogenic organisms, particularly in relation to the extreme temperature variations of Canadian agricultural soils, requires an understanding of the effects of temperature on membrane properties. Temperature-induced physical changes in *Fusarium* membranes were examined in a spin label study. Results showed that membranes of intact hyphae and conidia and isolated membrane fractions maintained physical properties such as fluidity, order, and activation energy for molecular motion over a wide range of growth temperatures (15–37°C). This was a result of the regulation of phospholipid composition, acyl chain unsaturation, and sterol-to-phospholipid ratios. Although the relative amounts of the individual lipids were altered by temperature changes, the membrane properties were maintained by the counteractive effects of the components. An abrupt, lethal increase in the activation energy for molecular motion occurred at 40°C. The increase in motion and loss of

order was caused by disruption of protein-lipid interactions, and apparently this effect limits the upper growth temperature of *Fusarium* species. Also, membranes were identified as the site of action of the fungicide cyprex, which caused a lethal rearrangement of labeled lipids in chlamydospores.

### Enzymes of Fungal Pathogens

Nonheme iron proteins were identified as the site of action of an iron antagonist, thenoyltrifluoroacetone, in *F. oxysporum*. Fungal dihydro-orotate dehydrogenase, a key enzyme in the de novo biosynthesis of nucleic acids, was inhibited by this reagent, which may find use as a fungal control agent. This enzyme was found to be a source of superoxide anion, a toxic cellular by-product of oxygen metabolism. A lipophilic site on the enzyme, which reacts with ubiquinones, was also inhibited by free fatty acids and surface-active agents.

### Spot Blotch of Barley

Certain actinomycetes and bacteria isolated from the root zone stimulated mycelial growth of different strains of *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur by means of volatile metabolites, but failed to stimulate germination of conidia of the fungus that were inhibited by soil fungistasis. Conidia that were not influenced by fungistasis germinated readily, and the presence of root-zone microorganisms stimulated abundant sporulation soon after conidial germination. In the absence of root-zone organisms no such sporulation followed germination.

A study of the role of toxins in the etiology of spot blotch of barley in Eastern Canada was undertaken, and symptoms of the disease on barley leaves were reproduced with sterile culture filtrates of the fungus.

A field survey of the incidence of spot blotch of barley in Eastern Canada was completed, and a report was prepared to show the distribution and the epidemiological factors affecting the disease in barley fields in Ontario, Quebec, and the Maritime Provinces.



## ENVIRONMENTAL CHEMISTRY

### Inorganic

**Selenium.** A commercial, resistively heated graphite furnace with an atomic absorption spectrometer was used to detect microgram and submicrogram levels of selenium in halibut, flour, oat cereal, round steak, and National Bureau of Standards liver. The detection limit was 25 ng/g.

**Chromium.** In the determination of chromium in sewage sludges and plants by atomic absorption spectrometry, several compounds were tested for their efficacy as masking agents for overcoming interelement interferences. Background absorption was corrected by using either a nearby emission line in the chromium lamp or a hydrogen hollow cathode lamp.

Chromium at levels lower than 1  $\mu\text{g/g}$  was determined by flame atomic absorption after extraction of the dichromate from acid solutions with methyl isobutyl ketone. Some instability of the organic solution was observed. Attempts to determine chromium at the nanogram level by gas chromatography of the trifluoroacetylacetone complex with the use of an electron capture detector were not successful.

**Copper, zinc, cadmium, and lead.** The development of analytical methods for estimating ultratrace levels of these metals in natural waters was started, and sample handling procedures were worked out.

### Organic

**N-Nitrosamines.** A method for detecting submicrogram amounts of N-nitrosamines was developed that involves UV irradiation on thin-layer chromatographic plates. This photolysis gives primary amines that are made visible by treatment with the highly sensitive fluorogenic reagent fluorescamine.

**Honey bee pheromones.** The pheromone produced by the queen to stabilize swarms of worker bees was investigated. The active component, an acid, was fractionated via its methyl ester, and then saponified and tested by field assay.

### Pesticides

**Soils.** The persistence and translocation of pesticides in organic soil were studied in collaboration with the Research Station at St.

Jean and the Soil Research Institute. Methods were developed for the extraction, cleanup, and quantitation of residues of carbofuran, its 3-hydroxy and 3-keto analogues, paraquat, and fonofos in soil samples and in lettuce, carrots, and onions grown on treated soil. Analysis showed that the half-life of carbofuran in the soil was about 2 wk and uptake by the crops was minimal. The uptake of paraquat by the food crops was in the low parts per billion range and no residues of fonofos were detected in them. Residues in the soil 125 days after band application of paraquat and fonofos at 2.25 kg/ha were about 3 and 12 ppm.

Studies of the biodegradation of lindane- $^{14}\text{C}$  in submerged mineral soil showed that the process was as complex as in plants and animals. Several degradation products were identified. A similar study in organic soil resulted in identification of three other metabolites. The degradative pathways in the two soils appeared to be similar and mainly involved nonoxidative reactions.

**Poultry.** In cooperation with the Animal Research Institute, the degradation of lindane- $^{14}\text{C}$  in liver homogenates was studied. In contrast with the results in soil, a significant number of the products were hydrophilic, possibly chlorophenols.

In another cooperative project with the Animal Research Institute in which atrazine was fed to chickens, methods were developed for the determination of atrazine and its metabolites in feces and eggs. No residues were found in the eggs, but the identification of three metabolites indicated that the hens possess a metabolic pathway for detoxification of the herbicide.

**Analytical methods.** A method was developed for the determination of Mesuro (Chemagro Corp.) and its oxidized analogues (sulfoxides, sulfones, and corresponding phenols) by treating it with trifluoroacetic anhydride (TFA) to form di-TFA derivatives. This method was used for determining residues in blueberries.

A method was developed for the simultaneous detection of atrazine and hydroxyatrazine in soil through derivatization studies for gas chromatographic (GC) analysis. Evaluation studies of a thermionic detector for S-triazine herbicides were completed. A GC method for determining residues of Kilmor (Ciba-Geigy) in soil and crops was developed and used for the simultaneous analysis



of the three components 2,4-D, dicamba, and mecoprop in samples of wheat, barley, and soil obtained from fields sprayed with Kilmor.

An improved extraction procedure was developed for the simultaneous determination of éthephon and fenoprop in apples.

A liquid chromatographic (LC) procedure is being applied to the analysis of ethylene-*bis*-dithiocarbamate fungicides and their decomposition products, especially ethylenethiourea and ethylenethiuram monosulfide, with the use of a scanning wavelength UV detector. A center of expertise in LC was established.

*Confirmatory tests.* A test involving the use of trifluoroacetic anhydride was successfully applied for the confirmation of the sulfoxides of finamiphos, Mesurol, fensulfothion, Counter (Cyanamid), Metasystox-R (Bayer), phorate, and carbathiin.

*Photodecomposition.* Residue levels of fenitrothion in stagnant and running water were determined after aerial spraying. The decomposition products were similar to those formed by irradiation of this compound with UV light.

## WINTERHARDINESS

### Environmental Factors Associated with Cold Hardening

The effects of artificially imposed environmental conditions in the field (removal of snow cover and application of ice sheets) to simulate extreme winter conditions indicated that ice sheets are a major contributing factor in winter injury to cereals in eastern Ontario. Application of ice sheets over experimental plots completely killed nonhardy cultivars and severely damaged hardy ones, even when snow was replaced on the iced plots to prevent marked reduction in soil temperature. Data on winter survival obtained under these conditions permitted short-term hardiness appraisals of cereal cultivars and correlated closely with their hardiness classifications based on long-term observations in the field under natural conditions and with freezing and icing tests in the laboratory. Such experimental tests may provide a means for rapidly appraising winter survival of new varieties of wheat.

The accumulation of ethanol during anaerobic respiration in cereals encased in ice may

cause injury to cereals under icing conditions. Survival within each cultivar was correlated with the amount of ethanol accumulated under the ice encasement, but not between cultivars.

### Membrane Lipids in Relation to Cold Hardiness

Membrane lipids from the bark tissues of winter-hardy and summer nonhardy black locust trees and from cultivars (Puma) of cold-hardened and nonhardened winter rye were examined by differential scanning calorimetry. Thermograms of the lipids of hardy and nonhardy tissues of either species showed no appreciable differences, indicating that the temperature of the gel-liquid crystalline-phase transitions and enthalpy of transition are almost the same. Also, the temperature of transition of the lipids from the tissues of the black locust tree is far above the critical temperature that causes freezing injury. Hardiness, therefore, is not associated with physical increases in fluidity of the membrane lipids as measured by temperatures and enthalpies of liquid-gel phase transitions.

A new fluorometric method for assay of deoxyribonucleic acid (DNA) was used to estimate the number of cells in plant samples. It was found that membrane substance increased during hardening of cereal cultivars.

Studies on the effect of temperature on respiration of mitochondria and tissue segments from seedlings of wheat and rye grown at 2° and 24°C disclosed no correlation between cold hardiness of the cultivars and the temperature at which structural transitions occurred in mitochondria. Discontinuities in Arrhenius plots of respiratory activity against temperature were obtained at about the same temperature from the seedlings grown both at 2° and at 24°C. Also, no differences were found in the swelling and contraction properties of mitochondria isolated from hardened and nonhardened wheat and rye, indicating no correlation between cold hardiness and the expansibility of mitochondrial membranes.

### Changes in Chloroplast Proteins and Physical Properties of Wheat Cells During Hardening

A new chloroplast protein that appears during hardening of wheat was found after



electrophoresis and fractionation of soluble chloroplast proteins of wheat. The electrophoretic mobility of a soluble chloroplast protein having carboxydismutase activity was found to change with hardening. Changes in the rate of water loss and an increase in soluble sugars were found to lower the freezing point associated with hardening of wheat.

Centrifugal studies on cells and investigations with the use of water-soluble spin label (Tempone) showed that the structural viscosity of wheat leaf protoplasm increases with hardening.

### Effect of Hardening on Growth

A new highly sensitive auxanometer, capable of measuring coleoptile growth responses to auxin at concentrations 100 times less than those normally used, was developed to examine the effect of cold hardening on growth responses of wheat coleoptiles.

### Dormoats

A dormoat strain was identified in which germination is inhibited by far-red light and reversed by red light. This discovery suggests that germination may involve the phytochrome system. Suitable treatment resulted in the induction of dormancy, which can be maintained in seeds kept dry for several weeks.

## HOST-PARASITE RELATIONSHIPS AND CELL MODIFICATION

### Clover Phyllody Mycoplasma

Various replicative forms of mycoplasma-like organisms, such as dumbbell-shaped cells, chains of cells interconnected by small filaments, and spherical cells with bud-like structures, were observed in preparations purified from infected plants. This discovery suggests that the organism reproduces by budding, or binary fission, or both. The protein concentration of the mycoplasma was determined to be about 63% and that of lipids 31%, based on the weight of freeze-dried purified preparations. The percentages of DNA and RNA could not be accurately determined because of their low concentrations.

Four tetracyclines (oxytetracycline, chlortetracycline, tetracycline, and doxycycline) were applied as a root dip or soil

drench to various species of plants to provide protection against mycoplasma infection. Uptake and persistence varied with the plant species.

### Aster Yellows Mycoplasma

Vector aster leafhoppers, infected with a celery-infecting strain of aster yellows mycoplasma (CAYM), were stored at  $-28^{\circ}$  or  $-64^{\circ}\text{C}$  to determine preservation of the causal agent. Results showed that infectivity of CAYM could be maintained up to 21 wk at both temperatures.

The so-called noncelery-infecting strain of aster yellows mycoplasma was shown to infect celery plants, but an unusually long incubation time of 116 days was needed before symptoms appeared, compared with 37 days for CAYM.

### Unidentified Clover Disease

Based on host reactions and characteristics of transmission by the leafhopper *Aphrodes bicinctus* (Schrank), this disease, encountered earlier in the Ottawa area, appears to be different from other known leafhopper-borne diseases. It was called clover yellow edge. The average incubation period of the causal agent in the vector was about 40 days, and the nymphs were more efficient vectors than the adults. Of 31 plant species in 12 families tested as hosts, 15 species in 6 families developed symptoms of the disease.

### Wheat Striate Mosaic Virus

The purified virus lost infectivity rapidly when heated at  $50$ – $55^{\circ}\text{C}$  for 10 min and was inactivated completely at  $60^{\circ}\text{C}$ . Neither the lipid content nor the serological properties of the virus were affected when heated up to  $85^{\circ}\text{C}$  for 10 min, indicating that the capsid integrity of the virions was fully retained. The virus particles, however, underwent morphological alterations and became increasingly more compact when heated to between  $50^{\circ}$  and  $70^{\circ}\text{C}$ . The viral RNA isolated from purified preparations sedimented at 28–30 S. After the purified virus had been heated, a direct correlation existed between virus infectivity and in situ degradation of viral RNA.

### Barley Yellow Dwarf Virus

The serologically specific electron microscopic technique was standardized so that the purified virus could be detected at a concentration as low as 3  $\mu$ g/ml. The latex agglutination technique was successfully applied to detect the virus infection in 5–10 g of field samples of wheat, barley, and oat plants, including those with symptomless infection or indistinct symptoms.

### Tomato Spotted Wilt Virus

*Frankliniella occidentalis* (Perg.), a species of thrips that occurs in British Columbia, transmitted the B.C. isolates of the virus less efficiently than *F. fusca* (Hinds), a vector that occurs in Eastern Canada. *Thrips tabaci* Lind., reported as a vector of the virus in other countries, did not transmit the B.C. isolates of the virus. The virus was serologically detectable in extracts of 50 *F. fusca* specimens reared on infected plants. Vector transmissibility of the virus declined considerably when propagated exclusively in plants through sap inoculation for a period of 18 mo.

### Cell Modification

Uptake and retention or integration or both of exogenously supplied labeled DNA of *Escherichia coli* by vegetative cultures of *Chlamydomonas reinhardtii* were examined. About 0.02% of the donor DNA radioactivity was found to be irreversibly associated with the cells. The extent of this binding could be increased by treatment of the cells with the polycations DEAE-dextran, poly-L-lysine, and poly-L-ornithine. The polycations, however, were toxic for wall-less cells of *C. reinhardtii*. It was demonstrated that the donor DNA was first degraded and its products subsequently used by the host cells for endogenous DNA synthesis, mostly for chloroplast DNA. There was no evidence of integration of donor DNA into the nuclear DNA of the host cells.

### Plant Regeneration in Culture

Several commercial and mutant races (mostly chlorotic) of tomato were tested for their in vitro morphogenetic potential. The effect of auxin and cytokinin levels on the growth of cultured leaf disks on Murashige Shoog medium showed that the regeneration of callus or roots or shoots or all three can be individually controlled in almost all tomato

races tested. The growth and cultural requirements for plantlet regeneration from cultured leaf disks, however, varied for each tomato race. The cytokinin zeatin was much more effective, over a wide range of concentrations, in producing plantlets than the commonly used benzylamino purine.

The ratio of cellulase to pectinase in 12 commercially available plant cell wall-degrading enzyme preparations was found to vary between 0.02 and 100. Also, the effect of pH and various ions on activity of cellulase and pectinase varied widely between preparations. This information was utilized in selecting optimal conditions for the isolation of protoplasts from leaf tissues of tomatoes.

## AGROMETEOROLOGY RESEARCH AND SERVICE

Research emphasized development of models simulating crop-weather relationships, and analysis and interpretation of agroclimatic data. Service was provided by assisting others in developing similar models and by applying the models developed within the Section. National and international liaison with the agricultural community was carried out through participation in the Canada Committee for Agrometeorology and the Commission for Agricultural Meteorology of the World Meteorological Organization.

### Agroclimatic Data Acquisition

The collection of data for use in international programs for determining crop-weather relationships continued, and for the 3rd yr of a 5-yr program phenological and weather data for two varieties of wheat grown under standardized experimental conditions were obtained. Research establishments cooperated in the Soil Moisture Data Network by collecting data on soil moisture in spring and fall at over 40 selected sites.

*Model development.* In cooperation with the Soil Research Institute, work was advanced on the development and testing of efficient numerical techniques for modeling water infiltration into soils and the techniques were applied to estimating soil moisture. A model for estimating the contribution of daily radiation and temperature to wheat yield was developed. At Ottawa, Harrow, and Swift Current, yields were 40% lower than those predicted by the model, whereas those at



Normandin and Lacombe were only 25% lower. The National Research Council cooperated with the Institute in developing a fluidic vertical anemometer and valve assembly to facilitate development of a system for measuring fluxes of agricultural pollutants under field conditions.

*Agroclimatic analyses.* Research on regional crop yield – weather relationships was extended to areas outside Canada where spring wheat is grown, and results indicate the possibility of weather-based predictions for the world spring-wheat crop. Mesoclimatic resource analyses with the aid of computer-mapping techniques were performed to help identify potential agricultural land in northwestern Canada. A study of the effects of climatic change showed that a 30% reduction in precipitation and a 3°C drop in the average temperature could reduce barley production on the Canadian prairies by nearly 40%. Analysis of winter survival and hardiness of forage crops in Canada, based on a national survey, was made. The correlation and interaction of 20 climatic variables with survival of alfalfa were investigated. Results indicated that the critical months (in decreasing order) for winter survival for Swift Current are April, December, and October and for La Pocatière are April, January, and November. Monthly soil-temperature averages for 623 locations were estimated from climatic data, and the results were sorted and published for use in agricultural planning. A study of the availability of phenological data for Canadian crops useful for agrometeorological studies showed that such data are not adequate, particularly for winter survival studies, but could be improved by establishment of a national agrophenological network. Further refinements were made to the versatile soil moisture budget, which is used to estimate soil water content under dryland conditions; improvements in methods for estimating the soil recharge from melting snow and internal drainage components were substantial, and verifications against periodic soil moisture observations at Swift Current, Vegreville, and Pelotas were obtained. A weather-based irrigation-scheduling procedure was used to determine the least amount of water required for irrigation without critically drying the crop. These procedures were combined with those of the versatile budget to simulate soil water regimes over any period for any

location for which climatic data are available. Thus, realistic estimates for the supplemental water required can be made for areas requiring irrigation.

## Services

*Crop yield predictions.* Computer programs and advice provided to the Canadian Wheat Board in Winnipeg enabled that agency to make its own weather-based predictions of Canadian prairie cereal yields in 1975.

*Mapping.* Seventeen maps of Canada showing the distribution of derived agroclimatic variables with descriptive texts were completed. Data on the maps integrate climate and soils data into forms useful for assessing land capability for agriculture. Agroclimatic resource data were derived and mapped for the Northwest Territories and Yukon for the Department of Indian and Northern Affairs, and for the rest of Canada for the Science Council of Canada.

*Applications.* Major services, mainly in the application of agroclimatic techniques, were carried out for establishments of Agriculture Canada and other governmental and non-governmental users. Techniques providing estimates of soil moisture, soil temperature, field work days, and hay-drying conditions were applied and many of the results interpreted for the user.

*Data processing.* The number of service requests for compiling and collating climatic data increased and more derived data, such as heat units and degree-days for growing corn, were provided. Some clients supported their requests by providing assistance with staff or data-processing funds or both. Programs for editing data and updating the agrometeorological archives were completed and long-term daily records to the end of 1974 for 87 selected climatic stations are available for use in research. Programming support was provided to researchers on subjects such as winter injury, climatic change, soil moisture analysis, and crop yield analysis.

## ANALYTICAL CHEMISTRY SERVICES

### Technological Services Unit and Microanalytical Laboratory

During the year 31 049 samples were analyzed (45 908 determinations). The proportion of the work carried out for the Institutes decreased from 50.9% for the previous year to 42.8%, whereas that done for research scientists throughout the Branch increased proportionately. A method for determining nanogram amounts of Mn in blood and animal tissues was developed.

### Instrumentation Centre

The total of 2832 spectra including 1819 mass spectra run during the year represents an almost threefold increase over the total for the previous year.

### Amino Acid Analysis Laboratory

A total of 1599 amino acid samples were run in 1975, compared with 735 for the previous year. The Beckman 120B amino acid analyzer obtained from Lennoxville was brought into production, and single-column methodology with the use of lithium citrate buffers for complete analysis of amino acids in physiological fluids is being used on the Beckman 121M with good results.

A cost-benefit analysis for the operation of the Analytical Chemistry Services from April 1, 1974, to March 31, 1975, showed that benefits over costs was more than \$420 000.

## ELECTRON MICROSCOPE CENTRE

The latest addition to the Centre's instrumentation was a sputter coater, for preparing

samples for scanning electron microscopy. Metal coating by this device becomes simpler, quicker, and more effective than the older vacuum-coating method for samples such as yoghurt gels and leaf or insect surfaces having fine hairs and protrusions, because the sputter coating penetrates better into crevices. Vacuum coating is still useful for samples that are sensitive to heat damage in the sputter coater.

The Centre continued to provide valuable research service to many Branch establishments through the Postal Service. During 1975, more than 4000 electron micrographs were taken in investigations resulting from five requests submitted to the Postal Service.

For the Research Station at Harrow, diseased watermelon and cucumber leaves were examined for virus identification, as well as soybean leaf samples of five different genotypes to determine the effect of flavonol glycosides on their chloroplast structure.

For the Research Station at Vineland Station, fruit and leaf surfaces of Courtland and Red Delicious varieties of apple were examined by scanning electron microscopy to determine the reasons for variable attraction of the apple maggot for oviposition. Also, the fruit and leaf surfaces of peach, plum, and two varieties of apple were similarly examined with respect to oviposition sites for the codling moth.

Five varieties of wheat seed (Cypress, Neepawa, Norquay, Park, and Variety No. 4137) were studied by scanning electron microscopy to determine structural changes caused by weathering for the Research Station at Winnipeg.

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# Food Research Institute

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## INTRODUCTION

The programs within the Food Research Institute are concerned primarily with research and development of methods for the optimum utilization of Canadian agricultural raw materials for food. In carrying out this mission, the research and technical staff of the Institute are continually striving to work primarily in those high-priority areas that have the greatest need for additional information. The Institute encourages communication and collaboration with all sectors engaged in research in food science and technology. Such cooperation assists the Institute in identifying priorities, in planning appropriate research and development projects to fill the requirement, and in maximizing the use of human and physical resources in conducting the necessary research and development tasks. Much of the total program of the Institute has included both short- and long-term projects arising directly from external interactions.

During this year, the Institute welcomed Dr. R. Lowrie, who is a National Research Council Postdoctorate Fellow from New Zealand. He will be conducting research in our bacterial genetics program.

Reprints of the papers listed at the end of this chapter and further details about research projects are available upon request by writing to: Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6

John Holme  
Director

## OILSEEDS

### Processing Rapeseed and Mustard Seed

During 1975, the Institute continued to supply various rapeseed and mustard fractions for studies conducted elsewhere in Canada. Significant progress was made toward substantiating the nontoxicity of the rapeseed protein concentrate (RPC) produced by the FRI-71 process.

A zinc deficiency was identified in growing rats fed RPC as the only source of dietary protein. The deficiency was relieved by zinc supplementation and is believed to be caused by the high phytin content (6%) of RPC. Removal of the phytin has been attempted by isoelectric pH washing.

During 1975 a new process for detoxifying rapeseed and mustard was devised. This process, identified as FRI-75, yields a 70% protein concentrate ( $N \times 6.25$ ) with superior color and taste, and improved functional properties. It contains only traces of phenolics and glucosinolates. A white protein isolate comprising 90% protein with good functionality is readily produced from this RPC.

Experiments showed that direct solvent extraction of dried rapeseed containing 2% moisture or less yields an oil with less than 1.0 ppm sulfur. This finding is of particular

importance to rapeseed oil refiners, because sulfur causes catalyst poisoning during hydrogenation of oils. The application of this process to other oilseeds will be evaluated in 1976.

Systems to crack seed and remove the hulls continued to be evaluated. Subjecting the seed to a short heat treatment before cracking it improved the result. Good percentages of hull were separated from seed by using gravity tables. The most effective separation was obtained using a destoner. This technology is being further evaluated with industry. Hull preparations showed no nutritional value in rat feeding tests.

A survey of 11 commonly used cruciferous vegetables showed that progoitrin was present only in white and yellow turnips. No glucosinolates were detected in cauliflower, and broccoli showed only low levels. Other vegetables studied contained measurable quantities of glucosinolates.

A high-pressure liquid chromatograph was installed and existing GC equipment updated to increase the Institute's commitment to development and improvement of methodology for analysis of glucosinolates and other toxic compounds in foods.



## Milk Replacers

Preparation of milk replacers from detoxified full-fat rapeseed has continued and these are being evaluated at the Research Station at Fredericton. Now nearly ready for commercial exploitation, this milk replacer is expected to have considerable impact on the use of the rapeseed crop in Canada.

## Phenolic Constituents of Rapeseed

Chromatographic and spectrophotometric studies indicated that hexane-extracted rapeseed meal contained phenolic acid derivatives and appreciable quantities of chlorophyll and carotenoids. When these substances were removed, a bland and nearly colorless protein concentrate resulted. RPC prepared by the FRI-75 process contained some phenolics and possibly an indole glucosinolate. Further work on the characterization of these compounds is now in progress.

Rapeseed protein isolates and soya isolates were found to contain insoluble bound phenolic acids that are thought to have adverse effects on the flavor of these materials.

Buckwheat and oats were analyzed for phenolic acids and tannins. Buckwheat contained condensed tannins, but oats did not. Both contained soluble and insoluble bound phenolic acids. Ferulic acid was high in oats but absent in buckwheat. Free phenolic acids could be released during processing to cause adverse taste and color changes in the cereals.

GLC was evaluated for measuring trimethylsilyl ethers of ferulic acids, and this method appears promising.

## Carbohydrates of Rapeseed

The detailed characterization of rapeseed cotyledon pectin showed that, like the mustard pectin, it does not contain the chains of (1→4)-linked  $\beta$ -D-galactopyranosyl that have been reported present in soybean pectin and a commercial citrus pectin. Most of the xylose is attached as single units to the galacturonan chain as in tragacanthic acid and pollen galacturonan. The results are also generally consistent with those on which the structure proposed for sycamore cell pectic polymer is based.

Further work on the fraction soluble in sodium hydroxide is continuing and is expected to be completed in 1976. Several new

projects dealing with the nutrition and functional importance of polysaccharides are now being considered.

## Development of a Full-fat Soy Beverage Powder

The process for manufacturing a full-fat soy beverage powder, developed in 1974 in cooperation with the Canadian Hunger Foundation, was further refined in 1975. The refinements decreased the phytin content an additional 20%, destroyed in excess of 95% of the trypsin inhibitors, and removed 95% of the soluble sugars.

## DAIRY PRODUCTS

### Genetics of Starter Culture Bacteria

A comprehensive study of the genetics of starter cultures (*Streptococcus cremoris* and *S. lactis*) led to the isolation and characterization of many strains that have potential industrial importance. A simple method has been developed for isolating bacteriophage-resistant bacterial mutants. It allows the study of the genetic mechanisms of host and phage relationships at the molecular level. Experiments showed that lactic acid bacteria usually contain more than one kind of plasmid DNA molecule and sustain a differential loss under certain conditions. Experiments are under way to investigate the mechanisms by which these molecules resist exclusion and their effects on the expression of other genetic characteristics.

### Milk Quality

Selected psychrotrophic bacteria have been shown to cause proteolysis in cold stored milk. The yield of cheese made from this milk is significantly decreased through loss of solubilized proteins in the whey. Examination of commercial milks from farms and processing plants indicates that such losses could occur when milk is stored for long periods before being processed. The potential magnitude of this loss is being assessed, and the results will assist in determining the possible direction of research in this area.

Two methods for enumerating coliform bacteria in cheese were compared: the violet red bile agar plate count method (VRB) and the five-tube most probable number method (MPN). The MPN method is more sensitive

than the VRB method at low coliform concentrations and will probably be designated as the official method by the Health Protection Branch of the Department of National Health and Welfare. The VRB method is reliable and is less expensive than the MPN method, and it is recommended for control purposes in the dairy industry.

### **Preservation of Dairy Products**

A new project to study methods for destroying microorganisms in mildly acid food (pH 4–5.5) is under way. A model system using sealed ampoules in a high-temperature glycerol bath fitted with sealed-in thermocouples to measure temperature has been devised. Time-temperature-pH curves for the destruction of *Bacillus stearothermophilus* and a putrefactive anaerobe, PA 3679 spores, have been constructed.

In collaboration with four Ontario dairies the Institute established a system of uniform quality testing for powdered skim milk. This program will be expanded in the coming year to include any dairy wishing to become involved.

### **Flavor of Cheddar Cheese**

Identification of cheese flavor compounds is continuing. Examination of cheese at 1 and 10 mo indicated that pyrazines developed during the aging of cheddar.

### **Rennet Replacements**

In collaboration with industry, the University of Guelph, and regulatory agencies, several enzyme systems were evaluated for efficiency as replacements for rennet. Bovine pepsin has been thoroughly evaluated, and studies will continue on the defects in yield shown by this enzyme. Approval for a previously recommended enzyme extracted from *Mucor miehei* was obtained.

### **Gelation of Milk Products**

Electron microscopical studies of thickening agents in yoghurts revealed that carrageenin (0.4%) induced the formation of a fibrillar microstructure that connected large clusters of casein micelles. Addition of pregelatinized waxy cornstarch (2%) produced yoghurts that contained short fibers and sheets with free terminations; only some terminals were attached to casein micelles. Gelatin (0.5–10.0%) had no effect on the electron microscopic image of yoghurts.

In another study, milk preheated to 90°C produced firm yoghurts free from syneresis. Omission of the heat treatment produced soft yoghurts that exhibited severe syneresis; the soft yoghurts were composed of large (0.46  $\mu$ m) micelles.

Electron microscopy was also used to study the Cheddar cheese structure that resembles chicken-breast muscle. A model has been devised to explain the transition of individual casein micelles in milk into the homogeneous structure of ripened cheese.

Milk gels formed by various agents such as acid-heat, calcium chloride, and ethanol were examined by electron microscopy for changes in microstructure. Hydrogen and calcium ions induced micelle-micelle attachment, whereas dehydrating agents such as ethanol distorted and disintegrated the micelles.

Milk gels with varied physical properties were prepared with D-glucono- $\delta$ -lactone. The firmness, microstructure, and other properties of these gels were then studied.

### **Whey Utilization**

The preparation of whey protein concentrate (WPC) by acid-heat denaturation (pH 2.5–3.5, 88–95°C) was continued in 1975. Institute preparations possessed unique properties: they are capable of thermal gelation, their color remains stable upon heating, and they are highly soluble. U.S. and Canadian patents were filed on the basis of these findings. Tests have shown that the whipping ability, foam stability, and gelling characteristics of the concentrate are similar to those of egg white and that it can be used for enriching white and whole wheat bread. Ultrafiltration as a method for recovering some of the soluble protein lost during the centrifugation step in the denaturation process will also be studied.

The physicochemical behavior of heat-treated acid whey and  $\beta$ -lactoglobulin at pH 2.5 is different from that observed at pH 4.5 or 6.5.

Cottage cheese whey was successfully dried using CaO, CaCl<sub>2</sub>, or both as lactate-complexing agents. Centrifugal clarification to remove insoluble Ca salts improves flavor and product clarity and allows broader use of the whey in food products despite a protein loss of 20% associated with clarification.



Initial studies of whey flavor show that neutralization of whey reduced the intensities of acid, bitter, and astringent characteristics.

## MEATS

### Role of Constituents in Comminuted Meats

Comminuted meat products constitute an important vehicle for the use of "lower-value" meats not suitable for roasts or steaks and meat by-products. A project to further elucidate the mechanisms of the formation, stability, and textural characteristics of meat emulsions and to permit more efficient utilization of the chemical components (particularly proteins) of comminuted meats is continuing. Work on the isolation of salt-soluble and connective tissue protein fractions of meat has continued with the objective of defining their effect on texture of the cooked product. Both fractions contribute to texture, and at the 1 and 2% replacement levels the salt-soluble fraction has the greater effect. This work is to be continued in wiener formulations prepared under commercial conditions.

An assessment of the performance of various nonmeat proteins as partial replacers of beef protein in wiener manufacture has been completed. A number of functionality tests and model systems were evaluated. These included fat-emulsifying capacity and emulsion stability, fat absorption, water adsorption and absorption, solubilities, viscosity, gelation ability, and various changes on heating. In the coming year work will be concentrated on determining the structural characteristics of the proteins and the products in which they are incorporated.

A contract research grant was awarded to Dr. Gray of the University of Guelph to study *N*-nitrosamine precursors in cooked bacon. It has revealed that *N*-nitrosohydroxypyrrolidine is not formed in raw and cooked bacon. Preliminary studies of the influence of nitrite on the development of cured meat flavor were conducted this year.

### Amino Acid Analysis

An accelerated method for the determination of desmosines, hydroxylysine, and methylated basic amino acids has been developed. A complete separation of all the 21 unusual amino acids can be achieved in less than 10 h. The method has been successfully applied

to the direct determination of the concentrations of elastin, collagen, myosin, and actin in tissues, and it is now being applied to the precise assessment of lean meat content of meats in composite meat products and determination of the actin-to-myosin ratio in the myofibrils.

### Effects of Rigor Mortis on Beef Muscle

Collaborative studies on the chemical and physiochemical properties of pure meat muscle proteins have continued. A study in collaboration with Dr. C. C. Bigelow of Memorial University on the thermal denaturation of cardiac G-actin has been completed. A study on the extraction and solubility properties of myosin and actin from beef muscles is under way. Data generated from these studies will help to elucidate the properties of the denatured state or states and to understand interactions of muscle proteins that occur during rigor and their effect on the manufacturing properties of meat.

## SENSORY EVALUATION

Our capability in sensory evaluation has been further expanded to better serve the increased needs of the Institute's programs for this service.

### Meat Preparation

A study to evaluate the reliability and validity of various methods of preparing meat for determining relative tenderness has been initiated. Beef in four tenderness categories was prepared by roasting, broiling, microwave cooking, and waterbath cooking. Tenderness was evaluated by a trained sensory panel, and Warner-Bratzler shear values, moisture content, and fat content were determined. The results of evaluating the tenderness of the beef cooked the various ways will be compared with each other and also with the results from a consumer study in order to determine if one of the faster cooking methods can replace the conventional roasting method in tenderness evaluation tests.

### Meat Quality

Sensory evaluation of meat that results from animal breeding and nutrition studies at Branch research stations is continuing. In

collaboration with A. D. L. Gorrill, Fredericton research station, the eating quality of meat from calves fed diets containing three levels of rapeseed oil, comprising 25, 50, or 75% of the total fat, was determined. No noticeable effect on the flavor of the meat was found. In collaboration with G. Lalande, Lennoxville research station, the eating quality of beef from different crossbreeds marketed at various weights is being determined.

### **Fruit-flavored Drinks**

A fairly new sensory evaluation method called descriptive analysis was tested and modified for characterizing and quantifying flavor differences in fruit-flavored drinks in our laboratory. This method is being applied to other food products.

## **CEREALS AND FIELD CROPS**

### **Oats**

Exploration of wet and dry processing methods led to the conclusion that the preparation of oat starch, protein, and gum is not feasible at present. Lack of sizable protein shifts, the buildup of solution viscosity caused by gum, and the presence of fine bran in starch are the main constraining factors.

A method for determining the  $\beta$ -glucan content in oat gum extracts has been developed and was applied to various extracts of oat gum. Under suitable conditions Hinoat flour yielded gum of exceptionally high viscosity ( $> 1000$  cSt for a 0.5 wt/vol solution in dimethylsulfoxide). Further studies are in progress.

Starch isolated from several oat varieties has been analyzed for iodine affinity, swelling power, phosphate content, and paste characteristics. As a group, oat starches behave differently from corn and wheat starches, although some oat starches differ to a greater degree than others do. The oat starches that exhibit high set-back viscosities often have less tendency to retrograde than others. This behavior cannot be explained solely in terms of the analytical parameters investigated, and plans are to fractionate oat starches and characterize amylose and amylopectin. These differences might be expected to assist in oat utilization.

A new starch viscometer has been designed and developed in cooperation with the Engineering Research Service. It is modeled

on a steam kettle and requires one-tenth the sample size and time needed for viscosity measurements made with conventional equipment. This instrument will be evaluated in 1976 for use both in research and quality control.

The extrusion projects were severely curtailed because of inconsistent results caused by feeder problems. A new rotary paddle feeder for the Brabender extruder has been designed and developed in cooperation with the Engineering Research Service. It eliminates previous problems with starches tempered within the 20–30% moisture range. Wheat, corn, and oat starches have been studied to date, and the behavior of their extrudates in solution was found to differ. In 1976 the interactions of the other flour components with starch will be studied.

### **Durum Wheat**

The international collaborative study of durum wheat quality is on schedule and progressing smoothly.

A study of the durum wheat properties that determine the quality characteristics of spaghetti has revealed that the functionally most important protein fraction in durum wheat is the insoluble or residue fraction. Strong positive correlations exist between the amount of residue protein in semolina, pasta, and cooked pasta and the semolina gluten strength and cooked pasta firmness. The changes in electrophoretic properties of protein induced by processing and cooking are under study.

Light microscopic examination of the protein and starch in uncooked and cooked pasta revealed that firmer pastas had coarser, more open structures than their softer counterparts. Examination of the cooked pasta samples revealed that firmer, better-quality samples had microstructures that did not disintegrate to the same extent that softer, poorer-quality samples did.

### **Buckwheat**

Statistical analysis of functional property data derived from comparisons of buckwheat with other crops revealed that positive correlations exist between emulsification, viscosity, and water and oil absorption.



## Dough Conditioners

Several long-chain acylated amino acids have been synthesized and proved to possess surface activity. The details of the synthesis have been accepted for publication. Experiments evaluating these compounds at the 1% level in baked products indicated that their addition had a dough-strengthening effect. Biological evaluation of the nutritional characteristics of these amino acid derivatives is under way.

## Field Beans

A collaborative study with several centers that are working on preventing off-flavor development in white beans during storage

and distribution has continued. Eight fields in southwestern Ontario were sampled to determine the range of initial fungal infestation of the beans. Processed products were evaluated for flavor quality following storage. Moisture content during storage was found to be most important in the development of musty off-flavors.

## Potatoes

A survey was conducted for 1 yr in cooperation with the food industry to determine the SO<sub>2</sub> content in instant mashed potato (IMP) available on the Ottawa market. The results are being evaluated to determine whether the levels of residual SO<sub>2</sub> in IMP can be reduced.

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### Research

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E. M. MACDONALD, B.Sc.	Pollution and land use
A. R. MACK, B.S.A., M.Sc., Ph.D.	Remote sensing
J. A. MCKEAGUE, B.A., B.S.A., M.Sc., Ph.D.	Soil classification and genesis
J. L. NOWLAND, B.A., M.Sc.	Soil correlation — eastern region
J. A. SHIELDS, B.S.A., M.Sc., Ph.D.	Soil correlation — western region
G. WILSON, B.Sc., M.Sc., D.I.C.	Engineering interpretations

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### **British Columbia Soil Survey Unit (Vancouver)**

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### **Cartography**

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## Water and Nutrient Transport in Soils

D. R. CAMERON, B.Sc., M.Sc., Ph.D.	Modeling
C. CHANG, B.Sc., M.Sc., Ph.D.	Simulation
C. G. KOWALENKO, B.S.A., M.Sc., Ph.D.	Nitrogen cycle
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## Nutrient and Waste Management in Soils

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A. J. MACLEAN, B.Sc. (Agr.), M.Sc., Ph.D.	Metals and fertilizers
S. S. SINGH, B.Sc., M.Sc., Ph.D.	Metals reactions
F. J. SOWDEN, B.S.A., M.S.A., Ph.D.	Nitrogen

## Organic Soils

M. LEVESQUE, B.S.A., M.S.A., Ph.D.	Organic soil characterization
S. P. MATHUR, B.Sc., Assoc. I.A.R.I., Ph.D.	Biochemistry
H. MORITA, B.Sc., M.Sc., Ph.D.	Organic soil chemistry

## Active Fraction and Soil Behavior

G. J. ROSS, B.S.A., M.Sc., Ph.D.	Mineralogy and weathering
L. COSTESCU, B.Sc., Ph.D.	Metals and sediments
D. S. GAMBLE, B.Sc., M.Sc., Ph.D.	Metal ion – organic reactions
H. KODAMA, B.Sc., M.Sc., D.Sc.	Clay mineralogy
N. MILES, B.Sc.	Soil mineral identification
M. SCHNITZER, B.Sc. (Agr.), M.Sc., Ph.D., F.C.S.S.S.	Soil humic compounds

## Departures

L. FARSTAD, B.S.A., M.Sc. Retired March 1975	B.C. Soil Survey
J. E. GILLESPIE, B.S.A., M.S.A. Retired September 1975	Ontario Soil Survey
W. K. JANZEN, B.S.A., M.Sc. Retired March 1975	Saskatchewan Soil Survey
K. K. LANGMAID, B.Sc., M.Sc. Retired December 1975	Maritime Soil Survey
J. G. ROBERTS Transferred to Department of Energy, Mines and Resources, July 1975	Cartography
W. J. STAPLE, B.Sc., M.Sc., Ph.D. Retired December 1975	Soil water movement
W. WATT, B.S.A. Resigned January 1975	B.C. Soil Survey



## VISITING SCIENTISTS

### *National Research Council postdoctorate fellows*

J. D. ADSHEAD, B.Sc., M.Sc., Ph.D.

Clay mineralogy

M. WAINWRIGHT, B.Sc., Ph.D.

Soil microbiology

*CIDA Research Fellow from the University of the West Indies at St. Augustine, Trinidad*

S. M. GRIFFITH, B.Sc. (Agr.), M.Sc.

Humic acid chemistry

*Hebrew University Fellow, Rehovot, Israel*

Y. CHEN, B.Sc., M.Sc., Ph.D.

Humic acid chemistry

*NATO Fellow from the University of Bari, Italy*

N. SENESI, Dr. Sc.

Humic acid chemistry

## INTRODUCTION

In 1975 the Soil Research Institute continued activities in soil survey, research on the properties and behavior of soils, interpretation of the soil inventory, application and development of the computerized Canada Soil Information System, initiation of a land evaluation program, and preparation of printed and computerized maps. The objective of these activities is to provide a sound basis for management of the soil resources of Canada.

The soil survey units continued to work in close cooperation with the Provincial Soil Survey agencies to provide basic soil survey information required to meet the increasing concerns for land management. Priority was given to updating soil surveys in areas of intensive agricultural production, to provide more detailed and reliable information. In many parts of the country, however, new surveys were still being made to provide the basic soil inventory. A soil survey unit was started in Quebec within the framework of the Quebec Institute of Pedology at Laval University. The production of soil maps was increased and all soil map information is being digitized to improve production and interpretation. A land evaluation program was started, to provide a quantitative basis for more effective management of land resources.

Research on soil properties included studies of the use of remote sensing to identify crops and soils, reactions of metals with humus and clays, structure of humic constituents, weathering of clays, and transport of nitrogen and other nutrients in soils and in watersheds. Work was continued to improve the classification of Canadian soils.

Reprints listed in this report are available from the authors. Requests should be addressed to: Soil Research Institute, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. S. Clark  
Director

## SOIL RESOURCE INVENTORY

The soil resource inventory program involves personnel of the soil survey units throughout Canada and a group at headquarters of the Soil Research Institute (SRI) in Ottawa concerned with correlation, research, and related functions.

Demands for soil survey information and its interpretation for many purposes were heavy throughout Canada in 1975. Some of the provinces hired additional staff to work cooperatively with the federal staff on projects of high priority. New projects were undertaken for other agencies, principally the departments of Indian and Northern Affairs and of Energy, Mines, and Resources, and the International Joint Commission (IJC).

The studies on land evaluation begun in 1974 were extended and refined. The purpose of land evaluation is to assemble, synthesize, and interpret information from several disciplines pertaining to land. This makes it possible to assess the productive potential of land under given management practices and to predict the probable economic returns. In the Brooks-Bassano area of

Alberta, studies were conducted on the movement of salt and degradation of soil under irrigation on hummocky land, and in the Oyen area ratings of soils for irrigation suitability were prepared. Studies were started to rate soils for grazing, and carrying capacity was determined for each soil series in the Oyen map area. The yields of cereal grains and rape, and the effect of climatic factors on those yields, are being analyzed for 265 stations in Alberta.

Losses from sheet erosion in 13 agricultural watersheds were investigated to assess the effect of agricultural land use on soil erosion levels. The watersheds chosen were representative of livestock and cropping management systems in the major physiographic and climatic regions in southern Ontario.

In Saskatchewan, a salinity hazard map was prepared at scale 1:1 520 640 showing the distribution, in five salinity classes, of the number of 65-ha units (quarter-sections) in each township in which 0.4 ha (10 ac) or more were condemned because of salinity. The effects of potash fallout on soil salinity and crop yields were monitored, and the



usefulness of dolomite was evaluated for improving production on salt-affected soils.

The soil data bank, CanSIS, is an essential tool in the land evaluation project. Development of the data bank was marked by the completion and introduction of four data encoding forms for routine use in soil surveys. Personnel of Parks Canada and the Government of Manitoba, as well as many soil surveyors, were instructed in the use of these forms. The data system now contains about 2050 descriptions of soils and sites coded by the soil survey units. Digitizing of soil maps continued, and production capacity was doubled by acquisition of a second digitizing table.

Progress was made in several aspects of interpretation of soil resource information. A report was prepared on production possibilities in the Prairie Provinces and on additional land that could be used for food production. Studies were conducted in northern Saskatchewan and northern Manitoba to determine the relationship between soil factors and yields of forest trees. In British Columbia, field studies were conducted that will lead to establishment of interpretive groups of soils for improved timber harvesting and slash burning techniques. Studies were conducted on behalf of Parks Canada to assist in planning and management of land for recreational purposes in Yoho, Banff, Jasper, Elk Island, Prince Albert, and Riding Mountain national parks and in many provincial parks.

Interpretations were prepared for urban and engineering uses in many areas, principally those around Brandon, Man., and Townsend and Ottawa, Ont. A study of slope stability problems of importance to forestry engineering in British Columbia and a field project to evaluate swamping hazards around reservoirs were completed. Measures to mitigate soil damage from pipeline construction in Ontario were drawn up and discussed with National Energy Board personnel. Engineering field tests were conducted at the townsite of Townsend, Ont.

Research continued on the usefulness of remotely sensed imagery for identifying terrain features and land use. In the cropland information system project, ground-truth data were obtained on 16 main test sites and 20 supplementary sites in Saskatchewan and Alberta. A project was started to prepare a hierarchical classification of crops involving soil and climatic data and test information obtained in 1973-74. Study of the use of

satellite data to map salt crusting continued, but problems were encountered that were caused by the size of crust relative to the resolution element of the scanner, and by reflectance of other natural features. Other projects were conducted on the spectral characteristics of soils and plants, on the electromagnetic properties of soils, and on comparison of accuracy and costs between Landsat and normal aerial photographic imagery for terrain mapping.

In work on soil genesis and classification, the proposed new order, Cryosolic soils, was further tested during northern mapping projects, in studies on the effects of cryoturbation, and in studies on organic terrain and organic soils. Modifications to the proposed definitions are under consideration. In northern Manitoba studies were conducted to establish relationships between vegetation communities and edaphic, climatic, and historical conditions, to improve the use of vegetation as a site indicator. In British Columbia, studies on alpine soils and the effects of time and topography were conducted and a paleosol site was characterized. In Ontario studies were conducted for IJC on agricultural watersheds and water quality; normal chemical and physical characteristics of soils and river sediments were identified and clay minerals, heavy metals, organic matter and N transformations, and engineering properties were characterized by a number of cooperating agencies. Along the Niagara escarpment the relationship of soils and land features to elevation of glacial lakes and bedrock was determined. Ortstein soils in the Atlantic region were characterized by field and laboratory methods.

Methods of soil analysis used in Canadian soil survey laboratories, compiled and distributed in a "Tentative Manual," were tested, revised, and expanded. The revised manual, which is ready for reproduction, includes sections on soil sampling, physical methods, chemical methods, soil testing laboratory methods, and mineralogical methods.

About 250 soil samples representing 60 soil series have been analyzed in a continuing project to determine background levels of minor elements in Canadian soils.

Preparations were continued to convene the International Society of Soil Science (ISSS) Congress in Edmonton in 1978. This scientific congress will welcome foreign visitors and provide an opportunity to show the



Canadian land resource and its agricultural, industrial, and social uses to the participants. Canadian pedologists of all agencies are deeply involved in preparations for Congress events, particularly the soil tours. Approximately 100 soil pits and accompanying agronomic or forestry sites have been located, described, sampled, and analyzed so that tour guidebooks can be compiled.

### Soil Survey

The Canada Soil Survey is a cooperative program involving federal and provincial agencies. During 1975, about 4.4 million ha were surveyed at the reconnaissance level and 37.5 million ha at the exploratory level. About 2.5 million ha were resurveyed at the reconnaissance scale in areas that were first surveyed many years ago. Data on the year's work are provided in the accompanying Table.

*Newfoundland.* Soil mapping at a scale of 1:250 000 was completed by the federal group in the Stephenville area (map sheet 12B). The soil capability maps for Port aux Basques (11O) and Stephenville (12B) were completed, and a soil capability map at 1:50 000 was completed for the Codroy Valley area. Mapping and sampling were conducted in the areas of Port au Port, Codroy Valley, and Stephenville to complete and integrate earlier survey projects.

Soil mapping was completed by the provincial group in the Botwood (2C) area and initiated in the Sandy Lake (12H) area. The mapping is being done at 1:250 000 so that generalized soil and soil capability reports can be prepared for resource assessment.

*Prince Edward Island.* The field survey of Island soils was completed, except for a small amount of field checking to be done in 1976. Compilation of the 1:10 000 maps for Prince County was started, and was to be completed in the winter. Information for soil interpretations was compiled.

*Nova Scotia.* Work on Colchester County was restricted to some field checking, correlation with previous mapping elsewhere in the province, and restructuring of the map legend. Effort was devoted instead to site-specific studies, including preparation of the site for the Maritime ortstein soil project and a series of organic sites, selection and sampling of ISSS tour sites, work on a site at Kentville for the Atmospheric Environment Service, Environment Canada, and a detailed

survey of 1000 ha in the Stewiacke area for the Soils and Crops Branch.

*New Brunswick.* Soil mapping and sampling continued in the Richibucto-Rogersville area (21 I/NW); about 15% of the area remains to be mapped. Six interpretive maps of the Rogersville area, related to drainage, surface texture, particle size, surficial geology, depth to impermeable layer, and present land status, have been published by the New Brunswick Department of Agriculture and Rural Development. A detailed soil survey of the agricultural land and watershed of the Petitcodiac area was initiated.

*Quebec.* The federal portion of the Quebec Institute of Pedology was established in 1975 and mapping projects are being started in St. Hyacinthe and Rouville counties. Field work was directed toward establishment of mapping legends and review of soil separations in adjacent counties.

The provincial group has surveys in progress in Témiscouata, Arthabaska, Wolfe, Frontenac, Charlevoix, Mégantic, and Beauce. The group has completed but not published surveys in Rivière du Loup, L'Islet, Dorchester, Portneuf, L'Île d'Orléans, and L'Île-aux-Coudres.

In the exploratory biophysical survey of the James Bay region by the Canadian Forestry Service, 20.7 million ha were mapped.

*Ontario.* Soil surveys continued in the southern counties, where there are intensive land-use pressures and existing information on soils is inadequate for making decisions on present or future agricultural, urban, and recreational uses of lands, and for choosing lands for waste disposal. Soil surveys at a detailed scale were in progress in Middlesex County, in the National Capital area and the remainder of the Ottawa-Carleton regional municipality, and in the Norfolk-Haldimand regional municipality. Other detailed surveys were conducted in agricultural watersheds for studies on soil losses by erosion and on pollution from land use activities.

Progress was made on the reports for Timmins, Brant, and Peterborough areas.

*Manitoba.* Work continued on the City of Brandon regional study, which covers 60 000 ha at 1:20 000 scale. The study is aimed at detailed land evaluation for agricultural suitability, engineering interpretations, and urban development planning.



AREA SURVEYED IN 1975 AND TOTAL AREA SURVEYED (thousands of hectares)

Survey type*	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.	NWT & YT	Total
Soil Survey												
New surveys												
Reconn.	1975	3 864	364	—	—	78	131	—	—	—	—	4 437
	Total	51 818	19 424	28 118	18 967	15 149	4 723	5 297	595	1 266	3 707	156 666
Detailed	1975	—	—	—	—	—	—	—	—	—	—	—
	Total	108	52	—	—	—	—	—	—	—	17	177
Exploratory	1975	—	—	—	6 337	—	—	—	—	1 619	8 802	37 478
	Total	2 630	42 410	10 926	12 284	5 284	—	—	—	3 469	40 206	160 481
Resurveys												
Reconn.	1975	—	405	890	—	—	—	—	—	—	1 214	2 509
	Total	4 534	15 949	20 015	46	339	28	526	—	—	1 214	43 122
Detailed	1975	—	35	—	60	98	—	1	113	—	—	307
	Total	366	1 669	2 079	1 099	719	—	24	595	—	—	6 550
Canada Land Inventory												
Agriculture												
New	1975	3 855	—	—	—	—	—	—	—	1 619	—	5 474
	Total	48 340	45 324	35 987	19 340	20 905	7 117	5 297	566	4 544	3 529	221 186
Reassess.	1975	—	—	—	60	98	131	—	113	—	1 214	1 617
	Total	4 010	—	1 756	816	430	283	—	595	—	1 214	9 104

\*Reconnaissance at scale 1:50 000 to 1:126 720; detailed at scale greater than 1:50 000; exploratory at scale less than 1:125 000.

Under the northern resource inventory program, the inventory covered approximately 6.3 million ha at 1:125 000 scale in northeastern Manitoba in 1975. The areas concerned were the National Topographic Service map areas of Island Lake, 53E; Oxford House, 53L; Knee Lake, 53M; Kettle Rapids, 54D (west 1/3); Split Lake, 64A (SE 1/4); and Sipiwesk, 63P. Data were gathered on landforms, soils, permafrost, vegetation, wildlife and its habitat, and lakes and streams. Biophysical surveys in the province have now covered 12.3 million ha, or about 30% of the 40.5 million ha of land in northern Manitoba requiring inventory. The area that has been surveyed under the new biophysical classification system is 8.5 million ha, or about 21%.

The backlog of mapping projects has been reduced by publication of the report and maps of the Red Rose – Washow Bay area; completion of an interim report with a 1:125 000 scale map of the Cormorant Lake area; and completion of 1:125 000 scale preliminary maps of the Wekusko, Norway House (west 1/2), and Cross Lake (west 1/2) areas. Compilation of the maps and report on the Virden area is continuing and publication is scheduled for 1976.

A specialized soil study of about 500 ha at 1:6336 in the area surrounding Deep Lake in Riding Mountain National Park was completed for Parks Canada. The objective of the study was to determine the sensitivity of the soil to intensive recreational use and traffic.

*Saskatchewan.* Soil survey activities during the past year included continuation of work on maps and reports for map areas where the field work had been completed; continuation of the basic resurvey of the Weyburn–Virden map area and the integrated resource survey of the Prince Albert National Park; the start of surveys in the Liard River valley in the Northwest Territories, and initiation of activity for the ISSS meetings of 1978. Research topics included remote sensing, saline soils, and forest productivity.

Soil reports on the Saskatoon, Pasquia – The Pas, and Prince Albert map areas have been completed and are currently being reviewed for publication. Map compilation and report writing have progressed on the map areas of Swift Current, Hudson Bay – Swan Lake, Amisk – Cormorant Lake, Wapawekka, Green Lake, and Waterhen.

Approximately 620 000 ha were mapped in the Weyburn–Virden area. Soil productivity studies, research on lithologic properties of glacial tills, and evaluations of near-surface glacial stratigraphy were conducted concurrent with this survey.

In the resource survey of the Prince Albert National Park, 161 874 ha were mapped. Monitoring of soil and atmospheric environmental conditions at six sites continued and a pilot study was started on the application of CanSIS to the evaluation and management of park resources.

The Saskatchewan portions of tours associated with the 1978 ISSS meetings were established and all soils were sampled for analysis. An outline for guidebooks for all conference tours was proposed. Activity also included participation in displays and other conference organization committees.

A soil survey of approximately 1.2 million ha along the Liard and Mackenzie rivers in the Northwest Territories was conducted as a basis for assessing agricultural capability. In addition, soils and materials in adjoining areas were sampled to provide information for several nonagricultural interpretations.

The joint Canadian–U.S. program to investigate the extent and vigor of the spring wheat crop by use of remote sensing imagery was continued.

Saline soil investigations included further studies on permanent sampling sites in the vicinity of potash refineries and on the application of dolomite to improve soils affected by K dust. Permanent sampling sites were established at six demonstration sites to evaluate methods for improving production on salt-affected soils. A salinity hazard map of Saskatchewan was prepared.

In cooperation with the provincial Forestry Branch, forest fertilization studies were continued and soils were evaluated at approximately 100 permanent growth and yield plots to permit interpretation of the relationship between soil type and the growth and yield of common tree species in northern Saskatchewan.

Miscellaneous activities included further exploratory soil examinations in northern Saskatchewan, a soil survey of the University of Saskatchewan's research farm, initiation of the soil section of the Qu'Appelle Valley Geolog, and silviculture investigations related to reforestation of denuded areas.



*Alberta.* The Oyen map was completed and awaits publication. Field checking and correlation of map units were started in the Eastern Irrigation District project. The Lethbridge map (82H/N) was undergoing final compilation. Reports on Elk Island and Yoho national parks were being prepared, and surveys were active in Banff and Jasper national parks.

Other activities included crop yield assessments, work on management of Solonchic soils, rating of soils for grazing and for irrigation, and investigation of remote sensing for crop identification.

The Research Council of Alberta group conducted surveys in Wapiti (83L) and Iosegun (83K) areas to characterize the soil resource and prepare interpretive groupings. Detailed surveys for planning were conducted in 10 provincial parks, the St. Albert urban area, and other locations involved with multiple land use and special projects. Studies were conducted on reclamation of coal mine dumps in the upper foothills, and on characterization and use of peat for reclamation in the oil sands areas.

*British Columbia.* The federal survey group conducted field checking and sampling and correlation studies in the Omineca-Parsnip area, the provincial capital region, and the Gulf Islands, Prince George, Cariboo, and Vancouver Island - Gulf Island areas.

Other activities included completion of forest capability maps with foresters in central British Columbia; preparation of interpretive classification of soil for timber harvesting and road construction, slash burning, and slumping around reservoirs; classification studies in alpine areas; and preparation of maps for regional planners showing topography, soil classification, soil parent materials, and wetlands.

The provincial group conducted surveys in the following areas: Stuart Lake - Omineca, Nass River, Terrace - Prince Rupert, South Vancouver Island, Central Vancouver Island, Tahtsa - Morice Lake, Babine River, and East Kootenay. They also made further progress on preparing reports for map areas previously surveyed: West Kootenay (N and S), North Thompson - Columbia, Bonaparte - North Thompson, Merritt - Kamloops, Vernon, Kelowna - Penticton, Nechako - François Lake, Prince George, Okanagan

Valley, Lower Fraser Valley, Kluskus, Williston Lake, Maxan Lake (vegetation study), Quesnel, and Bowron - Quesnel Lakes. Surficial geology and landform mapping was completed in a number of other map areas.

*Northwest Territories.* Cooperative terrain and environmental studies involve the Canada-Manitoba Soil Survey, Terrain Sciences Division of the Geological Survey of Canada, and the Canadian Forestry Service of Environment Canada. These studies, for the Eastern Arctic Pipeline Project, continued in the islands of Prince of Wales, Somerset, Bathurst, and Cornwallis.

During 1975, 8.8 million ha were surveyed on an exploratory basis. In this study landforms, vegetation, and soils were described and interpreted to provide a basis for the selection of a pipeline route.

In the Liard River valley area, about 1.2 million ha were resurveyed to provide more detailed soil information and interpretive groupings of soils. On the basis of these data, land use policy will be formulated by the Department of Indian and Northern Affairs. The work was done by members of the Saskatchewan Institute of Pedology assisted by federal personnel located in Vancouver, B.C., Edmonton and Beaverlodge, Alta., and Guelph, Ont.

*Cartography.* The Cartography Section published five soil maps and completed drafting on seven; 118 other maps are at various stages of drafting. The simultaneous scribing and digitizing process has been doubled in capacity by acquisition of a second digitizing table.

The section published 90 land capability maps and six miscellaneous maps for the Canada Land Inventory program. There are 52 maps awaiting printing, and 207 maps awaiting completion of general area descriptions; 395 land capability maps are at various stages of drafting.

Reproduction services were also provided on request to other institutes, agencies, and branches within the department. Some work was done for other departments under reciprocal agreements.

### Great Lakes Watershed Study

As part of Agriculture Canada's contribution to implementation of the Great Lakes Water Quality Agreement, the Soil Research Institute continued its participation in the Agricultural Watershed Studies, Task C,



Activity 1, International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG), International Joint Commission (IJC). This agricultural component of the PLUARG program is being implemented jointly by Agriculture Canada, the Ontario Ministry of Agriculture and Food, and the Ontario Ministry of the Environment. The coordination, data handling, and information and liaison aspects of the Agricultural Watershed Studies have been continued as a joint project by the Soil Research Institute (SRI) and the Engineering Research Service (ERS).

The Ad Hoc Committee for Watershed Selection was formed to review the information collected during the preliminary phase of the program, and a two-phase study was developed. Phase 1 consists of monitoring 11 small agricultural sub-watersheds selected to represent identified agricultural regions. Its objectives are to measure the ambient concentration and loading rates for various potential pollutants that occur with agricultural land use. Phase 2 consists of a series of studies on six of these identified sub-watersheds, and is intended to determine the effects of soil, land use, and associated practices on concentrations and loading rates of pollutants; to study the mechanisms of transport and storage of pollutants in agricultural watersheds; and to develop a predictive capability that will allow extrapolation to other areas. A possible phase 3, on future requirements, would be to develop remedial measures where significant problems are identified.

A second ad hoc committee was formed to review responses to a request sent to research institutions, universities, and consultants in southern Ontario for projects to meet the identified objectives. The resulting program reflected the high priority placed on nutrients and sediments by the planning committees. Projects on sediments included a study of erosional losses from agricultural land, use of a mathematical model of soil erosion, characterization of sediments, and an investigation of the transport of fluvial suspended sediments. Nutrients were to be covered by studies on movement of P and the development of a predictive capacity for that movement; included in the program were studies of N sources, transport and transformation of the element in a stream, transport and transformation of N in waters in agricultural soils, and development of a model of N

movement through the soil and in the groundwater zone. Metals and other pollutants were included in other studies on sources, transport and storage of heavy metals, and transport of pollutants from livestock operations.

The projects being carried out by the Soil Research Institute include: soil survey of agricultural sub-watersheds, and investigations of the nature and enrichment of sediments in agricultural watersheds; erosional losses from agricultural land; agricultural sources, transport, and storage of heavy metals; N transformation processes in the soils of the watershed; physical properties of the soils that control moisture storage and transport; and mathematical modeling of N transport in the agricultural watershed soils. These studies were started on April 1, 1975.

As part of the coordination project, a detailed study plan covering all projects in the Agricultural Watershed Studies was prepared as well as an Annual Report for 1974-75 and a Semiannual Summary Progress Report for 1975-76.

## ORGANIC SOILS

The organic soil program of the Institute was started in 1974 with the main objectives of improving methods of classification and conservation of these soils in Canada. In this connection, better methods were sought for the characterization of peats. These included refinements in methods for determining their fiber content and particle size distribution, use of thermogravimetric analysis to estimate the carbohydrate, humic, and lignin content of peats, and use of the distribution of phenolic compounds to measure the degree of decomposition.

The work started in 1974 in cooperation with the Research Station at St. Jean on degradation of pesticides in organic soils was continued. In 1975 the application of carbofuran to an Organic soil (St. Clothilde) in the laboratory did not confirm the increased loss of C that had previously been observed in the field. In other experiments it was found that paraquat increased the microbial and active mycetal populations in Organic soils, whereas linuron decreased them. The extent of changes in microbial populations did not have any detectable effect on available N and P and the rate of microbial activity. The degradation of lindane in a Humic Mesisol at



St. Clothilde showed that more pentachlorobenzenes and dichlorobenzenes were formed as metabolites than in mineral soils.

## WATER AND NUTRIENT TRANSPORT

The purpose of the water and nutrient transport program is to develop models of the soil-solution system that can be used to predict quantities and rates of movement of nutrients and water in soils. One objective is to quantify the transformation and transport of nutrients in soils as a basis for more effective fertilizer management and waste disposal in soils.

A mathematical model was developed to simulate the nitrification of  $(\text{NH}_4)_2\text{SO}_4$  and mineralization of soil N. The interaction of soil moisture content and temperature was to be the major controlling process, but fixation of ammonia by clay minerals was found to have an unexpectedly important influence on nitrification rates.

Computer simulations of N transport in soils were tested with data from the Research Station at Harrow and from fertilized plots at the Central Experimental Farm, Ottawa. The simulation included rainfall and runoff, measured hydraulic conductivities, water transport, and N transformations. Preliminary analyses indicated the need to develop a two-phase nitrate transport model (stationary and mobile solution of  $\text{NO}_3$ ) and to assess the effects of cold temperature on N transport in soils.

A project was started to determine the movement of N in soils used for agriculture in southern Ontario. Six experimental plots in two watersheds were established and instrumented to determine the disposition of N under various cropping regimes.

## NUTRIENT AND WASTE MANAGEMENT

The objectives of the nutrient and waste management program are to develop improved uses and management of fertilizers, manures, and wastes, in order to minimize pollution of the environment by regular agricultural practices and disposal of wastes in soils.

Sewage sludges from several sources were mixed with soils and incubated in the laboratory; metals were then extracted with 0.005

M DTPA, 0.05 M EDTA, 0.5 N HOAc, and 0.01 M  $\text{CaCl}_2$ . Adding sludge increased the amounts of extractable Zn, Cu, Ni, Pb, and Cd in proportion to the total amounts of metal added. Amounts of extractable Cu, Cd, and Pb were independent of soil properties but the DTPA-extractable Zn increased with increasing organic matter content; DTPA- and HOAc-extractable Zn decreased with increasing clay content. Incubation at higher temperatures ( $50^\circ\text{C}$ ) reduced Zn and Pb, anaerobic incubation reduced the amounts of Zn, Cu, and Cd, and liming reduced Zn.

When  $\text{NH}_4$  was added in the laboratory to a soil from the Central Experimental Farm, the clay-fixed N was reduced to close to its original value after 1 yr. With additions of manure and its liquid fraction, a smaller proportion of the N that had been fixed was nitrified. Addition of manure solids did not increase fixed-N,  $\text{NO}_3$ , or exchangeable  $\text{NH}_4$ , so that leaching during the year removed nitrate but had little other effect. Three leachings removed mineral N at a rate of 113  $\mu\text{g/g}$  soil from the control but at only 144  $\mu\text{g/g}$  from the manure-treated soil, even though mineral N had been added at 142  $\mu\text{g/g}$  by the manure. Clay fixation and immobilization apparently "tied up" most of the added mineral N.

Potato tubers and soybean roots grown in an uncontaminated surface soil contain 0.18 and 0.99 ppm Cd. Addition of 5 ppm Cd increased the amounts of the metal markedly, and high concentrations were observed in lettuce and tobacco leaves. The addition of Cd to the soil had little effect on yield with most crops but decreased the yield of lettuce. The Cd content of lettuce was lower on soils containing higher amounts of organic matter and was reduced by liming of acid soils. Additions of Cd increased the concentration of Zn in plants but addition of Zn did not affect the uptake of Cd.

In greenhouse studies of acid mine tailings varying in pH from 1.9 to 2.9, the amount of lime required to neutralize the initial acidity as well as that produced during cropping varied from 10 000 to 50 000 ppm. In two samples that contained more than 5% S, the pH was 2.5 after cropping even though  $\text{CaCO}_3$  had been added at 100 000 and 140 000 ppm. Reed canarygrass was grown successfully except in one unweathered tailing sample with a high S content. A soil layer on top of the tailings was used with varying effectiveness for establishing vegetation. With

inadequate lime the soils became strongly acid and released Mn, Fe, and Al to the plants.

## ACTIVE FRACTION AND SOIL BEHAVIOR

The program on the active fraction and soil behavior has as its purpose a better understanding of the nature and transformations of soil constituents. Work within the program has concentrated on investigating the reactions of nutrients, the structure of humic substances, transformations of clay minerals, and the reactions of metals and other constituents with humic substances and clay minerals.

Laboratory studies showed that chlorite was readily altered to vermiculite minerals in acid solutions. In these studies, oxidation of ferrous iron in the chlorite minerals was found to be an important step in the alteration process. The alteration products formed in the laboratory resembled products from the same kinds of chlorites in soils. Studies were started on the reactions of  $\text{NH}_4$  and K ions with the vermiculites formed in the laboratory. When micas were dissolved by

fulvic acid, the rate of dissolution was in the order biotite > phlogopite > muscovite, and substantial amounts of Fe, Al, Mg, K, and Si were released into solutions during dissolution.

Clay fractions of soils at two sites near Dawson, Yukon Territories, revealed the presence of a mineral with strong reflections at 0.7–0.8 ng. Detailed studies showed that the mineral was a mixed, irregularly stacked montmorillonite-kaolinite containing 60–70% kaolinite. Mossbauer spectroscopy was found to be a useful technique for identifying small amounts of hematite in the presence of goethite. The method was applied successfully to the characterization of iron oxides in soils.

The characterization of humic and fulvic acids in soils was continued; the analytical characteristics and chemical structures of fulvic acids in tropical soils from the West Indies were found to be similar to those in soils formed in other environments. However, these tropical soils contained unusually high concentrations of aspartic and glutamic acids, which appear to have interacted with the allophanic minerals in the soils. About 25% of the N in the soils was nonproteinaceous. Stable fulvic acid – silica complexes were found to be present in the soils.

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## INTRODUCTION

The highlights of the Institute's research activities for 1975 are summarized here. The activities include studies on the mode of action of toxicants (fungicides, herbicides, and insecticides); the search for new target sites; the interaction of insecticides and plants; the isolation and characterization of biologically active material such as phytoalexins, insect neurotransmitters, and insect attractants and repellents that may have potential use in crop protection. The assessment of current plant-protection programs in the environment and the development of more effective integrated control programs often require a multidisciplinary approach and cooperation within the Institute and with other establishments in the Branch and elsewhere.

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 5B7.

E. Y. Spencer  
Director

## PLANT PESTS

### Mode of Action of Selected and Potential Insect-control Agents

Activity was concerned with the development of a more efficient pest-control program by improving our understanding of sites in biological systems attacked by chemicals in order to improve pesticide design and use; by studying the mode of action of selected agents to increase their effectiveness; and by searching for new target sites to offer more selective methods of control.

In the study of the mechanism of action of DDT and several biodegradable analogues, the relative effectiveness of some as inhibitors of energy-transfer systems was compared. Further comparisons were made of the susceptibility of several other systems in order to better understand the basis of specificity and selectivity.

Progress was made during the year to further elucidate some of the general principles of structure-activity relationships based on studies on acetylcholinesterase. Substrate binding was found to occur in stages, and the poor substrates (including carbamate and organophosphorus insecticides) that are first bound outside the catalytic center subsequently contact it. Consequently the requirements for strong binding of such agents are quite different from binding of normal substrates.

The major achievement a year ago of identifying and confirming by synthesis proctolin, the pentapeptide neuromuscular transmitter substance found in insects, has resulted in the availability of sufficient pure material to gather more information on its pharmacological and electrophysiological properties in the insect. It has also enabled a study of the properties of the inactivation enzymes and the identification of the hydrolytic fragments, which should be useful for designing inhibitors. Proctolin analogues were synthesized; none showed antagonistic activity.

Another potential target site was found in a study of chitin synthesis, which showed that insects might be controlled by interfering with their molting process. The investigation of the chitin-synthesizing enzyme required two approaches to achieve control with chemical agents. Some experimental insecticides that appear to interfere with the molting process are being examined, and leads on the critical steps of this control have been obtained. In simultaneous work with fungi, the kinetics of initiation of chitin synthesis have been worked out.

Progress was made in the electron microscope study of the larvae of the European corn borer, before and during diapause. The distinct changes in specific structures, particular lysosomes, and "nut bodies" were characteristic for each instar. Conditions were found for the initiation of these specific structures so that one type can be developed rather than another.



## Fumigants — Mode of Action, Use, and Residue Analysis

Based on the observation that the toxicity of the fumigant phosphine is potentiated by carbon dioxide, a biochemical study was undertaken that established the site of action as predominately in one part of the respiratory chain. The mechanism of action was ascribed to a valence change of the heme iron. The basis of enhanced phosphine toxicity by carbon dioxide appears to be due to the carbon dioxide (acting as bicarbonate *in vivo*) simultaneously inhibiting a separate vital target site from that by the phosphine, thereby resulting in mortality levels greater than either agent acting alone.

Investigations on mechanisms of resistance to fumigants indicate that the resistance of the granary weevil to phosphine is partly caused by the reduced uptake of fumigant by the insect, whereas resistance to methyl bromide is based on some interval change related to detoxication or the site of action rather than on membrane permeability and uptake of fumigant. A mathematical model for designing dosage schedules based on concentration, exposure time, and an interaction factor has been developed for control problems where pests need to be killed without injuring sensitive living plants, fruits, and vegetables. Carbon dioxide, an effective synergist of many fumigants, does not have appreciable effect on oxygen consumption even at high concentrations where it paralyzes insects and enhances fumigant effectiveness; its action as a synergist is being studied. Low-temperature fumigation (below 0°C) can be done successfully with a formulation developed at this Institute; the formulation can be dispersed effectively in wheat at 0°C and the residues formed will desorb within a few weeks of the treatment. A suitable analytical method was developed for this mixture. Insects hidden in elevator-bin spouts, where air currents cause excessive loss of fumigant, can be controlled with phosphine generated from aluminum phosphide tablets at temperatures down to 10°C. Adults of the Colorado potato beetle can be controlled with concentrations of methyl bromide that will not injure mature harvested potatoes.

## Soil Insecticides — Ecological and Chemical Behavior

Investigations have been broadened to include insecticide-plant interaction. A plant physiological study has explained the variable effect on plant growth of a widely used carbamate insecticide and some of its metabolites.

Studies of factors influencing the behavior of some insecticides in soils have demonstrated the importance of certain cations on the extent of adsorption on certain soil types. Bioassay results correlated well with the effect of iron on the degree of adsorption of some organophosphorus insecticides on a sandy soil.

The interaction between insecticides and nontarget soil organisms has been extended to include some fungicides as a result of the frequent use of insecticide-fungicide seed treatments. Such mixtures have been shown to significantly affect soybean plant growth during the early stages partly because of a reduction in symbiotic nitrogen fixation. Of 13 fungicides examined, only 4 were found that had no significant detrimental effect. The significance of water stress was also studied and optimum conditions determined. The influence of insecticide-nematocide treatments on soil fertility by affecting organisms in relation to nitrification was examined for several treatments and shown to have little effect relative to known nitrification inhibitors. This study was in collaboration with the research stations at Vineland Station and Delhi, where significant recovery from the treatments with nematocides was found.

In addition to determining the influence of soil organisms and inorganic ions on insecticide behavior, studies included examining the influence of pH on the stability of several soil insecticides. This has been extended to include determining the persistence and degradation of some organophosphorus insecticides in different formulations in microplots. Also, the influence of soil moisture content on the persistence and mobility of one organophosphorus insecticide is being studied.

Only three new experimental insecticides were submitted for evaluation for foliar and soil insect control. Two of these, pyrethroids, were unique in exhibiting a negative temperature coefficient similar to DDT. Studies on the development of insect resistance were continued. Resistance by the onion maggot to



organophosphorus insecticides and the Colorado potato beetle to endosulfan and organochlorine insecticides was found.

When organochlorine insecticides were banned, new problems arose for controlling insects. Among those requiring attention are the Colorado potato beetle, the crucifer flea beetle, and the variegated cutworm. Cultures were established and rearing methods developed for each insect, followed by a screening program to determine new compounds that showed most effective control. Microplot and field trials were conducted on the carrot weevil, the crucifer flea beetle, and the Colorado potato beetle in order to develop effective measures of control. Good control of the European corn borer was obtained with either an ovicide or a larvicide, using the degree-day technique to predict optimum timing of spray applications. From ecological studies with some insecticides and fungicides, the fungicide benomyl was found to be highly toxic. This property is being evaluated in order to suppress earthworm populations at airports; the results have been satisfactory to date.

## PLANT DISEASES

### Mechanism of Disease Development and Resistance

Good progress has been made toward the goal of determining the nature of naturally occurring antifungal compounds and their role in disease resistance. The close relationship between the phytoalexins from different species of the Solanaceae have been further substantiated by biosynthetic experiments supplying  $^{14}\text{C}$ - $^{13}\text{C}$  labeling. Thus, results obtained with capsidiol from peppers and compounds from *Datura* (both plants are convenient model systems) throw light on the production and function of the phytoalexins of potatoes, particularly because two of the compounds from *Datura* are identical with two of the potato phytoalexins. Evidence has been obtained that some of the compounds are metabolized by both the plants and the tissue culture, indicating the possibility that their accumulation in infected tissue may be due to a metabolic block caused by fungal or bacterial invasion or by certain chemicals.

### Mode of Action of Selected Fungicides

A wide range of commercial and experimental material has been screened for fungitoxicity. Considerable variability among *Pythium* spp. was found in sensitivity to one commercial fungicide, whereas three other fungicides exhibited a different pattern of activity from some of these species. Current emphasis is on an antibiotic, phacidin, particularly active against Phycomycetes and dehydroorcinol, a synthetic compound closely related to the phytoalexin orcinol.

After the demonstration of the enzyme inhibited in the control of corn smut by carboxin, the initial systemic fungicide, the critical structure requirements for optimum activity were determined by assaying several analogues that were synthesized. Some were found to be highly active against strains in which resistance had been induced to the original fungicide.

There have been indications that some of these new compounds exhibit a fungitoxic spectrum extending beyond Basidiomycetes, for instance, to Phycomycetes. Advances have been made in the mode-of-action studies of the fungicide hymexazol (ISO), which is effective against *Pythium* spp., chiefly concerning its effect on cell permeability.

Progress has been made in the biophysical studies concerning selective transport and systemic action. Specific compounds have been found for use as a standard with which to compare the relative permeability of xylem to other compounds in the study of structural requirements for selective penetration. A sophisticated apparatus for measuring root pressure has been developed to give more accurate and reliable data. Permeability studies with parasitic fungi have demonstrated a transport system so highly active that it could conceivably be used to concentrate toxins in such a manner to provide a high degree of specificity.

As part of the study on new target sites in fungal inhibition, the kinetics of initiation of chitin synthesis have been worked out.

## WEEDS

### Herbicides and Plant Growth Regulators

In the auxin herbicide-enzyme interaction, plant indoleacetic acid oxidase has been shown to be composed of several isoenzymes



and to play an important role in its reaction to some hormone growth regulators like 2,4-D. The availability of these isoenzymes (bound or soluble form) has been found to have a significant effect on their reaction to these particular herbicides and on plant growth.

In the study of the influence of environment on the uptake of herbicides, the relative importance of transpiration and metabolic root pressure on the translocation of the herbicide monuron from the growth medium to the leaves has been examined under varying environmental conditions, resulting in contrasting effects on the two processes. The protein synthesis inhibitor cycloheximide stopped root pressure but had little effect on translocation of monuron or transpiration. These treatments and others indicate that transpiration has a major influence on translocation of monuron, whereas the solute transfer mechanism responsible for root pressure appears to have almost no effect.

For the response of soil microflora to herbicides, combinations of paraquat with several triazine herbicides were found to have little effect on the growth of certain rhizobia, radiobacter, and streptomycete phages. Soil fungi recovered from a fumigant (Vorlex; Nor-Am Agricultural Products) – herbicide (linuron) treatment had no toxic effect on the lettuce crop, in contrast to early field reports.

In an attempt to develop a herbicide bacterioassay by ultraviolet irradiation of soil microorganisms, linuron-sensitive mutants were isolated. However the mutants lost sensitivity when they were subcultured. The cause is being studied. Meantime mutants have been isolated that are sensitive to paraquat and glyphosate.

## ENVIRONMENTAL QUALITY

### Management of Pesticides

One phase of this topic is concerned with an analysis of pesticide residues in pesticide-management systems to determine their

acceptability. The other is concerned with investigations into possible new programs for pesticide management, particularly the study of insect pheromones and the sterile-male technique.

Extensive sampling of watersheds in several areas of southwestern Ontario as well as marshes north of Toronto showed that nutrient and insecticide transport was not always proportional between tributaries and whole watersheds. Excessive residues were found for one organophosphorus insecticide on two farm soils. From the development of an air-sampling technique, four organophosphorus insecticides were identified at various times from samples taken at the Holland Marsh.

In the examination of the feasibility of utilizing the sterile-male approach for control of the onion maggot, good progress was made in developing a mass-rearing technique. Two approaches were used for sterilization: irradiation of pupae and chemosterilization of adults. Results from the irradiation experiments were disappointing in comparison with those from the previous 2 yr, whereas those from the chemosterilization experiments were very promising.

Progress is reported in examining pheromones as possible aids for improving pest-control programs. Studies were continued on the utilization of the sex pheromone of the female European corn borer to monitor populations in several localities in southwestern Ontario. Results of studies during the past summer indicate that pheromone traps should provide a reliable and fairly convenient tool for monitoring populations of both first and second generations of European corn borers. With the use of electrophysiological methods (electroantenograms), sex pheromones of the European corn borer and related chemicals were studied. New electroantenogram data on the two geometrical isomers of a pheromone-active material were obtained and the electroantenogram responses from the two strains (New York and London) were found to be quite different. However, a hypothesis that the difference might be due to a plant-feeding substituent does not seem likely.

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## INTRODUCTION

The contracting-out program for research, development, and evaluation of agricultural mechanization equipment was expanded to 50 contracts for a total expenditure of \$800,000. The program was successful in expanding basic research at several universities; developing new machinery; evaluating new and special machines for cereal, forage, and horticultural crop production and animal waste management; and assessing energy utilization.

Twenty-five pieces of equipment and instruments were developed and evaluated to assist scientists in conducting their research in various biological and field activities. A mobile remote-sensing laboratory was completed and placed in operation to study crops and soils.

The Canada Plan Service in cooperation with the Information Division and the 10 provinces prepared 48 sets of new plans and 48 catalogs and leaflets for production of beef cattle and sheep. A major study was completed relating to cleaner feedlot cattle.

This report summarizes developments in 1975. Additional information and copies of the reports listed may be obtained by writing to Engineering Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

C. G. E. Downing  
Director

## MECHANIZATION AND SYSTEMS

### Research

A spinning disc distributor and a hydraulic winch for a haytower were developed to reduce labor and improve handling of materials. Six harvesting systems, compared in heavy alfalfa-brome, resulted in low field losses. Crested wheatgrass was easy to cure and superior in nutritional value. Wheat straw and chaff were harvested by adapting a chaff-saver to operate with a combine. Stackers, round and regular balers with tine pickups, lost chaff, but flail pickups on stackers lifted all the material.

A forage-system simulation program was modified, and system costs, nutrients, and energy units were compared. Direct-cut timothy silage systems for Prince Edward Island were simulated; results showed that net margin and system size increased with area, but not proportionally. The program was adapted to CANFARM facilities.

Rock crushers for potato land in New Brunswick were assessed and problems with potato planters were identified. Rock crushing was found to be undesirable.

### Contract Research and Development

Phase-in of the DREAM (development, research, and evaluation of agricultural mechanization) program to the approved level of expenditure was completed, with contracts totaling \$800,000. Fifty contracts

through agencies across Canada worked on mechanization problems involving crops, animals, and energy.

Provincial governments issued six extension publications based on contract work such as harvesting equipment for hay and forage and attachments for combines for heading soybeans. A departmental publication was issued on the production of methane gas from animal wastes. Drawings are available for construction of a hitch that pulls implements in tandem. Nine technical papers were presented at conferences by contractors and 17 contracts were reviewed in *Canadex*.

The contract reports contain performance information on items such as drum and disc mowers, harvesting systems for hay and forage, combine headers for sunflowers and soybeans, an apple harvester, harvesters for vegetable crops, a raspberry harvester, a fababean seeder, bunk feeders, feed mixers, and liquid-manure aerators. Information was developed on early planting of cereal crops, the role of mechanization in controlling wild oats, and compaction and traction problems on wet soils. Contracts on systems analysis and energy budgets expanded knowledge on these subjects. A summary of the 1974 contracts was prepared and individual contract reports are available.

Contracts have led to commercial exploitation of the developments. A tomato harvester, suitable for Ontario growers, is in

production. A grass seeder for seeding irrigation ditches was successful and will be marketed. A deep-tillage plow suitable for breaking and mixing Solonchic soils was built.

## RESEARCH SERVICE

### Equipment for Mechanization of Field or Laboratory Experiments

A four-row seeder was designed and a single-row harvester constructed for cereal test plots. A machine was developed to remove guard rows from cereal plots to facilitate harvesting. A four-row soybean planter was developed for seeding narrow-row experimental plots. The reporting of cereal yields in metric units was simplified by making a container to measure kilograms per hectolitre.

A system for recording urine and feces produced by cattle was improved. A scale attached to a mobile cart was developed to dispense accurately weighed quantities of feed to individual cattle.

The sorting of experimental cigarettes according to draw pressure, a quality factor in shredded tobacco, was automated by a machine that tested each cigarette in both directions. A survey of the needs for automation in chemical analysis was completed.

### Mechanization Applied to Crop and Animal Production

A survey of the automation potential of cannula milking techniques was completed. A bed shaper and a seeder were developed for planting baby carrots to maximize yield and to harvest with a bed-type lifter.

A new whole-plant chopped tobacco harvester was developed and evaluated. Processing equipment was developed to grind cured tobacco and then compress the material into plastic bags for shipping.

### Instrumentation

A detector was developed for seed counters and evaluated with various seeds. It maintained accuracy for a wide range of seed sizes. Instrumentation was developed to automatically measure the diameter of the stem and the height and area of the root system of plants, and to record the data on punched paper tape. An instrument was

developed for measuring the puncture resistance of seed coats to predict resistance to insect damage.

A continuous recording evapotranspirometer was developed that uses a capacitance probe to detect the level of water in the instrument. A portable degree-day integrator was developed to indicate the length of time that the ambient temperature was above a selected level in order to apply insecticides at the optimum time. A microprocessor system was assembled to explore applications of this technology to data acquisition in agricultural research.

A mobile remote-sensing laboratory was placed in operation to record and analyze the energy reflected by crops and soil using UV, visible, and IR spectra as well as laser-induced fluorescence. Field trials indicated that these measurements can differentiate between crops, varieties within crops, growth stage, and soil type.

### Processing and Quality Measurement

A pilot plant was developed to rapidly blanch individual pieces of fruits and vegetables in order to study methods of improving quality retention. A curing cabinet for uniformly cooking experimental wieners was completed. A simple pilot-plant food drier was constructed by converting a domestic clothes drier.

A study of the effect of processing parameters on the quality of extruded cereal products was completed. A 10-g electronic recording dough mixer was evaluated and found to be accurate. The viscosity of starch slurries during cooking was measured accurately and rapidly with a new viscometer developed to test sample sizes from 25 to 4000 cm<sup>3</sup>.

The effect of protein replacement in the formulation of wieners on their texture was measured instrumentally. Probes were made for measuring toughness of meat carcass to examine predictions of cooked tenderness. Apparatus for testing firmness of cheese and milk gels were improved. An electronic recording consistometer was developed to measure the foaming and emulsifying properties of cereal proteins. Two general-purpose instruments for measuring rheological properties of fruits and vegetables were developed and a Kramer shear press was modified to improve its accuracy. An instrument was developed to measure the graininess of



applesauce and the smoothness of fruit purees. Physical properties of tomatoes and onions in relation to processing and storage behavior were determined.

The use of ultrasonic measurements as a nondestructive means of determining eggshell thickness was evaluated and found to have potential. Correlations were established between egg characteristics and shell strength. Egg-size measurements did not improve the accuracy of prediction of shell strength, because the normal range is small.

Studies on differential scanning calorimetry to characterize the structural changes in milk gels were completed, and results show that the technique is ineffective. Instrumentation was developed to measure the rheological properties of air-liquid or liquid-liquid surface films to examine the effects of proteins on the manufacture of food emulsions. Equipment and techniques for measuring food stickiness were developed.

## STRUCTURES AND ENVIRONMENT

### Developmental Research

Porous ceiling ventilation in free-stall dairy and beef barns gave better cold weather humidity control than slot air inlets. Better design and maintenance of air filters extended the efficiency of a thermosiphon heat exchanger, which improved winter ventilation for caged laying chickens by reclaiming heat.

Design shear stresses were determined for galvanized steel, plywood, and Aspenite used as structural diaphragm cladding materials. Computer programs for design of prefabricated roof trusses for farm buildings were prepared. A method was developed for calculating and charting combinations of wind and snow loads for the design of square and round poles for walls of farm buildings.

Corn silage that was tractor-packed in a deep horizontal silo averaged  $242 \text{ kg/m}^3$  ( $15.1 \text{ lb/ft}^3$ ) dry-matter density. When the silage was not packed, the density was  $200 \text{ kg/m}^3$  ( $12.5 \text{ lb/ft}^3$ ).

Field studies of rates and times of manure application to cropland indicated that spreading in winter on gentle slopes results in greater nutrient loss than spreading in spring or fall. The principal loss was to surface runoff water during spring thaw. Runoff

equations were prepared to predict polluted runoff resulting from precipitation on feedlots and manure storages in southwestern Ontario. The runoff was more predictable for paved and unpaved feedlots than for a manure pile on pavement. Feedlot runoff was highly polluted with nutrients and organic matter, especially from the paved feedlot and during winter runoff. Soluble nitrogen was highest in runoff from the manure pile.

A system for handling cattle manure in a cold climate with a plunger manure pump, an earth-banked storage slab, and liquid-manure spreading by irrigation was evaluated. A tractor bucket loader was inefficient for handling the remaining semisolid manure, so a tractor-mounted pump was developed. For an 8-mo housing period and 12 mo precipitation, the liquid fraction was  $2.3 \text{ m}^3/\text{head}$  at 1% solids and the semisolid fraction was  $4.7 \text{ m}^3/\text{head}$  at 15% solids.

The committee for cleaner feedlot cattle completed its study of the problems of dirty cattle sold for slaughter at Canadian plants, and recommendations were made for action by the meat industry.

### Canada Plan Service

The CPS design center, cooperating with the Information Division and the 10 provinces, prepared 48 new sets of plans, 43 catalogs and leaflets, and 14 revised plans, mainly for production of beef and sheep. Twelve quick-release plans from provincial sources were distributed. In French, 48 plan sheets and 62 catalog leaflets were distributed.

A new series, *Building engineering*, was added to the original eight-plan series; it includes new general information on heating, ventilation, structural design aids, and foundations.

A 3-day training course in CPS drafting standards and illustrating techniques was presented to draftsmen from Nova Scotia, Saskatchewan, and Alberta. Short courses on animal environment control and agricultural building design were given to Prairie and Atlantic provincial engineers.

## TECHNICAL AND SCIENTIFIC INFORMATION

The agricultural engineering information retrieval system was expanded by one-third,

particularly by agricultural engineering research papers. Replies were prepared for many inquiries. There was emphasis on items related to energy, and holdings were expanded to meet this need. Projects relating to current agricultural engineering research and

development in Canada were compiled and disseminated.

Meetings were held with provincial agricultural engineering specialists to describe our service and to identify their problems and information requirements.

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# Ornamentals Research Service

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## INTRODUCTION

The two main programs in the Ornamentals Research Service are continuing. The first concerns research to service the floriculture, nursery, and turf segments of agriculture. Because of the wide diversity of crops and problems, projects were selected on the basis of the national priorities established at the Work Planning Meetings in 1974. The second program is the development of the Arboretum and Botanic Gardens, but because the position of Curator is vacant, the program was restricted to evaluating annual ornamental plants and selected perennials.

This report summarizes the research in 1975. Additional information and reprints may be obtained from the Ornamentals Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Allan Chan  
Director

## ORNAMENTAL PLANTS

### Floriculture

Fourteen cultivars of *Cyclamen persicum* (Mill.) were evaluated in a 3-yr study on their response to two growing temperatures, 13 and 17°C, and four holding temperatures. Results indicated that the higher growing temperature significantly reduced the time from seeding to flowering, without a significant effect on quality. An increase in growing temperature affected flower production among cultivars differentially. The cultivars Rose of Aalsmeer, White Carmel Eye, Cattleya, Cardinal, Rose of Marienthal, and Pearl of Zehlendorf had significantly longer keeping quality when grown at 17°C than plants grown at 13°C. The experiments demonstrated that there are wide differences in response to growing and holding environment among cultivars of *C. persicum*.

Experiments dealing with photoperiodicity of *Alstroemeria* showed that the cultivars Orchid and Regina responded differently to day length. The cultivar Orchid flowered earlier and uniformly when grown under long-day conditions of 16 h or more, whereas the cultivar Regina did not respond to day length. These two varieties were also exposed to 6 wk of different temperatures (5, 10, 15, and 21°C) and the control was grown in the greenhouse at 21–30°C. The plants grown at 5, 10, and 15°C flowered, whereas the plants grown in a controlled environment at 21°C and the ones kept in the greenhouse at 21–30°C remained vegetative. Therefore, it appears from these experiments that the flowering in *Alstroemeria* cultivar Orchid is

controlled by day length and in cultivar Regina it is controlled by growing temperature.

Use of Viterra (Union Carbide), a soil additive, at 24 kg/m<sup>3</sup> extended the periods between watering. Poinsettias and bedding plants grown in Viterra-treated soil lasted 2–4 days longer without watering than plants grown without Viterra.

### Tissue Culture and Histochemistry

Four cultivars of Rieger begonia were grown from meristematic cultures. The cultivars are Schwabenland Red, Schwabenland Orange, Crispa, and Aphrodite Pink.

Meristematic cultures were already established in 1974; however, when the plantlets were transferred from liquid media, they started to deteriorate and eventually died. After several failures, a technique was developed whereby the mortality rate was negligible.

Meristems were cultured the same way as was reported last year; however, the plantlets were left in the culture tubes until the roots developed to 0.5–1 cm long, then, instead of being planted in a solid medium, they were transferred to sterile vermiculite in clay pots and were fertilized with Hoagland's solution. Once the plantlets became established, they were grown on a regular cultural schedule for Rieger begonias.

The starch, lipid, cytochrome oxidase, succinic dehydrogenase, peroxidase, and acid phosphatase levels were determined histochemically and periodically in transverse sections of cut stem of rose, *Rosa hybrida* L. cultivar Forever Yours, kept in water or in an

aqueous solution containing 4% of sucrose, 100 ppm of sodium isoascorbate, and 100 ppm of 8-hydroxyquinoline sulfate. Senescence of the cut rose stem, including leaves and flower, was delayed by the use of the preservative solution. The levels of cytochrome oxidase and succinic dehydrogenase were not affected significantly by either of these treatments. Starch, lipid, peroxidase, and acid phosphatase levels decreased in the tissues in the rapidly senescing stems kept in water only. In tissues where senescence was retarded by use of preservative solutions, the lipid content was maintained at a relatively high level, whereas starch, peroxidase, and acid phosphatase levels increased. It is suggested that in cut rose stems, the onset or retardation of senescence is not related to the activities of acid phosphatase or peroxidase.

### Physiology of Ornamental Plants

Substituted oxathiin (P-293), in concentrations of 0.125 to 0.75% ai, was used to control development of side shoots on *Chrysanthemum morifolium* Ramat., cultivars Golden Shoemith, Fred Shoemith, Promenade, Improved Indianapolis White, Festival, and Wildfire. Chemical sprays applied on the 20th or 23rd day of the short days decreased the number of side shoots, slightly delayed flowering time, and injured leaves of the Shoemith cultivars.

The smallest number of side shoots and the largest blooms were obtained on the other four cultivars when the chemical was used at 0.50% ai on the 20th short day. The chemical reduces the manual disbudding requirement on certain cultivars, but its economic value is not certain.

Acetylcholine chloride (Ach) inhibited ethylene production in etiolated bean tissues and prevented to some extent the IAA-promoted opening of the bean hypocotyl hooks. The results were interpreted on the consistent basis of Ach mimicking the effects of red light on auxin content and ethylene production.

The activities of the acid and alkaline inorganic pyrophosphatases (EC.3.6.1.1) were determined in the petals of cut flowers of roses, carnations, and chrysanthemums kept either in water or in solutions of a flower preservative, or in flowers left uncut on plants. The use of flower preservative decreased the activity of both pyrophosphatases

in roses, but not in carnations or chrysanthemums. The activities of both enzymes were greater in the flowers of carnations and chrysanthemums than in roses, but were similar for each kind of flowers, which indicates that their effect on anabolism or catabolism in flower petals was minimal.

### Ornamental Plant Breeding

Winterhardy, disease-resistant, remontant, and abundantly flowering roses were selected from three breeding lines: *rugosa* hybrids, *kordesii* hybrids, and hybrids between hardy roses and garden cultivars. The most promising selections were evaluated at several other establishments. *Philadelphus*: Two of Dr. D. Sampson's selections, tentatively named 'Snow Belle' and 'Purple Heart', were the most outstanding and can be easily propagated by cuttings. *Weigela*: Several hardy seedlings with a prolonged flowering season were obtained and will be evaluated further.

### Evaluation of Annual Plants

Annual trials for 1975 were concentrated on snapdragons (208 cultivars), zinnias (140 cultivars), statice (29 cultivars), ageratum (30 cultivars), alyssum (23 cultivars), and dahlias from seed (25 cultivars). The top rating snapdragons were White Pixie (dwarf), Orange Topper, Floral Carpet White (dwarf), Yellow Monarch (short), Floral Cluster Crimson (dwarf), Orange Pixie (dwarf), Floral Carpet Bronze (dwarf), Floral Carpet Yellow (dwarf), and Frontier Dainty Orchid.

In the zinnias, the cultivars scoring the highest points were Scarlet Ruffles (tall, medium flowers), Cherry Ruffles (tall, medium flowers), Wind Witch Gold (tall, medium flowers), Lilac Gem (tall, small flowers), and Wild Cherry (medium, large flowers).

Among the other groups tested the top ratings in each were statice, Bonduelli Yellow; ageratum, White Cushion; alyssum, Minimum; and dahlia, Redskin (All-America Selection 1975).

### Turfgrass

Although *Poa annua* L. is a very invasive and persistent grass species in Ontario and Quebec, little is known about the kinds of *Poa* that may be found growing naturally in various parts of Canada. Thus a collection of 115 samples of *Poa* was assembled to initiate



studies related to the turf potential of this species. The clones were classified according to their growth habit, leaf width and texture, seed potential, seed germination, and heat tolerance.

Forty-four clones were classed as upright open-growing types, 16 were semiprostrate, and 55 were prostrate in growing habit. Seven of the latter remained vegetative. Plants of upright growing habit tended to have coarse, wide leaves, whereas narrow-leaved types were semiprostrate or prostrate. Thirty-five clones had a good, spreading growth habit and 28 of these were semiprostrate as well. Semiprostrate plants tended to produce more seed than the upright or prostrate plants. Germination tests indicated that percentage germination varied from 89 to 97% with most of the seed germinating in the first 10 days. Although 7 clones indicated good heat tolerance and 20 clones fair, *Poa* seedlings were less heat tolerant than Kentucky bluegrass. Of 35 clones that had a good or fair rating, 24 were collected from the Ottawa area and none were from west of Winnipeg.

### Nursery

The survival of eight containerized nursery species was compared during the winter of 1974-75 under five overwintering treatments: small polyhouse enclosure; straw mulch; styrofoam-insulated containers; air-insulated containers; and unprotected (controls). Container temperatures and root impedance for two species were monitored under each treatment. *Juniperus chinensis* L. 'Mint Julep' and *Picea glauca* Voss were the only species that effectively withstood all overwintering environments. Plants that overwintered in the polyhouse suffered most because of wider fluctuations in temperature; the most severe winter injury occurred under this treatment.

Forty-five cultivars of rose, totaling over 1200 plants, were successfully stored at  $1 \pm 3^{\circ}\text{C}$  ( $34 \pm 5^{\circ}\text{F}$ ) during the winter of 1974-75 in Plant Fresh plastic bags. Waxed rose plants stored in these bags initiated earlier spring growth, flowered earlier, and were more vigorous than nonwaxed plants stored in the bags, or waxed plants with exposed tops and roots kept moist in peat moss. Similarly, bare-root 46- to 61-cm plants of *P. glauca* and *Taxus cuspidata* Sieb. & Zucc. stored in Plant Fresh bags were superior in

quality and survival rating to plants otherwise treated.

When the rate of surface-applied Osmocote (18-9-12) was increased from 0 to  $610 \text{ g/m}^2$ , the rooting percentages increased from 13 to 47% for *Cotoneaster lucidus* Schlecht.; Osmocote applied at  $305 \text{ g/m}^2$  produced more vigorous rooted cuttings of several other species. Although ethephon alone had almost no effect on rooting, combinations of ethephon and IBA (3-indolebutyric acid) or of ethephon, IBA, and Osmocote at the higher rates increased root mass, root number, or root length, or all three, of *Cotoneaster dammeri* Schneid., *Thuja occidentalis* L., *Ilex verticillata* Gray, and *Ligustrum vicaryi* Rehd.

### Entomology

Two aspects of an integrated program for control of the greenhouse whitefly attacking poinsettia were examined. First, Dexon (Bayer), quintozone, and Truban (Mallinckrodt), applied as soil drenches, were tested for their effectiveness in modifying the attractiveness of the host plant to the pest. Quintozone-treated plants had the highest density of whitefly adults, whereas Truban-treated poinsettia had the lowest. Second, the pesticide chinomethionat combined with the chalcid parasite *Encarsia formosa* Gahan reduced the immature pests and increased the adult whitefly on the host plants more than did the parasite alone in 6 wk.

The development of self-sustaining colonies of *Amblyseius fallacis* (Garman) as a method of integrating biotic and chemical agents in an integrated control program of the twospotted spider mite continued with the propagation of the predator on two new food chains. First, *A. fallacis* was reared on *Tarsonemus confusus* (Ewing), which was propagated on the molds *Mucor* sp. and *Cephalosporium* sp. growing on a potato-dextrose medium. Second, *A. fallacis* was reared in small laboratory cultures on the wheat curl mite.

### Diseases of Ornamental Plants

Research was continued to determine differences in development and persistence of *Pythium splendens* Braun in soil and soilless mixtures. Fungi and bacteria were isolated from the various mixtures and tested for antagonism to *P. splendens*. Soilless media contained no antagonistic organisms except

Cornell peatlite Mix A, which supported growth of a species of *Penicillium* antagonistic to *P. splendens*. Correlation was observed between disease development and number and type of antagonistic bacteria and fungi present in a mixture.

Chlortetracycline hydrochloride provided some control of bacterial leaf spot in the Rieger begonia. The amount of protection given was greater than that provided by streptomycin sulfate, but the bacteria were not completely controlled in all plants.

Studies on fungicide resistance in *Botrytis cinerea* Pers. using benomyl, Easout (thiophanate-methyl), Bay Meb (triadimefon;

Chemagro), and Botran (dicloran) led to the conclusion that resistant strains of the fungus are present in nature and that failure of a fungicide to control the pathogen is due to rapid multiplication of a particular strain brought about by the selective pressure exerted by a particular chemical. It was observed that a strain that was resistant to one fungicide was susceptible to other unrelated fungicides and that, with the use of two or more unrelated fungicides, the fungus could be controlled.

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## INTRODUCTION

In 1975, the Statistical Research Service provided advice and assistance on some 150 problems in the design of experiments and the analysis and interpretation of experimental data. The demands on staff for review of scientific papers continue to increase; there is a little evidence that the quality of the statistical analysis of data has improved. However, there has been a heightened awareness of the importance of appropriate statistical analysis for toxicological studies, especially important in the continuing review of food safety.

Cooperation with other scientists in the Research Branch continues to be close and is shown by their willingness to publish in collaboration with our staff. The link with the station statisticians continues strongly; some unusual problems have been referred to us for assistance.

The library of computer programs has been enlarged and improved; among completely new techniques implemented are generalized Procrustes analysis and the related technique of canonical consensus coordinates, robust confidence interval estimation for the center of any symmetric distribution, nonhierarchical cluster analysis using projective methods, multiple linear regression with non-negativity constraints on the parameters, and a completely rewritten program for the analysis of diallel crosses (including covariance) by any of Griffing's methods. By means of the facilities given by OPTAB, balanced incomplete blocks can be analyzed efficiently. GENSTAT, produced by Rothamsted Experimental Station, is available for use directly by members of our staff and indirectly by members of the Department; its use increases the power of analysis of experimental data.

For more information, correspondence should be addressed to: Director, Statistical Research Service, Agriculture Canada, E-266, Sir John Carling Building, Ottawa, Ont. K1A 0C5.

L. P. Lefkovitch  
Director

## PLANT AND SOIL SCIENCE

The analyses of data from a fertilizer (N, P, K) trial on reed canarygrass grown on organic soils showed that dry matter yields increased with increased level of application of each of the three constituents of the fertilizer. The use of pretreatment soil levels of phosphorus and potassium as covariates in the analysis did not significantly reduce the residual mean square. Other investigations on forage crops included the design of an experiment for a 3-yr interdisciplinary study of the effects of various environmental and physiological factors on winter survival of alfalfa in Quebec; the design of a sampling scheme to estimate the incidence of alfalfa leaf spot under field conditions, and the analyses of data from trials of several varieties of grasses.

A study of root rot of pea showed that the disease reduced yield by as much as 67% in heavily infected stands. Other plant studies included a comparison of the growth curves of two varieties of corn grown on four mulch

treatments in a split-plot experiment; the analyses of data from a long-term factorial experiment on the effects of cultural practices on corn and tomato yields; obtaining estimates from a laboratory experiment of  $LT_{50}$  (temperature at which half the plants died) for two varieties of winter wheat by probit analysis.

Regression methods were used to investigate the relationship between time from harvest to ripening and various measures of skin and flesh color of peaches. A significant linear relationship was found between each of the independent variables and the ripening time. The slopes of the regression equations were the same for all varieties, but the intercepts were significantly different, not only among varieties but also among harvest dates within varieties. Other experiments on fruit crops included studies of calcium uptake (with the use of radioisotopic tracer methods) by apple trees; estimation of the fertilizer requirements of strawberries; design of a spacing experiment for six varieties of dwarf apple trees; testing of an apple-grading

machine; and the analyses of data from several blueberry trials. Data from an experiment to determine the amount of various sewage sludges that could be added to different soil types without raising the soluble metal content of the mixture to toxic levels were analyzed. The results for all types of soil showed a linear relationship between soluble metal in the mixture and soluble metal in the sludge. Other investigations on soil included a study of methods of altering soil characteristics to make the soil more suitable for a specified purpose; estimating optimum irrigation sprinkler spacing to ensure uniform distribution of water; and a comparison of the abilities of experienced and inexperienced observers to identify soil types from aerial photographs.

Collaborative work with agrometeorologists continued on prediction equations for cereal yield, soil moisture, and temperature. Statistical advice was given in problems encountered in the selection of weather variables to be included in a study of winterhardiness.

The results of an experiment on chrysanthemums showed that chemical spraying to control development of side shoots can replace hand-pruning without inhibiting growth or bloom size. However, the best time to spray and the correct concentration of spray varied among the 11 varieties tested.

Many other experiments for plant science were designed and analyzed. They included a study of tobacco management and curing methods; the design of a uniformity trial to assist in the design of future experiments on tobacco; the comparison of methods for the laboratory analysis of crops for chlordane and maleic hydrazide residues; a calibration experiment for testing a water-level indicator; a study of the distribution of root density of corn and tomatoes; and an investigation of the erucic acid content of pedigreed rapeseed crops as estimated from field samples. Data bank and information retrieval systems were set up for information on plant genes and breeding projects for corn and potatoes.

## ANIMAL SCIENCE

Nonparametric time series models were used to analyze vaginal and jugular temperatures of sheep. The magnitude of long-term trends and the response to changes in light exposure differed widely among the animals.

From an earlier study, the phase estimates for the intradian sinusoidal component of variation were computed from six sheep. Large differences among the animals were observed.

Exact probability discrepancy measures were used to examine the effect of diet on ovulation in sheep. As the breeding season deepened, the differences in ovulation rates between groups of animals on different energy levels increased.

A modified Zucker's function was fitted to the growth pattern of turkeys. In a study into the effects of nutritional level, it was found that birds compensated for the differences among energy levels by consuming less of the high-energy ration; this factor helped to explain why growth rates were not significantly different.

The effects of shelter and amount of feed on several characteristics of beef cows and their calves (for example, mortality and fertility rates and weight losses) were examined. Several experiments, relating vitamin E nutrition in beef cows to various rations, were analyzed.

The data from several experiments involving dairy cows were analyzed. One study dealt with the relationships among three circulating hormones, milk yields, and feed rations. In another experiment, the effects of pedigree, production stress, sex of calf, parity number, and year of birth on the gestation length and birth weight in Holstein cattle were investigated.

A computer system was established to facilitate the efficient analysis of an extensive data base concerning the cleanliness of beef cattle at several slaughterhouses. The problems of acquiring relevant data to measure the effects of feeding systems on the quantity of milk produced per cow and per hectare were considered; suggestions for the creation of a data file were made.

During the past year, statistical analyses were carried out on the data from several experiments on poultry eggs. The relationships between shell strength (measured by puncture force or quasi-static fracture force) and diet, age of bird, and strain were examined. In another study, the age and strain of bird and the time of year that the eggs were collected were found to affect the interior, exterior, and keeping qualities of eggs. The effects of the form of presentation of  $\text{CaCO}_3$  on the quality of egg shell and on feed intake were examined.



The metabolizable energy (ME) of several samples of poultry feeds was determined by traditional methods and by newly developed methods. The ME's so obtained were compared with each other, and with the predictions of several formulas found in the literature. New prediction equations were developed with the use of easily measured properties of the feeds.

Other projects included determining the effects of pregnancy and a longer breeding season on body composition of gilts; determining the effects of cooking time of the fababean on the absorption rate of various amino acids by hogs; computing the inbreeding coefficients in a poultry experiment; investigating the relationships between the incidence and the severity of myocardial necrosis in rats and the concentration of erucic acid in rapeseed oil.

## FOOD SCIENCE

The results of taste-panel experiments, in which various attributes of products such as wieners, beef, and fruit flavor crystals were recorded as a point on a 15-cm line, were analyzed. The points were shown to be close enough to being normally distributed, so a univariate analysis of variance was done for each attribute; multivariate analysis of variance is being considered. A graphical presentation was devised for identifying tasters who have unusual responses to some or all attributes.

Analysis of covariance and regression methods were used to investigate the relationship between moisture content and the thermal conductivity of meat emulsions. The relationship was found to be linear, but the intercept coefficient depends on the fat content and the type of binder used.

In connection with a proposed international collaborative study on the quality of durum wheat some difficulties of sampling and experimental procedures appeared to be likely to reduce its effectiveness. A modification of the original plan was recommended in order to have a good chance of achieving some of the many goals.

## BIOASSAY

Advice and assistance were given in a wide range of bioassay applications, including field and laboratory assays of herbicides,

chick assays of available amino acids in grains, fumigant trials, studies of lymphoid tumor transplants in chickens, and plaque neutralization assays of antisera for blue-tongue virus. The methodological spectrum was also broad: quantitative assays involved slope-ratios, parallel-lines, sigmoid curves for percentage data, and time-response data; quantal assays included variants of Wadley's problem, and formulations for immunity of test subjects.

Departure from classical distributions and models was often needed in this work, necessitating review of experimental techniques and statistical assumptions, and modification of methods of analysis. For example, the first set of experiments designed for the slope-ratio assays of available amino acids in grains gave results implying an implausibly high digestibility of wheat protein. Therefore, more experiments are in progress. In the plaque neutralization assays, a factor in the model is the "hit number," that is, the number of virus particles required to initiate plaque formation by a single cell. Experiments originally designed to study the change in assay precision with change in control count, and subsequent experiments designed specifically to study hit number, gave unacceptably low estimates of hit number under the usual (Poisson) distributional assumptions, unless the control count was less than about 80 plaques. For present practical purposes, the control count can be kept below that level (and above 35 plaques to give adequate precision). Meanwhile, a model to fit the results over a wider range is being sought, particularly because this may also apply to similarly low estimates of hit number in the literature. When the underlying distributions are evidently complex or unusual, simplified statistical methods may be more appropriate than fitting multiparametric models, provided there is enough replication. This was the case with the herbicide trials, both in rangeland and in the laboratory. The time-response assays, too, both for Marek's disease in chicks and for studies of insecticide residues, were more tractable and informative when analyzed in terms of median times.

The genetic resistance of chicks to lymphoid tumor transplants was studied in a series of factorial experiments involving over 8000 chickens, and the data were analyzed by maximum-likelihood fitting of multiple probit regressions. Strains were found to

differ in susceptibility to challenge, but the presence or absence of maternal antibodies did not appear to affect the percentage kill as assessed at 16 days after inoculation, although the highly lethal suspension of high-passage Marek's disease tumor usually caused death 1 day earlier in chicks without maternal antibody than in those with maternal antibodies for antigens related to Marek's disease. Resistance to challenge increased as age at inoculation was increased from 1 to 21 days, and a model including parameters for the regression of the proportion of immune individuals was fitted by maximum likelihood.

In studies of bluetongue virus, experiments on plaque neutralization designed to examine the effect of the size of the control count gave consistent estimates of the ED<sub>50</sub> over a wide range (15–150) of values, though the precision was highest between about 40 and 75 plaques. Continuing the analysis of cross-reaction data, a model was developed involving the hit number, the number of critical sites, and the concentration of antibody, which, for a limited range of concentrations, should give a linear regression of log (–log proportion surviving plaques) against log concentration, within the framework of a Wadley-type analysis. The data were reanalyzed on this basis. The main difference among strains appears to be an effective difference in numbers of critical sites.

## ECOLOGY

A study of spider and other populations in an Ontario meadow continued. It was shown that much of the variability in population of spiders could be attributed to regressions on simple meteorological data (rainfall and degree-days). Correlations among samples at any one time suggested the existence of positive relationships among web-spinning spiders, springtail insects, mites, and leafhoppers, and between hunting, web-spinning spiders and leafhoppers. When comparisons

were made on the basis of residuals from the regression equations, positive linear relationships were found between web-spinners and hunters and mites.

Population densities of mosquitoes were subjected to univariate time-series analysis with little success, but it was shown that for each of several years there was a strong correlation between certain environmental data and the mosquito data at a lag time of between 28 and 35 days. Further studies are in progress.

Other work included the investigation of an appropriate transformation and optimal sample size for tick data. In a study of the effect of insecticide on earthworm populations, no significance was found among levels of insecticide but each was significantly different from the control. An attempt to produce a prediction equation for crop loss due to damage by the corn borer failed because of excessive variation in yield data. Tabulations were made to help determine if spermatophores of the bertha armyworm disintegrate in the female body over a period of time.

## NUMERICAL TAXONOMY

Canonical analyses were used to determine if oat seed "size-shape" can be employed in discriminating among oat cultivars. The results of the analyses of the data, which consisted of measurements of the width of the seed at regular intervals along the upper and lower seeds, indicated that the measurements from both the upper and lower seeds, used together, are useful for cultivar discrimination. More exhaustive studies are planned when a mechanical method of measuring "size-shape" has been developed.

Some new methods of clustering having certain well-defined optimal properties based on projective methods, set partitioning and covering, and graph theoretical concepts have been developed and implemented for the computer. Experience in using them will determine their acceptance by taxonomists.



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## INTRODUCTION

The highlights of the research activities for 1975 are summarized here. The programs at the station emphasize breeding and physiology in beef cattle, swine, and poultry; and breeding, physiology and management, soil fertility and plant nutrition, cultural practices, and weed control in plant science. The selection project in swine was terminated. New genetic research deals with maternal influence on boar performance testing and with the relationship between biochemical parameters and postweaning performance traits. A project to develop lines of soybeans suitable for the eastern Prairie region was started.

Dr. E. D. Spratt, Canadian coordinator, and Mr. R. D. Dryden, Canadian expert, continue to serve with the India Dryland Project at Hyderabad, India. Dr. J. Moyer, weed control, and Dr. J. Sadler, soil fertility, joined the staff as replacements for Mr. Dryden and Dr. Spratt.

For further information concerning details of the work discussed or on related subjects, enquiries should be directed to: Research Station, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

W. N. MacNaughton  
Director

## ANIMAL SCIENCE

### Beef Cattle

In a study of puberty in hybrid heifers, nine hybrid combinations were produced from matings of Charolais, Limousin, and Simmental bulls with Angus, Hereford, and Shorthorn cows, and the females were compared for age and weight at first observed estrus. The calves were reared on commercial cattle farms and at weaning, at an average age of 196 days, they were transferred to the Research Station where the heifers were placed in a single drylot. They gained 0.68 kg/day and 99% of them had reached puberty by 15 mo of age. Simmental-sired heifers reached puberty about 2 wk earlier than Limousin-sired heifers (335 vs. 349 days;  $P < 0.05$ ). Differences in age at puberty between heifers with Charolais and Limousin sires were not statistically significant (342 and 349 days). At puberty, Charolais-sired heifers were heavier than those with Limousin and Simmental sires (319 vs. 300 and 297 kg, respectively;  $P < 0.025$ ). Heifers from Angus and Hereford dams reached puberty at the same age (347 and 348 days), but the heifers from Angus cows were lighter at puberty (294 vs. 307 kg;  $P < 0.01$ ). Heifers with high preweaning growth rates attained puberty at an earlier age ( $r = 0.24$ ;  $P < 0.01$ ). Weight at puberty was positively correlated with weaning weight ( $r = 0.61$ ;  $P < 0.01$ ), birth weight ( $r$

$= 0.41$ ;  $P < 0.01$ ), and preweaning average daily gain ( $r = 0.54$ ;  $P < 0.01$ ). Calves that were heavy at birth tended to be heavy at weaning, and heavy weaning weights were associated with heavy weights at puberty.

### Swine

*Response to selection.* Eleven years of recurrent mass selection for postweaning average daily gain in a population of Lacombe swine resulted in a predicted response of  $0.241 \pm 0.023$  kg, an observed response of  $0.146 \pm 0.018$  kg, an estimated heritability of  $0.327 \pm 0.031$ , and a realized heritability of  $0.198 \pm 0.016$ . There was little or no significant change in estimates of additive genetic variance, selection differentials, regression of postweaning average daily gain on generation time, and inbreeding in the Yorkshire control. The genetic correlation between sexes for growth was high.

*Heritability estimates for carcass traits.* Heritability estimates for carcass traits in the Lacombe selected and Yorkshire control populations estimated from sire components of variance were: carcass fat,  $0.63 \pm 0.15$  and  $0.91 \pm 0.17$ ; side length,  $0.68 \pm 0.14$  and  $0.53 \pm 0.17$ ; loin eye area,  $0.40 \pm 0.15$  and  $0.28 \pm 0.17$ ; ham weight,  $0.63 \pm 0.22$  and  $0.33 \pm 0.26$ ; percentage of lean in the ham face,  $0.56 \pm 0.25$  and  $0.87 \pm 0.30$ ; percentage of ham of the side,  $0.30 \pm 0.22$  and  $0.70 \pm 0.26$ ; color,  $0.10 \pm 0.16$  and  $0.17$

$\pm 0.19$ ; texture,  $0.40 \pm 0.16$  and  $0.24 \pm 0.18$ ; and marbling,  $0.47 \pm 0.17$  and  $0.23 \pm 0.20$ .

*Artificial insemination.* Mixed semen diluted with Beltsville 1 extender and stored from 2 to 48 h gave an 86% conception rate. Each of the 72 sows used was inseminated on the 1st and 2nd days of standing estrus with 50 ml of diluted semen containing  $4 \times 10^9$  spermatozoa.

*Reproductive performance of hybrid gilts.* Crossbred Lacombe  $\times$  Yorkshire and purebred Yorkshire gilts were inseminated on the 2nd day of estrus with mixed semen from groups of three Yorkshire boars ( $2.5 \times 10^9$  motile sperm in 100 ml diluent). Crossbreds were superior to purebreds for the number of pigs born per litter (9.4 vs. 8.2), the number weaned per litter (8.5 vs. 7.3), and the litter weight at weaning after 5 wk (73.7 vs. 60.3 kg). Piglets from crossbred dams were 16% heavier at birth than those from purebred gilts (1.4 vs. 1.2 kg).

*Blood hormone concentrations and growth rate in pregnant gilts.* Concentrations of progesterone, total estrogen, and luteinizing hormone were determined in samples of blood serum taken from Lacombe gilts every 3–4 days from day 10 to 56 of pregnancy. The gilts, housed in a heated piggyery, were fed 1.50, 2.25, or 3.00 kg/day to produce a low (L), medium (M), or high (H) growth rate. The groups had average daily gains of 0.15, 0.36, and 0.60 kg/day, respectively. When slaughtered at 59–61 days of pregnancy, the L, M, and H groups showed numbers of corpora lutea (ovulation rates) of  $13.4 \pm 0.5$  (SE),  $12.6 \pm 0.5$ , and  $15.1 \pm 0.8$ , and numbers of fetuses of  $11.2 \pm 1.0$ ,  $10.6 \pm 1.0$ , and  $10.7 \pm 1.3$ , respectively. Fetal weights were similar from gilts on the three treatments ( $122 \pm 5$  g). Concentrations of progesterone were fairly constant over the 46-day collection period and averaged 14.4 ng/ml. The growth rate of gilts had a significant effect on their blood progesterone concentrations, which were  $16.7 \pm 0.9$ ,  $14.0 \pm 0.8$ , and  $12.4 \pm 0.7$  ng/ml for groups L, M, and H. In contrast, total estrogen levels fluctuated considerably throughout the test period and large differences in concentration levels were found between animals. Estrogen concentrations for the L, M, and H groups were  $324 \pm 143$ ,  $172 \pm 52$ , and  $202 \pm 59$  pg/ml. The concentration of luteinizing

hormone was fairly constant over the collection period and averaged 0.48 ng/ml. Mean concentrations for the L, M, and H groups were  $0.37 \pm 0.04$ ,  $0.60 \pm 0.13$ , and  $0.46 \pm 0.05$  ng/ml.

## Poultry

*Rearing management of dwarf broiler breeders.* The level of protein in rearing rations, 12 or 15%, had no effect on the performance of “dwarf” broiler breeders or their offspring. When feeding was restricted during the rearing period to 8 h/day from 5 to 17 wk of age and 5 h/day from 17 to 21 wk, egg production increased by 30% (133 vs. 100 eggs) over production from birds fed ad lib. Dwarf breeders reared in floor pens on restricted feeding produced larger eggs (54 vs. 51 g) in the first 30 wk of lay than their counterparts reared in cages. However, over a 50-wk period of lay both groups produced the same number of eggs. Noticeable differences existed between the two strains of dwarfs used. In this trial all birds were housed in single bird cages during the laying period.

*Artificial insemination of dwarf broiler breeders in laying cages.* A difference in the semen dose, 0.05 or 0.10 ml, administered at 5- or 7-day intervals over 8 wk had no effect on fertility of dwarf broiler breeders. However, fertility was reduced from 86 to 80% when the interval between inseminations was long. Increasing the interval to 9 days resulted in a further drop of 15% in fertility. There was little difference between strains of dwarf broiler breeders.

## PLANT SCIENCE

### Forage Crops

*Response of grasses to sources of nitrogen.* Crude protein of brome grass, timothy, crested wheatgrass, and Russian wild rye-grass was increased and regrowth promoted by fertilization with N. Application of N in the fall stimulated early reproductive growth and application in the spring prolonged vegetative growth by 10–15 days, maintaining a high protein content. There were no significant differences in yield from either a split application or a single application in early spring.

Urea (46-0-0) and ammonium nitrate (34-0-0) increased yield, crude protein, and



mineral composition of grasses more effectively than solution N (28-0-0) and S-coated urea. The latter is a new product not commercially available.

*Bromegrass response to nitrogen fertilizer.* Dry matter (DM) yield per unit of N applied ranged from 20:1 to 30:1. High rates of N gave the lower DM returns per unit of N. Older stands responded more than younger stands when fertilized for the first time, but response patterns were similar when fertilizer was applied annually. Bromegrass should be harvested before June 25 for optimum quality (protein content) and quantity (yield of DM and protein per hectare). The most economical return for yield was obtained with N between 84 and 168 kg/ha. Higher rates of N (168–252 kg/ha) may be more economical in terms of hay quality and protein yield. Fertilizer should be applied annually to obtain high production and high protein content, as residual effects are minimal.

*Legume-grass mixtures for hay.* The mixture of Lincoln bromegrass with Vernal alfalfa gave average DM yields of 7140 kg/ha from 1969 to 1974. Mixtures of Lincoln bromegrass with other legumes were considerably less productive; with cicer milkvetch DM yields were 4220 kg/ha, with sainfoin 2910 kg/ha, with birdsfoot trefoil 3040 kg/ha, with Canada milkvetch 2720 kg/ha, and with crownvetch 2670 kg/ha.

Yields of second-cut hay were: bromegrass-alfalfa 2360 kg/ha, bromegrass – cicer milkvetch 600 kg, and the other mixtures, no yield.

## Oilseed Crops

*Nutrient requirements of fababeans and soybeans.* Increases in yield of fababeans and soybeans of 40–60% were obtained with P at rates up to 12 kg/ha, K up to 200 kg/ha, and S up to 13 kg/ha. Small increases in yield were obtained on coarse textured soils with Mo at rates up to 0.5 kg/ha and Cu up to 10–20 kg/ha. Applications of K, S, and Mo increased the number and size of nodules. Additions of K, S, Mo, and Cu increased concentrations of N in the plant. Unlike the effect on fababeans, high rates of P (18 kg/ha) did not depress the yield of soybeans. Soybeans had more and larger nodules per plant than fababeans. The addition of large amounts of inorganic N at seeding delayed

nodulation and decreased plant yield. Residual soil N after cultivation of a crop of fababeans was measured with barley. The  $\text{NO}_3$  -N level in the soil ranged from low to very low after fababeans. Barley responded to N applied at 30–120 kg/ha.

*Soybean evaluation.* The potential of soybeans on the eastern Prairies was evaluated in a large nursery planted with  $F_2$ – $F_6$  lines from wide crosses between USDA 00, 0, 1, and 2, and very early strains. Adequate maturity for this region was clearly demonstrated in many lines and segregates. The test plot of USDA 00 yielded 1.4 t/ha. Plants emerged slowly, from June 12 to 15, and heat units from the times of emergence and planting until killing frost were 1932 and 2019, respectively. Seeding at 269 kg/ha, in narrow rows 15.2 cm apart, resulted in a yield of more than 2 t/ha.

*Weed control in flax and rape.* HOE 23408 (Hoechst) at 0.84–1.68 kg/ha gave excellent control of wild oats in flax. Volunteer corn was effectively controlled. Asulam at 1.12 kg/ha gave good control of wild oats and acceptable control of green foxtail in flax. An antagonistic effect was observed when asulam was mixed with MCPA and applied at 0.28 kg/ha. HOE 23408 at 0.45 and 0.84 kg/ha gave good control of wild oats and green foxtail in rape. All treatments with EPTC, at 3.36 kg/ha, gave excellent control of grasses. Application of EPTC in the fall gave weed control and crop yields equal to those from application in the spring.

*Weed control in beans and lentils.* HOE 23408 at 0.84 kg/ha gave good control of grasses in fababeans. Mixtures of HOE 23408 and barban applied at 0.18 kg/ha showed compatibility in weed control and crop tolerance, but mixtures of HOE 23408 and metribuzin applied at 0.35 kg/ha showed antagonism. The mixtures of triallate applied at 0.84 kg/ha and trifluralin at 0.42 kg/ha were compatible and gave excellent weed control. In soybeans, trifluralin at 1 kg/ha, alone or in mixtures with other herbicides, gave good weed control. In lentils, trifluralin at 1 kg/ha, EPTC at 2 kg/ha, triallate at 1.35 kg/ha, and HOE 23408 at 1.12 kg/ha plus 0.5% Atplus (Atlas), a wetting agent, all controlled wild oats very well. Bentazon at 0.56 kg/ha, alone or in combinations, controlled all broad-leaved weeds but also killed lentils.



## Cereals

*Malting barley.* One blue-aleuroned line will be considered for licensing in 1976. This line should equal Conquest and Bonanza in malting quality. Extensive malting crosses have been made with two- and six-rowed barleys.

*Feed barley.* Several plant breeding lines have shown exceptional promise in advanced yield trials. A six-rowed selection will be considered for licensing in 1976. Another line ranked first in the Eastern Prairie Barley Project Trials in 1974, first in the USDA Mississippi Valley barley nurseries in 1975, and fifth in the Western Cooperative Barley Tests in 1975.

*Solution nitrogen mixed with herbicides for wheat.* Good wild oat control and N response in wheat indicated that triallate and solution N can be tank-mixed and applied without an antagonistic effect. Grain yields were increased by 17, 35, and 65% over yields of the check plot, which received no N or triallate, when triallate was applied at 1.68 kg/ha, solution N at 67 kg/ha, and solution N at 67 kg/ha plus triallate at 1.12 kg/ha, respectively. The combined postemergence application of barban plus solution N caused leaf burn at first, but yield increases were similar to those from treatment with triallate plus solution N. The postemergence application of WL 29761 (Shell) plus solution N gave good wild oat control but did not increase yield over that from solution N alone.

*Yield response to form and time of application of nitrogen with wheat.* Nitrogen was applied at 0, 22, 45, 67, and 90 kg/ha as  $\text{NH}_4\text{NO}_3$  and solution N before emergence of the crop and at the three-leaf stage of growth. Significant yield increases were obtained for each increment of N. The time of application and form of N did not affect yield.

*Weed control in barley and wheat.* HOE 23408 at 0.84–2.24 kg/ha gave good to excellent control of wild oats and green foxtail in barley. High rates, 1.68 and 2.24 kg/ha, injured barley and reduced yield. Wheat was more tolerant of HOE 23408 than barley. Postemergence treatments with HOE 23408 gave better weed control in wheat than preplant incorporation and preemergence treatments at equal rates. All treatments with WL 29761 at 0.42–1.12 kg/ha,

applied at two stages of growth, gave excellent control of wild oats.

*Effects of HOE 23408 on wild oats and barley.* Wild oat and barley seedlings were treated with HOE 23408 at 0.84 and 1.12 kg/ha in the greenhouse to investigate its effects on carbohydrate metabolism and adenosine 5'-triphosphate (ATP) production. In wild oats, sucrose and glucose increased in shoots but decreased in roots compared with levels in the controls; fructose decreased to a trace level. In barley, a similar pattern developed. HOE 23408 inhibited ATP production in the shoots and roots of wild oats but not in barley.

*Corn production.* Heat unit (HU) accumulation from May 15 to killing frost was less than normal (2200 vs. 2260 HU), and precipitation was above average (43.7 vs. 39.9 cm) in 1975. Yields in evaluation trials reached 6.2 t/ha for the third time in the past 4 yr. Silage yields reached the goal of 11.2 t/ha. Exceptionally early lines were identified and 15–20% kernel moisture, test weights of 72–82 kg/hl, and yields up to 8.0 t/ha were obtained. In a 1972–75 study on the date of planting, average grain yields were 5.5, 5.3, 4.3, and 3.5 t/ha from corn planted in the 1st, 2nd, 3rd, and 4th wk of May, respectively.

*Weed control in corn.* A combination of chemicals or one chemical plus interrow cultivation were required to control all weeds and obtain maximum corn yields. Corn was treated with butylate at 3.36 kg/ha plus atrazine at 1.12 kg/ha, incorporated before planting; atrazine at 2.24 kg/ha applied after emergence with oil on a 30-cm band over the row, plus interrow cultivation; atrazine at 2.24 kg/ha applied after emergence with oil; EPTC at 3.36 kg/ha plus R 25788 (Stauffer) at 0.263 kg/ha, incorporated before planting; interrow cultivation only; and butylate at 3.36 kg/ha. Corn DM yields were respectively 93, 93, 86, 85, 75, and 47% of yields from a weed-free control plot. Treatment with EPTC plus R 25788 in a tank mix with solution N resulted in yields equal to those from addition of EPTC plus R 25788 and granular  $\text{NH}_4\text{NO}_3$  applied separately.

*Nutritional status of corn in Manitoba.* Ear leaf samples were taken at silking from 121 farmers' corn fields in western Manitoba in 1975. The supply of N in soil and from fertilizer was limiting to growth of corn on



53% of the fields. Deficiencies of P and K were apparent in only 19 and 24% of the fields, and of S and Zn in 50 and 33% of the fields, respectively. Supplies of Ca, Mg, Fe,

Mn, and Cu were sufficient for maximum growth of corn on almost all the 26 soil types surveyed.

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## INTRODUCTION

This report summarizes briefly research conducted at the Research Station, Morden, in 1975. The program is directed toward improving cultivars and management practices in several established seed crops, vegetable crops, herbaceous and woody ornamentals, and new crops. The flax cultivar Dufferin and the black ash cultivar Fallgold were licensed. Dufferin has the attributes of the popular Redwood 65 along with the asset of resistance to present field races of flax rust. Fallgold is the first cultivar that can substitute for the American elm, which is threatened by Dutch elm disease. Pea seed-borne mosaic virus was detected in breeding stocks and commercial seed. A hyperparasite that attacks the fungus that causes basal stem rot of sunflowers has shown potential in controlling this disease. Jerusalem artichoke continues to show potential as a new crop.

Further information on research conducted at the Station is available in reprints of the publications and by personal communication with the scientists. The address is Research Station, Research Branch, Agriculture Canada, Morden, Man. R0G 1J0.

Eric D. Putt  
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### FIELD CROPS

#### Buckwheat

*Breeding.* A semidwarf plant habit is being crossed into existing cultivars and lines having large seeds in an attempt to reduce lodging. Among eleven dwarf plant habits, two are monogenic recessive and one appears monogenic dominant. Several cultivars were analyzed and CD 6183 and the Russian variety Bogatyr' were identified for their ability to set seed early. These lines will be used to produce early high-yielding diploids with large seeds.

*Management.* To determine the importance of soil moisture in seed set, the cultivars Tokyo and Tempest were irrigated twice each season for 3 yr. Increases in yield resulting from irrigation were 27%, 12%, and 11% for the 3 yr. Because seed size was not greatly affected, it was concluded that the higher level of soil moisture produced more seeds per plant.

Buckwheat tolerated the grass-control herbicide HOE-GRASS (HOE-23408; Hoechst) at up to 1 kg/ha applied at the three-leaf and five-node stages of growth.

#### Grain Corn

*Breeding.* Progress toward earlier maturity and higher yield of grain corn continued. Hybrids 74301 and 75371 flowered 3 and 4 days earlier, contained 5.2% and 3.6% less moisture in the grain at harvest, and yielded

9% and 16% more grain than the control hybrids. These hybrids will be offered to the seed trade.

When synthetics that were composed at Morden were grown in Europe, they were severely attacked by stalk rot, making it possible to select for resistance. Also, selections were made simultaneously for tolerance for low temperature in the seedling stage. Most of the European synthetics and inbreds grown at Morden were early maturing and of good plant type.

*Management.* Hybrids originating in Europe were better adapted than Canadian hybrids to the stress of higher than normal populations. Also, Canadian hybrids were slower maturing at high populations than the European hybrids. Within each group, hybrids also differed significantly in their tolerance for stress.

#### Field Peas

*Breeding.* A new disease, pea seed-borne mosaic virus (PSbMV), was detected in the breeding lines. The seed-borne nature of this virus increased its seriousness, because it can be spread by infected seed. Therefore, evaluation of all breeding lines was initiated to determine the extent of spread. Among 976 lines assessed visually, suspect plants in 81 lines were confirmed by using the local lesion host, *Chenopodium amaranticolor* Coste & Reyn. The range of infected plants within the

lines was 1–2%. It is anticipated that continued testing and rigid selection will eradicate the virus from the breeding program by the end of 1976.

**Diseases.** Two, and possibly three, pathogenic forms of *Ascochyta pinodes* L.K. Jones were identified from field peas in Manitoba. Most of the isolates belonged to the most virulent group.

PSbMV was found in 6–8% of the commercial seed from across Canada that was sampled. Because of the potential threat to the Canadian pea industry, investigations were undertaken to determine reliable visual symptoms and indicator hosts for diagnosing the presence of this virus. Field symptoms were characterized by stunting, mild to severe downward lateral leaf roll, and an erect compact-type growth. The virus also reduced the formation of pods and ovules. Field symptoms were detected best by two surveys made 5–7 wk after planting. A level of infection from less than 1 to 1.3% was detected in three fields planted with seed carrying 1–2% infection. A few infected plants were symptomless.

When two indicator hosts, fababeans and processing pea '447', were inoculated with sap from individual plants of peas, they confirmed the existence of PSbMV in plants that clearly had visual symptoms of the virus. The indicators also revealed the existence of PSbMV in some of the pea plants that did not show symptoms or had only mild symptoms. Fababeans were a more reliable host, because they could be easily infected.

**Management.** Subphytotoxic levels of simazine applied to the soil increased yield in 1973, but not in 1972 or 1974. Foliar applications did not affect yield in 2 yr of tests (1973 and 1974). Protein content and seed size showed no response in any of the tests.

## OILSEED CROPS

### Flax

**Breeding.** The flax cultivar Dufferin, from the breeding program at Morden, was licensed. Dufferin is comparable to Redwood 65 in yield, maturity, and other agronomic characteristics, but the oil content is slightly higher, the quality of the oil is slightly lower, and the protein content is lower. It is resistant

to races 370 and 371 of rust and is expected to replace the susceptible Redwood 65 in Western Canada.

**Diseases.** In 1975, rust, mostly races 370 and 371 or their hybrids with other field races, occurred throughout Manitoba and in the principal flax-growing areas of Saskatchewan. In 1975, rust was more prevalent than in 1974. Although rust was often severe in late-planted flax, a hot and dry period of 8 wk prevented widespread reduction in yield. Inoculations with rust race 371 showed that 18 of 142 Certified seed lots of Linott and 12 of 54 commercial lots contained more than 5% rust-susceptible plants, which is the standard tolerance.

**Management.** In a 3-yr study, the growth retardant SADH reduced plant height but did not reduce lodging. The treatments delayed maturity but did not affect yield. Increases in seed size and number of capsules per unit area were offset by a decrease in number of seeds per capsule.

**Quality.** Oil color is influenced by the cultivar, environment, and seed quality. Seed quality is affected by broken and damaged seeds, which always produce darker oil and have a higher iodine number.

Rust infections caused significant reductions in seed size, oil content, and linolenic acid content of the oil, depending on the timing and severity of infections.

The amount of oil extracted during single-stage crushing was influenced by where the cultivar was grown. The same cultivar grown at 16 locations yielded from 23 to 45% of the total oil. However, lines having high rates of extraction were usually consistent from location to location.

**Weed control.** The effects of the herbicides MCPA, dalapon, bromoxynil, and barban on the cultivars Redwood 65, Noralta, and Raja varied greatly over 3 yr. However, in any 1 yr, these herbicides tended to produce similar effects on the seed properties. The properties included yield, oil content, iodine number, and content of oleic and linoleic acids. Based on these characteristics, in 1974–75, Dufferin appeared to be slightly more susceptible to injury from these herbicides than Redwood 65 and much less than Newbud, which is known to be susceptible.



## Sunflowers

**Breeding.** Two introductions from the USSR showed promise as replacements for Krasnodarets. Salyut continued to produce higher yields and more oil than Krasnodarets, particularly in Manitoba. In Saskatchewan, Chernianka 66 outyielded Krasnodarets by 14% with an average oil content of 43.4%, whereas Krasnodarets averaged 40.7%. Both cultivars are early maturing, and Chernianka 66 is a dwarf type.

The average yield advantage in the 51 hybrids obtained from crosses of inbred lines onto sterile Krasnodarets was 19% over Krasnodarets. Heterosis also increased the oil content of the hybrids by more than three percentage points over the average of the parents.

Interspecific hybrids and backcross progenies have been obtained with *Helianthus petiolaris* Nutt., *H. giganteus* L., and *H. maximiliani* Schrad. They are being evaluated as a source of cytoplasmic male sterility.

**Diseases.** Selection for tolerance for basal stem rot or wilt caused by *Sclerotinia sclerotiorum* (Lib.) de Bary is feasible. On severely infested soil, Peredovik selections showed only half as many diseased plants, had a higher oil content, and outyielded unselected Peredovik by 20–35%. On normal soil, these selections and unselected Peredovik were similar.

Because basal stem rot spreads by root contact, fewer plants at wider plant spacings decrease yield reductions caused by disease. Highest yields and best control came from 55 000 plants or less/ha with row spacings of 60 or 90 cm.

*Coniothyrium minitans* Campbell was a major component of the fungal flora that contributed to death of sclerotia of *S. sclerotiorum* in sunflower fields in Manitoba. In the laboratory it was shown that *C. minitans* kills the hyphae and sclerotia of *S. sclerotiorum*. The hyphae are penetrated directly, then they collapse and disintegrate. This hyperparasite is also effective in the field, where studies showed that at the end of the season 59% and 76% of sclerotia produced inside and on sunflower roots, respectively, were killed by *C. minitans*.

**Quality.** The dehulled and defatted meal of 554 inbred lines contained from 1.1 to 4.7% chlorogenic acid. Wild *Helianthus annuus* L. grown from collections made at sites

from 30°N to 50°N contained from 1.6 to 2.7%. Material originating from collections made in the south contained the lowest levels.

**Weed control.** Trifluralin applied in spring at 1 kg/ha in a solution of 225 litres/ha and incorporated with a discer controlled 67% of the wild oats on a clay loam soil. Fluchloralin at 1.5 kg/ha was almost as effective and profluralin at 1.5 kg/ha was a little more effective than trifluralin at the same rate. HOE-GRASS at 1 kg/ha applied at the two- to three-leaf stage of wild oats satisfactorily controlled this weed without injuring the sunflowers. Combined control of wild oats and green foxtail with HOE-GRASS is not always possible. Green foxtail may emerge long enough after the wild oats to escape a treatment with HOE-GRASS, which is applied for control of wild oats.

## VEGETABLE CROPS

### Cucumbers

Ten cucumber cultivars were evaluated for yield in a commercial greenhouse between February and early August. Pin-Up, Farbio, and Brilliant produced the greatest number of fruits per plant. Pin-Up also had the highest yield in trials in 1974.

### Potatoes

**Breeding.** Seedling FS 6339, selected in the prairies from the cross Scott 2774-3R × Redskin made at the Research Station, Fredericton, is almost ready to be released as a midseason red table variety. It gives a high yield of uniform-sized, smooth, round, oval tubers. It has not shown serious susceptibility to disease.

**Management.** Studies on storage at a controlled temperature and humidity confirmed that the development of silver scurf increased on potato tubers when the temperature was above 4°C or the relative humidity was above 85%.

Aerial photographs taken with the aid of a 200-mm lens on a 35-mm hand-held camera with fast panchromatic film showed enough detail in 16×24-cm black-and-white prints to estimate size and frequency of gaps in potato plant stands.

**Quality.** A study to determine optimum conditions for storing tubers over long periods was conducted in cooperation with the Canadian Potato Chip Association. Of 11 lots of tubers from four locations in Canada, one lot of Kennebec and one lot of Norchip produced acceptable chips until late August when they had been stored at 5.5°C and 7.5°C, and until mid-August when they had been stored at 10.0°C. However, the tubers had lost some turgidity.

## NEW CROPS

### Jerusalem Artichoke

**Management.** Weekly increases in yield of tubers were highly dependent on soil moisture content. High humidity and  $0 \pm 2^\circ\text{C}$  were the best storage conditions for seed tubers. Forage yield reached 31 t/ha (30% dry matter) by mid-September. Second-year stands, which resulted from harrowing in the tubers left after the first harvest, yielded as well as conventional plantings. Modified equipment used for planting and harvesting potatoes and machinery used for making corn silage performed satisfactorily in Jerusalem artichoke.

**Diseases.** *Botrytis cinerea* Pers. ex Fr. was found in diseased tubers, but its pathogenicity has not been determined.

**Quality.** In cooperation with the University of Manitoba, forage analysis indicated that silage made from the crop when it was harvested at full bloom had good quality: i.e., protein 10.5%; crude fiber 24%; acid detergent fiber 33%; and lignin 12%.

### Pulse Crops

**Evaluation.** The following new accessions were tested: 71 mung bean, *Vigna radiata* (L.) Wilczek; 11 cowpea, *V. sinensis* Savi; 8 pigeon pea, *Cajanus cajan* Millsp.; 44 kidney bean, *Phaseolus vulgaris* L.; 5 grass pea, *Lathyrus sativus* L.; 4 white lupine, *Lupinus albus* L.; 8 fababean, *Vicia faba* L. Seed of 49 accessions of *Lathyrus* spp. showed none without alkaloids, although some were rated as low-alkaloid types.

**Management.** Azuki, mung, black, and navy beans, lathyrus, and lentils tolerated preplant applications of dinitroaniline herbicides. A combination of fluchloralin applied preplanting and bentazon applied

postemergence gave practical control of wild oats, redroot pigweed, and wild mustard, and selective control in all crops but lentils.

### Essential Oil Crops

Weekly harvests of monarda plants from July 2 to August 6 yielded 0.24–0.78% oil. Optimum dates were July 9–23. Sweet basil and summer savory yielded less than 0.1% oil; fennel yielded 0.2–0.3%, and sage 0.15–0.24%. Fennel yielded 896 kg/ha of seed. Monarda and fennel appear to have commercial potential.

### Miscellaneous Crops

Additional accessions of six millet, *Panicum miliaceum* L. and *Setaria italica* Beauv.; two coriander, *Coriandrum sativum* L.; and two niger, *Zinnia linearis* Benth., were tested. Niger seed had 34.9% oil with 85% linoleic acid.

## ORNAMENTALS

### Breeding

Two woody and one herbaceous perennial were released through the Canadian Ornamental Plant Foundation. *Fraxinus nigra* Marsh. 'Fallgold', a selection of native black ash, is the first known cultivar introduced in this species. The name describes the unique golden color of the foliage in the fall. 'Fallgold' holds its leaves longer in fall than most of the species. The cultivar has a straight stem with strong crotches, is hardy to at least Zone 2b of the Agriculture Canada *Map of Plant Hardiness Zones in Canada*, and can be readily propagated by budding on seedlings of green ash, *F. pennsylvanica* Marsh. var. *subintegerrima* (Vahl.) Fern. *Caragana arborescens* Lam. 'Walker' is a first-generation hybrid of *C. arborescens* 'Pendula'  $\times$  *C. arborescens* 'Lorbergii', which combines the weeping growth form of the former and the fine-leaved foliage of the latter. Mr. John Walker made the cross and the initial selections at the PFRA Tree Nursery, Indian Head, Sask. Final evaluation, naming, and distribution of propagation material was done at Morden. The plant is suitable as a ground cover on its own roots or as a weeping plant when it is grafted on a standard. *Chrysanthemum* 'Morden Fiesta' forms a compact plant 4.5 dm high, which



spreads about 4.5 dm. Its flowers are ruby red (R.H.S., 61A-B) and nearly fully double.

Interspecific crosses in *Lilium* (lilies) of distantly related species usually produce inviable seed consisting of rudimentary embryos with no endosperm. With the use of embryo culture techniques, embryos from four groups of distant crosses produced plants. None of the species used had been crossed by conventional procedures.

Dwarf plants with precocious flowering and repeat blooming appeared in the rose breeding program. They have potential as pot roses.

### Arboretum and Evaluation

Progressive developments have taken place in the Arboretum at the Research Station, which houses the major ornamental plant collection for the prairies. A new conifer-testing area was planted and about 400 accessions have been received, bringing the total number of plants acquired since 1970 to over 3000 taxa. Material distributed

to the parks departments of Winnipeg, Regina, and Edmonton for evaluation as shade trees and to zonation cooperators totaled 2500 plants of more than 200 taxa.

Dutch elm disease, first detected in Manitoba in 1975, caused losses of American elm in three localities in southern Manitoba. Based on observations in the Arboretum at Morden and elsewhere, the increased use of ash (*Fraxinus* spp.), hackberry (*Celtis occidentalis* L.), and basswoods (*Tilia* spp.) is recommended to replace American elm (*Ulmus americana* L.) and Siberian elm (*U. pumila* L.), which have been widely planted.

### Taxonomy

Hawthorns (*Crataegus* spp.) in southern Manitoba are often identified incorrectly by the use of existing taxonomic keys. A regional collection of herbarium specimens of flowers, leaves, and fruit from marked plants has displayed characters other than those previously used that will aid in distinguishing the species.

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<sup>1</sup>On transfer of work to the Crops Research Division, D.S.I.R., Christchurch, New Zealand, August 1975 to August 1976.

<sup>2</sup>On transfer of work to the Agricultural University, Wageningen, Holland, August 1974 to August 1975.



## INTRODUCTION

The Research Station at Winnipeg is responsible for research in genetics, pathology, and cereal chemistry leading to the development of improved varieties of cereals. The success of the program is indicated by the wide acceptance of new varieties by farmers in Western Canada. In 1975, more than 6.6 million ha (16.5 million ac) of wheat and 1.5 million ha (3.9 million ac) of oats were sown with varieties developed through this program. Terra, a superior strain of naked oats, was licensed in 1975.

Research on the preservation of grain, oilseeds, and their products is national in scope and involves close cooperation with the Plant Protection Division and the Canadian Grain Commission. Long-term ecological studies on stored products and short-term studies on chemical control of insects lead to recommendations for improvements in storage management.

Research on the control of field crop insects, particularly those that attack rapeseed, through the use of newer chemicals and the development of a management system of integrated pest control is the third area of responsibility at this Station.

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

The development of lines of common wheat with resistance to sprouting and weathering, resistance to leaf rust, and early maturity has received greater emphasis in recent years. The most advanced material with resistance to sprouting and weathering, which consists of 19 lines from a Neepawa backcross, has reached the first stage of yield testing. The incorporation of four genes for leaf rust resistance into Neepawa by backcrossing continued and several three- or four-gene combinations were entered in preliminary yield tests or were increased in small plots.

The genetic basis of resistance to leaf rust in adult plants of two wheat introductions was investigated. P.I. 181337 has three genes for leaf rust resistance, one of which is *Lr12*. The other two genes were not identified but are known to be different from *Lr13* and *Lr22*, two other genes for adult plant resistance. P.I. 250413 has a variable type of leaf rust resistance, thought to be slow rusting. This resistance, which is affected by the environment, may be controlled by a single

gene and is being transferred into the cultivar Thatcher.

A study on the genetics of leaf rust resistance in seedlings of four introductions was completed. P.I. 58548 had two genes, one giving a 1+ and the other a 2+ reaction. Backcross lines, homozygous for each of the two genes, were intercrossed and the lines produced with both genes gave a ;1<sup>-</sup> rust reaction similar to that of the resistant parent. P.I. 268454 was heterozygous; some plants had *Lr2b* and others a gene giving a 1+ reaction. P.I. 197249 had two genes, *Lr3* and an unidentified gene. P.I. 64149 had gene *Lr1*.

### Durum Wheat

The most advanced line of durum wheat in the breeding program is D.T. 411, tested for 4 yr in the Cooperative Test. It is comparable to Hercules in maturity, lodging, and disease resistance, and is slightly shorter-strawed. Its main advantage is in the Black soil zone, where it has outyielded Hercules and Wascana by 10 and 7%, respectively. In the Brown soil zone D.T. 411 is comparable to Wascana, the highest-yielding cultivar.

A fertilizer test was conducted at two locations to obtain information on the response of present and potential commercial cultivars to additional N. Levels of N tested

were 0, 45, and 110 kg/ha. No significant differences were observed at Morden, Man., but at Glenlea, Man., differences among both cultivars and treatments were significant. However, the treatment with no additional N gave the highest yield. The lack of a positive response of the cultivars to applied N may have been a result of the rather hot, dry growing season in 1975.

Loose smut resistance in Hercules was found to be conditioned by one dominant gene for resistance to each of the races T3 and T4.

## Oats

Terra, a superior strain of naked oats, was licensed in 1975. It originated from the cross (Random  $\times$  Vicar)  $\times$  Random and is earlier, shorter, and stronger-strawed, has larger kernels, and is about 15% higher-yielding than the standard naked oat variety Vicar. Terra lacks good rust and smut resistance.

The third backcross of rust resistance genes into Rodney, Harmon, Kelsey, Random, Gemini, Fraser, and OT 624 was completed. Many of the strains of *Avena sterilis* L. that were used because of their rust resistance were also highly resistant to new virulent races of oat smut, and selection for smut resistance was started.

Evaluation of oil content in seeds of F<sub>2</sub> plants and F<sub>3</sub> lines obtained from the cross Random<sup>2</sup>  $\times$  C.I. 4492 indicated that material is available with attractive agronomic characteristics and an oil content close to that of C.I. 4492.

## Barley

Two lines of two-rowed barley were advanced to the 1975 Co-operative Two-row Barley Test, and four lines were entered in the 1975 Eastern Prairie Barley Test. All lines possess improved malting quality, resistance to stem rust and net blotch (essential in the eastern prairie region), good threshability, and desirable kernel type.

One six-rowed, feed-type line performed well in Western Co-operative Barley tests in 1974 and 1975. This line has very good test weight, strong straw, and more resistance to root rot than any of the other lines or controls in the test. In 1975, five six-rowed lines were entered in the Eastern Prairie Barley Test and grown at eight locations.

Progress was made in improving the yielding ability and agronomic characteristics of

hulless two-rowed and six-rowed lines intended for use as high-energy feed grains. In a preliminary trial, several six-rowed hulless lines compared favorably with the hulled control varieties in yield. Genes for high lysine are being incorporated into hulless and hulled lines of both two-rowed and six-rowed types.

Progress was also made in developing two-rowed and six-rowed lines with resistance to the new races of loose smut and to barley stripe mosaic virus.

Automated techniques were developed for determining phenolic components and enzyme activities in barley. These properties are involved in the stability and flavor of beer. Significant differences in barley and malt were found.

An effective method for determining beta-glucanase activity in early-generation breeding material was developed. This enzyme system is associated with malting time and wort filtration, which are important economic factors.

Quality tests were conducted on approximately 2600 lines from the barley breeding programs at Brandon and Winnipeg, Man., Lethbridge and Beaverlodge, Alta., and the universities of Manitoba, Saskatchewan, and Guelph.

## CEREAL RUSTS

### Rust Surveys

*Stem rust of wheat.* Results of the 1975 survey of physiologic races of stem rust in wheat indicated that race C33 (15B-1L) predominated to a greater degree than in previous years. Only six other races were found. The overall variability of the stem rust population appears much less than in 1974 when 32 races, 11 of them new, were identified. The races found do not threaten commercial wheat varieties. Race C25 (38) is the only one identified with moderate virulence on seedlings of Neepawa, Manitou, and Napayo, but it has not demonstrated a capacity to cause damage in the field. The recommended varieties of durum wheat continued to show good stem rust resistance.

*Leaf rust of wheat.* Races of leaf rust on wheat were surveyed in 1975. The trend toward higher levels of virulence on alleles for resistance at the *Lr2* locus in wheat, first apparent in 1974, continued.



*Stem rust of oats.* A 2-yr study of oat stem rust in 15 countries revealed that virulence on host plants with resistance genes *Pg1*, *Pg2*, *Pg3*, *Pg4*, *Pg8*, *Pg9*, and *Pg13* occurs in most countries. Only resistance conferred by genes *Pg11* and *Pg13* is effective in most of the areas studied.

*Crown rust of oats.* There were no important changes in virulence of crown rust of oats in 1975. The two main genes used in the breeding program, *Pc38* and *Pc39*, remained highly effective. Two newly isolated genes, *Pc55* and *Pc56*, were also highly effective and are being incorporated into the breeding program.

### Rust Culture

Twenty-eight cultures of wheat stem rust, two of oat stem rust, one of rye stem rust, two of oat crown rust, and two of wheat leaf rust that originated in Canada grew on peptone medium. Of these, only three strains of wheat stem rust grew when subcultured. One grew for three subculturings, another grew for 1 yr when subcultured at 2- to 4-wk intervals, and a third "vegetative" culture produced fluffy, white mycelial colonies through numerous subculturings over 2 yr. The vegetative culture at first was pathogenic but later appeared to become nonpathogenic. Uredial cultures established from it varied in virulence and color of urediospores. Electron microscope studies showed that the culture is dikaryotic and apparently haploid.

### Rust Cytology

The detailed structure of the nucleus and its associated suborganelles in the rust fungi *Puccinia graminis* Pers. f. sp. *tritici* Erikss. & Henn., *P. graminis* f. sp. *avenae* Erikss. & Henn., *P. recondita* Rob. ex Desm., and *P. coronata* Cda. was investigated. The nonmitotic nuclei in intercellular hyphae of all the fungi were irregularly oval, had prominent nucleoli, and, except for *P. recondita*, usually showed uniformly dispersed heterochromatin. In *P. recondita*, densely staining patches occurred throughout the nucleus, and this was a distinguishing feature of the species. The nuclei in monokaryotic axenic cultures of *P. graminis* f. sp. *tritici* and *P. coronata* were larger than those in their respective dikaryotic parasitic hyphae or in a dikaryotic axenic culture of *P. graminis* f. sp. *tritici*.

The nucleoli varied in size and composition depending on the physiologic condition

or type of cell. In senescing cells the nucleoli occupied about 10% of the nuclear volume, whereas in young, active cells they occupied up to 60%. In haustoria the nucleoli were smaller and were composed mainly of fibrillar material. In active intercellular hyphae of all the fungi examined, the nucleoli consisted of approximately equal granular and fibrillar regions. A bipolar spindle pole body (SPB) was a regular feature of nonmitotic nuclei. The SPB consisted of two disclike structures located some distance apart on a layer of amorphous substance. The SPB was located outside the nucleus in a depression of the nuclear envelope, usually toward one side of the nucleus.

### Molecular Biology of Rust Resistance

Ribonucleic acid (RNA) preparations containing the gene-specific factor that determines resistance of wheat to stem rust were fractionated with 3 M potassium acetate or with isopropanol to remove high-molecular-weight rRNA and DNA. The biological activity tended to be associated with fractions containing low-molecular-weight (salt-soluble or isopropanol-soluble) RNA. When this material was tested in a bioassay, dose/response curves were not linear but showed a maximum at RNA concentrations between 15 and 40  $A_{260}$  units/ml. The main chemical constituent of these preparations is tRNA.

Puromycin, a tRNA analogue that inhibits protein synthesis by interfering with translation, was tested for its effect on the production of necrotic cells in an incompatible interaction between wheat and stem rust. Plants containing *Sr6*, the temperature-sensitive gene for resistance, were maintained at 26°C until some time after inoculation with the avirulent race. At this temperature the interaction is compatible and no necrotic cells are formed. Two days after inoculation, the leaves were flooded with puromycin and transferred to 20°C, which normally initiates the resistant reaction. Puromycin inhibited the formation of necrotic cells without restricting fungal growth, indicating that protein synthesis may be a prerequisite for the expression of the gene for resistance *Sr6*.

## OTHER CEREAL DISEASES

### Smuts

Studies were continued to determine the reaction of genera and species in the grass tribe *Hordeae* to infection by the smut organisms *Ustilago nuda* (Jens.) Rostr. and *U. tritici* (Pers.) Rostr. *Hordeum violaceum* Boiss. & Hohen. was found to be a new host for *U. nuda*. Wild barley, *H. jubatum* L., was found to be a new host of loose smut of wheat, *U. tritici*, and the virulent races were determined. *H. jubatum* was resistant to the test inoculum of loose smut of barley, *U. nuda*. Conversely, six other species of *Hordeum* tested were resistant to *U. tritici* but highly susceptible to *U. nuda*. *U. nuda* and *U. tritici* were hybridized on *Agropyron semicostatum* (Steud.) Nees ex Bois. The  $F_1$  spores germinated readily, with a germination type intermediate between those of the parents. Hybrids varied in the degree of lysis after germination, thus expressing different degrees of incompatibility between strains of the parental species. However, all hybrids produced viable dikaryotic hyphae, which indicates that production of an  $F_2$  generation is possible.

The genetic cause of virulence of covered smut of barley, *U. hordei* (Pers.) Lagerh., on the cultivars Lion and Plush was attributed to a single gene, designated  $v_6$ . This gene was recessive and unlinked to either  $v_1$  or  $v_2$ . Dikaryons with the genotype  $v_1v_1V_6V_6$  were virulent on Hannchen, whereas those with  $v_2v_2V_6V_6$  were virulent on Excelsior. However, the combination  $v_1v_1v_6v_6$  was required for virulence on Vantage. The resistance of other cultivars of the host was overcome by combinations of more than one virulence gene in the pathogen, indicating that some cultivars possess more than one gene for resistance.

A technique to use a single inoculum of *U. nuda* was developed to detect various types of resistance in barley. The inoculum is a mixture of buff and brown teliospores with different patterns of virulence. The ratio of buff to brown spores is adjusted to allow expression of the virulence carried by each strain of the pathogen.

### Foliage Diseases

Cultural and epidemiological factors favoring leaf disease development on wheat seedlings were evaluated by spraying plants

with inoculum of *Pyrenophora trichostoma* (Fr.) Fckl. A 2- to 4-h period between inoculation and incubation at 100% relative humidity (RH) was found to enhance disease development when the inoculum strength was  $3 \times 10^4$  propagules/ml, but overall results were not as reliable as with inoculation by dipping, the method previously used. The effect of pH of the culture media on growth was tested; 20% V8 juice agar with 2 g  $\text{CaCO}_3$  incorporated to give a pH of 7.0 resulted in the highest proportion of conidia to aerial mycelium produced by a virulent isolate of the pathogen. Preliminary tests with this spray inoculum indicate that development of lesions on test seedlings is more abundant than in previous tests.

### Viruses

In 1975, barley stripe mosaic virus (BSMV) was detected in 45, 30, and 25% of the fields of two-rowed barley examined in southern Alberta, southwestern Saskatchewan, and southeastern Manitoba. The disease was also detected in 12% of the fields of six-rowed barley surveyed in southern Alberta, but it was not found elsewhere in this crop.

The effect of strain C3 of BSMV on seed yield of Betzes, Herta, and Fergus barley inoculated at two stages of growth was assessed in a field plot. Yields of the respective varieties inoculated at the late tillering stage were 32, 33, and 47% lower than those of uninoculated controls. Yields of Betzes and Herta inoculated at the boot stage were not significantly affected, but the yield of Fergus inoculated at this stage was 10% lower.

Antiserum was prepared with 4.9 mg of oat necrotic mottle virus (ONMV). In micro-precipitin tests, the antiserum had a titer of 1/4096 with 1 mg virus/ml. About 0.12  $\mu\text{g}$  of virus could be detected when the antiserum was absorbed with healthy sap and the absorbed antiserum was reconstituted with polyethylene glycol to a titer of 1/4096. Optimal reacting proportions were 0.5 mg virus/ml and a 1:64 dilution of reconstituted, absorbed antiserum. ONMV was readily detectable in sap from oat leaves by the microprecipitin test when the sap was clarified with silver nitrate. In Ouchterlony double-diffusion tests, no immunodiffusion lines were obtained with reconstituted, absorbed antiserum and ONMV. A broad



band near the antiserum well was usually visible with unabsorbed antiserum and purified virus in high-pH-ammonia agar gel plates and in 1% agar plates when SDS-ammonium carbonate reagent was added to the virus preparation. The microprecipitin method was the most reliable test for detecting ONMV in partly purified preparations.

Antiserum to wheat streak mosaic virus had a titer of 1/8 to ONMV. The ultraviolet absorption spectrum of the virus was maximum at 259 nm and minimum at 247 nm, and the average 280:260 and max:min absorption ratios were 0.75 and 1.06, respectively.

## STORED-PRODUCTS ENTOMOLOGY

### Biology

Survival, development, and multiplication of nine species and one mutant of stored-product insects on clean Manitou wheat and wheat with various percentages of dockage in 10-g food lots were determined at 27, 30, 33, and 70% RH. When the insects were reared at 27°C on clean wheat and on wheat with 2, 5, and 7% dockage, the proportion of eggs that developed to adults was high for the rusty grain beetle, but moderate or low for the flour mill beetle (*Cryptolestes turcicus* (Grouvelle)), the sawtoothed grain beetle, the merchant grain beetle, the drugstore beetle, the red flour beetle, and the confused flour beetle. The number of adults of the sawtoothed grain beetle developing from eggs was significantly higher on wheat with 7% dockage. Adult survival of the foreign grain beetle was adversely affected by higher dockage levels at 30° and 33°, but not at 27°C. The presence of dockage at the 5% level significantly increased adult emergence of the American black flour beetle at 27°C and of a black mutant of the confused flour beetle at 33°C. Conditions of both 5 and 10% dockage at 33°C significantly affected adult emergence and the rate of multiplication of F<sub>1</sub> progeny of the rusty grain beetle, the sawtoothed grain beetle, and the red flour beetle reared on 150-g lots of wheat. The sawtoothed grain beetle was favorably affected by increasingly high levels of dockage. At the optimum temperature of 33°C, the red flour beetle, unlike the sawtoothed grain beetle, multiplied while on dockage-free

wheat. The red flour beetle was favorably affected by dockage only at the 10% level, whereas the rusty grain beetle was adversely affected by dockage.

Susceptibility of small bulks of rapeseed and sunflower seed to three species of stored-product insects was determined by infesting the oilseeds singly and collectively in an unheated granary. During the study, insects were never exposed to temperatures higher than 25°C for more than 2 mo. Sawtoothed grain beetles and red flour beetles reproduced well on both types of seed. Many adults and larvae were recorded from single infestations of these insects in the sunflower bulks. The rusty grain beetle did not reproduce or survive on rapeseed but maintained a low adult population on sunflower seed.

### Control

The effectiveness of microwave radiation in controlling the confused flour beetle in wheat and flour was determined with a pulsed magnetron oscillator operating at a frequency of 8.5 gigahertz ( $8.5 \times 10^9$  cycles/s). Wheat at 15.6% moisture content (MC) heated at a faster rate and produced higher insect mortalities than wheat at 12.5 or 8.5% MC. The higher heating rate in wheat at 15.6% MC was attributed to its higher dielectric permittivity. Insect mortality was higher in wheat than in flour, which suggests that flour infested with the confused flour beetle should be heated to higher temperatures than wheat to obtain comparable control. Larvae were more tolerant of the heating effects of radio frequency energy than eggs, pupae, or adults. There was no evidence that insects were selectively heated at a higher rate than the commodity they infested.

Malathion, bromophos, and iodofenphos were evaluated to determine their persistence on fir plywood surfaces for protection against five species of stored-product insects. Malathion was significantly more effective than iodofenphos or bromophos against flour beetles, but iodofenphos was the most persistent insecticide against all species tested. Although bromophos was the least effective of the three insecticides, its persistence over a 52-wk period was enhanced when the dosage was increased to 2.5 g/m<sup>2</sup> and the exposure period prolonged to 24 h. The rusty grain beetle was the most susceptible species tested. The results indicated that malathion



can provide short-term protection against all species for a period of 8 wk at 0.5 g/m<sup>2</sup>, which is half the rate currently recommended.

Measurements of insect control in two country elevators indicated that both transferring grain in cold weather and fumigation with hydrogen phosphide are highly effective methods of insect control. A population of rusty grain beetle larvae at a density of 40/kg in rye was eliminated in one elevator when the grain was transferred four times in cold weather. A population of the sawtoothed grain beetle as high as 8/kg in oats and in barley suffered nearly total mortality after fumigation with hydrogen phosphide at the rate of six tablets per tonne.

Aluminum phosphide was applied in bags or as pellets to 327 kg of wheat and generated about 1 g of hydrogen phosphide. This killed all eggs and adults of the rusty grain beetle and adults of the red flour beetle in parts of the grain where gas concentrations declined from 1300 to 350 ppm during the first 3 days of fumigation. Eggs of the rusty grain beetle survived where gas concentrations declined from 290 ppm on day 1 to 1 ppm on day 7 of the fumigation. Fewer eggs survived at the 8-cm depth in grain treated with the pelleted formulation of aluminum phosphide.

In wheat at 13.5 and 18.0% MC treated with aluminum phosphide pellets, hydrogen phosphide was generated most rapidly at 18.0% MC. After day 3, the wheat at 13.5% MC had the higher hydrogen phosphide concentration. Survival of rusty grain beetle eggs was about the same in both kinds of wheat.

Methyl bromide applied to columns of wheat at -0.5° and -3.3°C penetrated in sufficient quantity to control the rusty grain beetle to a depth of 51 cm at concentrations of 49–50 mg/litre, and to a depth of 33–42 cm at concentrations of 32–34 mg/litre. Penetration of the fumigant was greater at -0.5° than at -3.3°C, but the difference was not significant.

Malathion, tetrachlorvinphos, fenitrothion, and bromophos eliminated infestations of the rusty grain beetle in stored wheat at 19°, 24.4°, and 30°C. Fenitrothion and bromophos were the most effective; malathion and tetrachlorvinphos were slower in action, although in time most of the beetles were eliminated.

## FIELD CROP INSECTS

### Grasshopper Surveys

In 1975, grasshopper eggs began to hatch during the last week in May, about the same time as in 1974. However, with low temperatures and heavy rains in June hatching progressed slowly and continued until mid-July. Because crop growth was excellent during this period and infestations developed slowly, feeding by grasshoppers had little effect and damage was negligible in most areas. The forecast of grasshopper infestations for 1976 show that the area affected would be approximately 38% less than in 1975, and all areas would be less severely infested. About 80% of the total area infested is in the Red River valley. The dominant species is the two-striped grasshopper.

### Sugar Beet Insects

In field trials with sugar beet, BAY 92114 (Chemagro) and Dacamox (Diamond Shamrock Corp.) were applied at seeding as in-furrow granules above the seed, and BAY 92114 and diazinon were applied 1 wk after seeding as granules in 12.5-cm bands over the seed furrow. Both preparations were more effective against the sugarbeet root maggot than carbofuran, the recommended insecticide, applied as in-furrow granules at seeding.

### Rapeseed Insects

Control of flea beetles in rape was attempted by seed treatment with Gammasan (Chipman), Lindasan (Ciba-Geigy), and PP 505 (Chipman), and in-furrow granular applications of carbofuran, CGA 12223 (Ciba-Geigy), and disulfoton. These treatments provided good protection against seedling damage by flea beetles, and seed yields were significantly greater than without treatment. Although Gammasan provided the best seedling protection, the yield increase was not as great as with carbofuran or disulfoton, which appeared to have greater residual action. Methamidophos, methidathion, azinphos-methyl, carbofuran, NRDC 143 (Chipman), Ofunack (Chipman), BAY MEB 6046 (Chemagro), diazinon, and malathion applied as sprays at seedling emergence were less effective than the seed dressings or granular applications.

Carbofuran and Counter (Cyanamid of Canada) were more effective than aldicarb,



Dacamox, or BAY MEB 6046 against the cabbage maggot on rape. Seed yields were increased significantly (41–90%) over those of the controls with all treatments except BAY MEB 6046.

## INTEGRATED CONTROL OF INSECT PESTS

### Flea Beetles

In 1975, flea beetles were the main pest of rape on the prairies. In southern Manitoba, *Phyllotreta cruciferae* (Goeze) was the chief species, followed by *P. striolata* (Fabricius) and *Psylliodes punctulatus* (Melsheimer). Studies of the natural enemies showed that a braconid, *Microctonus vittatae* Muesebeck, parasitized less than 5% of *P. cruciferae* and only a slightly higher percentage of the less abundant species of flea beetles. Details of the life history of *M. vittatae* were obtained and techniques for propagating this parasite on adults of *P. cruciferae* were developed.

Experiments on damage assessment were repeated, and heavy rains during the feeding period are believed responsible for an observed reduction in the impact of feeding on rapeseed yield. Tests of a technique by which an unswathed border strip of rape is used as a trap crop for flea beetles showed that the overwintering population could be reduced by up to 97% by spraying these limited areas with insecticide.

### Bertha Armyworm

In Manitoba, populations of the bertha armyworm were low in most fields, averaging 0.4 larva/m<sup>2</sup>. Two fields with larval densities of 10.5/m<sup>2</sup> were sprayed by the grower. The two main parasites of the bertha armyworm, *Banchus flavescens* Cresson and *Athrycia cinerea* (Coquillett), attacked over 70% of the larvae in some fields, indicating that natural control remains at a high level even when the pest is scarce. A newly identified pupal parasite, *Ichneumon canadensis* Cresson, and a new larval parasite, *Apanteles xylinus*

(Say), are rare and probably of little significance as control factors. In experiments on damage assessment, bertha armyworm larvae were caged over rape plants in the field. Yield losses of the cultivars Span and Midas showed a consistent linear trend of 0.32 g/0.8 m<sup>2</sup> per larva for larval attacks at various stages of plant growth and degrees of plant vigor. Tests of four artificial sex pheromones showed that three were more efficient than light traps in catching male moths. The fourth instar is the stage when the larva is sensitive to both temperature- and photo-period-induced diapause. Temperatures of 17°C induced total diapause whereas at 20°C no diapause occurred, irrespective of photoperiod. The lethal doses (LD<sub>50</sub> and LD<sub>95</sub>) of a new insect growth regulator were determined for third- and fourth-instar larvae of the bertha armyworm. The material is extremely potent, especially in the earlier larval stage.

### Red Turnip Beetle

Adults of the red turnip beetle caged over plants of Midas rape at a density of 100/0.84 m<sup>2</sup> for 13 days in August did not reduce the yield of rapeseed. The plants had completed flowering but had not reached maturity at the time of the experiment. Further oviposition experiments showed that temperature affects the rate of egg-laying, the total number of eggs laid, and the duration of the oviposition period. In the field, adults were observed to continue copulation and, presumably, oviposition in rape stubble after swathing. In the Peace River district, the practice of growing rape as a cover crop for fescue is associated with the development of heavy infestations of red turnip beetles. The adult beetles leave a "source" field in the spring and can detect and move toward adjacent rape fields. Because movement is by foot, heavy infestations develop along the edge of new rape fields and beetles move into the field along a front, destroying all seedlings in their path. Preliminary distribution data indicate that the sampling procedure should include a number of transects, 0.5 m wide, extending at right angles from the edge of the field. In the Peace River area, the estimated number of beetles averaged 1000 per 1-m transect in three fields.

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## INTRODUCTION

The production, harvesting, and utilization of forage crops and the production and utilization of cereal, oilseed, and special crops are the main research programs at the Station. A strong livestock program involving beef cattle, sheep, and swine is undertaken to evaluate the efficiency of the crop production and harvesting programs.

In early 1975 the purchase of 113 ha of productive, irrigable land adjacent to the Station provided a dependable feed base for the livestock and also permitted better control of research projects in forage harvesting. Good progress was made in developing pasture and wintering facilities for the 270 beef cows involved in the cow management research project carried out in cooperation with the Saskatchewan Department of Agriculture.

The Melfort hay drying tower has been under development since 1971 and is now perfected. It offers the forage producer a means of putting up and storing a high-quality product. Further work on finishing beef steers on ground, high-forage rations has shown that top-grading beef can be produced with very little grain if cattle are carried to the same weights as comparable grain-fed steers.

Favorable growing conditions occurred in 1975. Late-maturing cultivars performed better than usual because of the long frost-free period. Winter wheat suffered considerable winter injury but tillered and produced good yields. Good progress in the chemical control of wild oats and green foxtail occurred in 1975. On sulfur-deficient soils the application of sulfur fertilizer to alfalfa produced an increase of 2173 kg/ha.

Each year the staff publishes *Research Highlights* prepared mainly for farmers and extension personnel. This publication and any further information on items in this report can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom  
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## FORAGE PRODUCTION AND UTILIZATION

### Forage Production

*Pasture renovation using herbicides and direct seeding.* In June 1973, 2,4-D at rates of 1.1, 2.2, and 3.4 kg/ha and mixtures of 2,4-D at 1.1 kg/ha with dicamba or 2,4,5-T at 0.6 kg/ha were applied to pastures infested with dandelion, *Taraxacum officinale* Weber. Immediately after spraying and at successive 2-wk intervals, a mixture of 9.0 kg/ha of brome grass, *Bromus inermis* Leyss., and 2.2 kg/ha of alfalfa, *Medicago media* Pers., was seeded and fertilized with N at 26 kg/ha and P at 11 kg/ha using a triple-disk drill. All 2,4-D rates and formulations controlled dandelion initially, and after 2 yr only 5% or less of the ground cover was dandelion. Alfalfa was also eliminated. Brome grass establishment was good from the first seeding, fair from the second, and poor from later seedings. Alfalfa did not reestablish itself. Forage production 1 yr after treatment was

increased significantly on areas treated with 2,4-D at rates of 2.2 and 3.4 kg/ha and on areas treated with the mixture of 2,4-D and dicamba.

In the same experiment paraquat and glyphosate, each applied at 1.1 and 2.2 kg/ha, were compared for total sward control. Glyphosate at both rates killed dandelion and suppressed the grass, but the higher rate produced better results. Paraquat suppressed grass satisfactorily only when applied at 2.2 kg/ha and neither rate controlled dandelion. Both rates of both herbicides permitted good to excellent forage seedling establishment from the first seeding date, but good forage establishment was obtained from the second seeding only when the higher rate of paraquat or glyphosate was applied. Forage establishment from later seeding dates was poor. Neither herbicide provided any residue to control dandelion seedlings, and they were growing in large numbers in 1975.

*Effects of spring-applied herbicides on yield of alfalfa seed.* In 1973, simazine at 0.8 and

1.7 kg/ha; 2,4-D at 0.6 and 1.1 kg/ha; and asulam, dichlobenil, and propham each at 2.2 and 4.5 kg/ha were applied to established alfalfa just as spring growth started. The same treatments were repeated on the same areas in 1974 and 1975. Each year the alfalfa was pollinated by 50 000 leafcutter bees per hectare. The application time was too early for 2,4-D to control the main weeds, dandelion and perennial sow-thistle, *Sonchus arvensis* L., but the alfalfa exhibited severe formative effects and stunting. Seed yields over the 3-yr period were 600 and 490 kg/ha from areas treated with 2,4-D at 0.6 and 1.1 kg/ha compared with 760 kg/ha from control areas. Dichlobenil controlled both main weeds but caused some alfalfa yellowing and stunting each spring. Although the alfalfa population was reduced, seed production totaled 980 and 850 kg/ha from areas treated with dichlobenil at 2.2 and 4.5 kg/ha, which is a substantial increase over yields from the control areas. The simazine, asulam, and propham treatments did not affect alfalfa seed production.

## Forage Harvesting

*Evaluation of forage-harvesting systems.* Bromegrass-alfalfa was cut and allowed to wilt in the field in windrows. The material was then stored as silage (S), which contained 64% moisture; as chopped hay (C), which was field wilted to 32% moisture, chopped, and blown into a hay tower where drying was completed; as mechanically stacked long hay (ST), which contained 27% moisture; and as baled hay (B), which contained 24% moisture. The amount of dry matter (DM) harvested annually by each system over the past 3 yr averaged 5152, 4988, 4986, and 4923 kg/ha. Forage from each system was fed ad lib. to groups of long yearling Hereford heifers. Dry-rolled wheat at 0.9 kg/head per day was also provided.

In contrast to results obtained during the previous 2 yr, when treatment C produced the fastest rate of gain, heifers fed silage had the highest average daily gains. Average daily gain in 1975 (and the averages for the past 3 yr) were: S, 0.74 (0.66); C, 0.67 (0.68); ST, 0.65 (0.57); and B, 0.64 (0.62) kg.

Protein and organic matter digestibility were lower in the 1974 crop than in crops from either of the previous 2 yr. Digestible

organic matter measured in vitro was found to have decreased 3–6% during storage.

For the 3-yr period, the average liveweight gain produced per hectare of standing crop was 405 kg for S, 445 kg for C, 333 kg for ST, and 435 kg for B.

*Effect of wilting and the use of a preservative on the feeding value of oat silage.* Chopped direct-cut (23% DM) and wilted (30.5% DM) oats, *Avena sativa* L. cultivar Random, harvested at the early dough stage were ensiled in separate bunker silos. Each silo was partitioned, and one-half was filled with oats treated with formic acid (0.35–0.5 kg/100 kg wet wt), and the other half was filled with untreated silage. The four silages were fed, with and without two levels of grain, to groups of eight yearling Hereford heifers for 52 days.

As a result of fermentation of forage in a silo, the amount of DM removed when the silo is emptied is always lower than the amount stored. The addition of formic acid to direct-cut silage reduced this loss from 12.8 to 6.8% but had the opposite effect when added to wilted silage (12.5 vs. 16.1%). Formic acid had little effect on losses caused by spoilage when added to direct-cut silage but did result in significantly less spoilage when added to wilted silage.

Heifers fed direct-cut silage had higher average daily gains than those fed wilted material (0.59 vs. 0.54 kg/day).

Silage to which formic acid was added produced higher average daily gains than untreated silage (0.59 vs. 0.53 kg/day). Feeding grain at 1.35 kg per head per day increased average daily gain from 0.31 kg to 0.6 kg. Groups fed 2.7 kg of grain per day gained an average of 0.78 kg/day.

*Effect of harvesting method on hay quality.* Crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., was harvested at moisture levels of 13 and 20%, intermediate wheatgrass, *Agropyron intermedium* (Host.) Beauv., at 19 and 24%, and bromegrass at 20 and 24%. The grasses were harvested at each moisture level with a Hesston stacking wagon (Model 10), a Vermeer large round baler, and a conventional baler.

The machine used had little effect on protein content, digestibility, or the amount of hay consumed by lambs. Protein content, digestibility, and intake by lambs were lower for bromegrass harvested at the lower moisture level. This decrease in quality was



attributed to greater weathering of the low-moisture hay in the swath. Moisture level had little effect on quality of the other grasses. Digestibility of crested wheatgrass and intermediate wheatgrass declined only 2% during winter storage, whereas digestibility of the bromegrass declined 10%.

### Forage Utilization

*Annual vs. perennial pastures for sheep.* Oats cultivar Fraser was compared with sainfoin, *Onobrychis viciaefolia* Scop. cultivar Melrose, sainfoin mixed with bromegrass cultivar Magna, and alfalfa cultivar Rambler mixed with bromegrass, when pastured by sheep. Ewes and lambs were used as grazing units until the lambs reached 25 kg in weight, at which time the ewes were removed from pasture.

Sainfoin produced the highest average daily gain (191 g). Average daily gains on the other treatments were similar, averaging 150 g. Average stocking rate and period of grazing were less for sainfoin than for the other treatments with the result that total gains per hectare for the grazing season were 310, 283, 372, and 375 kg for oats, sainfoin, sainfoin with bromegrass, and alfalfa with bromegrass. The respective DM yields were 6034, 4009, 6732, and 6092 kg/ha.

*Maximizing ground forages in finishing rations for early- and late-maturing beef steers.* Bromegrass-alfalfa (11.4% crude protein, CP; 48.1% digestible organic matter, DOM), mixed crested and intermediate wheatgrass hays (8.6% CP, 48% DOM), and oat hay (8.5% CP, 46.5% DOM) were each ground through a 13-mm (½-in.) screen, and mixed with 2% tallow, minerals, vitamin A, and an antibiotic supplement. These three mixtures were self-fed to Angus-sired crossbred steers (305 kg) and to Charolais-sired crossbred steers (335 kg) until the animals reached finished condition, averaging 445 and 507 kg respectively. A control ration of 75–80% grain and ground straw was also fed to one pen of each type of steer. A grain supplement was hand fed to each pen of forage-fed steers during the latter part of the feeding period to maintain a reasonable rate of gain and improve carcass yield and grade. Averaging both breeds, steers fed the control ration of high grain gained 1.65 kg/day, required 5.67 kg feed/kg liveweight gain, required 95 days feeding, dressed out at 55.6%, and were all graded either A1 or A2,

which produced a net return to labor of \$51.64/head. The steers that were given bromegrass-alfalfa with 13.4% grain gained 1.07 kg/day, required 10.57 kg feed/kg liveweight gain, required 142 days feeding, and dressed out at 53.5%; 94% were graded A1 and A2. This produced a net return to labor of \$20.34. Steers that were fed oat hay with 19.8% grain gained 1.13 kg/day, required 10.29 kg feed/kg liveweight gain, required 140 days feeding, and dressed out at 54%; 72% were graded A1 and A2. The net return to labor was \$12.20. The steers that were fed wheatgrass with 9.3% grain gained 1.26 kg/day, required 8.99 kg feed/kg liveweight gain, required 125 days feeding, and dressed out at 54.8%; 89% were graded A1 and A2. The net return to labor was \$55.40.

On an 81% grain ration, Angus crossbreds gained more slowly (1.53 vs. 1.76 kg/day), had a slightly better feed-to-gain ratio (5.55 vs. 5.79) and a higher dressing percentage (56.2 vs. 55.0%), graded the same (100% A1 and A2), and returned less (\$42.93 vs. \$60.35) than the Charolais crossbreds whose rations contained 75% grain. Averaging all three high-forage rations, Angus crossbreds on rations averaging 13% grain gained slightly more slowly (1.14 vs. 1.18 kg/day), had a better feed-to-gain ratio (9.75 vs. 10.15) and a lower dressing percentage (53.4 vs. 54.8%), graded better (93 vs. 78% A1 and A2), but returned less (\$22.80 vs. \$35.82) than the Charolais cross steers whose rations averaged 15.3% grain. Therefore, steers of both types can be properly finished on high-forage rations (even of only medium quality) with minimal grain feeding, if they are fed to weights equivalent to those of grain-fed steers before marketing.

*Nutritive value and yield of silages.* Five kinds of silage, oats, Indian corn (*Zea mays* L.), Indian corn with alfalfa hay, fababeans (*Vicia faba* L.), and a mixture of fababeans and field peas (*Pisum sativum* L.), were assessed in a feeding trial with yearling lambs.

Intake of corn silage was very poor, probably because of the high moisture content of the corn. Addition of hay to the silo improved intake of the corn silage by 57%, but intake was still 20% below that for oat silage. Intake was highest for fababeans, followed by fababeans with field peas, and then oats. Liveweight gain followed the same



pattern as intake. Yield of DOM was 3889, 6112, 4251, and 5047 kg/ha for oats, corn, fababeans, and fababeans with field peas respectively.

## PRODUCTION AND UTILIZATION OF CEREAL AND SPECIAL CROPS

### Crop Evaluation

Because of the long growing season, late-maturing crops and cultivars were not damaged by fall frosts. In the Non-Bread Cooperative Wheat Test conducted for the first time at Melfort, three entries substantially out-yielded Pitic 62 (*Triticum aestivum* L.), but they matured 10 days later, which would normally result in frost damage and reduced yield.

*Barley* (*Hordeum vulgare* L. and *H. distichon* L.). Beacon and Klages were tested regionally at four sites in northeastern Saskatchewan. Beacon was earlier maturing than Conquest but about equal in yield. Klages yielded equal to or better than the highest-yielding two-row barley cultivars. Three European cultivars yielded well, Diva having the highest yields.

*Fall rye* (*Secale cereale* L.). Plot yields of Frontier, Puma, and Cougar averaged 28–38% higher than the yields of Neepawa spring wheat (*T. aestivum* L.) over the 3-yr period 1973–1975 at Melfort. Despite this yield and other agronomic advantages for the producer, fall rye is not widely grown because of its low cash return.

*Buckwheat* (*Fagopyrum esculentum* Moench.). Yields of Mancan, Tokyo, and Tempest in 1975 were 50% higher than the average of the past 4 yr. Some lines in the Coop Test, however, produced twice as much seed as the named cultivars.

*Jerusalem artichoke* (*Helianthus tuberosus* L.). A small observation plot established a good stand despite fairly late seeding. Plants grew to a height of about 2 m and produced about 0.5 kg tubers per plant.

### Production Management

*Magnetic seed treatment.* A trial evaluating the effects of subjecting seeds to a magnetic field before planting was conducted in 1975 and included eight well-adapted commercial crop cultivars. No differences in dates of emergence, heading, maturity, number of

plants emerged, plant heights, or seed yield were observed between two magnetic treatments and the control seeds.

*Weed control.* Competition studies show that wild oat infestations of 150 plants/m<sup>2</sup>, which is the number found in many fields, significantly reduced the yield of rapeseed by 30% in 1975. When rapeseed sells for 22¢/kg, this reduction in yield would lower the return by \$149.60/ha. Wild oats and green foxtail were effectively controlled by a new herbicide, HOE 23408 (Hoechst), applied postemergence at 0.5–1 kg/ha. There are other herbicide treatments that are also effective in controlling wild oats in rapeseed.

Green foxtail and wild oats in wheat can also be effectively controlled by the herbicide HOE 23408. However, when it was applied in a tank mixture with one of a number of phenoxy herbicides (2,4-D, dicamba and 2,4-D, or bromoxynil and MCPA) to provide combined control of grasses and broad-leaved weeds, it was less effective in controlling wild oats.

*Summerfallow.* Summerfallow studies show that the production of wheat can be maintained and erosion controlled better by substituting some of the tillage on summerfallow with herbicides for weed control. These studies show that if herbicides are used to control broad-leaved weeds, the first tillage on summerfallow can be delayed until June 1 and tillage discontinued again about August 15 with no loss in yield. The practice of summerfallowing with phenoxy herbicides to control the susceptible broad-leaved weeds when they are the main problem and tillage to control cereal growth and grassy-type weeds is often more economical and efficient. It also provides trash cover to protect the soil from erosion.

*Yield response of flax as affected by N and P fertilizers and available soil N and P.* Noralta flax grown on stubble in northeastern Saskatchewan was fertilized with N at 0, 22, 45, 67, and 134 kg/ha, with and without P at 20 kg/ha. Yield response was related by regression analyses to NH<sub>4</sub>-N and NO<sub>3</sub>-N, to NO<sub>3</sub>-N alone, and to NaHCO<sub>3</sub>-soluble P in the soils. NO<sub>3</sub>-N alone accounted for 78% of the variation in flax yield response among sites. NH<sub>4</sub>-N with NO<sub>3</sub>-N accounted for 84.2% of yield response variation among sites. Nitrogen was highly significant in increasing yields of flax. Three equations



showed that the  $\text{NaHCO}_3$ -soluble P also accounted for some of the variation in yield response when applications of P were added. Soil test ranges for  $\text{NO}_3\text{-N}$  and  $\text{NaHCO}_3$ -soluble P were 5.8–34.9  $\mu\text{g}/4\text{ g}$  for N and 5.7–17.5  $\mu\text{g}/\text{g}$  soil for P. Minimum yield response to N at 134 kg/ha was 60 kg/ha and the maximum yield response was 1202 kg/ha.

*Uptake of N and P in barley grain as affected by N and P fertilizers and available soil N and P.* The uptake of N and P by Conquest barley with N at 0, 22, 45, 67, and 134 kg/ha in combination with P at 0, 10, 20, 30, and 40 kg/ha was significantly related by regression analyses to  $\text{NH}_4\text{-N}$ ,  $\text{NO}_3\text{-N}$ , and  $\text{NaHCO}_3$ -soluble P in six soils of northeastern Saskatchewan. Quadratic equations obtained from the regression analyses were used to develop tables for estimating uptake of these elements from unfertilized and fertilized plots. Maximum uptake of N (76 kg/ha) and P (13.4 kg/ha) by barley grain from control plots was obtained when soil contained  $\text{NO}_3\text{-N}$  at 35  $\mu\text{g}/4\text{ g}$  and  $\text{NaHCO}_3$ -soluble P at 12  $\mu\text{g}/\text{g}$ . Maximum control yield (3504 kg/ha) also was obtained at the same level of available soil nutrients. Applications of N at 120 kg/ha and P at 40 kg/ha produced a maximum increase in N uptake of 74.7 kg/ha and a minimum uptake of 13.2 kg/ha among the six soils. Similarly, maximum increase in P uptake was 13.6 kg/ha and minimum uptake was 2.0 kg/ha. Maximum yield response of 3747 kg/ha and minimum response of 237 kg/ha also were obtained at these rates. Soil test ranges for  $\text{NO}_3\text{-N}$  and  $\text{NaHCO}_3$ -soluble P were 4.8–45.2  $\mu\text{g}/4\text{ g}$  and 2.7–18.8  $\mu\text{g}/\text{g}$  respectively.

*Harvesting.* A 5-yr harvesting study showed that rapeseed can be swathed when it has matured to a seed moisture content of 30%. Swathing at this stage (when the seeds are in the firm dough stage and starting to turn from green to brown) saved several days in the harvesting season and often reduced the danger of losses from shattering or frost damage. A similar 3-yr study with spring wheat indicated that it can be swathed as soon as the kernels have matured to a moisture content of 35% (firm dough stage) without loss in yield or quality.

## Crop Identification Technology

*Identification of cropland and area estimation from aerial photography and satellite imagery.* The feasibility of using multiband aerial photographs and ERTS-1 imagery for manual field identification and measurements was studied at Melfort. A simple six-step scale was used to assign numerical values to the gray-level densities on black and white photographs for the infrared and red radiation bands. The gray-level densities were calibrated to known crops and other features that were determined from data taken on the ground from training sites. Using the classification key that developed, more than 90% of the harvested cereal crops, unharvested cereal crops, rapeseed, and fallow land were identified on areas adjacent to the training site.

## Crop Utilization and Animal Nutrition

*Nutritive value of three oat cultivars.* Two forage oat cultivars, IH 1863-4 and OA 123-81, and a grain oat cultivar, Fraser, were harvested in the dough stage and artificially dried. They were evaluated in a lamb feeding experiment in which DM intake, liveweight gain, and digestibility were measured. Fraser and OA 123-81 proved to be significantly better ( $P < 0.05$ ) than IH 1863-4 for the factors tested.

*Evaluation of rapeseed cultivars.* The potential of rapeseed as a nutrient source for growing-finishing pigs was examined using four cultivars (*Brassica campestris* L., Span and Torch, and *B. napus* L., Midas and Tower).

Tower was superior to the other cultivars in growth rate and efficiency of feed conversion of pigs fed ad lib. diets containing 10% rapeseed, although slightly poorer carcass grades were obtained with this diet (99.6 vs. 101.4 average carcass value index). In a comparison of Midas and Tower rapeseed, included as 0, 5, 10, and 15% of growing-finishing diets, increasing the level of Midas rapeseed adversely affected growth rates by 36% at the highest level, but had less effect upon the efficiency of feed conversion. In contrast, pigs fed the 15% Tower diet had a slower (8.5%) rate of growth but a similar efficiency of feed conversion (3.40 vs. 3.38 kg feed/kg gain) to pigs on the control diet. Inclusion of rapeseed in the diet did not appear to affect carcass grade or Record of Performance measurements. When Span or

Torch rapeseed was included as 0 or 10% of pelleted diets supplied to pigs fed twice daily, consumption of either cultivar depressed growth rates by at least 20%, but did not appear to influence the other criteria of performance.

The results suggest that the superior quality of Tower is related to the lower levels of glucosinolates present, which appeared to influence feed intake. Although rapeseed is not a normal ingredient of swine diets, under certain economic conditions it could be employed as an alternative source of energy and protein.

*Comparative performance of boars, barrows, and gilts.* Four growing-finishing diets, barley and soybean meal (SBM), barley and rapeseed meal (RSM), wheat and SBM, and wheat and RSM, were fed ad lib. to swine. Results showed that boars were superior to

barrows in efficiency of feed conversion (3.29 vs. 3.49 kg feed/kg gain) and carcass leanness but had a slightly slower rate of growth (704 vs. 738 g/day) and dressing percentage (78.0 vs. 79.5). For boars and gilts fed ad lib. the two SBM diets, boars were superior in live performance (802 vs. 692 g/day; 3.09 vs. 3.42 kg feed/kg gain), had a lower dressing percentage (78.9 vs. 80.3), but were equivalent in carcass leanness to gilts.

Under conditions of restricted feeding of the two wheat diets, barrows were superior to boars or gilts in growth rate but had a similar efficiency of feed conversion and carcass leanness. The lower dressing percentage of boars was also evident under these conditions.

No incidence of sex odor or taint was recorded in any of the 65 boar carcasses marketed, although an average trim-demerit (1 kg) was assessed in respect to removal of genitalia and perineal tissues.

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## INTRODUCTION

This report outlines the work done in 1975 at the Research Station, Regina, and the Experimental Farm at Indian Head. The Regina Station is the main center for weed control research in Canada.

The program at Indian Head evaluates new cultivars of cereal, forage, oilseed, and pulse crops for adaptability to conditions in southeastern Saskatchewan. Management research designed to increase efficiency of production of these crops is also conducted at Indian Head.

The facilities at Regina and Indian Head are used to increase and distribute Breeder seed and seed of new cultivars of cereal, forage, oilseed, and pulse crops developed by the Branch.

We welcome Dr. A. G. Thomas, a weed ecologist, who joined the staff at Regina to do research on population dynamics of weeds and to set up computer methods for surveying weeds on the Prairies. We also welcome Mr. N. W. Holt, an agronomist, who joined the staff at Indian Head to evaluate adaptability of new cultivars and conduct management research on forage crops and new crops for southeastern Saskatchewan.

Detailed information on research results can be obtained from scientists at the following address: Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask., S4P 3A2.

J. R. Hay  
Director

## BIOLOGICAL CONTROL

In 1975 the weevil *Rhinocyllus conicus* Fr. destroyed 68 and 88% of nodding thistle seed at two release sites in Saskatchewan. *Ceutorhynchidius horridus* Panz., a root-crown weevil, bred successfully on nodding thistle after release.

The seed fly *Urophora affinis* Frfld. continued to increase, reaching a density of 2736 galls/m<sup>2</sup> on diffuse knapweed at release sites in British Columbia, and 1475 galls/m<sup>2</sup> on spotted knapweed. The fly *U. quadrifasciata* Mg. attained a density of 2764 galls/m<sup>2</sup> on diffuse knapweed.

*Coleophora parthenica* Meyr., a stem-boring moth of Russian thistle released at Regina and Swift Current, provided no evidence of breeding.

*Longitarsus jacobaeae* Watr., a root-boring beetle that attacks tansy ragwort, was recovered at two sites in British Columbia, but establishment is not certain.

Also, the root-boring moth *Chamaesphecia empiformis* (Esp.) was not recovered in 1975. It was released on leafy spurge at Regina in 1973.

Screening tests on the mullein moth *Cuculia verbasci* (L.) continued and is now nearly complete.

Screening tests were started on two root-feeding moths imported from Europe: *Celypha purpurana* Hw. for control of perennial sow-thistle and *C. striana* (Den. & Schiff) for control of dandelion. Laboratory results are promising.

Screening tests on the leaf-feeding beetle *Cassida hemisphaerica* Hbst. for the control of bladder campion were completed. Because the host range of the beetle is not sufficiently specific as determined under experimental conditions, this insect will not be released.

Two species of cactus moths from Argentina, *Cactoblastis doddi* Heinr. and *C. bucyrus* Dyar, bred successfully in the laboratory on native species of prickly-pear. However, no further work on these species is planned in view of the conflict of interest in the ecological role of prickly-pear in North America.

A collecting trip was made in Germany for insects and rusts that attack narrow-leaved hawk's-beard as well as for insects that attack Canada thistle. Fifteen hundred galls of *Urophora cardui* (L.) were obtained from five sites. Specimens of *Ceutorhynchus litura* (F.) were collected from nine sites. Specimens of *Lema cyanella* L. were also obtained.

In 1975, the fly *U. cardui* bred successfully at seven release sites in five provinces. The weevil *C. litura* bred well at the two release sites on the Prairies but not at the one in



British Columbia. By 1975 one colony of *C. litura* that was started in Saskatchewan in 1973 had spread 85 m from the release point, and the number of mined stems had increased fourfold.

The Canada thistle rust *Puccinia punctiformis* (Strauss) Röhling, previously not reported from Saskatchewan, was found on two plants near Indian Head. The optimum temperature for germination of the spores was 14°C, rather than 18–23°C as reported in the literature. A colony of this rust has been established in the laboratory.

## HERBICIDE BEHAVIOR IN THE ENVIRONMENT

### Persistence of Atrazine

The persistence of atrazine in five Brown soils was investigated, using the repetitive-cropping technique. Persistence decreased for various soil types in the following order: Cabri, Nobleford, Success, Battrum, Swift Current. The degree of persistence appears to be related to Ca content and pH of the soil.

### Mobility Studies

Atrazine was leached through soil columns to obtain its distribution coefficient in six soils. Nobleford soil was the type through which atrazine leached most readily, followed by Asquith, Cabri, Success, Swift Current, and Regina in that order.

The distribution coefficients of three uracil herbicides in five soil types were similarly determined. The ranges were 0.4–9.4 for bromacil, 0.5–2.9 for terbacil, and 0.5–2.4 for lenacil. The most mobile of the three herbicides was bromacil, followed by terbacil and lenacil in that order.

### Monitoring Studies

A technique using gas chromatography and mass spectrometry was developed to confirm the presence of 2,4-D in air samples. Previously, 2,4-D had been detected using gas chromatography alone. Now 2,4-D at levels of 0.05  $\mu\text{g}/\text{m}^3$  or above can be detected in air samples by this new technique.

Air at Regina was sampled in June and July again this year for the presence of 2,4-D. During the 41 days of sampling, 2,4-D was detected by gas chromatography on 13 days at levels between 0.002 and 0.017  $\mu\text{g}/\text{m}^3$ . It

was the 2nd yr in a row that levels were well below the 0.05  $\mu\text{g}/\text{m}^3$  limit set previously.

### Vapor Drift

The rate of volatilization of the isooctyl ester of 2,4-D from Asquith sandy loam was studied by measuring concentrations of the ester in the soil at various intervals. The initial rate of volatilization of the ester increased from 71 to 99 to 126  $\mu\text{g}/\text{cm}^2$  when the herbicide was mixed in the soil at 100, 200, and 400  $\mu\text{g}/\text{g}$ . After the initial 24-h period, volatilization was negligible, especially at the two lower concentrations, presumably because the ester is hydrolyzed in the moist, sandy loam soil.

### Herbicide Degradation in Soil

The persistence of C-2242 (Ciba-Geigy) was studied in three soil types with moisture levels at field capacity at 25°C. Negligible degradation occurred in steam-sterilized soils, which indicates that microbiological processes are important for the breakdown of this herbicide. Two degradation products were isolated and identified.

Soils treated in the spring with asulam, benazolin, benzoylprop-ethyl, alachlor, nitrofen, profluralin, and picloram were sampled during October and analyzed for herbicide residues. Residues of all herbicides, except asulam, were detectable at all sites. Further, alachlor, nitrofen, profluralin (CGA10832; Ciba-Geigy), and benzoylprop-ethyl were only detected in the top 5 cm of soil, whereas residues of benazolin and picloram and the acid derivative of benzoylprop-ethyl were observed at lower depths.

Studies of the persistence of bromacil, monuron, atrazine, and simazine in irrigation water were continued. Analysis of 500 soil and water samples showed that simazine was the most persistent, followed by atrazine, monuron, and bromacil in that order.

### Herbicide Residues in Plants

A system was developed for measuring residue levels of trifluralin, profluralin, dinifluralin, and fluchloralin in rapeseed, flax, and mustard. The detectable limit is less than 0.1 ppm. Similarly, a method has been developed to measure terbacil in blueberries to a minimum concentration of 0.01 ppm.

Autoradiography was used to follow the uptake, distribution, and accumulation of  $^{14}\text{C}$

from  $^{14}\text{C}$ -trifluralin, which was fed to rapeseed plants via the leaf surfaces, petioles, or roots. The technique was developed as a first step in determining the fate of this herbicide in rapeseed plants.

## WEED INVESTIGATIONS

### Wild oats

Dichlorfop-methyl (HOE 23408; Hoechst) satisfactorily controlled wild oats in spring wheat and durum wheat again in 1975. It performed best when applied when wild oats were at the two- to three-leaf stage. It also controlled green foxtail and Persian darnel.

Dichlorfop-methyl mixed with phenoxy herbicides did not control wild oats satisfactorily. When 7 days were left between applications of dichlorfop-methyl and 2,4-D, the antagonism was not apparent. Mixing triallate with CP 53619 (Monsanto) in the spray tank also reduced control of wild oats. Of seven herbicides tested, flufenprop-methyl (WL 29761; Shell) at 0.84 kg/ha and dichlorfop-methyl at 1.4 kg/ha controlled wild oats best.

### Green Foxtail

Dichlorfop-methyl gave excellent control of green foxtail in wheat again in 1975. Better control resulted when the herbicide was applied when green foxtail was at the two- to three-leaf stage than at later stages. Dichlorfop-methyl also markedly reduced root development of green foxtail and some other grass species.

### Rye Tolerance

Spring rye was tolerant of dichlorfop-methyl and difenzoquat (Avenge; Cyanamid), but barban, benzoylprop-ethyl, and flufenprop-methyl reduced plant height. Barban also reduced grain yield even when applied at the minimum rate needed for acceptable control of wild oats. Tolerance for barban was greatest at the one-leaf stage.

### Canada thistle

Glyphosate applied at 1.68 kg/ha gave excellent control of root growth of Canada thistle in the top 30 cm of soil, satisfactory control at 30–90 cm, and only fair control (38%) at 90–120 cm. Rates higher than 1.68 kg/ha improved control at depths lower than 30 cm. The application of 2,4-D alone gave

better control of top growth than mixtures of 2,4-D and dicamba. Dicamba alone at 1.12 kg/ha compared favorably with glyphosate for control of Canada thistle.

In the field, 5.3% of Canada thistle seeds germinated; of these, 84.5% germinated in the 1st wk and 12.3% germinated in the 2nd wk. Germination did not occur after July 24.

When growing in competition with a wheat crop, 90% of Canada thistle seeds that germinated produced established plants by July 4 and 38% of these survived to the end of the season.

After growing in a root box in the field for 4.5 mo, a Canada thistle plant had 200 m of roots with 979 lateral roots, 218 emerged buds, and 13 above-ground shoots. Contrary to previous reports in the literature, the seedlings flowered and produced seed in the 1st yr. Roots examined after 2 yr of growth had developed 'dead areas' that effectively segmented the root system into several independent parts.

When the shoot of Canada thistle was removed at the flower bud stage, translocation of  $^{14}\text{C}$ -2,4-D out of the treated leaves increased by as much as 50%, and translocation into the roots increased by 35–40%. When only the shoot apex was removed, growth of axillary shoots was stimulated, which suppressed root bud response and reduced translocation of  $^{14}\text{C}$ -2,4-D into the roots. Translocation of  $^{14}\text{C}$ -2,4-D out of the treated leaves was reduced by nitrogen deficiency. In this work  $^{14}\text{C}$  was the entity measured, and it was assumed that it remained attached to 2,4-D.

### Root Rot

The incidence of root rot was not influenced by the use of herbicides. When triallate was incorporated into the soil, incidence increased in both Cypress, a susceptible cultivar of wheat, and Manitou, a resistant wheat cultivar. However, the disease also increased on test sites that were subjected to the same incorporation procedure with the active ingredient, triallate, omitted.

### Weed Control on Rangeland

Aspen poplar became very competitive when it reached 2.5 m tall. Up to that height the yield of forage growing beneath the trees was not affected by the presence of the trees.



Fertilizer-herbicide combinations increased forage production substantially. Nitrogen and phosphorus each applied at 33.6 kg/ha in combination with 2,4-D, dicamba, or picloram for brush control produced forage yields the next year that were five or six times that of untreated areas. The fertilizer alone or herbicides alone increased forage yields by nearly three times.

The optimum bandwidth of glyphosate for reducing resident vegetation to facilitate the establishment of legumes on rangeland is 20 cm. Alfalfa is superior to sainfoin or cicer milkvetch when seeded directly into sod.

### Foxtail Barley

Seeds of foxtail barley germinated in the spring and fall. After seed germination, plant mortality was high, following the classical, type III Deeney curve; mortality increased rapidly in the 1st yr, but a few plants lingered on for several years. However, sufficient seedlings became established to maintain the infestation. Mortality of mature perennial plants ranged from 30 to 60% over the summer. Glyphosate at rates as low as 1.1 kg/ha gave excellent control of foxtail barley. However, the use of such materials does not prevent reestablishment of the population from seed.

### Stinkweed

In further comparative studies of early-flowering and late-flowering strains of stinkweed, all seedlings that emerged in the spring were of the early-flowering phenotype, but the majority were genetically of the late-flowering strain. The expression of the late-flowering genotype was prevented by natural vernalization that had been received over the winter.

When the two strains were crossed artificially, all plants in the  $F_1$  group were of the late-flowering phenotype. Self-pollination of the  $F_1$  plants resulted in a ratio of three late-flowering to one early-flowering type. This ratio indicates that the two strains differ by a single gene and that the late-flowering strain is dominant.

### Prickly Rose

Seedlings of prickly rose (*Rosa acicularis* Lindl.) produced numerous rhizomes during the 1st yr of growth. The first rhizomes arose from the base of the stem, but others were subsequently produced on the roots. The

production of rhizomes on roots is an unusual feature that has not been previously reported. This feature likely contributes to the remarkable tenacity of prickly rose as a weed.

## SEED SECTION

In 1975 Agriculture Canada released three new varieties to seed growers: Dufferin flax, Cavell oats, and R-500 rapeseed. R-500 is high in erucic acid and intended for the industrial market; therefore, distribution will be restricted to contract production.

Select growers received a quantity of Hinoat seed. This second release of Hinoat is part of a contract program set up by the Canadian Wheat Board.

The winter increase of Sinton wheat (CT 440) provided enough seed for 12 contracts, on a total of 243 ha. Select seed was also increased at Indian Head. This increase will provide enough seed for complete distribution in 1976.

The number of plant breeders using the winter nursery in California increased by seven to a total of 36. Although the 4.25-ha nursery cultivated this year represents a small reduction from that used in 1974, an additional 2.4 ha was used for small-increase plots of DT 411, a durum wheat; Cal 15, a utility wheat; and CZY 3-1821, a new rapeseed.

## CROP MANAGEMENT

### Cereals

Cropping sequences have been compared for 18 yr successively at Indian Head. Without fertilizer the average yields for each hectare cultivated were the same on fields subjected to continuous cropping, a crop sequence of fallow-wheat, and one of fallow-wheat-wheat. When fertilizer was applied, the yields were 1550, 1220, and 1380 kg/ha cultivated, respectively. The yield of wheat on fallow, when a grass-legume mixture was included in the rotation, was similar to that of wheat fertilized in the 3-yr, fallow-wheat-wheat sequence.

Barnyard manure has been applied to Indian Head clay soil at 13, 20, and 26 t/ha once every 3rd yr for 29 yr. Yields gradually increased, particularly after the first 10 yr. During the 5 yr from 1971 to 1975 the average yield of wheat on fallow was 3100,

3370, and 3450 kg/ha and that of wheat on stubble was 1160, 1430, and 1560 kg/ha for each rate of application. The average yields of the control plots for the same period were 2700 kg/ha on fallow and 960 kg/ha on stubble. There was a decided increase in the level of available phosphorus in the soil, even to depths of 120 cm.

Fertilizer 11-48-0 was applied at rates up to 112 kg/ha every 3rd yr for 27 yr. The level of available phosphorus in the soil reached 40 kg/ha at the higher rates. Even though the levels of available phosphorus gradually increased with the higher rates, the pattern of response with the higher rates did not change.

Ammonium nitrate (34-0-0) and urea (46-0-0) were compared as the source of nitrogen for stubble crops. In 1975 when urea was applied to wheat on clay soil, it was about 50% as efficient as ammonium nitrate; in the 10-yr average it was 72% as efficient. On loam soil, the relative efficiency of urea was about 60% of that of ammonium nitrate in 1975.

### Alfalfa and Grass

From results obtained over 4 yr at Indian Head, increasing the seeding rate of alfalfa from 1.1 up to 3.4 kg/ha in combination with

a grass in the same or alternate rows did not increase the yield of dry matter harvested as pasture (two or three cuttings) nor did it increase the percentage of alfalfa in the forage. The alternate row arrangement produced 15% more alfalfa in the clippings but did not increase total dry matter significantly.

In a similar test when the crop was harvested for hay (one cut per year), a slight yield advantage to alternate over same-row seeding was obtained. For 4 yr the annual yields of alfalfa with Magna brome grass, Parkway crested wheatgrass, Chief intermediate wheatgrass, or Sawki Russian wild ryegrass were similar at about 4150 kg/ha whereas alfalfa with Carlton brome grass produced only 3360 kg/ha. There was a significant interaction of row arrangement on the percentage of alfalfa in the stand. All combinations contained about 40% alfalfa in the forage when grown in alternate rows, but the variation within and between treatments was much greater for same-row seeding of alfalfa and grass. The percentage of alfalfa was very low when the alfalfa was combined with the strongly competitive Magna brome grass or Chief intermediate wheatgrass.

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J. D. SMITH, B.Sc., M.Sc.	Forage diseases

## Departures

N. S. CHURCH, B.Sc., M.S., Ph.D. Died July 26, 1975	Insect endocrinology
R. J. LEDINGHAM, B.Sc., M.Sc. Retired November 29, 1975	Cereal root diseases
R. PICKFORD, B.S.A., M.Sc., Ph.D. Retired September 26, 1975	Grasshoppers; ecology

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D. C. MCGEE, Ph.D., 1974-75	Oilseed diseases
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*Consejo Nacional de Ciencia y Tecnologia*

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## INTRODUCTION

The program of the Research Station, Saskatoon, emphasizes research on oilseeds, cereals, and forage crops. A new cultivar of rapeseed, R-500, was released. It was developed to supply a source of high erucic acid oil for industry.

A highlight of the year was the selection of Dr. R. K. Downey to share the Royal Bank Award given for outstanding achievement contributing to human welfare and the common good. The other recipient was Dr. B. R. Stefansson of the University of Manitoba.

Dr. R. Pickford retired in August after 32 years' service. His excellent research in grasshopper ecology and life histories has made a valuable contribution to the understanding and control of this insect on the prairies. R. J. Ledingham retired in November leaving behind a wealth of information on common root rot of wheat and barley collected over a period of 38 yr. Dr. N. S. Church died suddenly in July. His well-known research on insect endocrinology is extremely valuable to a deeper understanding of developmental morphology in insects.

This report summarizes some of the more important research results from the Station in 1975. Further information can be obtained from the Director, Research Station, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2.

J. E. R. Greenshields  
Director

## CROPS

### Oilseeds

*Rapeseed breeding.* Strain CZY3-1821, *Brassica campestris* L., which combines the three quality characteristics of low erucic acid, reduced glucosinolate in the meal, and a high proportion of yellow seeds, is being increased for seed in California during the winter. Further contract multiplication in Canada in 1976 will provide sufficient seed for processing on a commercial scale and permit an evaluation of the chemical and nutritional characteristics of oil and meal. This strain has yielded well in Alberta but less favorably in Saskatchewan and Manitoba.

Strains of *Brassica napus* L., which segregate yellow seeds, have been selected from populations with low erucic acid and low glucosinolate seed characteristics. It has been shown that yellow seed is associated with high oil and protein contents and low fiber in *B. campestris* and *B. juncea* (L.) Coss, but this relationship remains to be confirmed in *B. napus*. Several lines of low erucic acid, low glucosinolate *B. napus* continue to show yield and maturity performance equal or superior to the widely grown cultivars Tower and Midas.

To meet the need for oils containing 50% or more erucic acid the *B. campestris* cultivar R-500 was licensed in February 1975, and

seed was distributed to commercial processing firms for contract production. No problems were encountered in keeping this seed pure, and the cultivar will be used again in contract production in 1976. A program of hybridization and selection is under way to develop high erucic acid (>50%) and low glucosinolate strains that are superior to R-500 in agronomic performance.

Crosses between adapted low erucic acid, low glucosinolate *B. campestris* plants and plants from introduced strains from Mexico that are resistant to white rust, *Albugo candida* (Pers. ex Lév.) Ktze., have yielded a high proportion of resistant progeny.

*New and improved methods for determining levels of erucic and other fatty acids in Brassica seed oil.* A new, rapid, and simple test has been developed to determine the erucic acid content of rape and mustard seed. The test is based on a relationship between the time required for an oil to separate from a warm alcoholic solution and its erucic acid content. As the oil separates, the rate of clouding is observed visually and compared with that of standard oils of known erucic acid content. The test requires a minimum of equipment and technical expertise. The stability of the reagents and simplicity, sensitivity, and speed of the test make it suitable for determining the erucic acid levels of seed at

farm delivery points and throughout the transportation and marketing system.

Increased precision for measuring erucic and other fatty acids is required to develop more desirable *Brassica* oils for edible and industrial uses. Investigations of commonly used methods of oil extraction, methylation, and gas-liquid chromatography indicated that under some circumstances erroneous values are obtained. A procedure has been developed using high-speed mills to extract the oil, sodium methylate to esterify the fatty acids rapidly, and short chromatographic columns. When the chromatographic data are processed with a minicomputer, a large number of fatty acid analyses can be handled with sustained efficiency, accuracy, and precision.

*Hail damage to rapeseed.* Field observations and simulated hail damage experiments have been conducted to elucidate the nature of hail damage to rapeseed and develop criteria for projecting loss of seed yield and quality. Simulated hail damage experiments indicated that *B. campestris* may recover from hail damage better than *B. napus*. Field observations showed that, when hail bruises immature pods, seed below the bruised area usually turns brown and shrivels, thus reducing yield and perhaps crop grade.

*Mustard breeding.* Canada has recently become the main world supplier of mustard. Selections of superior strains of brown and Oriental mustard, *B. juncea*, with increased seed yields and containing higher levels of allyl isothiocyanate have been developed for industrial use. Within the yellow mustard species *B. hirta* Moench, both low (<5%) and high (>50%) erucic acid strains have been selected. Inheritance studies on erucic acid content in *B. hirta* oil indicated that it is controlled by a single gene, with a degree of dominance of 49.2%. One high erucic acid yellow mustard selection, BH-1245, appears suitable as a condiment as well as a source of high erucic acid oil.

*Tissue culture as a tool in Brassica breeding.* Research aimed at reducing the time and expense of breeding programs in *Brassica* is in progress using haploid techniques and tissue culture. Attention has been focused on obtaining haploid embryos from pollen culture and on developing methods for rapid

propagation and chromosome doubling of haploid plants.

A study of free pollen culture in *B. napus* showed that formation of small proembryos occurred with high frequencies in some cultures. The development of these proembryos has not been observed outside the anther. Apparently, further growth requires the addition of some undefined nutrient or nutrients to the culture medium. Evidence suggests that the nutrient or nutrients may be present in the anther itself.

A tissue culture technique perfected to promote morphogenesis of complete plants from haploid stem explants is being used for mass production of identical haploid plants. Some of these regenerates have spontaneously doubled chromosomes. The technique offers promise as an alternative to the use of colchicine in chromosome doubling of haploid plants.

## Grasses

*Grass-alfalfa mixtures under irrigation.* Crested wheatgrass, despite its reputation as a dryland grass, gave high yields of hay in a 4-yr test of grass-alfalfa mixtures under irrigation. The average yield of six crested wheatgrass strains was 7.80 t/ha compared with 6.95 t/ha for seven brome-grass-alfalfa mixtures, 7.40 t/ha for two intermediate wheatgrass mixtures, and 6.68 t/ha for two reed canarygrass mixtures. The highest yielding strain of crested wheatgrass was Parkway. Baylor gave the highest yield of the brome-grass strains. Higher amounts of alfalfa with crested wheatgrass and better resistance to winter damage appeared responsible for the good performance of crested wheatgrass - alfalfa mixtures.

*Brome-grass seed pests.* In 1975 extensive damage to brome-grass seed setting at the Station and on a few farm fields resulted from the brome-grass seed midge, *Contarinia bromicola* (Mar. & Ag.). Population peaks were observed on June 11 at heading and July 2-3 at flowering. Because there are two generations per season, control by use of insecticides is best directed at the first rather than the second peak. Approximately one-third of the florets were sterilized by larvae by July 14. A survey of 15 fields indicated that damage was most severe in old fields where harvesting in 1974 was done late by direct combining rather than early by swath-ing and picking up.



Another pest that became apparent in 1974 was *Limothrips consimilis* Pr. One week after flowering approximately one-quarter of the florets of brome grass contained actively feeding larvae and these florets were rendered sterile. This insect has been reported as causing serious seed losses to brome grass in northern areas of the USSR.

## Legumes

*Breeding for nonbloating alfalfa.* The total soluble protein (TSP) in alfalfa, which is the main foaming agent responsible for pasture bloat in cattle, was found to have a low heritability estimate of 0.23–0.31. Therefore, a breeding program was started to develop an alfalfa low in TSP. This program is based on consecutive cycles of recurrent selection with well-replicated progeny tests. In 1975 a large replicated progeny test was established.

*Tannins.* Because the tannin constituents of sainfoin are believed to be responsible for the nonbloating nature of this legume forage, the induction of condensed tannin synthesis in alfalfa is another possible approach to the development of a nonbloating alfalfa cultivar. No condensed tannins were found in 25 annual *Medicago* spp., 14 perennial *Medicago* spp., or 25 *Trigonella* spp. Therefore, seed from diploid *Medicago falcata* L. and tetraploid *Medicago sativa* L. was treated with a chemical mutagen, ethylmethanesulphonate, and a field nursery was established. Treated plants in this nursery were screened for the presence of tannins. Work continued on methods for the analysis of tannins in forage crops and a study was started on the inheritance of tannin synthesis.

The antibloat property of tannins is beneficial, but tannins may also reduce palatability or digestibility or both. A chemical study of selected forage legumes revealed a procyanidin component that appeared to be associated with low nutritive value; the occurrence of other tannin constituents was not correlated with low nutritive value.

Cicer milkvetch, a crop that is reputed to be nonbloating, does not contain tannins. Birdsfoot trefoil at the prebud (pasture) stage of development does not appear to contain sufficient tannins to account completely for its nonbloating characteristics. These findings suggest the occurrence of additional or alternative pathways to account for nonbloating forage legumes.

## Cereal Varieties for Forage

In 1973, 1974, and 1975, up to 35 cultivars of wheat, oats, and barley that were grown for grain production at seven project farms in northwestern Saskatchewan were also harvested for forage at the early to medium-dough stages. Protein and in vitro digestibility determinations were completed for five of the locations used in 1973. Based on 22 station-year averages (Loverna location was added in 1975), when the top-yielding licensed cultivars were used for forage they produced the following amounts of dry matter per hectare: Pitic 62 wheat 7.35 t, Kelsey oats 7.42 t, and Bonanza barley 7.29 t. The unlicensed oat strain 1863-4 gave the highest overall yield; the cultivar Gemini, selected in Eastern Canada for forage potential, was the lowest-yielding oat cultivar. Significant yield differences ( $P = 0.05$ ) were obtained between cultivars for 46 out of 66 trial locations. Based on 3-yr averages involving the three top-yielding cultivars, wheat performed best on the loam soil at Scott; oats yielded best under irrigation (Saskatoon) on the northern Black or Gray Luvisol soils (Glaslyn, Lashburn, Loon Lake); and barley performed best on the heavy soils at Rose town and Kindersley.

In vitro digestible organic matter (DOM) was significantly different between cultivars at 9 out of 15 crop locations. The average percentage DOM levels ranged from 57.7 (Pitic 62) to 53.1 (Cypress) for wheat; 51.2 (Random) to 47.7 (1863-4) for oats; and 59.0 (Paragon) to 57.2 (Betzes) for barley. The DOM levels for oat cultivars were consistently lower than for wheat and barley cultivars. Using all available data, average yields of DOM in tonnes per hectare were: Pitic 62, 4.26; Kelsey, 3.61; and Bonanza, 4.24. Wheat and barley were superior to oats. Significant protein differences between cultivars occurred at only 5 out of 15 crop locations and at no locations for barley.

## Agronomy

*Phosphate placement.* Ammonium phosphate 11-55-0 was applied on several soil types at the time of seeding; the rates of P were 4.8–39.3 kg/ha with the seed or side-banded (2.5 cm below and to the side of the seed) for wheat, barley, rapeseed, and peas. Yields of wheat and barley were similar for the two placement methods at all rates of P on all soils. Similar results were obtained



with barley except on two Gray Luvisol soils, where sidebanding of P was slightly superior at higher rates when moisture was deficient. Sidebanding produced larger yield increases than placement with seed at all rates of P for rapeseed and peas. In 1975 the average yield increase of Torch rapeseed was 11% (130 kg/ha) for sidebanding over placement with seed at P rates up to 19.6 kg/ha. On two Gray Luvisol soils the average increase was 22% (220 kg/ha). Over a period of 4 yr the overall average increase at the above rates of P was 16% (180 kg/ha) for all soils, and 28% (270 kg/ha) for the two Gray Luvisol soils. In 1975 yields from P at 19.6 kg/ha on some soils were up to 440 kg/ha greater than control yields.

For similar rates of P, field peas on Scott loam yielded 18% more when the P was sidebanded than when it was placed with the seed. Peas showed a strong response to applied P; yield increases above the control were as high as 1400 kg/ha (130%) from a sidebanded application of P at 29.2 kg/ha.

**Nitrogen placement.** Urea and ammonium nitrate (AN) were: (a) placed with the seed, (b) broadcast and incorporated to 10-cm depth, and (c) sidebanded in the spring of 1975 at rates of N of 11–224 kg/ha for the rapeseed cultivar Torch on stubble land on Scott loam and Sutherland clay. Available soil  $\text{NO}_3\text{-N}$  levels at seeding time were 87 kg/ha for Scott loam and 58 kg/ha for Sutherland clay. Although yields increased as the rate of N was increased up to 90 kg/ha on Scott loam and 134 kg/ha on Sutherland clay, the most profitable rates were 22 kg/ha (yield 270 kg/ha) on Scott loam, and 45 kg/ha (yield 680 kg/ha) on Sutherland clay. When broadcast with incorporation or sidebanded, urea and AN were equal in effectiveness at all rates, but both sources reduced yields when placed with the seed at N rates in excess of 22 kg/ha.

## PLANT DISEASES

### Common Root Rot of Cereals

Yield losses in wheat from common root rot generally were significantly correlated with disease intensities based upon incidence and extent of lesioning on the subcrown internodes. Thus lesions of this plant part were confirmed as useful indices of disease; they have been used frequently to assess the

reaction of cultivars and lines. Estimated percentage losses in cultivars averaged over five tests were: in common wheat, Neepawa 5.2 and Chinook 7.5; durum wheat, Hercules 6.0 and Pelissier 7.9; and barley, Conquest 10.8 and Olli 21.2. Losses in 1975 for Saskatchewan were estimated at 8% in red spring wheat and 11% of the potential yield in barley. These values are lower than those for the preceding 2 yr.

Screening of lines of wheat and barley for resistance was continued and entries that appeared promising were retained for further testing. From thousands of lines screened previously, 10 of the most resistant and of diverse parentage were selected and intercrossed by plant breeders for use in a program to develop superior resistance.

The application of herbicides had no influence on the intensity of common root rot in tests conducted over a period of years. Recently, an increase in disease severity was associated with triallate incorporated in soil as a preemergence treatment in trials at the Research Station, Regina. Results of cooperative work indicated that the enhanced disease level apparently resulted from the incorporation process and was not attributable to the herbicide per se.

Prematurity blight was conspicuous in 1975 particularly in durum wheat fields. Symptoms appeared comparable to those of fusarium root rot as described in northwestern USA. However, isolations from blighted plants suggested that whereas *Fusarium culmorum* (W.G.Sm.) Sacc. was the primary fungus in one area, *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur was the chief incitant in others. Some greenhouse tests indicated that each of the fungi may be associated with the disease. Because both fungi can cause common root rot, presumably prematurity blight is a severe phase of it.

The possibility of employing toxic culture filtrates in laboratory screening of large populations of wheat for resistance was further explored. The results were not encouraging and the technique seems to have limited usefulness.

Cultural conditions, particularly the effects of controlled pH and carbohydrate levels, were refined for comparative studies of isolates of *C. sativus*. Biochemical criteria for distinguishing *C. sativus* from related species and for detecting differences between isolates have been investigated. Some differences



were found in the production of hydroxyanthraquinone pigments; electrophoretic protein patterns differentiated *C. sativus* from other species but not isolates within the species.

Some fungicides applied as sprays decreased the inoculum potential of *C. sativus*. A treatment to wheat plants in the field in mid-June or early or late July reduced sporulation on their crowns by 30–50%. The number of conidia per gram of soil was lowered by about 70% following application of fungicide to stubble after harvest. The viability of conidia in the treated plots rapidly declined to low levels.

### Diseases of Forage

**Grasses.** In infection studies competition between isolates of either *Typhula ishikariensis* Imai or *Typhula* FW snow molds reduced the pathogenicity of mixtures of isolates to grasses. Competitive effects were noted between colonies of the low-temperature basidiomycete snow mold on turf giving a characteristic symptom, but not between colonies of *Fusarium nivale* (Fr.) Ces. or *Sclerotinia borealis* Bub. & Vleug. snow molds in which colonies overgrew one another.

*Didymella festucae* (Weg.) Holm, the cause of a severe stem eyespot disease on fescue seed crops in northern Alberta and British Columbia and endemic on native fescues in western North America, was found on native and introduced fescues in western Norway for the first time. A psychrophilic *Cephalosporium* sp., antagonistic to snow mold fungi and common across Canada, was also found for the first time in Norway.

Two new experimental systemic fungicides gave as effective control of artificially induced outbreaks of *S. borealis* and *Typhula* FW snow mold on fine turf as the standard quintozone. These systemic materials and benomyl showed residual effects in controlling natural prehibernal attacks of *F. nivale* at 12 mo from application.

### Diseases of Oilseeds

**Rapeseed.** It was shown that in host reaction and cultural characters isolates of the strain of *Leptosphaeria maculans* (Desm.) Ces. & De Not., which causes blackleg of rape in Australia, resemble highly virulent Wisconsin cabbage isolates. The western Canadian rape strain is identical to the

weakly virulent “Puget Sound” (western USA) strain. The latter types produce a yellow to brown pigment in culture, whereas the highly virulent ones do not. In contrast to the situation elsewhere, ascospore discharges begin in July in Western Canada and by this time rape plants are no longer very susceptible to the disease. Observations indicate that, barring the appearance of highly virulent types, blackleg will be a problem in this area only where rape is sown on rape residue from the preceding year. Resistance to virulent strains superior to that in Canadian rape and turnip rape cultivars has been identified.

Techniques were developed to screen rape-seed lines for resistance to *Alternaria brassicae* (Berk.) Sacc. Although none was immune, most *B. napus* cultivars and a few *B. campestris* introductions exhibited fair resistance in growth-room and field tests. A relationship was established between leaf age, inoculum concentration, and disease severity. Two dithiocarbamate fungicides markedly reduced incidence and severity of the disease.

It was demonstrated that a disease of rapeseed in the Prairie Provinces, formerly attributed to *Mycosphaerella brassicicola* (Duby) Oud., is caused by *Pseudocercospora capsellae* (Ell. & Ev.) Deighton. The common names of the disease are white leaf spot and gray stem. Benomyl gave excellent control in field tests.

**Rapeseed and sunflowers.** A field nursery of lines and cultivars of *Brassica* spp. and *Helianthus annuus* L. was established to screen for resistance to *Sclerotinia sclerotiorum* (Lib.) de Bary. Inoculum consisted of infested rye kernels placed in the rows above the seed. Of 53 *H. annuus* lines tested, Salyut, I.N.R.A. 4701 and 7702, and a Morden selection from Peredovic were the most resistant. Differences in resistance between *Brassica* spp. entries were less conspicuous. However, the *B. napus* cultivar Bronowski had the highest proportion of healthy plants of 25 lines tested.

## ENTOMOLOGY

### Oilseed Insects

**Flea beetles.** Flea beetles are a common pest of rape crops in the Prairie Provinces and in 1975 they caused severe damage to



seedlings in various localities in Saskatchewan. Observations indicate that there are two ways in which adult flea beetles move into seedling rape crops: one is a slow, creeping, plant-to-plant movement into a field from adjacent early spring-feeding grounds of volunteer rape or cruciferous weeds; the other is a much more rapid and even infestation of whole fields by flying beetles. The two infestation processes may occur separately or simultaneously. Warm, sunny weather is conducive to infestation and to severe crop damage.

In the Saskatchewan parklands the flea beetle species that attack rape apparently overwinter as adults in several different habitats. Flea beetles overwinter in soil in rape stubble fields if green food plants are available until the onset of cold weather in the fall. However, if ripening, harvesting, or tillage destroys the food supply while the weather is warm, the beetles leave the field and overwinter in leaf litter or turf beneath hedges, along fencerows, and in groves of poplar trees. Flea beetles that attempted to overwinter in cracks and crevices of standing rape stubble did not survive.

*Insects on flax and sunflowers.* Surveys showed that the flax bollworm infested some flax fields in west-central Saskatchewan, but populations were low. Consequently, the 1976 populations are expected to be below economic levels. Ninety-six percent of flax bollworm pupae were parasitized when they were collected from field soil in the spring. Of four parasites found, two hymenopterous ones, *Exetastes brevicornis* Cush. and *Dusona laticincta* (Cress.), accounted for 87% of the parasitism.

In 1975 three head-infesting insect pests were present in most fields of cultivated sunflowers in Saskatchewan and Alberta. The sunflower moth predominated in experimental plots at the Station, where infestations up to several hundred larvae per head occurred, and severely reduced seed production. The other two sunflower pests, the picture wing fly, *Neotephritis fnalis* (Loew.), and the banded sunflower moth, were common but below economic levels.

### Wireworms

The spatial field distribution of eggs, larvae, and adults of the prairie grain wireworm was determined from statistical analyses of samples. Eggs were highly aggregated

but the degree of contagion decreased progressively from small to medium to large larvae. Most of the aggregated distributions conformed to the negative binomial expectation. Sampling by emergence cages showed that adults of both sexes were aggregated. Emergence cages, which trap emerging adults in the spring, were more efficient than soil samples in detecting aggregation. The relation of the standard error to the mean was used to develop an efficient sampling plan in which the margin of error and four levels of statistical significance could be determined.

### Grasshoppers

*Improved forecasting method.* A computerized method of developing the annual grasshopper forecast and forecast maps from the Saskatchewan survey data has been developed. The method results in a saving of several months' time and a less subjective analysis than was obtained by the hand-mapping method of analyzing survey data. After the data have been keypunched and verified, the new system can process, summarize, and map them in less than 10 min. This method produces contour maps that show the infestation levels in crops and along roadsides and in combination. Other procedures are available that include mapping of individual species densities. The 1975 survey data mapped by the method indicate an expected decrease in the general severity of the infestation for 1976, but that there will be problems in some areas of Saskatchewan. However, dry, warm weather in 1976 will increase the risk of crop damage.

*Crop damage.* Studies indicate that grasshoppers feeding on spring wheat waste six times as much foliage as they actually consume. A mathematical simulation model for estimating plant biomass at harvest provides a realistic output when defoliation is a continuous process and plants survive, but it has some deficiencies in providing realistic estimates when defoliation is severe.

*Seasonal occurrences.* A mathematical model was developed to predict seasonal occurrence of grasshopper species in Saskatchewan based on the amount of embryonic development occurring in the fall and the rate of egg and nymphal development in the spring. This model will be useful for decision-making processes in grasshopper



control and also for accurate population sampling and damage assessment.

**Control.** A field trial was conducted to compare a nonresidual insecticide, Bioethanomethrin (McLaughlin, Gormley, King Co.), and a relatively persistent one, dimethoate, against field populations of grasshoppers. Under conditions where pests were small and considerable grasshopper migration occurred, Bioethanomethrin maintained reduced populations for only 4 days compared with 8 days for dimethoate. In laboratory tests spray concentrations of carbofuran, dimethoate, and carbaryl generally had to be increased to kill older grasshoppers. Carbaryl was an exception; lower spray concentrations were required to kill fourth-instar than to kill second-instar grasshoppers, but adults could not be controlled at any reasonable concentration.

### Mosquitoes

**Insecticides.** The insect growth regulators PH 60-40 (Philips-Duphar, Ciba-Geigy Canada Ltd.) and Altosid SR 10 (Zoecon Corp.) were tested against mosquitoes in naturally infested ponds near Saskatoon. PH 60-40 25% wettable powder at rates of active ingredient (ai) of 56 g/ha completely prevented emergence of adults for 20 days after treatment; at 33.6 g/ha for 9 days; and at 44.8 g/ha for more than 9 days but less than 20 days. Altosid SR 10 completely blocked adult emergence for 10 days with ai at 70 g/ha, and for 21 days at 140 or 280 g/ha. Mortality from PH 60-40 was greatest in larvae, less in pupae, and least in adults; Altosid showed the reverse activity.

**Ecology.** In population studies at a pond near Saskatoon, larvae were present from April 24 to June 18 and adults from May 9 to October 1. Adult populations were about 50% and larval populations about 1% of those of 1974. Levels of abundance of pestiferous larvae in decreasing order were: *Aedes flavescens* (Müller), *Culiseta inornata* (Williston), *A. fitchii* (Felt & Young); for pestiferous adults *C. inornata*, *A. campestris* Dyar & Knab., *A. flavescens*, *A. dorsalis* (Meigen), *A. fitchii*, *A. vexans* (Meigen), and *Culex tarsalis* Coq. These species accounted for 100% of all larvae and 98% of all adults taken. Approximately 35% of the total larvae and adults were *C. inornata*.

### Control of Black Flies

Fifteen tests with single injections of black-fly larvicides in the Saskatchewan River have been completed since 1967. Temephos was ineffective when a concentration of 0.22 ppm was maintained for 15 min. Chlorpyrifos at concentrations of 0.11 ppm and 0.2 ppm for 15 min was as effective as similar dosages of methoxychlor. Twelve tests with methoxychlor showed it to be a reliable larvicide against *Simulium arcticum* Malloch when applied as single injections into a river as large as the Saskatchewan. For example, one injection of an emulsifiable concentrate, sufficient to provide 0.3 ppm of methoxychlor throughout 15 min, eliminated 90% or more of the black fly larvae from more than 100 km of the river. In another test a similar dosage eliminated 66% of instars 3-6 from a site 161 km downstream. Such reductions were adequate to prevent damaging outbreaks.

The larval populations of *S. arcticum*, derived from overwintered eggs, were at their maximum each year when they were treated in late May. However, populations of *S. luggeri* N & M peaked several weeks later and were not affected by the larvicide treatments. Thus far, populations of *S. luggeri* have not required control.

Populations of nontarget organisms, especially Plecoptera, in exposed sites were also severely affected by the larvicide treatments, but recovered within 1-7 wk, mainly as a result of natural downriver drift from the untreated section, and continued hatch. Fish were unharmed. Residues were short-lived and did not become magnified in food-chain organisms. Methoxychlor was rapidly absorbed onto silt and clay particles suspended in the river water. This suggests that methoxychlor applied to turbid river water may act selectively against filter-feeding species such as black flies.

### Pesticide Chemistry

**Methodology.** Two improvements were made in the method of recovering lindane from weathered soils. The conventional extraction procedure recovered lindane at 0.21, 0.74, and 1.40 ppm from three different soils. After acidification of the soil with dilute sulfuric acid and conventional extraction, lindane was recovered at 0.27, 0.98, and 1.57 ppm from the same soil samples. Extraction

with methanolic boron trifluoride resulted in recoveries of 0.35, 1.16, and 1.93 ppm.

*Translocation and retention.* Lindane and technical chlordane residues remaining in soil were about 15 and 50% of the initial levels 28 mo after application in both dryland and irrigated plots. Carrots and potatoes grown in the treated irrigated soils had residue levels similar to those of the vegetables grown in treated dryland soil.

*Stability of insecticides in alkaline water.* The stability of dimethoate and carbofuran in alkaline water was examined by both biological and chemical methods. In an alkaline buffer of pH 9, 60% of the total carbofuran was decomposed in 72 h from a suspension formulation. It was concluded that only the carbofuran in solution was decomposed and that the solution concentration was kept constant through replacement of carbofuran from the suspended particles. The contact toxicity of the spray to grasshoppers did not decrease in the 72 h during which the total amount of carbofuran in the spray decreased markedly, likely because only the solution concentration contributed to contact toxicity. Oral toxicity of the spray on wheat plants decreased with the decomposition of carbofuran. Dimethoate showed only slight decomposition under the same conditions and no significant reduction occurred in either contact or oral toxicity to grasshoppers.

## Insect Nutrition

*Dietary relationships.* The carbohydrate portion of a chemically defined diet for larvae of the yellow mealworm has an important influence on the rate of growth of these larvae. Dextrin was more satisfactory than glucose in an amino acid diet and doubled the rate of growth of the larvae. Further improvement in growth rate was obtained when the carbohydrate fraction of the diet consisted of equal parts of dextrin and sucrose.

Yellow mealworm larvae require a dietary source of the same 10 amino acids essential for growth of rats, other vertebrates, and some protozoa. Alanine, cystine, proline, and aspartic acid were found to be semidispendable in the diet, and serine, tyrosine, glutamic acid, and possibly glycine were dispensable for growth in this insect. This information is useful in interpreting the results of larval growth on cereal and oilseed proteins.

*Mycotoxin detection.* Screening for mycotoxins produced by field and storage fungi with yellow mealworm larvae has resulted in the identification of 10 isolates of *Fusarium* (unidentified as to species) with toxic metabolites of greater effect than those reported in 1974. Preliminary investigations suggest that fungi-producing mycotoxins for larvae of the yellow mealworm have a similar mycotoxic effect for rats.

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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 various soils, and cattle are raised on natural and cultivated grasslands. Small areas are irrigated. Research is focused on improving the economy and stability of this production.

The rainfall during March and April was more than twice that of the 90-yr average. The average temperature in April was the lowest in 90 yr, and cool temperatures persisted into early May. These adverse conditions delayed seeding of cereals by as much as 2 wk in some areas. Seasonable temperatures and precipitation during most of May and June gave good growth, and hot, dry conditions during July and the first half of August rapidly advanced crop growth but depleted soil moisture. Cool temperatures and heavy rains during the last half of August and normal temperatures and precipitation during September and October resulted in average to above average yield of cereals and much above average yield of forages.

A license was obtained for Sinton, a hard red spring wheat, developed by Dr. E. A. Hurd. Mr. C. H. Anderson developed a chemical system for the maintenance of summerfallow based on the use of atrazine. Mr. H. C. Korven developed a system for controlling growth on irrigation ditches. 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 Mr. P. I. Myhr, or from individual scientists. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

A. A. Guitard  
Director

## CEREAL CROPS

### Breeding and Evaluation of Spring Wheat

License No. 1613 was obtained for Sinton spring wheat, and seed will be distributed for planting on the eastern prairies in the spring of 1976. The cultivar was developed at the Station from a cross made at the Research Station, Regina, in 1963, between Manitou and a selection from Thatcher – Lee – Kenya Farmer. It is higher yielding than Neepawa in the Black soil zones, awned, resistant to prevalent races of leaf and stem rust, moderately resistant to loose smut, moderately resistant to bunt, and fully equal to Manitou in milling and baking quality. It is adapted to the eastern prairies of Western Canada, where it is expected to occupy much of the land sown to spring wheat as soon as seed stocks become available.

### Management—Chemical Maintenance of Summerfallow

Research during the past 5 yr has shown that atrazine at 1 kg/ha sprayed on the soil in the fall after the wheat crop has been harvested will suppress most growth during the subsequent summerfallow year without

affecting the production of wheat the following year. Control during the summerfallow year was accomplished by killing emerging stinkweed, flixweed, Russian thistle, lamb's-quarter, wild oats, and volunteer grain. If some weeds escaped the first spraying or if green foxtail was present, further spraying or cultivation was needed during the summerfallow year. Restricted registration was obtained for the use of atrazine for minimum tillage summerfallow on the Brown soils of southwestern Saskatchewan and southeastern Alberta. The acceptance of this chemical as a substitute for tillage of summerfallow will cause the first major change in management of summerfallow since the development of trash-cover farming.

## TURKEY NUTRITION

### Rate of Change of Fatty Acid Composition

Core samples of skin and subcutaneous fat taken weekly for 9 wk from Wrolstad Small White turkeys after each change of dietary fat were analyzed. Results showed that the half-time of the exponential rate of change of



individual fatty acids is unrelated to either the length of the fatty acid carbon chain or the degree of unsaturation. The average half-time of 2.4 wk was influenced by the sex of the bird. The data will be helpful in predicting the fatty acid composition of carcasses of turkeys fed specific dietary fats and in estimating the effect of a change of dietary fat on the characteristics of carcasses.

### Evaluation of Feeding Programs

Five commercial turkey-broiler feeding programs were compared with a control program by feeding the diets to turkey poults from day-old to market weight. Performance of turkey poults fed the commercial feeds varied widely in rate of growth, feed consumption, feed conversion, carcass grade, and cost of meat production. Carcass composition was not greatly influenced by the feeding program, but the eviscerated carcass yield of birds requiring an extended growing period was reduced. Chemical analysis of the registered commercial feeds showed that little relationship could be found between the actual and the guaranteed analyses except for crude protein. Differences in the amounts of crude protein and amino acid contained in the feeds accounted for part of the observed variation in early growth.

### Medication of Drinking Water

The drinking water of 1021 sexed Wrolstad Small White poults being fed eight experimental or commercial rations was either unmedicated or medicated for 6 days with chlortetracycline alone or combined with soluble vitamins. Cool weather during the 1st wk decreased early growth and feed conversion and increased mortality. The medicated water did not influence mortality or improve early or subsequent growth or feed efficiency.

## FORAGE CROPS

### Breeding and Evaluation

*Alfalfa.* A selection program based on quick and slow emergence in 10 alfalfa genotypes indicated that quick-emerging seedlings produce plants having a higher yield potential than those that emerge more slowly. After two cycles of selection, the quick (Q) and the slow (S) germinating populations differed in yield by 22% in the

greenhouse. In the field, Q progeny lines from the third selection cycle yielded 7% more than the S lines in the first season of growth. In the greenhouse a Q synthetic yielded 10% more than an S synthetic, and in the field it yielded 11% more. The results strongly suggest that rate of germination may be a good selection criterion to use when breeding for higher yield in alfalfa.

*Russian wild ryegrass.* Studies of progenies from a five-genotype diallel cross indicated that N content of the foliage is conditioned by specific combining ability and reciprocal effects, but not by additive effects. The genetic variance for P content was largely additive with significant specific combining ability and reciprocal effects. This apportioning of genetic variance indicates that selection for increased P content could be achieved by ordinary breeding methods, but that these methods would be unsuccessful in increasing N content. Genetic variation for organic matter content was not significant for additive, specific, or reciprocal effects, but variation for digestible organic matter content was strongly additive and lacked specific and reciprocal effects. Therefore, there is a high potential for selecting for increased digestible organic matter.

Segregation in populations derived by crossing heterozygous plants of Russian wild ryegrass showed that the temperature-sensitive yellow foliage character carried by this population is monogenic and recessive. The temperature-sensitive plants were yellow when grown at about 10°C, but were a normal green color when grown at higher temperatures. The gene symbol *ty*<sub>1</sub> has been proposed for this character.

*Altai wild ryegrass.* When progenies from a six-genotype diallel cross were studied in the field, genetic variance for N content and spring vigor were apportioned about equally to general combining ability, specific combining ability, and reciprocal effects. Thus, little progress could be expected in breeding for these characteristics. However, P content, organic matter content, and digestible organic matter content were strongly additive, indicating that good progress could be made with these characters.

Roots of mature plants of Altai wild ryegrass were found to penetrate 3–4 m deep in the ground and to utilize a perched water table. Roots of adjacent mature plants of Russian wild ryegrass did not penetrate



below 1.8 m. Altai wild ryegrass appears to have a unique root system among the cultivated grasses adapted to Western Canada, and this root system will make the species very useful for growing with alfalfa in areas having a high water table or as an interceptor crop for saline seep areas.

### Establishment of Russian Wild Ryegrass

The effect of seed size and moisture stress on rate of water uptake and alpha-amylase activity in seed of Russian wild ryegrass was determined. The rate of water uptake was very rapid for the first 20 h after wetting seed of Russian wild ryegrass. On the basis of total weight of seeds, water uptake was greater for the light seeds, but based on the weight of individual seeds it was greater for the heavier seeds. Increasing moisture tension reduced the rate of water uptake. Alpha-amylase activity was detected 20 h after wetting the seed, and the light seed had higher activity than the heavier seed during the first 48 h. Increased moisture tension reduced alpha-amylase activity: tensions of 12–15 atm nearly eliminated activity. Although the effect of moisture tension on water uptake somewhat paralleled the effect on alpha-amylase activity, the moisture content of the seed did not completely account for the low levels of alpha-amylase activity in seeds exposed to high moisture stress.

### Irrigation

*Evaluation of an overextended sprinkler irrigation system for alfalfa and brome grass.* Yields and consumptive use of water were measured for plots of alfalfa and brome grass for hay. The data were used to assess the cost of extending a wheel-roll sprinkler irrigation system to irrigate 1½ and 2 times the area for which it was designed, based on peak water requirements. The frequency of water application had more influence on yield than the time of application, and the yield of alfalfa and brome was not significantly decreased when the system was extended to serve an area 1½ times larger than the design area except in extremely dry years. Economic analysis showed that when the annual cost of land, water, and management is under \$62/ha, the 1½ times partial extension of the system reduces the cost of alfalfa hay production and that a full irrigation system for the production of alfalfa hay should only be considered when costs exceed \$62/ha.

Because the yield of brome grass was only reduced 10% when the system was extended 2 times compared with a reduction of 24% for alfalfa, the 2-times extension of the partial system should be considered for brome grass regardless of production cost.

*Maintenance of irrigation ditches.* Three years after four sterilants had been applied to irrigation ditches to control vegetation, their ratings in descending order of effectiveness were simazine, atrazine, monuron, and bromacil. Vegetation was also controlled by annual applications of paraquat, paraquat + diquat, and dalapon + amitrole-T. These treatments had the advantage of leaving some growth on the ditches to prevent erosion, and they cost only slightly more than the sterilants. Seeding of the ditches with streambank wheatgrass or Russian wild ryegrass also gave good control. Sheep fescue and dwarf timothy were less effective.

Over 3 yr, the order of decreasing persistence for the four herbicides was simazine, atrazine, monuron, and bromacil. Residues of atrazine, bromacil, and monuron were distributed uniformly throughout the 90-cm soil depth by the third growing season. Most of the simazine residue was still present in the top 7.5-cm layer of soil. In irrigation waters, the highest concentrations of herbicide were in the initial ponding in the spring, and the concentrations decreased by a factor of 2 to 5 the following year. The relative amount of each herbicide in the first two water samplings was inversely proportional to its solubility.

### Yield

*The efficiency of yield tests with grasses.* Analysis of yields from tests of intermediate wheatgrass, Russian wild ryegrass, and Altai wild ryegrass seeded in different row spacings showed that the moving mean adjustment of plot yields before analysis improves the control of experimental error as compared with variance analysis of unadjusted values. A lattice analysis of several trials suggested that the lattice analysis and the use of moving mean adjustment in a random block design are similar in relative efficiency but that the moving mean adjustment in a random block design provides greater choice of the number of lines that can be tested.

*Alfalfa varieties with Russian wild ryegrass for pasture.* Rambler, Roamer, and Drylander alfalfa were each seeded with Sawki



Russian wild ryegrass in 1972 and grazed by cattle for the next 3 yr. In the first production year the percentage basal ground cover of the Russian wild ryegrass was 7.3–11.4%, but 4 yr after seeding the ground cover had stabilized at 11.0–12.7%. During the same period the percentage basal ground cover of Roamer alfalfa increased from 2.1 to 2.5%, whereas Rambler decreased from 4.7 to 2.9% and Drylander from 2.0 to 0.8% basal ground cover.

*Effect of row spacing on the carrying capacity of Russian wild ryegrass.* When cattle were grazed on stands of Russian wild ryegrass that had been seeded in rows spaced 20, 40, and 60 cm apart, the 9-yr average yields of dry matter were 751, 864, and 1328 kg/ha. The 20-cm-spaced stands provided 23–25 days of grazing, whereas the 60-cm-spaced stands provided 33–37 days. Throughout the experiment there was a small annual average weight gain for all animals on the medium–heavily grazed pastures and almost no weight change on all heavily grazed pastures. Row spacing and intensity of use did not cause important differences in nutritional quality of the forage despite more seed culms on the wider-spaced rows.

*Pasture potential of Altai wild ryegrass – alfalfa, Russian wild ryegrass – alfalfa, and green needlegrass – slender wheatgrass – alfalfa pastures.* A mixture of Russian wild ryegrass, crested wheatgrass, and alfalfa utilized as summer pasture yielded the same as a mixture of Altai wild ryegrass, crested wheatgrass, and alfalfa. Carrying capacity and steer gains were similar. The mixture containing Altai wild ryegrass was slightly higher in nutritive value than that containing Russian wild ryegrass because of more alfalfa in the stand. Russian wild ryegrass was more competitive than Altai wild ryegrass, and it crowded out most of the alfalfa after 4 yr. Crested wheatgrass, a volunteer invader, made more rapid inroads into Altai wild ryegrass than into Russian wild ryegrass stands. Russian wild ryegrass appears to be a better pasture grass for early summer grazing than Altai wild ryegrass, mainly because of its earlier growth and better ability to compete with other species. Green needlegrass and slender wheatgrass nearly disappeared from the stand by the second grazing year and most of the yield came from the alfalfa and the invading crested wheatgrass.

## Quality

*Contribution of leaves and stems to quality of Russian wild ryegrass and Altai wild ryegrass.* In an experiment to relate growth habit to quality, Russian wild ryegrass started growing early in May and continued growing until early July. Altai wild ryegrass started growing about 7 days later and continued growing until late July. Because of the lack of stems in Altai wild ryegrass, leaves made up from 70 to 90% of the total plant yield from June to October. During the same period, the leaves of Russian wild ryegrass contributed from 50 to 60% of total plant yield. The leaves of Altai wild ryegrass varied in crude protein content from 21.0 to 5.5% throughout the season, whereas those of Russian wild ryegrass varied from 13.5 to 7.5%. The crude protein content of stems was similar for the two grasses throughout the season, ranging from 10 to 2%. The digestible organic matter of the leaves of the two grasses was about 70% in mid-May and decreased to about 50% in October. From July to September, however, the values for Russian wild ryegrass were 5–7% higher than those for Altai wild ryegrass. The digestibility of stems of the two grasses was similar and fell to less than 40% after mid-July.

*Curing quality of Altai wild ryegrass, Russian wild ryegrass, and crested wheatgrass.* Laboratory analysis of plant material harvested at weekly intervals from May to December during 1973 and 1974 showed that Altai wild ryegrass retained a somewhat higher crude protein content than did Russian wild ryegrass or crested wheatgrass from May to October. By December, all species had levels of crude protein below those considered adequate to meet a dry cow's protein requirements. Altai wild ryegrass was higher in digestible energy than Russian wild ryegrass or crested wheatgrass, but Russian wild ryegrass was slightly higher than crested wheatgrass late in the grazing season. In vitro digestibilities indicated that the energy density of all grasses was marginal by late autumn.

## Flora of the Canadian Prairie Provinces

The third paper in the series *Biological Flora of the Canadian Prairie Provinces* was published. The paper described low larkspur, *Delphinium bicolor* Nutt., which occurs at montane altitudes in southern Saskatchewan and Alberta, mainly in the fescue grasslands,

in deep coulees and ravines, and in forest margins. This plant is a major cause of livestock poisoning.

## ENVIRONMENT

### Nitrogen

*Effect of environment on soil microbial changes.* When measurements were made on summerfallowed Wood Mountain loam in the field and when temperatures and moisture changes measured during one growing season were simulated in the laboratory using three soils, moisture change was found to have the most influence on microbial change.

Microbial change was directly proportional to moisture change but populations increased in response to both increases and decreases in temperature. The inverse relationship to temperature appeared to be the result of the dry surface of the soil being wetted by dew, which accompanied low temperatures at night. The effect of moisture change was usually influenced by temperature or initial moisture content before the change or both.

Microbial responses were greater in the top 2.5 cm than in the 2.5- to 15-cm soil segment. Bacteria and actinomycetes responded to environmental stimuli in a similar manner, but the response of bacteria was usually greater than that of the actinomycetes.

*Effects of a wheat–summerfallow rotation on subsoil nitrate.* Cores 8 m deep were taken in 1974 from fields that had been sampled in 1939, when they were broken, and in 1953, after they had been cropped for 14 yr to a wheat–summerfallow rotation. Virgin soils were almost devoid of  $\text{NO}_3\text{-N}$ , but after they had been cropped for 14–18 yr  $\text{NO}_3\text{-N}$  accumulated in the subsoil. After 35 yr,  $\text{NO}_3\text{-N}$  was still accumulating in the Sceptre clay, but the  $\text{NO}_3\text{-N}$  bulge had disappeared from the Wood Mountain loam leaving the  $\text{NO}_3\text{-N}$  uniformly distributed in the subsoil. Only 43% of the  $\text{NO}_3\text{-N}$  that was present in the Wood Mountain profile after 14 yr of cultivation was still present after 35 yr. In the first 14 yr of cultivation, total nitrogen was lost from the Wood Mountain loam at an average of 1.8%/yr and in the following 21 yr at 0.65%/yr.

### Water

*Suppression of evaporation from farm dugouts.* When a monomolecular layer of cetyl alcohol was spread on the surface of water in a dugout, the reduction in evaporation over 122 days in the summer with an average wind speed of 8.3 km/h was 18.4%. For short windless periods the film covered the entire dugout and evaporation was reduced by as much as 30%. However, in southwestern Saskatchewan with an average wind speed of 11 km/h during the months of high evaporation, the effectiveness of this method of evaporation control is reduced because the film breaks. Although further reduction in evaporation was achieved by combining the monomolecular film with windbreaks and floating grids, the cost of water saved increased from \$0.43/kl to \$0.77/kl.

The effectiveness of various types of rafting material was also examined, particularly for durability during both summer and winter. The most economical raft made from lightweight concrete saved water at \$0.44/kl. Rafts made of styrofoam-type material were also effective.

*Quality of runoff water from summerfallow.* Over 3 yr the nutrients lost from the surface of fertile summerfallow were insignificant, even though concentrations of nutrients present in the surface runoff water sometimes exceeded levels sufficient to sustain algal growth. Water from summerfallow plots contained a weighted mean concentration of 0.43 mg of  $\text{NO}_3\text{-N}$ /litre. Occasionally, samples contained as much  $\text{NO}_3\text{-N}$  as 1.5 mg/litre, which exceeds the suggested provincial limit of 1 mg of  $\text{NO}_3\text{-N}$ /litre. However, in terms of nutrient removal, the average loss of soil N was 0.12 kg/ha, which is only 0.07% of the average potential amount of the nutrient available for loss from the surface to 15 cm deep.

The weighted mean concentration of  $\text{P}_2\text{O}_5$  in runoff water was 0.20 mg/litre, which exceeds the suggested provincial limit of 0.15 mg/litre. Occasionally, concentrations of  $\text{P}_2\text{O}_5$  in the runoff water reached 0.5 mg/litre. Even so, the amount of P removed was only 0.05 kg/ha, which represents a loss of 0.15% of the potential P available for loss from the surface to 15 cm deep.



## Temperature

A corn heat-unit (CHU) map was developed for Saskatchewan. It is based on at least 30 yr of temperature data from 42 observation sites. CHU's varied from 1600 in the Cypress Hills in the southwest to 2000 across the north-central part of the Province and 2400 in the southeastern part, near Estevan. Much of the central part of the Province averaged 2200 CHU annually, and some areas near Outlook and Leader reached 2400. Based on a minimum requirement of 2200 CHU, there would appear to be an estimated 100 000 ha in the Province that have a suitable combination of temperature, precipitation, soil, and topography for the production of silage corn.

## RESEARCH EQUIPMENT

### Tillage and Seeding Equipment for Indian Agriculture

A training program for Indian design engineers culminated in the design and construction of the following machines.

*Bullock-drawn seeder and interrow cultivator for Eastern Uttar Pradesh.* This is a two-row bullock-drawn machine for placing seed and fertilizer for both kharif and rabi crops. Hoe openers were designed to place the fertilizer 2 cm below the seed, or 2 cm to the side and below the seed. The fertilizer applicator utilized an overshot, edge-cell, vertical rotor metering device and an agitator

to distribute powder, granular, and lumpy fertilizers. The machine is also capable of interrow cultivation of three rows spaced 23 or 30 cm apart.

*Interrow sprayer for Eastern Uttar Pradesh.* A two-row sprayer was designed and built for spraying herbicide between rows spaced 30 cm apart. The unit consists of a frame 25 cm from the ground that is supported by a 2-cm pipe frame on two 30-cm wheels. It is equipped with 65° angle nozzles, each shielded by a 25×6.25-cm hood wrapped in canvas. The hood is designed to protect the row crops from spray when chemicals injurious to them are being sprayed. When the nozzles are being used, they are attached to the delivery side of a standard knapsack herbicide cylinder.

*Single-row manually powered safflower harvester.* The machine was designed to cut and windrow single rows of safflowers. It comprises two rotary blades for cutting the safflower stems and has a shield that can be adjusted to windrow the plants on both sides of the machine. The ground wheels, components of the power transmission system, the two circular blades, and the handles are attached to a frame of rectangular steel tubing. Each ground wheel transmits power to a set of beveled gears, which in turn transmit power to one circular blade through a sprocket-and-chain transmission system. Two pairs of handles are provided at the rear of the machine to push and guide the machine.

## PUBLICATIONS

### Research

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<sup>1</sup>On special assignment to Tanzania, September 1973 to February 1976.

## 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., is largely responsible for research on agricultural problems of northwestern Canada. This report presents highlights of research in 1975.

The fairly short growing season in northern Alberta and British Columbia, the severe winters, and the rather cool summer temperatures, as well as a climate that varies from place to place in the region and from year to year make it particularly important to understand the response of crops in the north to the environment. Accordingly, research on the crop-environment relationship was continued as one of the main concerns.

The forage breeding program was highlighted by the introduction of the alfalfa cultivar Anik, selected for its winterhardiness in northern areas. Horticultural breeding programs produced six apple cultivars, Norson, Noran, Norcue, Norda, Noret, and Norhey. All are very hardy and productive in the northern area. Other breeding programs were advanced by the development of superior cultivars of barley, utility wheat, creeping red fescue, meadow foxtail, reed canarygrass, and strawberry.

Research continued in apiculture, forage seed production, plant survival and disease control, soil fertility and microbiology, and weed control. Research on production and management of forage crops continued as the main activity at Prince George and Fort Vermilion. Forage utilization experiments using steers continued at Prince George.

This report and reprints of 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. V2N 2H8.

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## APICULTURE

### Nutrition

Rapeseed flour, soybean flour, wheast (R), and pea protein concentrate in patty form, prepared with 60% sugar syrup, were fed to honey bees to determine their preferences, longevity, and brood rearing. Comparisons of the diets showed that rapeseed flour was preferred to soybean flour and pea protein concentrate when fed to package bees in spring; rapeseed flour was equal to wheast and mixed fresh pollen for longevity; and rapeseed flour was equal to wheast but both were inferior to mixed fresh pollen for brood rearing when fed to small colonies (nuclei) as the only protein source.

Rapeseed flour is a suitable supplemental feed for honey bees but pea protein concentrate produced by air classification, an air-stream process that sorts flour particles on the basis of size, is not suitable.

### Breeding

Artificially inseminated (AI) queens shipped in packages from California weighed less than the control bees (174 vs. 190 mg) on arrival at Beaverlodge on April 30. The capped brood production of AI queens on May 20 was also less than that of the controls. However, all other capped brood measurements and queen weights were similar. Honey production was not different.

### Disease

Chalkbrood disease, *Ascophaera apis* (Maassen ex Claussen) Olive & Splitoir, was first reported in Canada in 1971. Since then it has been noted in at least five provinces, where a survey conducted showed that 32% of the 5374 colonies of bees were infected. The extent of infection in each province was: Quebec 25%, Manitoba 26%, Saskatchewan 37%, Alberta 47%, and British Columbia 20%.



## Behavior

*Honey bee queens in solitary confinement.* Seventy-two virgin honey bee queens and the same number of mated queens were stored in solitary confinement without worker bees, in incubators at temperatures of 21° or 27°C and relative humidities (RH) of 40, 60, or 80%. The mated queens lived significantly longer than the virgin queens. As the temperature increased and the relative humidity decreased, the length of survival of the queens increased. The longest survival was among the mated queens held at 30°C and 40% RH; one lived for more than 120 days. No relationship was established between the length of life of virgin queens and the temperature and RH. Two groups of 10 mated queens were held for 55 days at 40% RH, one group at 30°C and the other at 32°C; at 32°C all queens died, but at 30°C four queens survived.

Twenty-four mated queens were stored at 30°C and 40% RH for 56 days (March 1 – April 26) and 12 survived. Eight of these queens were introduced into small colonies, and 12 small colonies with sister queens that had overwintered outdoors were used as controls. Queen losses, supersedures, and net weight gains in the two groups were not significantly different.

*Effect of confinement on the weight of honey bee queens.* Thirteen newly emerged honey bee queens were caged, with access to candy, for 15 h at 34°C and 60% RH. Their weight at emergence was significantly correlated with their weights after 3, 6, 9, 12, and 15 h, but less significantly correlated with their weights during egg laying and some time after its cessation. Weights shortly after mating, and when egg laying ceased, were not significantly correlated with weight at emergence. When 45 laying queens were caged for 3 days with attendant workers and candy at 30°C and 45% RH, their weights before and after storage were significantly correlated with their weight at emergence; the closest correlation, however, was between weights before and after storage. Results for 16 mated queens from overwintering colonies confined for 14 days under the same conditions were similar. During the 3- and 14-day storage periods the mean weight loss per queen was 38.02 and 36.16 mg respectively. Weight after storage (such as for transport) is likely to be a useful indicator of the egg-laying potential of a queen.

## CEREAL AND OILSEED CROPS

### Barley

The mean yields of barley varied only 7% when it was seeded at 0.7, 1.5, 3.0, and 6.0 million seeds/ha. This result was obtained from a test crop grown for 2 yr at Beaverlodge (55° 12' N) and Fort Vermilion (58° 18' N) in Alberta and at Fort Simpson (61° 52' N) in the Northwest Territories. Parkland yielded best at 1.5 million seeds/ha and Olli and Conquest at 3.0 million seeds/ha. The time to maturity was reduced by an average of 3.4 days, height by 11.8 cm, and seed size by 5.5 g/1000 kernels when the highest seeding rate was compared with the lowest. Seed test weight (kg/hl) was unaffected. For the optimum combination of yield, maturity, seed size, and seed cost, the seeding rate for barley in the north is around 3 million seeds/ha. However, the optimum rate for individual varieties may differ.

### Wheat

*Breeding methods.* Yield performance of eight wheat cultivars was compared in two-row plots with 38 cm between rows and in three-row plots with 19 cm between rows. The interaction between cultivar and row spacing was not significant in any of four tests. The range of cultivar yields from two- and three-row plots as a percentage of the mean was similar. Duncan's multiple range test was applied to yields of cultivars grown in two- and three-row plots. The grouping of cultivar yields from two-row plots was similar to the grouping of cultivar yields from three-row plots. The standard error of a mean and coefficient of variation were consistently lower for three-row plots than for two-row plots. The relationship between yield performance of a line in two- and three-row plots was positive, such that two-row plots would be suitable for yield tests of early-generation progeny with final evaluation in multiple-row plots.

*Postseedling response to stem rust.* The seedling and postseedling reactions of five wheat cultivars to eight races of *Puccinia graminis* Pers. f. sp. *tritici* Erikss. & Henn. were compared under growing conditions in Kenya. The seedling and postseedling reactions of Florence Aurore to eight races of stem rust were similar. The cultivars Hope, Africa Mayo, Kenya Page, and Conley differed from Florence Aurore in that seedlings

of these cultivars were susceptible to several races, whereas postseedlings expressed a degree of resistance to the same races. Postseedling resistance may be identical with horizontal resistance. The stage of growth during which resistance became effective was determined by inoculating each cultivar at various stages of growth. The reaction of Hope and Africa Mayo to races EA4(295) and EA8(40) changed from susceptible to moderately susceptible between the fourth- and the fifth-leaf stage, and the reaction of Kenya Page and Conley to both races changed from susceptible to moderately resistant at about the third-leaf stage. The growth stage at which the plants began to show resistance was independent of the test race.

### Rapeseed

In 1974 at Beaverlodge and in 1975 at Beaverlodge and Fort Vermilion, Torch Polish rapeseed and Tower Argentine rapeseed were planted at weekly intervals from early May to mid-June. Two levels of soil fertility were used for each planting date: no nutrients added, and nutrients added to meet the requirements of a rapeseed crop to yield 1680 kg/ha.

Torch seeded in late May to early June yielded more than when it was planted earlier or later. At Beaverlodge the application of fertilizer increased yield by 24% in 1974 and 22% in 1975.

Torch planted between the 3rd wk of May and early June required the least number of days to reach maturity. Torch planted in early May, however, matured before rape planted in late May.

Plots of Tower planted in the last 2 wk of May yielded more than earlier or later plantings. At Beaverlodge application of fertilizer increased yield by 15% in 1974 and 29% in 1975.

In 1974 none of the plantings of Tower matured. In 1975 Tower took the least number of days to mature when planted in the 2nd wk of May. Tower requires 10 to 30 more days to mature than Torch. The variation in time required for cultivars to mature is smallest when they are planted in the 2nd wk of May and largest when they are planted in late May or early June.

## ENVIRONMENT

### Plant Survival

Forty alfalfa fields in their 2nd yr or older were examined for root and crown diseases after the winter of 1973-74. The root and crown rot complex was expressed by four main types of symptoms: root rot, internal crown rot, external crown rot, and winter crown rot. Root rot was moderate or severe in 68% of the fields and very slight in 24%. Infection was greater in the northern part of the area. Internal crown rot was prevalent throughout all fields. External crown rot and winter crown rot were of little significance.

### Crop Diseases

Snow cover of moderate depth and duration caused widespread but generally moderate snow mold damage. Snow cover combined with a dry autumn and frosts shortly after snowmelt resulted in extensive winter-killing of forage grasses and turf. Winter rye mortality caused by snow mold occurred mainly where snowbanks persisted, but in some cases most of the field was destroyed. *Sclerotinia borealis* Bubák & Vleugel was the most prevalent snow mold at snowmelt on Gramineae in the field, *Typhula* sp. was dominant on turf, and at least five other species were very widely distributed in the region. Chloroneb is the only commercial fungicide as effective in controlling snow mold of turf as the mercurials Mersil (May and Baker) and PMAS-10 (W.A. Cleary Corp.).

### Weed Control

*Effect of herbicides applied to seedling creeping red rescue on subsequent yield and quality of seeds.* In field-plot trials 2,4-D ester (0.56 and 1.12 kg/ha), 2,4-D amine (0.84 and 1.68 kg/ha), MCPA amine (0.84 and 1.68 kg/ha), dicamba mixed with 2,4-D and mecoprop (0.13 + 0.35 + 0.08 and 0.26 + 0.70 + 0.16 kg/ha), bromoxynil with MCPA (0.42 + 0.42 and 0.84 + 0.84 kg/ha), picloram with 2,4-D (0.04 + 0.52 and 0.08 + 0.52 kg/ha), and 2,4,5-T with MCPA (0.39 + 0.31 and 0.78 + 0.62 kg/ha) were applied to seedling fescue in the three-leaf stage in 1971, 1972, and 1973. Seed yields from the first trial were reduced by the highest rates of 2,4-D ester, 2,4-D amine, MCPA amine, and dicamba with 2,4-D and mecoprop. Other herbicide treatments did



not affect seed yields. Seed yields obtained from the second and third trials were not affected by any of the herbicide treatments. Similarly, seed weight and seed germination were not affected. Since the lowest rates of each herbicide or herbicide combination provide adequate annual control of broad-leaved weeds, using them in seedling stands of creeping red fescue grown for seed causes only minimal risk.

*Quack grass control with glyphosate.* The effectiveness of glyphosate in quack grass control has been evaluated in field experiments since 1972. In 3 out of 4 yr the herbicide gave good to excellent quack grass control (85% or more reduction in number of shoots) during the first growing season after application. Applications of glyphosate at 1.68 kg/ha generally gave better control than applications at 2.24 kg/ha, and applications at higher rates were not more effective. The growth stage of quack grass at the time of application did not appear to be critical, although treatments sprayed at the shot-blade stage (12 cm or more in height) or later controlled the grass somewhat better than treatments sprayed before that stage. Fall treatments gave good to excellent control but also tended to be less effective than spring treatments applied at the shot-blade stage or later. Treatment followed by tillage and planting of rapeseed 1 wk after herbicide application tended to improve quack grass control when compared with treatment without subsequent tillage.

The use of summerfallowing during the year of glyphosate application (first tillage operation 2 wk after treatment) improved the duration of quack grass control in the year after treatment. Spring-applied glyphosate at the shot-blade stage or later provided longer-lasting control of quack grass than fall-applied glyphosate.

## FORAGE CROPS

### Alfalfa Breeding

Anik, a new alfalfa cultivar selected for winter survival in northern areas, was licensed in January 1975. It is a landrace strain of *Medicago falcata* L., which originated from strain Ottawa 1191 planted at Fort Vermilion in 1954. Being winterhardy and tolerant of brown root rot, the crown rot complex, and snow mold, Anik is particularly

adapted to areas north of latitude 57° N in northwestern Canada and to areas farther south where only one hay cut is usually taken. First-cut hay yields are equal to or higher than those of Beaver and Rambler. The cultivar is slow to recover from cutting, so it yields much less in the second cut. Anik is persistent under grazing and should prove useful in pasture mixtures. It should also prove useful for seeding roadsides and rights-of-way, and making ecological repairs in northern areas. Anik yields less seed than Rambler or Beaver and harvesting requires specialized care because the seed pods have a tendency to shatter when ripe. Seed is distributed by the Canadian Forage Seed Project.

### Seed Production

*Grasses.* Thirty-five plants of native slender wheatgrass, *Agropyron trachycaulum* (Link) Malte, from northern Canada were categorized as to the latitude of origin. Categories were 53–55°, 55–58°, 58–61°, and 61–68° N latitude. In field plots at Beaverlodge (latitude 55° N) the plants originating from the farthest north had the shortest number of days from heading to maturity and lowest average height and seed yield. Controlled environment studies confirmed that plants from north of 60° latitude have a low capability for producing seed culms in summer environments with less than continuous light. Seed production of such species would be suspect in the current farming areas at lower latitudes. If large quantities of seed were required, new seed production areas may have to be developed in northern latitudes.

*Legumes.* Leafcutter bee populations of 50 000 and 100 000 cells/ha were used to pollinate 1.5-ha fields of Grimm alfalfa. Seed yields of 1030 and 1195 kg/ha respectively indicate a high potential for alfalfa seed production in the Peace River region.

### Herbage Production

*Evaluation of Slave River Lowlands, N.W.T.* The area known as Grand Detour on the Slave River, N.W.T., was studied as a representative portion of the Slave River Lowlands. This area of 832 000 ha has equal parts of woodlands and sedge-grass meadows varying in their degree of wetness. Plot areas were established on two meadow soils, Taltson and Grand Detour, and on one forested soil, Slave. On these three types the

adaptability of forage and cereal crops and the need for additional fertilizer both on native and cultivated stands were determined.

Climate of the area, particularly the rainfall and soil temperature, varied widely from year to year. Rainfall for the 3-mo period from June to August varied from 0.09 cm in 1971 to 23.34 cm in 1973. Killing frost ( $-2.2^{\circ}\text{C}$ ) occurred during July in 4 of the 7 yr. Soil temperatures at 10 cm below the surface did not rise above  $12^{\circ}\text{C}$  in either of the meadow soils. Frost often remained in the ground until early July.

A mixture of awned sedge, *Carex atherodes* Spreng, and northern reed grass, *Calamagrostis inexpansa* A. Gray, yielded 2490 kg/ha averaged over a 4-yr period. A similar amount was taken annually from a stand of whitetop, *Scolochloa festuacea* (Willd.) Link, and awned sedge on a wetter site. An area of pure awned sedge produced 3637 kg/ha. Yields from these three native forage stands ranged from 1284 to 5719 kg/ha with the highest yield in 1971 and the lowest yield in 1973. The percentage of protein diminished during the growing season; sedges dropped from 10.5 to 9.4%, sedge-grass mixture from 10.9 to 7.6%, and whitetop grass from 7.5 to 5.5%. Protein content was the lowest in wettest years. A single application of N at 250 kg/ha increased production by 30% over a 3-yr period. Supplemental N also increased the protein content of the native vegetation by about 3% up to 2 yr after application. Continuously cutting the native vegetation resulted in lower yields but did not change the species composition.

The best-adapted forages were brome-grass, wheatgrass, and alfalfa. Cereals were not able to survive the summer frosts and never matured to ripe grain. Three-year average yields of unfertilized brome-grass-alfalfa hay were 4080, 2670, and 2460 kg/ha for the Taltson, Grand Detour, and Slave soils. Supplementing the Taltson plots with P at 200 kg/ha increased hay yields by 1000

kg/ha. However, P in the forage remained at a low level. The yields of Grand Detour plots were increased by 1000 kg/ha when N was added at 200 kg/ha and P at 100 kg/ha. Slave plots showed only minimal increases from fertilizer application. On all three sites alfalfa diminished in the stand and by the end of the 4th yr brome-grass was predominant.

The P content of both native and cultivated species was less than 0.2% and could be deficient for livestock nutrition.

This study is now being used to compare agricultural potential with the value of bison to the local economy.

*Selenium concentrations in feeds.* Selenium concentrations are lower in forage from the Peace River area than in the average forage from the rest of British Columbia. In cereal grains the concentration of Se was shown to be  $0.17 \pm 0.13$  ppm in 105 samples from the Peace River;  $0.25 \pm 0.15$  ppm in 75 samples from the Creston area; and  $0.37 \pm 0.15$  ppm in 122 samples from the Thompson River area. The average concentration of Se in Peace River cereals was lowest for oats at 0.13 ppm, followed by barley at 0.16 ppm, and wheat at 0.23 ppm. Peace River feed-stuffs should be analyzed for Se content and an Se supplement fed when concentrations are less than 0.1 ppm.

## SOILS

The poorly drained Grand Detour complex of Rego Humic Gleysols in the Slave River Lowlands is 832 000 ha in extent. About 80 000 ha of these soils have electrical conductivities (EC) exceeding 4 mmhos/cm to a depth of 20 cm. Sodium is the prevalent cation and is present in some soils in amounts sufficient to limit agricultural production. When the soil surface was disturbed, as in land preparation for cropping, salinity in the surface layers of soil increased. Soils of the Grand Detour type on the western side of the Slave River had higher EC and more Na, Ca, Mg,  $\text{SO}_4$ , and Cl than the same type on the eastern side of the river.

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### Research

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## INTRODUCTION

Research workers are encouraged by the stimulation associated with a breakthrough or the development of a new variety, procedure, or substance that can contribute to improved production. Scientists in weed research, in collaboration with the chemical industry, have experienced a succession of developments that improve the control of noxious weeds and, in turn, improve crop production. The latest is a chemical that significantly extends the period of control of wild oats and should give farmers much greater protection against that weed, which annually reduces crop production. Results of research into this material and other research at Lacombe are summarized in this report.

Our meats program has expanded in recent years and several interesting and important results of work with both beef and pork are reported. Of special significance is a study which showed that Canadian swine have improved in the 6 yr since the new carcass grading system was inaugurated. Research leading to this system was conducted mainly at Lacombe, in cooperation with industry and other government agencies.

A new oat variety, Cavell, was licensed during the year and should prove valuable where early maturity is important.

This report contains only summaries. For details please address correspondence to: Research Station, Research Branch, Agriculture Canada, Lacombe, Alta. T0C 1S0.

J. G. Stothart  
Director

## ANIMAL SCIENCE

### Beef Cattle

Sex differences have been found in carcass characteristics of beef cattle. In a sample comprising carcasses of 1065 young bulls, 493 heifers, and 876 steers, the bulls outweighed the heifers by 50 kg (10%). The bulls had 3.3 mm (25%) less fat cover over the rib eye and a higher proportion of separable lean in the carcass (69.7 vs. 66.4%). Steers were intermediate between bulls and heifers in all of these traits. Quality attributes, measured both objectively and subjectively, did not differ between sexes with the exception that bulls were more subject to preslaughter stress and showed a somewhat higher proportion of dark cutters (grade B). When compared on the basis of equivalent weight and grade, carcasses from steers and heifers were identical in quantity and quality attributes; bull carcasses invariably showed superiority in lean content. Within grade class, heifers had a marginally higher dressing percentage than steers or bulls. These results clearly demonstrate that there is no valid basis for a price differential between steer and heifer carcasses and that, because they have a higher lean content and equivalent meat quality, bull carcasses of

grade A should actually command a premium at the retail level.

### Meats Research

*Postmortem muscle properties in relation to pork quality.* In a study involving 306 carcasses, 22% developed complete rigor and 42% showed no evidence of rigor at 1 h post-mortem. Rigor was fully developed in 56% of the carcasses by 2 h post-mortem and 9% showed no rigor development. Rate of onset of rigor was not related to PSE (pale, soft, exudative) score, water binding capacity, or measures of tenderness. However, rapid onset of rigor was associated with lower pH, lower solubility of sarcoplasmic proteins, and higher deep muscle temperatures. In all measures of lean content, carcasses showing no rigor at 1 h were inferior to those with fully developed rigor ( $P < 0.05$ ). Shear values were correlated ( $P < 0.05$ ) with the percentage of separable lean in the loin (0.39), muscle temperature 1 h post-mortem (0.29), muscle pH (-0.35), and percentage transmission (0.28). However, they were not correlated with the degree of rigor or PSE score. Ultimate meat quality as measured by percentage transmission could be predicted with moderate precision ( $R^2 = 26\%$ ) from knowledge of pH and muscle temperature,



but the precision of predictions was not improved by measuring rigor.

*Methods for assessing beef tenderness.* Four methods for objective measurement of tenderness of beef muscle were studied using samples of the longissimus dorsi from 282 beef carcasses. Measurements with the Warner-Bratzler shear and the Kramer press, both applied to the cooked product, gave correlations of 0.78 and 0.64 respectively with subjective scores assigned by a trained taste panel. Two tests performed on the raw product, by Armour probe and Ottawa Texture Measurement System (OTMS) press, gave low correlations with panel scores (0.24 and 0.02) and Warner-Bratzler shear values (0.24 and 0.02). The degree of marbling was directly related to tenderness, giving correlations of 0.34 with results from the Warner-Bratzler shear and 0.38 with panel scores. Shear values and panel scores were not correlated with measures of fat or lean of the carcass.

*Predicting fat-to-lean ratio of pork bellies.* The utility of carcass measurements and specific gravity of the belly for predicting the fat-to-lean ratio of pork bellies was examined with a sample of 109 boars, 379 gilts, and 242 barrows. Sex differences were important: bellies from boars had 4.5% less fat than gilts, and gilts 2.7% less fat than barrows. Within each sex, the fat content of the belly increased in a linear fashion as the thickness of backfat increased, and 46% of the total variance in fat content was explained by variation in average backfat. Carcass weight had no predictive value after backfat was considered. The percentage of belly fat of gilt carcasses was correlated 0.67 with backfat and -0.87 with specific gravity of the cured belly, which indicates that the latter measurement, taken directly on the belly, was a more reliable predictor than a measurement taken on the carcass. Substantial within-belly variation in both the ratio and distribution of fat to lean was revealed by detailed study of belly cross-sections. Physical measurements of individual bacon rashers did not provide any useful criteria for predicting either trait, but visual grading of rashers based on photographic standards did show considerable potential for this purpose. It was concluded that market index values (carcass grading) provide a sound and consistent basis for selection of bellies for bacon production before curing. However, to ensure

that the final product (sliced bacon) is uniform, any procedure for selection before curing must be supplemented by a procedure of visual inspection before packaging.

## Swine

*Trends in carcass merit of Canadian pigs.* In the Canadian hog slaughter from 1968 to 1974, the proportion of commercial hog carcasses with an index of 102 and higher increased from 48 to 60%. Large sample surveys conducted before and at the end of this period established that the higher index values resulted from a reduction of 4.5 mm in graded fat measured on a weight-constant basis, or an increase of 4.5 kg in carcass weight when measured on a fat-constant basis. This change is equivalent to an increase of 0.47 kg of commercially trimmed retail product per carcass, or a reduction of 3.7 million kg of fat trim for the total commercial slaughter in 1974. The reduction in fat was greater for barrows than for gilts, with the sex difference in graded fat reduced from 6.6 to 5.3 mm. The regression of fat on carcass weight decreased from 0.87 to 0.73 mm/kg carcass weight.

*Selenium retention by the growing pig.* Selenium content of the offal and dressed carcass was measured on 86 pigs reared on rations that reflect the natural selenium environment of the area, that is, without selenium supplementation. The selenium levels recorded were  $189.4 \pm 8.0 \mu\text{g/kg}$  offal and  $142.2 \pm 5.5 \mu\text{g/kg}$  dressed carcass. These values were interpreted as normal physiological levels for the growing pig.

*Developmental changes in ash and water content of pig carcasses.* Water content of the carcass increased throughout the growing period of 10–132 kg liveweight, with the most rapid increase in the weight range of 10–34 kg. Ash content increased in a linear fashion up to 90 kg and decreased thereafter. Femur size, considered a measure of bone growth, followed a developmental pattern similar to that of body ash.

## PLANT BREEDING AND PATHOLOGY

### Oat Breeding

An oat cultivar developed at Lacombe was named Cavell and licensed in 1975 for sale in Canada. Cavell originated from the cross



(Beacon × Laurel) × Glen made in 1961. In central and northern Alberta, Cavell is slightly lower in yield than Random and slightly higher than Fraser. It matures about 3 days earlier than Random and 5 days earlier than Fraser. Cavell has good resistance to lodging and a high protein level. It lacks disease resistance but this characteristic is not important in the area where it is intended for production. Because of its early maturity, good yielding ability, and good lodging resistance, Cavell should be a valuable cultivar in central and northern Alberta.

## Cereal Diseases

Surveys on the Canadian prairies from 1970 to 1973 provided information on barley yield losses from common root rot caused by *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. and *Fusarium* spp. Losses were estimated to average 10% and varied from 20% in 1972 in Saskatchewan to almost none in Manitoba in 1970. The percentage losses of plants suffering from slight, moderate, and severe amounts of root rot were 9.4, 17.1, and 29.7% respectively. The yield loss could be attributed to reductions in the number and size of kernels. The number of heads per plant was reduced from 1.9 in healthy plants to 1.4 in plants with severe root rot. Losses caused by root rot were greater in the Gray Luvisol zone than in the Brown or Black soil zones; this finding may reflect the greater proportion of highly susceptible and earlier-maturing cultivars such as Gateway and Olli that are grown on the Gray Luvisols.

Barley diseases in central Alberta in 1975 were less severe than in 1974. About 35 out of 55 barley fields examined had net blotch, caused by *Drechslera teres* (Sacc.) Shoem., and half the diseased fields were rated as severely affected. Scald, *Rhynchosporium secalis* (Oud.) Davis, was found in 70% of all fields but only 10% were rated as severely diseased. Root rot (*B. sorokiniana*) was also found in 70% of all fields, but only 35% had about moderate levels of disease. One-third of all barley surveyed had trace amounts of smut, *Ustilage* spp. Some spot blotch (*B. sorokiniana*), ergot (*Claviceps purpurea* (Fr.) Tul.), and various head blights caused by *B. sorokiniana*, *Fusarium* spp., or *Alternaria* spp. were also noted, but these organisms did little damage.

Oats were generally free from disease, though a trace amount of gray speck, possibly a manganese deficiency symptom, was noted. Flax was free from all disease.

Common root rot was found in all 25 wheat fields examined but the incidence was of slight intensity, less than 9.0%. Powdery mildew, *Erysiphe graminis* DC. ex Mérat, was reported from 15% of wheat fields and septoria leaf blotch, *Leptosphaeria avenaria* Weber f. sp. *triticea* T. Johnson, was recorded in all fields, although damage was not severe. Traces of leaf rust, *Puccinia triticea* Erikss., were found in more than half the fields. Trace amounts of take-all (*Ophiobolus graminis* Sacc.), ergot, and smut were recorded.

## Silvertop of Forage Grasses

Silvertop, a blasting of the heads of grasses, was examined in Alberta. Mites, thrips, and *Fusarium poae* (Pk.) Wr. were generally but not consistently associated with the disease, and a causal agent could not be specified. *Poa pratensis* L. and *Festuca rubra* L. were very susceptible. *Bromus inermis* Leyss., *Elymus junceus* Fisch., *E. angustus* Trin. ex Ledeb., and *E. sibericus* L. were less susceptible. Varietal differences were found in *Agropyron cristatum* (L.) Gaertn. and *A. desertorum* (Fisch.) Schult. The disease can seriously reduce seed yield, but has little effect on forage production.

## CROP MANAGEMENT AND SOILS

### Weed Research

*Dormancy, germination, and emergence of wild oats.* Mature seeds of the wild oat, *Avena fatua* L., were completely dormant when freshly harvested. About 46% of the seeds lost their dormancy during storage for 33 wk at room temperature. Gibberellic acid was very effective in overcoming dormancy in freshly harvested or stored seeds. Water extracts from dormant seeds inhibited germination of wild oat seeds more than did water extracts from nondormant seeds. Various chemicals, comprising the nitrates of potassium, ammonium, and sodium; the cytokinins (benzyladenine and kinetin); and thiourea, were effective to varying degrees in stimulating germination and emergence. The percentages of germination and emergence of seedlings were greatest at temperatures ranging from 10 to 21°C, although germination



and emergence were slower at 10°C than at the higher temperatures. A temperature of 32°C was detrimental to normal germination and emergence. The highest percentage of seedlings emerged when soil moisture was maintained at one-half or three-quarters of field capacity; at field-capacity moisture levels, no seedlings emerged and nearly all the seeds rotted within 11 days of planting. Planting depths of 2–8 cm were best for seedling emergence. From deeper planting the rate and percentage emergence were greater for larger seeds than for smaller or medium-sized seeds, separated on the basis of kernel weight. The time to maximum emergence was 8, 11–13, and 13–17 days from depths of 0.5–3, 4–12, and 16–20 cm respectively.

*Penetration, translocation, and metabolism of Avenge in wild oats and barley.* Avenge (Cyanamid of Canada) labeled with  $^{14}\text{C}$ , in the presence of a surfactant (0.1%), rapidly penetrated the leaves of both wild oats and the barley cultivar Conquest. Penetration continued at a nearly constant rate for 3 days, the longest time studied. During this period, 93 and 84% of the applied dose was absorbed by the leaves of wild oats and barley respectively. In each case, penetration into wild oats was greatly enhanced when the concentration of surfactant was increased from 0.01 to 0.4%, the relative humidity from low to high, and the temperature from 10 to 30°C. It was also increased by commercial formulations of bromoxynil plus MCPA ester (1:1 wt/wt); 2,4-D ester; and barban. The amine formulation of 2,4-D, on the other hand, had no effect on penetration.

Results from autoradiography and radioassay indicated that labeled Avenge applied to the leaves of wild oats and barley was rapidly translocated, mainly in the acropetal direction. Most of the absorbed  $^{14}\text{C}$ , however, accumulated in the treated area and a few centimetres above it. Acropetal movement in the treated leaf occurred at a rate of about 2.5 cm/h. There was evidence of limited basipetal movement and  $^{14}\text{C}$  was detectable in the roots 24 h after treatment. Some  $^{14}\text{C}$  was retransported upward to the shoot. Roots rapidly absorbed the labeled herbicide from solution cultures. Translocation from roots to the shoot started 8 h after treatment but little  $^{14}\text{C}$  moved upward and even 3 days after treatment most of it was retained by the roots.

Chromatographic analysis of ethanol extracts from plants treated with  $^{14}\text{C}$ -labeled Avenge for up to 15 days revealed no evidence that wild oats, barley, or the wheat cultivar Thatcher metabolized the herbicide. Thus, expression of the selective action of Avenge in wild oats and barley cannot be accounted for by differences in its foliar penetration, translocation, and metabolism.

*HOE 23408, a new selective herbicide for wild oats and green foxtail.* In a series of experiments in field plots, the growth chamber, and the laboratory, HOE 23408 (Hoechst; 4-(2,4-dichlorophenoxy)-phenoxypropionic-acid-methyl ester) was assessed as a postemergence herbicide in wheat and barley. It provided selective control of wild oats and green foxtail that was equal to or better than that of barban over a growth period extending from the second- to the fifth-leaf stage of both weed species. Control of wild oats decreased slightly as the application date approached the fifth-leaf stage. Wheat was more tolerant of HOE 23408 than barley. In barley, the herbicide inhibited crown root development and if applied at the second- and third-leaf stages caused yellowing and retarded the growth of barley. The six-rowed cultivars Galt and Bonanza recovered with no significant effect on yield. However, Conquest suffered yield loss from treatments at the second- to fourth-leaf stages and the two-rowed cultivar Betzes was reduced in yield by treatments at each of the growth stages.

Spot applications of HOE 23408 at the midpoint of any one of the first four leaves of the wild oats resulted in gradual necrosis of the leaf area above the point of application but not below it. Application at or below the meristematic area of the stem apex caused rather rapid necrosis of the stem apex and eventual death of the entire plant.

When seeds of wild oats and green foxtail were placed above, below, or within a 3-cm band of soil treated with HOE 23408, the compound was more phytotoxic to the emerging weeds if it contacted the shoots rather than the roots. Phytotoxicity from soil applications, particularly under field conditions, was significantly less than from foliar applications. Although HOE 23408 is fairly insoluble in water, it was moved to a limited extent by water applied to the soil.

*Interactions of broadleaf herbicides, certain adjuvants, and HOE 23408.* HOE 23408



applied at the low rate of 0.56 kg/ha in combination with various adjuvants provided as effective control of wild oats as when it was applied at the recommended field rate of 1.12 kg/ha without adjuvants. Barley was more tolerant of HOE 23408 when adjuvant mixtures were used. The herbicidal activity of HOE 23408 on wild oats was severely reduced when it was mixed with the growth hormone type of broadleaf herbicides. The antagonism was caused by the active ingredients in the broadleaf herbicide formulations rather than any incompatibility of solvents. Ester formulations of broadleaf herbicides were less antagonistic to HOE 23408 activity than amine formulations. Nonhormonal, contact types of herbicides, such as bromoxynil at 0.28 kg/ha, were compatible with HOE 23408. Attempts to find a formulation containing HOE 23408 and an extra wetting agent with both bromoxynil and MCPA ester, all at low rates, were unsuccessful; such a formulation would be effective against both broadleaf weeds and wild oats.

*Crop yield losses caused by wild oats in Alberta.* Weed surveys carried out over the past 3 yr revealed that 64% of all grain crops in Alberta were infested with wild oats at an average density of 26 plants/m<sup>2</sup>, as well as with other weeds. The competitive index for wild oats in wheat and barley indicates that this degree of infestation and density resulted in an estimated loss of almost 10% of the wheat and 8% of the barley. On the basis of production in 1973, the latest year for which complete statistics are available, this percentage represents a loss of 360 000 t of wheat and 346 000 t of barley in Alberta alone.

The percentage loss of wheat ranged from 3.3 to 31.1% and of barley from 2.2 to 18.7% in various crop districts, because of varying degrees of infestation and density.

### Soils

Effects of nitrogen on the protein content of barley were studied. The NO<sub>3</sub>-N content of the soil to the 30-cm depth plus added fertilizer N accounted for approximately half of the variance associated with the percentage of N and the total N in Galt barley, and one-third of the variance associated with barley yield. Variance explained by regression was similar for both 30- and 60-cm soil depths and it was greater for each of these depths than for the 15-cm depth. Barley yield and total N in grain increased quadratically

with increasing NO<sub>3</sub>-N in soil plus fertilizer, whereas the percentage of N in grain increased linearly. The change in the percentage of N with added increments of fertilizer N was dependent on the amount of soil NO<sub>3</sub>-N to the 30-cm depth. Below a soil NO<sub>3</sub>-N level of 20 kg/ha, the percentage of N in barley remained constant or decreased slightly with the addition of fertilizer N at 34 or 67 kg/ha, but it increased with additional increments. At soil NO<sub>3</sub>-N levels between 20 and 99 kg/ha the percentage of N in the grain generally increased with each added increment of fertilizer N, whereas at soil NO<sub>3</sub>-N levels of 133–314 kg/ha the percentage of N did not change or increased very slightly with increasing fertilizer N.

### SOLONETZIC SOIL SUBSTATION, VEGREVILLE

In a greenhouse study concerned with soil reclamation, various nitrogen-supplying sulfur products and ammonium nitrate were applied to a Solonetzic soil, to compare their effects on crop yield and N uptake, and on water penetration and acidity in the soil. Ammonium bisulfite, ammonium polysulfide, ammonium thiosulfate, and ammonium nitrate were applied to samples of the Ap horizon of Duagh silt loam, each chemical supplying N at 14 mg/100 g of soil. The treated soils were incubated at 23°C for 40 days; then barley seedlings were grown for 60 days.

Each of the three sulfur products significantly increased yield at least as much as ammonium nitrate, and ammonium bisulfite gave a significantly greater yield increase than ammonium nitrate. Recovery of applied N by the plants was greater than 75% from the sulfur products, compared with 62% from ammonium nitrate.

The rates of water infiltration were 11, 14, 8, and 18 mm/min into soil samples treated with the nitrate, bisulfite, polysulfide, and thiosulfate products respectively, compared with 7 mm/min into untreated soil. The sulfur products caused a shift of sodium from the exchange complex into the soil solution. Titratable acidity was increased by the sulfur products from 7 meq/100 g in the untreated soil to more than 8.5 meq/100 g in the soils treated with the sulfur products. Whether the beneficial effects of these products on soil water movement and plant yield would be



outweighed by the deleterious effect of increased acidity that might result from their

continued use is now the subject of field study.

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# Research Station Lethbridge, Alberta

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M. G. ROACH	Administrative Officer—Personnel
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Food science

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

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M. D. MACDONALD, B.Sc., Ph.D.

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D. J. MAJOR, B.Sc., M.Sc., Ph.D.

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S. SMOLIAK, B.Sc., M.S.

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

Barley breeding

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J. B. BOLE, B.S.A., M.Sc., Ph.D.

Plant nutrition

J. M. CAREFOOT, B.S.A., M.S.A.

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J. F. DORMAAR, B.S.A., M.S.A., Ph.D.

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S. DUBETZ, B.Sc., M.S.

Irrigation agronomy

E. H. HOBBS, B.Sc. (Eng.)

Irrigation engineering

K. K. KROGMAN, B.Sc., M.Sc.

Irrigation efficiency

L. E. LUTWICK, B.Sc., M.Sc., Ph.D.	Chemistry and genesis
J. L. NEAL, <sup>4</sup> B.S., M.S., Ph.D.	Soil microbiology
M. OOSTERVELD, B.Sc. (Eng.), M.Sc., Ph.D.	Hydrology
U. J. PITTMAN, B.Sc.	Dryland agronomy
T. G. SOMMERFELDT, B.Sc., M.S., Ph.D.	Drainage engineering
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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.	Ecology and control of ticks

### Departures

D. T. ANDERSON, B.S.A., M.Sc., F.C.S.A.E. Retired December 29, 1975	Agricultural engineering
W. C. COATES, B.Sc., M.Sc., Ph.D. Resigned June 20, 1975	Forage crop engineer
G. A. HOBBS, B.S.A., M.Sc., Ph.D. Retired December 29, 1975	Forage-crop insect pollinators
R. KASTING, B.Sc., M.Sc., Ph.D. Died March 2, 1975	Plant and insect biochemistry
J. J. SEXSMITH, B.Sc., M.Sc. Retired December 29, 1975	Crop weeds
S. B. SLEN, B.A., B.Sc., M.S., Ph.D. Retired September 4, 1975	Animal production
A. D. SMITH, B.Sc. Retired December 29, 1975	Dryland forages
W. E. TORFASON, B.S.A., M.Sc., Ph.D. Retired December 29, 1975	Vegetable culture

### VISITING SCIENTIST

K. W. RICHARDS, B.Sc., M.Sc., Ph.D., 1974–75 National Research Council postdoctorate fellow	Insect pollinators
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<sup>1</sup>Seconded from the Research Division of the Economics Branch.

<sup>2</sup>On educational leave, Purdue University, West Lafayette, Indiana, from August 1973 to July 1976.

<sup>3</sup>Seconded to Indo-Canadian Dryland Research Project, Hyderabad, India, from December 1973 to December 1975.

<sup>4</sup>On transfer of work to Macaulay Institute for Soil Research, Craigiebuckler, Scotland, from August 1975 to August 1976.

## INTRODUCTION

The Research Station at Lethbridge has regional and national responsibility for a broad and comprehensive research program in basic and applied science related to agriculture.

The scientists represent a wide range of disciplines and functions, and are integrated into multidisciplinary, mission-oriented program groups. Particular emphasis is placed on the breeding, nutrition, and management of crops and animals; soil management for resource utilization, conservation, and erosion control; biological disposal of crop and animal wastes; the assessment and control of crop and animal losses from pests; and the control of crop diseases. Economists seconded from the Economics Branch have been integrated into the research program to assist in the planning of research and the evaluation of research results and to facilitate the presentation of this information to the agricultural industry.

Highlights of the 1975 research program include the release of Chester, a hard red spring wheat, and Fairfield barley; the discovery of sex attractants for adult males of six species of cutworms; an assessment of crop loss from diseases, and evidence of the successful incorporation of resistance to winter crown rot in alfalfa; the establishment of chloride requirements in chick diets; the discovery of an abnormality in bovine sperm that may be viral in origin; the identification of a selection procedure for improved growth rates in lambs; the establishment of cost-benefit ratios for pest control in beef production; and an indication that one of the main causes of soil salinity in dryland farming areas is excess runoff, which keeps the saline water table close to the surface.

As part of Canada's program of assistance to developing nations, the Station has continued to collaborate with the Indian Council of Agricultural Research to improve dryland production in India. Twenty-three locations in India are active in the Indo-Canadian Dryland Research Project and negotiations for continued collaboration over the next 4 yr are nearing completion.

During 1975, construction progressed on a new office-laboratory complex to accommodate the staff of the Station, the local offices of the Production and Marketing Branch, and the regional and district offices of Alberta Agriculture. This arrangement will facilitate communication, coordination of effort, and service to the agricultural industry of southern Alberta. Completion of this facility is planned for November 1976.

We regret to announce the death in March 1975 of Dr. Robert Kasting, who served for 28 yr with the Department of Agriculture. He was one of the leading insect nutritionists in Canada and he had been conducting research also on the phytotoxin of the rape plant in recent years.

We wish to record with appreciation the long and valued professional careers of Mr. D. T. Anderson, Dr. G. A. Hobbs, Mr. J. J. Sexsmith, Dr. S. B. Slen, Mr. A. D. Smith, and Dr. W. E. Torfason, who retired this year.

This report summarizes some of the main research results of work done in 1975. More detailed research results may be obtained from the scientists or publications listed in the report. Correspondence or requests for reprints should be directed to: Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews  
Director

## ANIMAL SCIENCE

### Dairy Cattle

Grain intake and milk production of dairy cows were studied. Average milk production of Holstein cows increased by 0.15 kg/0.01 kg increase in the intake of oat-barley concentrate. The increases were similar for

cows with low or high milk production potential. The concentrations of fat, solids-not-fat, protein, and energy in the milk were not affected by concentrate intake. Hay intake remained fairly constant with increases in concentrate intake from 0.15 to 0.35 kg/kg of milk produced. The percentage of digestible energy converted to milk energy



declined from 26.8% in cows fed 0.15 kg concentrate/kg of milk produced to 23.5% in cows fed 0.35 kg of concentrate. As the level of concentrate feeding increased, weight gain by the cows also increased.

### Beef Cattle

*Brewer's yeast.* Heat-treated (74°C) brewer's yeast was added to spent brewer's grains at about 15% on a dry matter basis. Up to 34 kg/day of the mixture, containing 23% dry matter, was fed with hay to cows without any harmful effects. Because this yeast was previously discharged into the sewage system, when it was added to spent brewer's grains it not only increased the protein content of the brewer's grains but also reduced the load on sewage treatment facilities.

*Growing heifers of different sizes.* Age at first breeding averaged 459 days and at calving 755 days and did not differ significantly among Simmental × Angus, Charolais × Angus, Hereford × Angus, and Jersey × Angus heifers fed individually from shortly after weaning. Gains averaged 0.51 kg/day up to the first breeding and 0.46 kg/day from breeding to calving. Heifers on a high feeding level consumed 1.3 Mcal/day more digestible energy and gained 0.1 kg/day more than heifers fed to grow at a rate projected to be normal for heifers of each crossbred type. Comparisons of body measurements at 365 days of age with those at 815 days of age showed that the higher energy level increased heart girth more than wither height. This suggests that the extra energy was used to produce flesh rather than bone.

*Carcass characteristics of yearling crossbred bulls and heifers.* Bull and heifer progeny from a Red Poll bull bred to Simmental × Angus, Charolais × Angus, Hereford × Angus, and Jersey × Angus dams were slaughtered at 390 days of age. The breed of dam influenced hot carcass weight, dressing percentage, proportions of individual wholesale cuts such as round and flank, and total deboned, defatted primal cuts per day of age in the progeny. Bulls produced leaner carcasses with more deboned, defatted primal cuts per day of age than heifers. Carcasses from heifers scored higher for marbling than those from bulls.

*Metabolism of silica by cattle.* The concentrations of silicic acid in rumen fluid, blood

plasma, saliva, and urine were measured in cows given prairie hay (5.7% silica) or alfalfa hay (0.4% silica). Estimates based on the results indicated that 7% of the silica in prairie hay and 16% of that in alfalfa hay were taken into solution in rumen fluid. Of these amounts, not more than 12% was absorbed with the prairie hay diet, whereas up to 45% was absorbed with the alfalfa hay diet. Because the prairie hay contained more than 10 times as much silica as the alfalfa hay, nearly twice as much silica was absorbed on the prairie hay diet as on the alfalfa hay diet. Between 60 and 75% of the absorbed silica was excreted in the urine of cows given prairie hay and between 40 and 60% was excreted when they were given alfalfa hay. The absorbed silica that was not excreted was returned to the digestive tract as a constituent of digestive secretions. It was calculated that as much as 20 g of silica would have to be removed from the solution in the rumen fluid of cows on a diet of prairie hay to reduce the absorption and excretion of silica sufficiently to prevent formation of siliceous urinary calculi.

*Feedlot bloat.* Feedlot bloat in cattle has been shown to be related to the production of bacterial slime and the lysis of bacterial cells in the rumen. A combination of bacterial slime and macromolecules released by cell lysis apparently traps fermentation gases and thus produces frothy feedlot bloat. Alkaline phosphatase (APase) was found in the bovine rumen in both cell-free and cell-associated states and the levels were influenced by changes in diet. Reaction-product deposition showed that the enzyme was associated with the bacteria but not the protozoa. The presence of large amounts of APase in cell-free rumen fluid of cattle on a bloat-producing diet is believed to be caused, in part, by lysis of bacterial cells. Thus, the level of cell-free APase in rumen fluid may indicate the onset of conditions associated with feedlot bloat.

*Rumen microbiology.* The bacteria present in normal rumen contents are predominately gram-negative and always have an external coat layer. Ten morphologically different coat layers were described in such bacteria. The external coat layers appear to have both protective and adhesive functions. Coat layers of *Ruminococcus albus*, an important cellulose-digesting bacterium in the rumen, appear to enable the cells to adhere to

cellulose fibers added to the culture medium and thus to facilitate digestion of fiber.

*Reproductive physiology.* In studies on the relationship between abnormal sperm morphology and subfertility in the bull, electron microscopy was used in an attempt to determine the ultrastructure of a 'crater' defect of the bovine sperm head. The defect, a nuclear invagination that is about 0.3  $\mu$  m deep and 0.6  $\mu$  m wide and appears to be membrane-bound, has occasionally been observed to contain particles with a virus-like morphology. The possible viral origin of the defect is supported by the finding of a temporary increase in the proportion of 'cratered' sperm in ejaculates from affected bulls after injecting the synthetic glucocorticoid dexamethasone, and by the isolation of a cytopathic agent or agents from heavily affected semen. A virus-inhibiting agent or agents in the seminal plasma of bulls has also been discovered.

## Sheep

*Out-of-season breeding of sheep.* Suffolk and Rambouillet ewes were placed in pens where day length was gradually reduced (by 3 min/day for 76 days) to obtain four lambing cycles in 2.5 yr. Estrus in May, June, and July was induced more easily ( $P < 0.01$ ) in the Rambouillet than in the Suffolk. The advantage of higher conception rates in the Rambouillet during the first anestrus was offset by the high prolificacy rates in the Suffolk in the other three lambing cycles. Thus, each breed produced an average of 128 lambs/100 ewes exposed per lambing cycle (2.04 lambs/ewe per yr). The use of Syncro-Mate (progestinated pessary with 20 mg of fluorogestone acetate) and pregnant mare serum gonadotrophin (PMSG at 5 ml/ewe) in conjunction with shorter day length did not affect ovulation or conception rates.

*Sheep selection.* Responses to selection for weight-per-day-of-age (WPDA) at about 170 days in Rambouillet and Romnelet sheep over 5 yr, comprising two generations, were measured by two methods. Correlated responses in weaning weight (WW) at about 100 days and postweaning gain (PWG) for 70 days were also estimated. The estimates of annual genetic increases in WPDA were similar in both breeds and from both methods. Annual improvements in WPDA in Rambouillet and Romnelet were estimated as 9.7 and 6.0 g/day by one method, and as

9.1 and 7.8 g/day by the other. Estimates of correlated responses in PWG obtained by both methods and in both breeds were close to expected values, but correlated responses in WW appeared to be overestimated. This work demonstrated that sheep production can be improved significantly by selection.

## Poultry

*Chloride requirements of broiler chicks.* Ammonium chloride was tested as a source of chloride for broiler chicks and was found to give satisfactory results. No extra growth response could be attributed to the presence of the ammonium ion. To estimate chloride requirement, seven experimental diets containing graded levels of chloride (as ammonium chloride) were fed to chicks beginning at 1 day of age for 21 days. Body weight at 21 days was lower and feed-to-gain ratios were higher ( $P < 0.01$ ) for chicks fed diets containing chloride at 600 and 800 mg/kg of diet than for chicks fed higher levels (1000, 1200, and 1600 mg/kg). The minimum chloride requirement for maximal growth was about 1000 mg/kg of diet. Diets based on wheat-soybean meal appear to require chloride supplementation for maximum chick growth.

*Effect of palmitic acid on calcium requirement.* Body weight of chicks at 21 days was not influenced by calcium level (0.4, 0.7, and 1.0% of diet) when palmitic acid was not included in the diet. However, with palmitic acid present (10% of diet), the body weight of chicks on diets with 0.4 and 0.7% calcium was lower ( $P < 0.01$ ) than for chicks on the diet with 1.0% calcium. Bone ash was lower ( $P < 0.01$ ) in chicks on the 0.4% calcium diet than in those on the two higher levels when no palmitic acid was present. The presence of 10% palmitic acid reduced the bone ash in chicks on the 0.4 and 0.7% calcium diets ( $P < 0.01$ ). The results indicated that palmitic acid increased the dietary calcium requirements by at least 30% and may help to explain the wide variation in the calcium requirements recommended by different laboratories.



## CROP ENTOMOLOGY

### Aphids

The discovery of two species of Hymenoptera new to the prairies indicates that biological control of the pea aphid by naturally occurring agents could be less effective in the future. Species of *Aphidius* (Hymenoptera), which are important parasites of the pea aphid, have been found to be parasitized by a small hymenopteran that has not yet been identified. Ladybird beetles, which are major predators of the pea aphid, were found for the first time in the prairies to be parasitized by a braconid, *Perilitus coccinellidae* (Schrank).

*Hippodamia quinquesignata* Kirby is the commonest of the ladybird beetle predators of the pea aphid. Four sites have been found at which adults of this species congregate to overwinter. The sites are located in the foothills or mountains at elevations of more than 1700 m. Winter mortality in niches at one of the sites varied from 22 to 61%.

### Cutworms

Sex attractants for adult males of the army cutworm and of *Euxoa drewseni* (Staudinger) and *Leucania commoides* (Guenée) have been identified and the chemical work has been completed. In addition, inhibitors of these attractants have been found. Attractants that may require more refinement have been found for males of the pale western, variegated, and darksided cutworms. Over 70 species of moths have been attracted to various chemicals in field tests. Most attractants have been shown to be mixtures of two or more chemical compounds.

The attractant for males of the clover cutworm, which was discovered in 1974, was shown to be more effective than virgin females. The attractant system for this species has been perfected and was used in a field monitoring program.

Of seven insecticides tested in the laboratory for toxicity to the army cutworm, four were as toxic as leptophos. In microplots of barley, however, the highest level of control was obtained with leptophos applied at 0.56 kg/ha, although, at 0.28 kg/ha, endrin and monocrotophos were as effective as leptophos. On bare soil, endrin was the most effective insecticide.

Endrin applied to control cutworms in corn left residues of only 0.004 ppm on the corn

and less than 0.024 ppm in the soil 37 days later.

### Grasshoppers

The grasshopper outbreak in Alberta was forecast to continue in 1976, but at a lower level than in 1975. For 1976, light infestations were forecast on 4.7 million ha, moderate on 2.1 million ha, and severe on 0.6 million ha. The light and moderate areas were slightly larger than for 1975, but the severe area was expected to be about half of that for 1975.

In field tests, nymphs of the migratory grasshopper reduced yields of Thatcher wheat by 23 and 65% when caged at 12 and 24 nymphs/0.74 m<sup>2</sup>. Up to 28% of the plants were completely destroyed. The influence of weather on damage by grasshoppers is shown by a comparison with results from 1974, when up to 15 nymphs/0.74 m<sup>2</sup> caused only 7% loss.

Studies on rangeland for 6 yr showed that heavy grazing consistently increased numbers of the grasshopper *Melanoplus dawsoni* (Dawsoni) and decreased numbers of *Chorthippus longicornis* (Latrielle). The clear-winged grasshopper appeared to be unaffected by grazing.

Of 17 insecticides tested in the laboratory, 15 were at least as toxic to grasshoppers as dimethoate and two were more toxic. Results showed that dimethoate acts mainly as a stomach poison, because it was six times more toxic orally than as a contact insecticide. Carbofuran exposed to rain loses its effectiveness in 24 h, but, when a sticker was added, it was effective for at least 72 h.

In field tests, carbofuran was the most efficacious insecticide tested for grasshopper control, although chlorpyrifos at double the rate used for carbofuran and malathion at six times the rate also gave more than 90% control. Carbaryl was ineffective. Baits containing carbofuran effectively controlled grasshoppers in a sparse crop and on summerfallow, but were ineffective in a dense crop of alfalfa.

### Pollinators

The advantage of the univoltine strain of the alfalfa leafcutter bee was demonstrated in 1975. This strain, now in its fourth generation, produced only 1.4% second-generation adults, whereas the standard strain produced a much higher percentage.

Second-generation adults, because they emerge so late in the season, produce few offspring that can survive the winter and, hence, they effectively reduce the population of bees for the next year.

Leafcutters that are not attracted back to the shelters do not produce offspring for the next year's pollinating population. To overcome this problem, various colors and patterns on the hives and shelters have been tested for their attractiveness to the bees. The best combination of colors tested was black stripes on a white background.

### **Sugarbeet Insects**

Counter (Cyanamid of Canada) has been favored by the Canadian Sugar Factories Company as a potential insecticide for control of the sugarbeet root maggot. Field tests in 1975, however, showed that this insecticide was highly toxic to sugar beets, causing a loss of 4.5 t/ha. Two other potential insecticides were even more phytotoxic. The registered insecticides for maggot control, carbofuran and carbophenthion, were not phytotoxic.

### **Insecticide Residues**

Two varieties of rapeseed, Span and Zephyr, were treated with methamidophos at 0.28 kg/ha and 7 days later at 0.56 kg/ha. Residues in the seed 10 days after the last application were negligible in Span, but were 0.25 ppm in Zephyr. After 17 days, the residues were only 0.02 ppm.

When methoxychlor was applied to the Athabasca River for control of black flies in 1975, no residues were found in the river 30 km downstream 72 days after application. Residues were found in some tissues of the three species of fish collected in the river, but the levels of residue were low (0.034 ppm maximum in any tissue). Residues were found in 60% of the suckers, 49% of the walleyes, and 36% of the pike. In the suckers, fat was the only tissue with residues. The walleyes had residues in the muscle, fat, liver, and gonads. None of the pike had residues in the muscle and few in the gonads, whereas 29% had residues in the liver and 44% in the fat. In all cases, the levels of residue were below actionable levels.

### **Wheat Stem Sawfly**

Rescue wheat was very susceptible to sawfly damage in 1975. Of the infested stems of Rescue, 62% were cut by the larvae, whereas 70% of stems of the susceptible wheat Thatcher were cut, giving only 11% control. In 17 of the past 26 yr at Lethbridge, Rescue has been moderately to highly susceptible, demonstrating the need for more stable resistance.

Crop loss studies with Thatcher wheat showed that in the past 2 yr sawfly larvae reduced the yield by 21–33% and also reduced the protein content of the grain. Even though winter mortality was high and conditions for oviposition were unfavorable, the population of sawflies in the study area still increased from 1.5 million/ha in 1974 to 2.2 million in 1975.

## **ECONOMICS**

### **Simulation Models for Farm Business Planning**

A simulation model for cereal and oilseed production in the Brown soil zone was developed and used to compare several production technologies at several prices for grain and fertilizer. In one application, the model was used to compare the level and stability of income for a farm on fine textured soils under three crop rotations: continuous wheat, wheat–fallow (1/2 crop), and wheat–wheat–fallow (2/3 crop). Each rotation was tested under 25 different 5-yr rainfall patterns. Net income was highest under the 1/2 rotation and lowest with continuous cropping. With high application rates for N and low fertilizer prices, the 1/2 and 2/3 crop rotations were similar in average net income. Income variation caused by rainfall pattern was similar on the 1/2 and 2/3 crop rotations, but was substantially greater with continuous cropping for all price combinations compared. The model is being changed to improve its ability to simulate economic and biological processes. It will also be adapted to other soil and climatic regions.

A beef–forage–grain simulation model developed earlier was extended to include additional technology options and production systems. The model is being used in agricultural policy analysis. One example is an evaluation of the on-farm effects of changes in community pasture supply to



farms that differ in size, location, and enterprise mix.

### Derivation and Evaluation of Diets for Feeder Cattle

A linear programming model that selects feeding programs and formulates diets for feeder cattle was tested in a feeding trial. Several combinations of model-formulated diets that varied widely in ingredient composition and energy concentration (digestible energy (DE) at 25.3–33.0 Mcal/kg) were used. The high degree of similarity between results in the feedlot and from the computer model suggests that the model can be used to select feeding programs and formulate diets to provide maximum return over feed costs. Further feeding trials to expand the model's coverage of sizes and types of feeder cattle are continuing.

## PLANT PATHOLOGY AND PHYSIOLOGY

### Forage and Turf Diseases

The importance of winter crown rot to the longevity of alfalfa was shown by crop loss assessment experiments. After 3 yr of testing, yields of resistant *Medicago falcata* L. and the susceptible variety Beaver treated with  $\text{HgCl}_2$  were significantly greater than those of nontreated Beaver. Early evidence in a breeding project to develop cold-hardy alfalfa lines resistant to winter crown rot and crown bud rot indicates that resistance to both diseases may be possible in some lines of *M. falcata*. Screening alfalfa for resistance to winter crown rot was improved by the discovery that the time for adequate testing in the low-temperature rooms could be reduced from 7 to 5.5 wk.

Results from uniform tests in southern, central, and northern Alberta made from 1968 to 1974 indicate that chloroneb and quintozone are suitable replacement fungicides for mercurials to control snow mold on turfgrass. The combination of nitrogenous fertilizers with mercurial fungicides applied in the fall reduced the incidence of snow mold and improved the virescent condition of turfgrass the next spring.

### Cold Hardening of Wheat

Of the three forms of invertase present in the leaves of wheat during cold hardening, the most abundant form in cold-hardy plants had the lowest energy of activation. The change in proportion of these forms during cold hardening is largely responsible for the concurrent drop in energy of activation of invertase.

### Potato Diseases

Yield of Netted Gem potatoes decreased as the severity of leaf roll symptoms increased. The yield of plants with slight, moderate, and severe stunting caused by leaf roll was only 35, 20, and 8% of the total yield of plants that showed no symptoms of the virus. However, plants with only mild symptoms of leaf roll yielded as much as those that showed no symptoms. The equation formulated to estimate yield loss by leaf roll is: Yield loss (%) =  $100(n_d k)/(n_h + n_d)$ , where  $n_d$  is the number of plants with slight to severe stunting,  $n_h$  is the number of plants with no or mild symptoms, and  $k = 0.8$ .

### Bean Diseases

Sequential methods of inoculation were developed for the bean breeding program. These methods are used for screening individual plants for resistance to the common bean mosaic virus and to halo and common blight bacteria.

### Crop Disease Loss Assessment

*Ergot in rye.* In Alberta in 1973–75, ergoty rye tillers yielded 30% less seed than comparable healthy ones. This loss resulted from fewer seeds developed on the ergoty tillers and also from lower weight of the seeds produced. In spite of the substantial yield reduction from ergot in individual tillers, surveys showed that the disease caused little yield loss in commercial rye fields during 1973–75 because infection levels were very low.

*Powdery mildew on cereals.* In 1975, a survey showed that powdery mildew caused an estimated loss of yield of nearly 7% in soft white spring wheat in Alberta. The variety Springfield was more severely damaged than the variety Lemhi.

*Powdery mildew on sugar beets.* A trace of powdery mildew was found on a few plants in 7 of 15 fields of sugar beets examined at

harvest in southern Alberta. This first recorded occurrence of the disease on sugar beet in Canada coincided with a severe epiphytotic in western USA in 1974 and a more widespread but less severe one in 1975. The selection of sugar beet currently grown throughout Western Canada appeared to possess some resistance to powdery mildew.

### Remote Sensing

Aerial photography and satellite data were successfully used to determine the area devoted to cereal cover crops, which are commonly used for fall pasture in southwestern Alberta. This information, which was not otherwise available, was important because the forage yield and quality of these late-sown crops of oats and barley are often lowered by barley yellow dwarf virus. False-color infrared aerial photography from a flight on October 3, 1972, provided ready differentiation of the immature cereal pastures, and enlargements of corresponding black and white photographs permitted field-size determinations. Cover crops were shown to account for 10 672 ha or 7% of the 150 466 ha surveyed. Digital data from an orbit of the LANDSAT-1 satellite on the same date agreed with the photo-interpreted results when processed through the Image 100 Interactive Multispectral Image Analysis System at the Canada Centre for Remote Sensing. These results demonstrate the potential usefulness of remote-sensing techniques for agricultural surveys.

## PLANT SCIENCE

### Beans

*Growth at low temperatures.* Tolerance of the common bean, *Phaseolus vulgaris* L., for suboptimal temperatures during early stages of growth would permit earlier seeding and contribute to faster plant development and earlier maturity. By screening for tolerance for suboptimal temperatures, a few lines have been found that are capable of germinating or continuing growth at 10°C. In addition to germination and initiation of flower buds at 10°C, the primary leaf of several bean cultivars continued growth at that temperature. Examination of segregating populations involving one outstanding cultivar indicated that duplicate recessive genes may control leaf growth at low temperatures; this characteristic is independent of tolerance

for low temperature during germination and flower initiation.

*Protein quality.* In a study of the amino acid composition of varieties of the common bean, protein quality (protein score) was not affected by the geographical location or the year in which the varieties were grown. There were, however, pronounced differences among the 13 varieties tested. The content of methionine, the most limiting amino acid, was between 1.0 and 1.7% for the varieties tested. The average protein score was 60 for soybean compared with scores between 41 and 59 for common beans; Seafarer and Pink Sutter varieties had the highest scores. Several lines are being screened in a broader study of the range of protein quality.

### Cereals and Oilseeds

*Winter wheat.* Forty-three introduced varieties of winter wheat, *Triticum aestivum* L., were grown in a yield test on dryland in 1975. Yields ranged from 2.8 to 5.7 t/ha with a mean of 4.2 t/ha. The 13 varieties from Romania gave the highest yields, 3.6–5.7 t/ha with a mean of 4.6 t/ha. Twelve introductions from the USSR yielded 3.2–5.2 t/ha with a mean of 4.0 t/ha. Six Canadian varieties yielded 3.6–4.3 t/ha and averaged 3.9 t/ha. The 10 Chinese introductions were the least promising, yielding 2.8–4.5 t/ha and averaging 3.7 t/ha.

Most of these introductions lacked the winterhardiness needed in Western Canada. Some could be useful additions to breeding programs as sources of genes for high yield, strong straw, and early maturity.

*Cytogenetics.* In a dryland yield test of the wheat varieties Rescue and Cadet and 41 of their reciprocal chromosome substitution lines, Rescue averaged 2.4 t/ha and Cadet averaged 3.1 t/ha. No Rescue line with a substituted Cadet chromosome had a yield significantly different from that of Rescue ( $P < 0.01$ ). Three Cadet lines with substituted Rescue chromosomes yielded less than Cadet: C-R 3B at 2.6 t/ha, C-R 1B at 2.5 t/ha, and C-R 5B at 2.2 t/ha. C-R 5B is as susceptible to common root rot as Rescue, is the shortest of all lines, and is earlier than Cadet in heading but not in maturity.

*Hector barley.* Hector barley, licensed and distributed to seed growers in 1973, was grown on a total of 115 300 ha in Alberta, Saskatchewan, and Montana in 1975. There



is now a large amount of experimental information from small-plot tests on the performance of Hector under a wide range of environmental conditions. In tests where moisture was limited and average yields were less than 2.2 t/ha, Hector averaged 10% higher yields than Galt and 15% higher yields than Betzes. In areas where yield levels were 2.7–3.2 t/ha, Hector yielded about the same as Galt and 10% higher than Betzes. In the Park Belt, where yield levels were 3.8–4.8 t/ha, Hector averaged about the same as Betzes and 10% less than Galt. At high levels of soil fertility under irrigation, where yields were 5.4 t/ha or more, Hector yielded 8% more than Betzes but 15% less than Galt. Hector is being grown largely on the open prairies where drought is often the main factor in limiting yields.

*Hybrid maize.* The goal of the corn breeding project is to produce grain hybrids that are early maturing, strong-stalked, and suitable for a 2100-heat-unit season. Inbreds were produced that are earlier than those from other areas and they were tested in single-cross hybrids and three-way crosses. Some of the hybrids were significantly earlier than the best control hybrid, but most had poor stalk quality or were low in yield of grain. No inbred was identified as superior, but 4 of 180 were worth retesting in different hybrid combinations. These inbreds will also be rated for seed production and ease of harvest.

*Grain sorghum.* A completed study on sorghum showed that, without irrigation, row spacing and population density within the range studied had no effect on grain yield because of compensating variations within yield components. As grain yield per panicle increased with increasing row spacing, the number of panicles per plant and per square metre decreased. Grain yield per panicle and panicles per plant and per square metre decreased as population density increased. The choice of row spacing and population density in field production in Alberta should therefore depend on convenience factors related to crop management. Efficiency of water use (kg grain/ha-cm water used) was highest at the low population densities and narrow row spacings.

*Photosynthesis in rapeseed.* In rapeseed (*Brassica napus* L. and *B. campestris* L.), stomatal frequency was high on the abaxial

leaf surface, intermediate on pod and beak tissues, and low on stem and pedicel tissues. One cultivar had high and another had low stomatal frequencies on the adaxial leaf surface. It was concluded that all green parts of the rape plant possessed the potential for photosynthesizing. A  $^{14}\text{C}$  study showed that stems, pods, beaks, and leaves assimilated  $^{14}\text{CO}_2$  but only leaves and stems exported assimilates to other plant parts. The importance of photosynthesis in tissues other than leaves was shown in a growth analysis study, in which leaves withered at the time of rapid seed development.

## Forage Crops

*Grass seedling competition.* Crested wheatgrass, Russian wild ryegrass, and Altai wild ryegrass, three grass species that characteristically develop slowly in the seedling stages, were grown in monoculture and in mixed cultures with two rapidly developing species, pubescent wheatgrass and slender wheatgrass. Within 30 days after sowing in flats in the greenhouse, crested wheatgrass and Russian and Altai wild ryegrasses had made greater seedling growth when grown with slender wheatgrass than when grown with pubescent wheatgrass. This suggests that of the two rapidly developing grasses, slender wheatgrass is less competitive in the seedling stage and could be sown with the slower-developing crested wheatgrass or Russian or Altai wild ryegrass. Under arid conditions where crested wheatgrass and Russian wild ryegrass are often used, slender wheatgrass and pubescent wheatgrass would normally not persist beyond 2–4 yr after seeding. However, further testing of the mixtures under field conditions is needed to determine the extent of the competition in more mature stands.

*Sainfoin seeding rates.* A test of sainfoin-grass mixtures on dryland has shown that the rate of seeding of sainfoin, *Onobrychis vici-aefolia* Scop., has a considerable influence on the proportions of legume and grass in the mixtures. During a 5-yr period, sainfoin constituted 38, 48, and 59% of the total forage dry matter yield when seeded at 7.8, 15.7, or 31.4 kg/ha respectively, in mixtures with Russian wild ryegrass at a fixed rate of seeding. In mixtures with brome grass, sainfoin at the same seeding rates constituted 32, 34, and 54% of the total yield during the 5 yr of testing. Total yields also tended to be

higher at the heavier seeding rates. The higher legume percentages and total yields obtained at the heaviest sainfoin seeding rate would more than offset the higher initial seed costs. When sainfoin was grown alone, varying the seeding rates from 7.8 to 15.7 and 31.4 kg/ha had no influence on yield.

*Irrigated pasture.* Forage species were individually evaluated for suitability for irrigated pasture under grazing by yearling steers. The main parameters measured were average daily gain of the steers and the amount of dry matter used per head per day and per kilogram gain in body weight. Supplementary observations included length and continuity of the grazing season, *in vitro* digestibility of the herbage, and subjective evaluations related to pasture management. All species were compared with orchardgrass as the standard.

During 10 yr, average daily gain of the steers on orchardgrass was 0.88 kg. Reed canarygrass, pubescent wheatgrass, creeping red fescue, and Kentucky bluegrass produced similar gains to orchardgrass, but rankings varied from year to year. Sainfoin and bird's-foot trefoil produced one-third greater daily gains than the grasses.

The amount of dry matter used over the 100- to 120-day grazing season averaged 11.0 kg/head per day on orchardgrass. On sainfoin, it was 9.5 kg/head per day, and on creeping red fescue it was 13.8. The higher figure for creeping red fescue indicates poor utilization of the forage, rather than greater intake of the forage.

The stocking rate was a uniform 7.4 steers/ha. Orchardgrass invariably provided more grazing time than any of the other forage species, and it gave continuous pasture throughout the season. On all other species, it was necessary either to provide alternate pasture for 3–4 wk annually during the season or to stop grazing early in the fall. Reed canarygrass provided almost as much grazing time as orchardgrass during the season, but its stands tended to deteriorate after 4 yr.

## Weeds

*Tolerance of grain sorghum and fababeans for herbicides.* Dryland grain sorghum exhibited good to fair tolerance for preemergence-applied linuron, and for postemergence barban, tricamba, or atrazine with oil. Sorghum

was insufficiently tolerant of normal herbicide rates of EPTC, Eradicane (Stauffer), alachlor, vernolate, dalapon, cyanazine, metobromuron, metribuzin, triallate, trifluralin, and AC 92553 (Cyanamid). Fababeans grown on irrigated land tolerated normal rates of fluchloralin, dinitramine, trifluralin, profluralin, triallate, bentazon, metobromuron, MCPB, barban, and HOE-GRASS (Hoechst), but were insufficiently tolerant of chlorbromuron, metribuzin, linuron, and HOE-GRASS mixed with bentazon or desmedipham.

*Aquatic vegetation management.* Green water milfoil, northern water milfoil, and Eurasian water milfoil attained maximum vegetative growth rates of 7.6 cm/day *in vitro* using blue fluorescent light (8-h photoperiod) and layered hydrosol (sand : peat : loam). Photosynthetic studies in 1.6- and 0.6-litre net assimilation chambers, in which oxygen production was used as a measure of photosynthetic rate, revealed that northern and Eurasian water milfoil could use bicarbonate as a carbon source but green water milfoil could not. Addition of Ca and Mg had no effect on oxygen-production rates. Growth and oxygen production in water from various natural sources after filtering to remove organic matter differed between plant species and between aquatic environments; this difference indicates the critical importance of the chemical composition of water on the growth rates of plants in natural environments.

## SOIL SCIENCE

### Saline Soils

*Dryland salinity.* Experiments were conducted to explain the causes of salinity in a complex watershed at Nobleford, Alta. Measurements showed that the chief sources of water contributing to the high water table in the discharge basin were precipitation that fell in the basin and runoff from the surrounding area. Contrary to popular opinion, groundwater flow provided less than 10% of the total input to the basin. These results indicate that reclamation at this site would be feasible if excessive runoff to the discharge area is prevented or if it can be removed.

*Reclamation of Solonetz soils.* Deep plowing is a promising method of reclaiming Solonetz soils. The B horizon is broken up



and mixed with subsoils containing Ca. A recent survey, however, showed that about 70% of the Solonetz soils in the Brown soil zone did not contain gypsum at 40 cm below the surface. Laboratory studies indicate that gypsum should be applied for reclamation and that deep plowing may not be successful for reclaiming these soils, particularly if the exchangeable sodium percentage (ESP) of the B horizon exceeds 15. In the laboratory, infiltration of these low-Ca Solonetz soils could be improved quickly only when the required amount of gypsum was incorporated. Infiltration was not significantly increased when gypsum was deposited on the surface or when it was mixed with fine textured soils. Because many of the Solonetz soils in the Brown soil zone of southern Alberta are classified as sandy loam to loam, shallow plowing and incorporation of applied gypsum should be a promising reclamation method.

*Irrigated Solonetz soils.* In 1975, the yield of dry barley grain plus straw averaged 9.6 t/ha on irrigated Brown Solonetz soils that had been deep-plowed in 1974, and 9.7 t/ha on similar soils that had been shallow-cultivated. Average dry yield of grain-plus-straw was 9.1 t/ha when the crop was irrigated on July 21 and August 12; this was significantly less than the yield of 10.0 t/ha from a crop irrigated on July 18, August 5, and August 14. In the laboratory, capillary rise of soil moisture from a water table 60 cm below the soil surface in undisturbed soil cores was several times faster in the deep-plowed soil than in the shallow-cultivated Solonetz soil.

*Reclamation with shallow drains.* A saline soil near Vauxhall, Alta., was effectively reclaimed with irrigation and shallow drains (1.25 m deep). The water table was lowered sufficiently to allow normal root activity, and then, through the mechanism of radial flow toward the drains, salts were leached from the soil to depths below the drains. Most of the salts in the top 1.2 m of soil were flushed out in the 1st yr; those at greater depths continued to be removed down to 2.4 m in the 2nd and 3rd yr of leaching. Resalinization occurred slowly after normal irrigation was resumed, and reclamation procedures may be required again in about a decade.

*Tolerance of cereals for salinity.* Under saline conditions (mean conductivity 7.3 mmhos/cm; range 1.5–10.0), six-row barley outyielded two-row barley and wheat (2.6 vs. 1.7 and 1.5 t/ha), largely because of the effect of salts on the number of mature heads. In soil at 10 mmhos/cm conductivity, the number of heads in wheat and two-row and six-row barley was reduced to 87, 43, and 27% of those in low-salt soil. Only 46% of the wheat seeds germinated compared with 63.8 and 62.1% for the two-row and six-row barley seeds.

## Resource Conservation

*Seeding cereals on zero tillage.* In a 7-yr study of seeders used commercially for spring wheat production, the double-disc press drill and the triple-disc press drill (an experimental unit) were frequently unsatisfactory. These units failed to penetrate untilled surfaces adequately when soil bulk density exceeded about 1.2 g/cm<sup>3</sup> in the upper 5 cm of soil or when the quantity of surface residues exceeded about 3.7 t/ha. Hoe openers penetrated the soil but failed to clear heavy residues when stubble and straw lengths exceeded 25 cm. In small-plot trials, yields were generally similar under all treatments, except that double- or triple-disc seeding was superior to wide-spaced hoe-drill seeding in 2 yr (1.2 vs. 0.7 t/ha in 1969 and 0.7 vs. 0.6 t/ha in 1973). This difference occurred mainly because the tillage action of hoe openers enabled wild oats to germinate in ridge areas between rows, and the wild oats, despite the use of herbicides, seriously reduced yields in wide-spaced rows (23 and 36 cm). On 0.4-ha chemical fallow fields, yield was reduced 15–45% within tractor-sprayer wheel traffic areas (bulk densities 1.2 g/cm<sup>3</sup> or greater in the top 5 cm of soil) because of inadequate seed placement when double-disc seeders were used but not when hoe openers were used. Among present commercial drills, those equipped with hoe or lister-shovel openers are best adapted for zero-till seeding, but a great need exists for drills and openers designed specifically for zero-till cereal production.

*Soil depletion from cropping.* Six of seven unfertilized dryland crop rotations, consisting of combinations of fallow, wheat, grass, and alfalfa, have seriously depleted several major plant nutrients and components in the soil since 1954. The average contents of organic

matter (OM), total N, and exchangeable K have decreased by 13, 10, and 26% in the top 15 cm of soil on all rotations. The amount of  $\text{NaHCO}_3$ -extractable P has also decreased by about 38% in all but a manured fallow-wheat-wheat rotation, where it increased 31%. This rotation received manure at 11 t/ha during each fallow year. Total P content of the soil changed very little during the 20 yr of cropping.

*Sewage effluent for irrigating forage.* The forage species alfalfa, reed canarygrass, brome grass, Altai wild ryegrass, and tall wheatgrass were irrigated for 4 yr with municipal wastewater from the town of Taber, Alta. Plots receiving effluent rates that approximated evapotranspiration minus precipitation yielded an average of 7.5 t/ha, whereas plots receiving double this rate yielded 10.1 t/ha. The increased yield was apparently caused by the additional  $\text{NH}_4\text{-N}$  in the wastewater.

Alfalfa yields were more than double the yields of the grasses at the low effluent rate without fertilizer; however, with the high effluent rate and additional N fertilizer, the grasses outyielded the alfalfa.

*Pathogenic fungi in feedlot manure.* After storage of 4 mo, the fungal flora in fresh feces of beef cattle and manure from the surface of four commercial feedlots was dominated by a white fungus, identified as *Petriellidium boydii* (Shear) Malloch, formerly *Allescheria boydii* (Shear). It is the most common cause of human mycotic mycetoma (nonneoplastic inflammatory tumors) in North America. In addition to being a human pathogen, *P. boydii* is one of the causes of mycotic abortion in cattle. The pathogenicity of one of the strains of *P. boydii* isolated from feedlot manure has been demonstrated by the production of mycotic mycetomas in New Zealand rabbits after intramuscular inoculation. Serum from infected rabbits failed to produce a precipitin reaction with homologous soluble antigen using the Ouchterlony double diffusion technique.

*P. boydii*-induced mycotic abortion is not a major concern of feedlot operators who are finishing cattle for slaughter. However, it could have serious consequences for those who keep breeding cows in open feedlots.

## Irrigation Practices

*Response of crops to soil moisture stress.* Pitic 62 wheat can tolerate lower levels of available soil moisture than those levels normally suggested for beginning irrigation. Stress of about 1 bar, or 30% available soil moisture, for 1–3 days did not significantly reduce grain yield, but stress to about 3 bars, or 20% available soil moisture, for up to 10 days reduced yield by 80%.

Under adequate irrigation, most of the moisture used by alfalfa grown for seed came from the upper half of a 100-cm profile. As irrigation was restricted, moisture was extracted from successively greater depths but moisture stress was not apparent until only about half of the available water remained in the lower quarter of the profile. Leaf water potential did not decrease appreciably until calculated mean soil moisture suction exceeded 1 bar.

*Rapeseed on irrigated land.* Results of experiments conducted over a 4-yr period showed that yields of 2.2–3.3 t/ha of rapeseed are attainable on irrigated land. Response to fertilizer depended on the relative fertility of the soil. When soil fertility was low, yields were increased by 25–110% with the application of N at 90–130 kg/ha and P at 75–100 kg/ha. The greatest response was to applications of N. The average oil content of the seed decreased from 40.1 to 38.2% and the protein content of the seed increased from 29.8 to 31.7% when N was used at 100 kg/ha. The changes in oil and protein occurred regardless of the yield response. Yields were the same with 2.2- or 4.4-kg/ha seeding rates and did not differ between varieties Echo and Span. Irrigation requirements varied with soil type and season. A clay soil that had been irrigated the previous fall required only one 15-cm flood irrigation. Loam or sandy loam soils required up to six sprinkler irrigations of 5.0–7.5 cm of water per application.

*Irrigation return flow.* The total salt content in the return flow from the Bow River Irrigation District in 1974 was about 32% more than the salt content in the incoming irrigation water (365 vs. 275 ppm). Although the irrigation season was fairly dry, the return flow from a sprinkler-irrigated block averaged about 40% of the gross diversions, and from a flood-irrigated block, about 26%. The



calculated net accumulation in the entire district was about 38 500 t of salt.

In 1975, total P content averaged 74 ppb ( $10^9$ ) in the supply water and the return flow contained 60–1000 ppb. Two drains averaged 463 ppb, three drains averaged 254 ppb, and one drain with significant ponded areas averaged 69 ppb. A strong correlation existed between sediment content and the total P content. A very large decrease in sediment content could be achieved by ponding.

### Plant Nutrients

*Response of corn to fertilizers and irrigation.* At the Vauxhall Substation, silage corn that was irrigated to maintain soil moisture in the upper half of the available range responded to P fertilizer only when the soil test for P ( $\text{NaHCO}_3$ -extractable) was less than 56 kg/ha. Maximum silage yield (57 t/ha) was obtained with N and P applied at 56 kg/ha. Response of corn to irrigation was unusually small in 1975, and only one irrigation in mid-July was required to maintain adequate soil moisture.

Maximum yield of grain corn (4.0 t/ha) was obtained without irrigation and with N and P applied at 56 kg/ha. Anthesis in silage corn and in grain corn was hastened on the average by 2.2 and 0.3 days by irrigation and by 3.7 and 4.6 days by N fertilizer compared with anthesis time in corn that received no irrigation or fertilizer.

*N fertilization of dryland grasses.* In the Chernozemic soils of southern Alberta, an adequate but not excessive N pool must be established to overcome very pronounced N deficiencies for dryland grasses. Also, annual applications of N fertilizer are required to maintain the N pool and maximize production. The initial amount of N required increases from about 135 kg/ha in the Brown soil zone to about 200 kg/ha in the Black soil zone where annual precipitation is higher. Preliminary results indicate that subsequent annual N applications must be slightly greater than the N removed by the previous crop.

*Organic matter studies.* To characterize soil OM fully, the portion remaining after alkaline extraction should be further fractionated because it often represents up to 80% of the total C. Although dithionite and HF-HCl treatments were effective in eliminating much Fe, Al, Ca, Mg, and Mn, they each released

less than 4% of the total C of Brown, Dark Brown, and Black Chernozemic soils and a Dark Gray Luvisol. The OM of these soils soluble in  $\text{CH}_3\text{COBr}$  represented 23, 20, 2.9, and 6.2% of the total C respectively. The presence of this “undecomposed” OM had an effect on the infrared spectra of OM extracted before the  $\text{CH}_3\text{COBr}$  treatment. The OM insoluble in  $\text{CH}_3\text{COBr}$  represented 10, 12, 17, and 23% of the total C respectively. Therefore, in spite of the arbitrary nature of the fractionation procedure, it was shown that the various environmental conditions associated with soil great groups have major effects on the nature of the soil OM.

*Soil variability.* Statistical analyses of soil variability of 33 plots on 15 farms in the Brown, Dark Brown, and thin Black soil zones of Alberta indicated that 30–40 soil samples must be composited to obtain a mean within the desired confidence interval of  $\pm 10$  kg/ha for N and  $\pm 5$  kg/ha for P. The usual degree of compositing of soil samples by farmers and researchers is inadequate.

## VETERINARY-MEDICAL ENTOMOLOGY

### Biting Flies

*Mosquitoes.* The pathogenicity in mosquitoes of the fungal parasite *Coelomomyces psorophorae* Couch was tested extensively because low infections in larvae of *Aedes vexans* (Meigen) have been found in association with heavily infected larvae of *Culiseta inornata* (Williston) in the field. Larvae of *A. vexans*, *A. dorsalis* (Meigen), and *A. flave-scens* (Müller) exposed to zygotes of *C. psorophorae* in the laboratory failed to become infected. However, *Culex pipiens* Linnaeus, *C. quinquefasciatus* Say, *A. aegypti* (Linnaeus), *A. sierrensis* (Ludlow), *A. triseri-atus* (Say), and *Culiseta inornata* (Louisiana strain) did become infected. Therefore, *Coelomomyces psorophorae* is not a host-specific pathogen. Zoospores from resistant sporangia produced in *A. sierrensis* readily infected the intermediate copepod host, which produced zygotes that were highly infective in *Culiseta inornata*. Zygotes from other mosquito species were less virulent. Resistant sporangia of *Coelomomyces psorophorae* can be stored at  $-10^\circ\text{C}$  for 18 mo with a loss of less than 30% in germination rate.



*Horn flies.* A 4-yr series of field experiments on host-parasite interactions has produced estimates of the impact of infestations of horn flies, *Haematobia irritans* (Linnaeus), on growth rate of yearling beef cattle on irrigated pastures. Protection with pesticides can account for 34% of the total summer growth of tolerant Hereford cattle and 40% of growth of resistant Hereford cattle during moderate infestations averaging 100–250 flies/head. Selection within a herd for tolerance for infestations at the same levels can account for up to 21% increases in growth. A quantitative model can now be developed for the interaction of parasitic infestation and efficiency of animal production on irrigated pastures.

*Black flies.* Controlled experiments in the Athabasca area with cattle used as bait have shown that the rate of attack by *Simulium arcticum* Malloch is uniform among animals of the same breed. This contrasts with the known distributions for infestations of other arthropod pests of animals. The rate of attack is higher ( $P < 0.01$ ) for Angus steers than for Hereford.

*Other biting flies.* Estimates of infestations on farms in the Athabasca Black Fly Control Program for the period 1973–75 indicated that economic protection of cattle in northern areas will have to involve more than a specific control for *S. arcticum*. A wide range of biting species of black flies, mosquitoes, ceratopogonids, and tabanids were found to attack cattle at various times of the day in numbers equal to *S. arcticum*. Some species of ceratopogonids and tabanids may be more troublesome for animal production than the currently recognized pests.

### Warble Flies

Infestations of *Hypoderma lineatum* (De Vill.) have been reduced to 1.4 grubs/animal after three annual treatments of systemic pesticides on all cattle on a large ranch. The reduction of parasites by pesticides is the first phase of a pilot project to evaluate the sterile-male technique. This technique is designed to eradicate low residual infestations in control programs of organized regions. Heterogeneous distribution of grubs in the ranch herd complicates the strategy for the release of sterile males. Subpopulations are perpetuated by localized pasturing of cattle in restricted areas of the ranch containing warble fly mating sites. A release of

sterile males has established conditions and procedures for the ranch-scale experiment next year. The main problem in production of sterile flies is the management of emergence in laboratory cultures for phenological synchronization with fly populations in the field. Infestations of cattle to supply flies for sterilization in the next release have been delayed 1 mo to avoid prolonged development of irradiated puparia, which reduces the viability of the released males. With the heterogeneous distribution of surviving grub populations on the ranch, it may be necessary to employ a corresponding pattern of male release related to known mating sites rather than to release uniform numbers of males per unit area as previously planned.

### Host-Parasite Relations

*Resistance of cattle to grubs.* Treatment of cattle with systemic insecticides after controlled inoculations of *H. lineatum* larvae inhibited the development of resistance in the cattle to subsequent inoculations. Therefore, annual treatments of pesticides cannot be stopped in control programs of organized regions without an immediate recurrence of heavy infestations. Heavy infestations in imported cattle are likely to cause disproportionate increases in infestation rates in warble control areas because of the reduced level of resistance of cattle regularly treated in the eradication program.

*Host immunity to ectoparasites.* An infestation of the sheep ked *Melophagus ovinus* (Linnaeus) confined to one part of the host for one generation causes the skin on the remaining parts to become resistant to infection by the second generation of the parasite. This indicates that acquired resistance of sheep to sheep keds is induced by circulating antibodies. Cutaneous basophil hypersensitivity, which has been shown to be a factor in resistance of hosts to ticks, is not evident in sheep that have acquired resistance to sheep keds.

### Synanthropic Flies in Cattle Feedlots

*Biological control.* Unidentified species of fungi, *Scopulariopsis* sp. and *Aspergillus* sp., have been cultured from cattle manure and evaluated for effectiveness as biological control agents against the housefly, *Musca domestica* L. Both species caused high pupal



mortalities when they were present in combination with chalcidoid parasites but were ineffective without the parasite activity.

*Recycling of animal waste.* Production of housefly pupae in cattle manure was not increased by enriching the larval medium with N and other nutrients. Enrichment causes high larval mortality that appears to negate the possibility of raising the production to the level achieved with poultry manure. In these recycling studies, other insects are being compared with the housefly. *Ceroxys latiusculus* (Loew) was superior in its ability to process wet manure. Its protracted life cycle, erratic oviposition behavior, and variable development require too much labor and limit its usefulness as an economic recycling agent.

### Pest Control

*Biting flies.* The growth regulator PH-60-40 (Thompson Hayward) was found to be most effective in controlling late third- and early fourth-instar mosquito larvae. Its toxic residues, which persist for at least 21 days in treated pools, make it environmentally unacceptable for general use in mosquito control programs.

A 50% formulation of the repellent *N,N*-diethyl-*m*-toluamide (DEET) applied by hand at the rate of 36–54 g/head provided cattle with almost 100% protection from all biting flies for 6 h. Effectiveness decreased to 50% within 20 h. Phosmet applied as sprays provided no protection from biting flies.

*Cattle lice.* Various treatments for control of the cattle louse, *Haematopinus eurysternus* (Nitzsch), during the winter were compared.

A pour-on application of ronnel at 30 mg/kg was most effective and reduced populations of the louse by 92% for 6 mo. A spot-on application of fenthion at 10 mg/kg reduced infestations by 77% for 2.5 mo. Ronnel dust freely accessible in a back rubber reduced infestations by 85% when cows were continuously exposed to the back rubber for up to 2.5 mo.

Circulating levels of anticholinesterase in the blood of cattle after treatment with crufomate varies with season. Systemic activity in the circulatory system is much higher during summer than in either fall or winter. This variation appears to explain the relative ineffectiveness of systemic pesticides in controlling lice and other ectoparasites as compared with their effectiveness in grub control.

*Black flies.* Applications of larvicide to a river were repeated for the 2nd yr in a 3-yr interagency program for the control of black flies in the Athabasca area of Alberta. Methoxychlor was injected into the Athabasca River to give a concentration of 0.3 ppm according to a hydrological model for 7.5 min. The injection time in the previous year was 15 min. Larval control was limited to 40 km from the point of injection as compared with more than 160 km the previous year. Although pretreatment larval populations were lower in 1975 than in 1974, fly populations in the area were higher as a result of insufficient reduction in the 1975 larval population.

*Warble extermination programs.* Grub infestation per head for 1975 in monitored areas remained unchanged in Alberta from 1974 (1.7 vs. 1.6) but was reduced further in Saskatchewan (3.2 vs. 4.7).

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## INTRODUCTION

This report deals with some of the results of research in 1975. Four new herbicides were advanced to the authorized recommendation stage for small fruits and vegetables and satisfactory controls were recommended for snow mold control on turf. Requests for reprints or for further information should be directed to: Research Station, Agriculture Canada, Box 1000, Agassiz, B.C., V0M 1A0. Telephone (604) 796-2221.

J. E. Miltimore  
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### CROP SCIENCE

*Fungicides for snow mold control in fine turfgrass.* Single late-October applications of fungicides gave good control of *Typhula* snow mold at three locations in the interior of British Columbia over a 4-yr period. The causal organisms *T. incarnata* Lasch ex Fr., *T. ishikariensis* Imai, and *Typhula* F W were identified by Mr. J. D. Smith of the Research Station, Saskatoon.

The most effective treatment was an inorganic mercury mixture at 1.52 g/m<sup>2</sup>. The best nonmercurial treatment was chloroneb in granular or wettable powder (WP) form at 1.83–2.74 g/m<sup>2</sup>, followed by quintozone WP at 3.05 g/m<sup>2</sup>. The October application date was too late to effectively control minor, early-fall outbreaks of snow mold caused by *Fusarium nivale* (Fr.) Ces.

*Interaction of light, minor elements, and pH on plant growth in nonsoil media.* Failure of some commercial peat-vermiculite mixtures to produce suitable tomato transplants was shown to be caused by insufficient fertilizer content, high pH, and inadequate lighting. With normal light intensity and supplemental major and minor elements, all media produced satisfactory plants. When the supplementary minor elements were omitted, plant growth in media of pH 7.0 and below was not adversely affected; apparently some minor elements were available from the media. In media above pH 7.0 plants showed impaired apical growth and characteristic leaf chlorosis due to calcium-induced iron deficiency. The high pH had an adverse effect upon either the availability of iron in the media or its mobility within the plant.

By reducing the light intensity to that encountered under dull January greenhouse conditions, it was shown that plant growth in media supplemented with complete nutrients

was again pH dependent. Apparently excessive lime in nonsoil media was detrimental to tomato transplants under conditions of low light intensity or under normal lighting when minor element levels were low.

*Tomato ringspot virus on raspberry.* In a study undertaken in cooperation with the Research Station at Vancouver, tomato ringspot virus (TomRSV) infection retarded the growth of young raspberry plants arising from the root cuttings of 8 of 10 cultivars. Chlorotic ringspot markings were evident on many of the young plants, but in subsequent years very few foliar markings were observed. By the third cropping year, Avon, Glen Clova, Latham, Lloyd George, and Meeker all showed a significant reduction in yield. When all growth parameters were considered, the cultivar ranking in order of decreasing susceptibility was: Lloyd George, Avon, Latham, Glen Clova, Meeker, Matsqui, Malling Jewel, Carnival, Puyallup, and Canby.

*Herbicide treatments for cucumber seedbeds.* Paraquat and glyphosate sprayed at rates of 1.1 and 2.2 kg/ha when weeds were small and immediately after seeding of the cucumbers (stale seedbed) gave fair to good control of broad-leaved weeds and grasses. Field horsetail was not controlled by either herbicide. No treatment affected germination or crop stand detrimentally.

*High-density planting of bush beans.* Bush Blue Lake 290 planted at within-row spacings of 5.1, 7.6, and 10.2 cm in rows 38.1, 45.7, 53.3, and 61.0 cm apart performed best at the greatest population density. Total plant weight, yield of marketable pods, and total pod yield increased as population density increased. Pod lengths were not affected by changes in population density. Increased

returns from the closest spacing more than paid for the additional cost of the seed.

*Response of broccoli to water stress.* In a lysimeter experiment Gem produced satisfactory yields of heads when exposed to water stress prior to bud formation, if adequate soil water was supplied thereafter (dry-wet treatment). Plants exposed to water stress after bud formation (wet-dry) or both before and after bud formation (dry) had the lowest yields. Plants not exposed to water stress (wet) had yields equivalent to the dry-wet treatment.

## ANIMAL SCIENCE

*Quality of rib roasts from Holstein-Friesian steers and bulls.* Rib roasts from 36 steers and 36 bulls from 11 sire groups were compared by taste panel evaluation. All animals were reared on an all-concentrate ration, and at 340 kg half the steers and bulls were implanted with hormones (200 mg progesterone plus 20 mg estradiol-17 $\beta$ -benzoate). After slaughter at 450 kg, the 9th-11th rib sections from the left carcass sides were compared by taste panel evaluation.

Hormone treatment did not affect quality factors such as tenderness, juiciness, and flavor, but hormones tended to increase the fat deposition in bulls and decrease it in steers. Rib roasts from bulls were significantly less desirable than roasts from steers in all quality factors. Significant differences between the 11 sire groups for all taste panel evaluations were also noted. Although rib roasts from steers are more desirable than those from bulls, this advantage must be viewed in conjunction with the superior rate and economy of gain exhibited by bulls over steers.

*Growth rate, health characteristics, and blood components to evaluate quality of milk replacers.* Three commercial milk replacers and whole milk were fed to male Holstein calves from 0 to 42 days of age. A calf starter and water were made available to all calves from 22 to 42 days of age. Whole milk at 12% of body weight resulted in a more rapid rate of gain: 0.58 kg/day vs. 0.32, 0.30, and 0.27 for the milk replacers. During the first 21 days of the trial, calves fed milk replacer just maintained body weight and the milk-fed ones gained 0.31 kg/day. Calves fed whole milk or a milk replacer containing 15%

fat had lower veterinary costs than those fed milk replacers containing 8 or 11% fat. Blood glucose levels were significantly correlated with rate of gain ( $r = 0.62$ ). A feeding trial using 10 calves per treatment can provide a sensitive estimate of the quality of milk replacers.

*Protected lipid for increasing milk fat test values.* When tallow coated with soybean meal and treated with formaldehyde was incorporated at the 5 and 10% levels in a pelleted grain ration, it did not consistently improve milk fat test values of cows on lush spring pasture. A further trial designed to test the influence of pelleting on the effectiveness of the protective process showed that the protected lipid at 15% of a nonpelleted grain ration resulted in an improved fat test value when compared with the control pelleted grain ration. The grain intake of the nonpelleted ration was only 8.6 kg/day compared with 10.1 kg/day for the pelleted control ration.

*Utilization of spent filter cake.* The apple juice industry of British Columbia produces some 550 t of diatomaceous-earth spent filter cake annually as a waste product. This material at 2.5% of a broiler diet had no adverse effect on growth, feed efficiency, or mortality of the birds. Although the physical properties are quite similar to bentonite, the material had no beneficial effect on the pelleting properties of feed. Spent filter cake from this source is recommended as a dilutant for mineral mixes used in livestock feeds.

*Effect of dietary protein level on the distribution of egg weight.* Feeding diets containing 15.6, 14.3, or 13.0% protein had very little effect on mean egg weight, which is contrary to previous results. The age of the bird may be a significant factor so the experiment will be continued. The levels of protein had no effect on egg production or other economic traits measured. A knowledge of the distribution of egg weight is important in determining economic returns to the producer under periods of high protein prices.

*The incidence of cracked and dirty eggs on an integrated operation.* Eggs from four flocks of 140 000 layers each and spaced 10 wk apart in age were examined over four successive seasons to determine what factors significantly influence the occurrence of cracked and dirty eggs. With increasing age



of the birds, cracks increased significantly from 3.0 to 7.3%, whereas dirty eggs remained relatively constant at about 7.4%. The flock manager and the house environment significantly affected the incidence of both cracked and dirty eggs, but the season of the year did not. Egg collectors picked out two-thirds of the dirty eggs but less than one-tenth of the cracked eggs. The remainder of the defective eggs were identified on the candling machines. Less than 2% of sound dirty eggs were broken in the washer.

*Egg production profits studied on an integrated operation in Scotland.* In a commercial operation 850 000 layers were divided equally into 24 flocks and spaced 4 wk apart in age. Weekly profit was not affected by the season of the year, quality of eggs, flock management, house environment, mortality, wages, house expenses, depreciation, or interest on capital, but it was significantly influenced by percentage lay, feed consumption, and age of the birds. These latter factors accounted for 92% of the variability in weekly egg returns.

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# Research Station Kamloops, British Columbia

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## Departure

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## INTRODUCTION

The program at the Research Station at Kamloops emphasizes research on forage production and utilization on British Columbia rangelands, as well as forage crops grown under irrigation for pasture or winter feed. Studies on integrated resource use play a large role in the program, including multiple use of grasslands and forested ranges by cattle and deer and cattle-tree competition on logged and reforested areas.

Only highlights of our 1975 research are presented in this report. Details of the work discussed can be obtained from the Director, Research Station, Agriculture Canada, P.O. Box 940, Kamloops, B.C. V2C 5N5.

D. E. Waldern  
Director

### PLANT BIOCHEMISTRY

#### Relation between Miserotoxin Concentration of Timber Milkvetch and Precipitation

Daily precipitation patterns were compared to the variation in miserotoxin concentration of timber milkvetch, *Astragalus miser* Douglas ex Hooker var. *serotinus* (Gray) Barneby, sampled sequentially during the spring and summer of 1973 and 1974. On rough fescue grasslands the substantial increase in rainfall from April to August 1974 not only extended toxicity intervals, but also increased miserotoxin levels during the pre-bud growth stage. A large-scale rainstorm induced miserotoxin synthesis during the pod stage. Greater soil moisture-holding capacity at one grassland experimental plot prevented a rapid decline in miserotoxin levels when drought conditions developed. The toxicity trends on Douglas-fir forest sites did not show a response to variations in precipitation, and toxin differences between local sites were not significant. Consequently, a predictability equation was developed for timber milkvetch toxicity in Douglas-fir forests on Gray Luvisol soils.

#### Poisonous Principles in Crownvetch

The glucose esters of 3-nitropropanoic acid in crownvetch, *Coronilla varia* L. 'Penngift', were isolated, identified, and quantitatively determined; 6-(3-nitropropanyl)-D-glucopyranose and 1,6-di-(3-nitropropanyl)- $\beta$ -D-glucopyranose were present as 2.0 and 2.6% of the dry weight of aerial shoots. Although the suitability of crownvetch for erosion control on highway embankments and disturbed slopes has been demonstrated, the

advisability of widespread seeding of crownvetch near rangelands is questionable because other workers have shown that 3-nitropropanoic acid is toxic to ruminants.

### FORAGE PRODUCTION AND UTILIZATION

#### Selenium Content of Alfalfa Grown on Gleysolic and Luvisolic Soils at Creston, B.C.

In a previous survey, selenium contents of livestock feeds grown in the Creston area were found to vary widely. Samples taken from the flats of the Kootenay River had a mean of 1.04 ppm selenium (Se) and a range of 0.34–2.66 ppm, whereas those from the adjacent benchlands had a mean of 0.15 ppm Se and a range of 0.03–0.48 ppm. The level of most of the samples from the benchlands fell below the recommended minimum of 0.10 ppm for livestock. The striking difference in Se contents was thought to be related to geologic origin of the soils. Six sites with well-established alfalfa on each of two soil series, Kuskanook, a Carbonated Orthic Gleysol on the flats, and Lister, an Orthic Gray Luvisol on the benchlands, were chosen for sampling in 1973. The surface-cultivated Ap and partially altered C horizons were sampled. Alfalfa stems at about the bud stage were collected on May 25 and July 13.

The Se content of alfalfa was significantly ( $P < 0.05$ ) higher for Kuskanook (0.53 ppm) than for Lister (0.11 ppm). However, there was no significant difference in total soil Se of either the Ap or C horizons of the two soils. Therefore, geologic origin of the soils does not readily account for the differences. Other

soil characteristics that may affect Se availability were considered. The Kuskanook soil is alkaline (pH 7.2–7.5) and calcareous throughout the profile, whereas the upper horizons of Lister are acidic (pH 6.0). The Kuskanook soil has a higher level of organic matter throughout the profile than Lister and does not have a restricting clay layer below the Ap horizon as does Lister. Rooting may be more extensive on Kuskanook and account for a greater uptake of Se.

On Lister soil, the Se content of the second-crop alfalfa sampled on July 13 tended to be lower than that of the crop sampled on May 25. This may be related to drought in the latter part of the season because most of these alfalfa stands were not irrigated. The Kuskanook soil was subirrigated and so less subject to drought throughout the growing season.

The wide range of alfalfa Se, 0.05–1.88 ppm for Kuskanook and 0.01–0.41 ppm for Lister, emphasizes the need for analyzing each particular lot of forage for Se to determine its nutritional adequacy for cattle.

### **Selenium Concentrations in British Columbia Forages and Grains**

Hay, silage, and grains grown throughout British Columbia were sampled and quantitatively analyzed for Se to assess their suitability as Se suppliers for livestock.

Some relatively high Se values were found, but they did not exceed 1.8 ppm. Little harm would be expected from their use. On the other hand, about 21, 41, and 76% of the samples of legume and grass forages, oat and sedge forages, and corn silages had 0.11 ppm Se or less, which is the assumed minimum level for livestock feeds. On the average, wheat grain samples contained more Se and only 12% were below the minimum. Legume and grass forage samples from most of the southeastern area of British Columbia, which accounted for 57% of the total, had a mean Se content of 0.20 ppm or greater, whereas samples from other areas had less. Correlations between most weather components and plant Se levels were not significant, except that a significant negative correlation existed between mean grass Se content and precipitation ( $r = -0.61$ ,  $P < 0.05$ ).

In view of the variability in Se content between feeds and within regions, it appears necessary to analyze all feeds in British

Columbia to determine the proper Se supplementation of livestock rations.

### **Effects of Dates of Seeding of Crested Wheatgrass on Range**

A 4-yr date-of-seeding study at five locations in the Kamloops grasslands indicated that seedings between early April and early June produced adequate stands except during very dry springs. Low surface soil moisture appeared to be the main reason for lack of germination. This occurred during springs with below-normal rainfall after low winter snowfall. Spring and early summer seedings that did not germinate at the time did so with the fall rains. Early fall seedings germinated immediately if adequate surface soil moisture was present. Late fall seedings did not germinate until the following spring because of low temperatures.

Weather records taken at each site were daily air and soil (3 cm deep) temperatures, weekly precipitation, and weekly soil moisture values at depths of 2, 5, 10, and 25 cm. Germination counts were taken every 2 wk throughout the first growing season and once in the spring during subsequent years. Harvesting of plots started the 3rd yr after seeding. The trend of spring drought was reflected in low stand yields and in poor survival of young plants in the years following seeding.

### **Alfalfa Variety Evaluation**

Differences in alfalfa variety performance for dry matter production are being obtained at Creston and at the Station (Kamloops). At Creston, the Flemish rapid-regrowth types are giving higher yields than the standard or intermediate-growth varieties. In a 4-yr period (1971–74), Saranac at Creston with a mean yearly yield of 9641 kg/ha exceeded Beaver by 12%. These yields were obtained without irrigation and with two cuts a year. At the Station, with irrigation and three cuts a year, the yield of Saranac was 8% lower than that of Beaver. The mean yearly yields were 9170 and 9932 kg/ha respectively.

### **Alfalfa Winter Injury and Yield Reductions**

Within the 4-yr test period, 1971–74, severe winter injury to alfalfa stands occurred during the winter of 1972–73. First-cut yields in 1973 were much lower than those obtained the previous crop year. Beaver and



Saranac yields at the Station were reduced 52 and 70% respectively. At Creston no reduction occurred with Beaver; the yield of Saranac was reduced 23%. This is indicative of the relative winterhardiness of the varieties and the need for hardier varieties at the Station.

## BEEF CATTLE MANAGEMENT

### Residual Effect of Acaricides in Controlling Rocky Mountain Wood Tick

The protection of cattle against paralysis by the Rocky Mountain wood tick by back-line sprays of 0.5% coumaphos as wettable powder (WP), 0.5% toxaphene as emulsifiable concentrate (EC), and 0.25% lindane EC and WP was tested using 9–10 dry cows per treatment. A control group was sprayed with water. After being sprayed in early

April, the cattle were placed in a 130-ha grassland spring range selected for its high tick population. The animals were checked daily and tick counts made weekly or more frequently as required. Ticks were removed from untreated and treated animals when numbers indicated a potential for paralysis.

Based on tick counts, toxaphene was failing to give good tick control by 8 days after spraying, and both toxaphene and coumaphos failed to provide control of tick numbers after 15 days. Much of the residual effect of lindane EC was lost by 21 days, whereas lindane WP provided good protection for this length of time. The residual effect of lindane WP had declined by 28 days and was not significantly different from that of the EC form of the pesticide. Because environmental conditions affect tick activity, a residual effect from the acaricide for 5–6 wk is felt necessary for adequate tick control.

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# Research Station Sidney, British Columbia

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R. E. HARRIS, B.S.A., M.S.A., Ph.D.	Ornamentals
N. V. TONKS, B.S.A., M.S.	Insects of ornamentals
D. R. BERTOIA, <sup>1</sup> B.S.A.	Officer-in-charge, Post-entry Quarantine Station
J. STEVENSON, <sup>1</sup> B.Sc. (Agr.)	Post-entry Quarantine Station

## Departure

A. L. OLIVER, <sup>1</sup> B.Sc. (Agr.) Appointed Officer-in-charge, Audit Laboratory, Plant Protection Division, Agriculture Canada, Sidney, B.C., May 1975.	Post-entry Quarantine Station
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<sup>1</sup>Production and Marketing Branch



## INTRODUCTION

The Research Station at Sidney, B.C., emphasizes research on problems of ornamental and greenhouse crops. Particular attention is being paid to the culture of greenhouse vegetables and ornamental nursery stock grown in containers of soilless media. Priority is also given to the propagation of superior clones of Douglas-fir in cooperation with the forest industry. The work is rapidly expanding at the Post-entry Quarantine Station, which is operated jointly with the Plant Protection Division, Agriculture Canada.

Dr. R. E. Harris, Research Scientist, transferred to Sidney from the Research Station, Beaverlodge, Alta., in November 1975. He will be working on tissue culture methods of propagating virus-indexed material with Mr. J. Stevenson, Agriculture Officer, who joined the staff of the Quarantine Station in August 1975.

Requests for information or publications should be addressed to the Research Station, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

H. Andison  
Director

## HORTICULTURAL CROPS

### Ethephon Applied to Greenhouse Tomatoes

Ethephon sprays were applied at rates from 600 to 2400 ppm to greenhouse tomatoes in a number of trials to accelerate ripening and shorten the picking season. A single overall foliar application at 900 or 1200 ppm either in June or November, depending upon whether it is applied to a spring or fall crop, has increased the amount of fruit ripening in 7–10 days after treatment. Most of the crop remaining to be ripened at the time of spraying can be picked within 2 wk.

Although the 1200-ppm rate tends to be more effective than 900 ppm, the difference is usually small, particularly in the spring crop when the weather is usually bright and warm. An alternative is to direct the spray, at a rate of 1200 ppm, to the fruit only. This method produces results similar to an overall application at 900 ppm and saves spray material, but it is more time consuming.

There have been no apparent adverse effects on the quality of fruit ripened by this method. The advantages are considerable, particularly in the late fall, when natural ripening is protracted because of dull, cool weather. Under these conditions, ethephon spraying permits quicker harvest, with savings in labor and fuel, and provides more time between crops for greenhouse repairs and sanitation procedures.

### Greenhouse Cucumbers in Soilless Media

Work continued on raising cucumber plants in soilless mixtures. It is necessary to obtain a high proportion of quality transplants from the expensive seed of all-female stem-fruited seedless hybrids; this requirement can become a serious problem for growers. In experiments investigating soilless culture systems for cucumbers of this type, a method has been devised that consistently yields more than 90% good-quality transplants.

Seed is sown on blotters and kept moist in a saturated atmosphere at a constant temperature of about 25°C. In 24–48 h the sprouted seeds are removed individually to plastic pots filled with a 2:1 mixture of sphagnum peat and vermiculite with hydrated lime at 200 g/100 litres. The mixture is soaked with a dilute nutrient solution containing N at 126 ppm, as used for soilless culture of greenhouse tomatoes. To encourage rooting, a depression 4 cm in diameter and 2 cm deep in the surface of the mixture is first filled with a 1:1:1 mixture of peat, perlite, and medium coarse sand. The sprouted seed is inserted into a slit in this mixture and soaked with nutrient solution. Early in the season when days are short and light intensity is low, additional light from fluorescent tubes for 12 h/day helps keep plants stocky, which is highly desirable in greenhouse cucumber production, and the temperature is held at a minimum of 20°C. The plants are usually transplanted at the four-true-leaf stage, from

3 to 3.5 wk after sowing. The method can be modified for the individual grower.

## Ornamentals

*Watering methods and soilless media for container growing.* Plants of *Thuja occidentalis* L. 'Pyramidalis', *Juniperus chinensis* L. 'Pfitzeriana Compacta', and *Erica* × *darleyensis* Bean. were grown in containers. In a comparison of watering methods, the use of saturated sawdust or sand mats for embedding the containers or of a flood system for submerging them in a water reservoir to a depth of 2.5 cm generally produced greater growth responses than either overhead sprinkling or trickle tube irrigation. Sprinkler irrigation tended to be more effective in the early part of the season than in the late part, whereas the saturated mats or flood system resulted in greater growth during the whole season, mainly because late-season growth was better.

Of the three subjects, *Juniperus* thrived best in a continuously saturated growth medium and produced 61.8% more green weight from flood irrigation than from overhead sprinkling. In *Thuja* and *Erica* the increases were 40.6% and 16.0% respectively.

The best response of plants to the rooting media, based upon green weight at the end of the season, was to soil, followed closely by 3:3:2 sawdust-peat-sand and 3:1 ground fir bark - peat mixtures, and ground fir bark alone. Other media included sawdust alone, and 3:1 sawdust-sand and sawdust-peat mixtures.

## Weed Control

*Control of common yarrow in turf.* Common yarrow is a perennial weed in lawns; it continues to spread even under good turf management and is resistant to 2,4-D or MCPA. In experiments where artificial infestations permitted reliable comparisons of herbicide treatments, good control was obtained with both dicamba and mecoprop. The best results were obtained from two applications of a combination of these herbicides applied in the spring, with dicamba at 0.28 kg/ha and mecoprop at 1.12 kg/ha. Although no consistent differences in effectiveness of the treatment were established when the length of times between the two sprays was varied, 2-4 wk is suggested as a suitable interval.

## Control of the Black Vine Weevil

*Container-grown grape cultivar Baco.* Oxamyl applied at 30 ml/1000 cm<sup>3</sup> of soil effectively controlled black vine weevil larvae on Baco at dosage rates that supplied the active ingredient (ai) at 0.12-1.0 g/litre. Root weights were less for treated plants than for uninfested, untreated plants.

*Container-grown fuchsia cultivar Display.* A single soil drench of carbofuran at 0.6 g ai/litre applied at 30 ml/1000 cm<sup>3</sup> of soil effectively controlled black vine weevil larvae on Display when applied at intervals from 1 wk before egg placement to 9 wk after egg placement. Root weights were not reduced when the interval of weevil infestation before treatment was 9 wk. Some marginal leaf burn occurred on all treated plants.

*Control of the twospotted spider mite.* Bioassays of recommended miticides and potential alternates conducted on twospotted spider mites in the greenhouse showed almost complete control with standard rates of cyhexatin, dicofol, chlorobenzilate (Acaraben; Ciba-Geigy), propargite, and chlor-dimeform. Dienochlor, benzoximate, and tetradifon were only partly effective. Seven cultivars of Long English cucumber sprayed with cyhexatin 50% wettable powder showed no phytotoxic effects at 0.25 g/litre. Slight leaf mottling occurred at 0.50 g/litre and severe mottling at 0.75 g/litre.

*Black root rot of greenhouse cucumbers.* Three growth-room experiments were conducted on black root rot (*Phomopsis sclerotoides* Kest.) of long English cucumber cultivar Greenspot, F<sub>1</sub> hybrid. A single drench of benomyl at 100 ppm (ai wt/vol soil) applied 8 or 15 days after transplanting seedlings into infested soil (10% wt/vol inoculum) was somewhat more effective in preventing infection than a drench applied 1 day after transplanting. A single drench applied 25 or 32 days after transplanting was even more effective. In all drenched plants, symptoms developed later than in untreated ones.

*Propagation of woody plants.* MacMillan Bloedel Ltd. and Pacific (CPR) Logging Co. continued to cooperate in propagation studies by supplying 20 000 cuttings from 179 clones of 'plus' or superior selected trees. The best results were obtained when cuttings



were taken during January, dipped in indolebutyric acid (IBA) with naphthalene acetic acid (NAA) in 50% alcohol solution at 2000 ppm, rooted in a 1:1:1 peat-perlite-sand medium, and grown under mist conditions. Terminal cuttings 46 cm long gave the highest percentage of rooting. Promising results were obtained using new or 'juvenile' growth produced by 3-yr-old clonal trees grown and pruned as a hedgerow for propagation stock.

About 80% rooting was obtained by taking cuttings in mid-February from five difficult-to-root evergreen shrubs, *Cupressocyparis leylandii* (Jacks. & Dall.) Dall. & Jacks., *Tsuga canadensis* L. Carr. 'Prostrata' and 'Pendula', *Pinus mugo* Turra. var. *pumilio* (Haenke) Zenari, and *Chamaecyparis lawsoniana* (Murr.) Parl. 'Nana'. These were dipped in IBA at 1000 ppm for 5 s and grown under mist in 6-cm peat pots containing coarse sand and peat at a 1:1 ratio. Vitalite fluorescent tubes used to give additional light for 16 h did not influence the rooting percentage.

Cuttings of the virus indicator grape Baco 22A taken during early March gave complete rooting response when soaked for 1 h in

captan 50W at 1.0 g/litre before the cane base was treated with 0.8% IBA powder (Seradix 3; May & Baker Ltd.) and rooted in a 1:1:1 peat-perlite-sand medium. Banrot (Mallinckrodt) and benomyl wettable powders at the above rate appeared to reduce the number of roots produced by one-half.

*Post-entry Quarantine Station progress report.* New introductions for 1975 included about 260 clones of tree fruits and grapevines for virus indexing. About half of these new introductions were found to be infected with a virus. The method of detection was improved this year by the addition of the Pinot Noir grape variety as an indicator for leaf roll virus. Three new introductions of apricots from Europe are suspected of containing Sharka disease (plum pox virus).

About 120 tree fruit cultivars were heat treated and are in the process of being reindexed for virus. Preliminary projects have commenced using meristem tip culture techniques for grapes and tree fruits to improve the heat therapy program.

This is the first year that the Post-entry Quarantine and the Plant Quarantine Advisory Committee have distributed a list of virus-indexed tree fruit material now available from this station.

## PUBLICATIONS

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# Research Station Summerland, British Columbia

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M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

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## Soils Section

J. L. MASON, <sup>1</sup> B.S.A., M.Sc., Ph.D.	Head of Section; Plant nutrition
D. S. STEVENSON, B.S.A., M.S., Ph.D.	Soil moisture

## Departures

J. F. BOWEN, B.S.A., M.S.A., Ph.D. Retired July, 1975	Microbiology
D. V. FISHER, B.S.A., M.S.A., Ph.D., F.A.S.H.S. Retired December 1974	Director
L. E. LOPATECKI, B.A., B.S.A., M.S.A., Ph.D. Retired December 1975	Tree fruit fungus diseases
J. D. MACNEIL, B.Sc., M.Sc., Ph.D. Resigned October 1975	Pesticide and environmental chemistry
J. M. MCARTHUR, B.A., M.A., Ph.D. Retired December 1974	Head of Animal Science Section; Bloat research in cattle
R. M. ROSHER, B.A., M.A. Resigned March 1975	Tree fruit fungus diseases
M. F. WELSH, B.S.A., Ph.D. Retired April 1975	Virus diseases of pome fruits

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<i>National Research Council postdoctorate fellows</i>	
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E. WARRENDORF, B.Sc., M.Sc., Ph.D.	Food processing

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- <sup>1</sup>On work transfer to the Research Station, St. Jean, Que., from August 1974 to August 1975.  
<sup>2</sup>On work transfer under C.I.D.A. from September 1975 to August 1976.



## INTRODUCTION

The research programs at the Research Station at Summerland are concerned with all aspects of production, protection, and use of tree fruits and grapes. A substation at Kelowna, an experimental area at Creston used in conjunction with the Research Station at Kamloops, and numerous off-station research sites and plots throughout the fruit growing areas of British Columbia are necessary to the research.

During 1975 a new apricot variety, Sundrop, was released. The Similkameen Valley, almost 690 ha of pome fruit orchards, was prepared for the release of sterile codling moths to begin in 1976; this is a cooperative venture involving growers, the British Columbia Department of Agriculture, and the Research Station. Cherry mottle leaf was found to be present in apricot trees, a disease not previously known to occur naturally. A small number of grape selections show promise for wine production and table use.

This report contains some of the highlights of our progress in research during 1975. Detailed information and reprints of published papers are available on request from the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

G. C. Russell  
Director

## AGRICULTURAL ENGINEERING

### Spray Deposit Studies

Studies were carried out in a mature orchard of semidwarf apple trees, to compare deposition patterns of the spray emitted from two airblast sprayers. The experimental tower sprayer deposited more spray than a good commercial sprayer in the portion of the trees above 2.4 m and on the ground. The commercial sprayer deposited a little more spray in the lower parts of the trees. The tower made similar deposits on both upper and lower surfaces of the leaves, whereas the commercial sprayer tended to apply more spray to the underside of the leaves. Because of the difference in airstream direction, the use of the tower sprayer resulted in less spray drift above the trees.

### Tree Fruit Harvesting Aids

The orchard work platform was modified, and a smaller, more maneuverable picking aid was designed and constructed. A crew of three men picked 30% faster with either machine than with ladders in a block of Golden Delicious apples on semidwarf trees, and about 10% faster in a tree-wall planting of Bartlett pears.

### Preventing Blockage of Trickle Irrigation Emitters

Trickle irrigation water was treated with weekly injections of seven chemicals separately to evaluate their effectiveness in preventing emitter blockage. The most effective chemical treatments were NaOCl and CaOCl injected at 10 ppm of active chlorine for 2 h/wk, or 50 ppm of active chlorine for 30 min/wk. Over an 8-wk period, only 2% of emitters became plugged whereas 61% became blocked when untreated water was used. Other chemicals tested were sodium hexametaphosphate, copper sulfate, hydrogen peroxide, trisodium phosphate, and xylene. None of these were effective when applied at 50 ppm for 30 min/wk.

### Agitating Processes for Institutional-sized Cans

The effects of several types of agitating motions upon rates of heat transfer into viscous food products canned in 2.8-litre containers were evaluated. Mixtures of bentonite clay and water were used to simulate food products. When cans were oscillated in a circular path 2.5 cm in diameter, heat penetration rates were similar to those from end-over-end rotation with a 71-cm diameter. Because food products can be agitated with this rather simple motion, the oscillation method could be used commercially with only minor modifications to existing systems.

that use still retorts. A pilot plant model of a circular agitator has been constructed, and it will be adapted to a conventional retort to demonstrate the application of this method to various food products.

## ENTOMOLOGY

### Codling Moth

In 1975 the Similkameen Valley, comprising almost 690 ha of pome fruit orchards, was prepared for release of sterile moths to begin in 1976. Neglected host trees were removed and extra sprays were applied to reduce the codling moth infestation. About 600 sex pheromone traps were used to monitor the adult male population from early May until late August and the trap records, coupled with examination of fruits, served as a basis for control recommendations. Fruit examination at harvest showed that codling moth populations were unacceptably high in 81 ha. These areas will require chemical sprays in May and June, and release of sterile moths will not start until July. In all other areas, sterile males will be released from the time when apple trees are at the pink bud stage.

### Leafrollers

*Control by chemicals.* Azinphos-methyl, diazinon, trichlorfon, and *Bacillus thuringiensis* Berliner were evaluated for control of two leafroller species, *Archips argyrospilus* (Walker) and *A. rosanus* (Linnaeus), as sprays at the time of pink bud and petal fall. All materials except *B. thuringiensis* provided satisfactory control at either the pink bud or petal fall stage. No adverse effects on beneficial insects or mites were noted. It was concluded that application at petal fall was preferable because there was less hazard to pollinating insects and other pests could be controlled in the same period.

*Monitoring populations with sex pheromone traps.* The sex pheromones of *A. argyrospilus* and *A. rosanus* were used to monitor male populations and determine whether the number of trap captures could be related to the percentage of injured fruits. There was a close correlation between trap captures and fruit injury with the sex pheromone of *A. argyrospilus*, which indicates that traps could be used to determine the need for spraying. Traps containing the sex pheromone of *A.*

*rosanus* caught large numbers of males regardless of the amount of fruit injury, which indicates that this species may be attracted from considerable distances.

### Orchard Mites

Chemical control of orchard mites was studied. ZR 856 (Zoecon) applied at the 13-mm green stage of apple gave as good control of eggs of the European red mite as the currently recommended oil spray. However, it was toxic to apple rust mites, which are an alternative food source for predacious mites. Cyhexatin, benzoximate, PP 199 (Chipman), R 28627 (Stauffer), and ZR 856 sprayed at the pink bud stage controlled the European red mite; all but benzoximate were toxic to apple rust mites, and only PP 199 was toxic to the predator *Typhlodromus occidentalis* Nesbitt. As summer sprays, all the above materials except R 2867 were effective against the European red mite. PP 199 was the only acaricide that was highly toxic to *T. occidentalis*. Benzoximate was the most selective of the candidate acaricides and the only material that was not toxic to the stigmacid predator *Zetzellia mali* (Ewing).

### Pear Pests

*Pest management.* The population levels of the main insect and mite pests were assessed by standardized sample techniques in eight commercial pear orchards. Orchardists were advised of the need for chemical control based on the samples, which indicated safe or potentially injurious pest populations. In the eight orchards the number of pesticide treatments was reduced by an average of 1.8 with no loss of fruit yield or quality.

*Chemical control of pear psylla.* A synthetic pyrethroid, NRDA-143 (Chipman), applied at a low rate per hectare gave excellent control of overwintered adults of the pear psylla. During hot weather, six times as much material was required and the summer application was toxic to predators of the pear psylla. Three applications of a growth regulator Altosid 5E (Zoecon) greatly reduced pear psylla numbers but failed to prevent honeydew damage to the fruit.

### Cherry Fruit Flies

*Control by fumigation.* Infestations of maggots of the western cherry fruit fly in mature sweet and sour cherries were reduced 53–68% by fumigating for 3 days with CO<sub>2</sub>,



N<sub>2</sub>, or CO<sub>2</sub> with N<sub>2</sub> at 21–23°C. Significantly more maggots survived when exposed for only 2 days.

*Trapping cherry fruit flies.* Unbaited, saturn yellow Prokobil traps (E. F. Boller, Wadenswil, Switzerland) caught an average of 141 western cherry fruit flies per trap compared with 138 caught in Pherocon AM traps (Zoecon) with bait incorporated into the sticky surface. Ratios of trapped male to female flies was 1.3:1 on Prokobil traps and 1:1.5 on Pherocon AM traps. Pherocon Type 3 traps (Zoecon) caught an average of 20 flies per trap compared with 33 captured in Pherocon AM traps, but Type 3 traps caught 7% more flies when the sticky surface was exposed outward rather than inward.

### Fumigation

Ethylene dibromide at the rate recommended for killing eggs of the European red mite did not give complete mortality of apple rust mites. CO<sub>2</sub> or CO<sub>2</sub> with N<sub>2</sub> killed European red mite eggs and apple rust mites in 2 days, but McDaniel spider mites survived for 7 days. When CO<sub>2</sub> was combined with ethylene dibromide, the mortality of apple rust mites increased, but that of McDaniel spider mites and European red mite eggs decreased. Indications are that the three species cannot be killed by a single treatment.

## FOOD PROCESSING

### Wines

*Improvements in wine processing.* Eighteen grape varieties were fermented in the laboratory using *Schizosaccharomyces pombe*. The average reduction in acidity was 49%, with a range of 18–73%. The study was expanded to a commercial winery where an 18 000-litre lot of Foch and an 11 000-litre lot of de Chaunac were fermented with *S. pombe*. Acid reduction was 24 and 49% respectively. These trials provided considerable information about the problems which might be encountered during commercial fermentation with *S. pombe*.

Hungarian Riesling grapes were treated with the pectic enzyme Irgazyme 100 (Ciba-Geigy) and allowed to stand for 24 h at 20°C, before juice extraction. Yield of free-run juice was increased by 31% and total yield, after pressing, by 11%. Soluble solids,

pH, and titratable acidity were similar for all treatments. Trials with grapes that had been frozen before testing proved inconclusive, because naturally occurring enzymes and cell rupture from freezing and thawing resulted in control yields similar to those of enzyme-treated samples.

*Wine grape variety trials.* Ninety-two cultivars were tested for wine quality and as a result 32 have been eliminated from the program. Labrusca quality, bitter hybrid flavor, and bad cultural properties were the main reasons for deletion. Several numbered selections were evaluated by winery personnel and three whites and six reds were rated equal or superior to standard Hungarian Riesling or de Chaunac wine.

### Dehydrated Apples

A new technique was devised for preparing fully flavored, low-moisture dried apple slices from low-flavored fruit such as that held in controlled-atmosphere (CA) storage. Apple pieces were infused under vacuum with a 30% syrup containing sugar polymers, concentrated apple aroma, and glycerol; then they were vacuum-dried. The sugar polymer apparently became sufficiently concentrated to encapsulate the aroma volatiles before reduced water activity caused them to be lost.

### Fruit Essences and Concentrates

*Encapsulation and storage of essences.* Raspberry and strawberry essences of 5000- to 7000-fold strength were prepared in a pilot plant type of vacuum aroma concentrator. The lower strength of berry essences compared with 30 000- to 40 000-fold apple essence obtained with the same equipment was apparently caused by the lower volatile contents of the berry juices. Berry essences were successfully encapsulated in sugar polymer but water-soluble citrus essences were not. One-third of total water-soluble orange essence was lost during encapsulation and one-third more during drying. Furthermore, patterns of volatiles from oranges changed significantly during storage.

*Browning of concentrates.* Storage tests for 24 wk on a series of samples of apple juice concentrates were completed and results quantified. The extent of browning was determined by measuring the absorbance at 420 nm of solutions diluted to 7.2% solids.

The rate of browning in natural concentrates increased as pH decreased. A semi-log

plot of absorbance vs. pH at 22°C gave a line that had a slope of -0.45 between pH 2.20 and 4.10 and a slope of -0.009 between pH 4.10 and 9.18. This may indicate a considerable difference in browning chemistry at the lower pH levels. Samples of synthetic juice stored at 38°C showed more browning at pH 3.5 than at pH 2.7, a result more in keeping with previously studied browning reactions.

Concentrates stored at high temperature and low pH browned rapidly and reached a plateau beyond which no further browning took place. Other samples did not reach this plateau in 24 wk.

*Pulpy juice concentrates.* Juice products that contain pulp are difficult to concentrate because of the viscosity of their insoluble solids components. Concentrates of apple pulp and tomato juice at fairly high density were prepared by centrifuging out insoluble solids, concentrating the liquid fraction in a vacuum rising film or other suitable evaporator to approximately 72% total solids, and recombining the pulp and concentrate. Apple pulp at 41.5% total soluble solids and tomato paste at 35% total soluble solids were produced by this process. Advantages are the low capital cost for equipment, the greater concentration of the product, and its superior quality because only part of the material is subjected to the concentration process.

## PLANT PATHOLOGY

### Apple Diseases

*Crown rot.* A more sensitive selective medium was developed for the recovery of propagules of *Phytophthora cactorum* (Leb. & Cohn) Schroet. from soil, with which it may be possible to obtain quantitative data on population numbers in orchard soils. Optimum temperature for germination of oospores recovered from soil appears to be 20°C, although appreciable numbers germinate at 15° and 25°C.

*Control of perennial canker.* A canker paint prepared from ziram and linseed oil retained fungitoxicity for 12 mo in the orchard. Some treated cankers were colonized by woolly aphids over this period but there was no evidence of extension of the fungus lesions.

### Sweet Cherry Diseases

*Tomato bushy stunt virus.* Twelve species of native plants and seven common orchard weeds were repeatedly tested for presence of tomato bushy stunt virus (TBSV). It was not recovered from any of the native plants, but occurred occasionally in chickweed, often mixed with other viruses. TBSV was recovered by trap methods from soil samples. Another virus was recovered from these soil samples, which did not resemble either cherry rasp leaf or TBSV, the only known soil-transmitted viruses in this region. TBSV was not recovered from apple trees planted in sites vacated by cherries that were severely affected by TBSV. Transmission of TBSV to cherry by budding with material from infected cherry trees was slow, infrequent, and unpredictable.

*Chlorotic leaf spot virus.* A virus judged to be apple chlorotic leaf spot was recovered from 24 Van, Bing, and Lambert cherry trees out of 194 tested from one planting. The same virus was recovered from cherry seed.

*Little cherry disease.* Virus-like symptoms were induced in *Gomphrena globosa* L. by injecting leaves with partly clarified sap from leaves and blossoms of the oriental flowering cherry and from leaves of the sweet cherry suspected of being infected with little cherry. Similar symptoms were obtained when leaves of *G. globosa* were rubbed with extracts from petals of oriental flowering cherries. The entity transmitted has not been characterized.

### Apricot Disease

Several apricot trees that exhibited symptoms suggestive of virus infection and had unexpectedly low yields proved to be infected with the causal agent of cherry mottle leaf. Previously, this disease was not known to occur naturally in apricots. Adjacent clumps of *Prunus emarginata* (Hook.) Eat. were found to be infected and may have served as the source of infection for the apricots.

### Diseases of Harvested Fruits

*Fungi on stored apples and pears.* Adding sodium lauryl sulfate to ziram greatly increased inhibition of both growth and spore germination in *Mucor piriformis* Fischer over that obtained with ziram alone. *M. piriformis*, which causes a storage rot of pears,



had not been controlled satisfactorily by treatment with fungicides alone. Increased inhibition by this mixture appeared to be associated with leakage of phosphate from cell walls of the fungus.

When harvested fruit was artificially loaded with spores of *Neofabraea perennans* Kienholz, then dipped in Bavistin (BASF), benomyl, or mixtures of these with captan, control of bull's-eye rot was excellent. Captan alone was much less effective.

*Postharvest diseases of stone fruits.* A rapid method was developed for biologic assay of fungicide residues on treated fruit. Disks of fruit skin were removed and placed with the surface side down on a thin agar plate previously seeded with spores of *Rhizopus* spp. for assay of dichloran, or with spores of *Penicillium* spp. for assay of benomyl. Twelve hours later, disks from fruit that had received adequate amounts of fungicide were surrounded by a clear zone 1 cm in diameter or larger.

## POMOLOGY

### Breeding and Variety Evaluation

*Grape breeding program.* Of an original population of 3900 seedlings involving 50 crosses, 60 selections involving 17 crosses remain. Six selections are particularly promising for the production of either Burgundies or Clarets, three are highly promising for the production of white table wines, and one has consistently produced a high-quality Muscatel. Five other selections promise to be better than existing table varieties grown in the interior of British Columbia, based on 3 yr of testing.

*Apricot variety named.* Sundrop apricot was named in 1975. It arose from Perfection, open-pollinated, and was selected in 1956. The tree is medium to large, spreading, very productive, and moderately hardy in both wood and bud. It is more wood-hardy than Blenheim or Perfection and about equal to Skaha and Wenatchee. The fruit buds are hardier than those of Blenheim, Perfection, Skaha, or Wenatchee and about equal to those of Tilton. The fruits are medium to large, larger than those of Blenheim or Wenatchee but smaller than those of Skaha. Skin color develops early and is bright orange before picking maturity has been reached. If the fruits are picked early the

flavor can be quite flat. Sundrop matures about 3 days earlier than Wenatchee. The attractive, round fruits are firm, the texture and flavor fair. Sundrop was named with the support of the New Zealand Fruit Commission who recommended it to their growers.

*Nectarine variety testing.* The following nectarines, in order of ripening, have for several years appeared superior to other varieties in trials at Summerland: Zee Gold (ripening Aug. 1-9), New Jersey N-21 (white-fleshed, excellent and reliable), Ruby Gold, Starks Earliblaze, Cherokee (despite a tendency to russetting), Early Sungrand, Nectared 3, and Starks Red Gold (Sept. 6-9).

### Physiology and Management

*Physiology of spur-type growth in apples.* The discovery of McIntosh mutants that impart their spur-type growth habit to half of their progeny is having a profound effect on our breeding program. A physiological study is being conducted to determine the hormonal basis of this spurry genotype. Absciscic acid levels were found to be similar in normal and spur-type progeny, and a study in progress aims at quantitative and qualitative assessment of endogenous gibberellins.

*Rootstocks and training methods for apple cultivars.* The cultivars McIntosh, Golden Delicious, Harrold Red Delicious, and Sturdeespur Red Delicious (spur-type) were budded onto three rootstocks, MM 111, M 7, and M 26, and established in a replicated planting in 1966. All rows were spaced 4.9 m apart, but tree spacing within rows varied in accordance with rootstock vigor. Trees were trained either to a central-leader bush-tree (Xmas tree) system or to a palmette trellis system.

The most efficient combinations of rootstock and training for the cultivars, as reflected by cumulative yields in the 9th yr of growth, were McIntosh on M 7, Xmas tree, 166.6 t/ha; Golden Delicious on MM 111, Xmas tree, 240.9 t/ha; Harrold Red Delicious on M 25, Xmas tree, 164.4 t/ha; and Sturdeespur Red Delicious on MM 111, Xmas tree, 165.7 t/ha. In no case to date has the palmette system, with its added expenses of trellising, pruning, and tying, resulted in higher yields. However, trellising might have appeared more advantageous if the trellised rows had been spaced optimally.

*Bloom delay in apples with overtree sprinklers.* When cycled overtree sprinkling was applied during periods when the air temperature exceeded 7°C between April 15 and May 15, 1975, full bloom of apples was 15 days later than in an adjacent control block. This technique shows promise for protecting apples from spring frosts.

Trees with bloom delayed by sprinkling are also being used in a long-term study of seasonal effects on fruit maturity. Other trees are induced to bloom early by enclosing them in portable polyethylene tents for several weeks before bloom, and a third group of control trees are allowed to bloom depending entirely on the season. The aim of this study is to determine whether air temperatures in the 30-day postbloom period influence fruit maturity and quality at harvest.

*Management techniques for improving quality of de Chaunac grapes.* Applications of gibberellic acid (GA) and thinning of clusters were tested in an attempt to improve quality of de Chaunac grapes growing in heavy soil. The test confirmed many of the findings of a similar study conducted in 1974 on vines with fairly low vigor growing in a light-textured soil. In both studies, thinning to one or two clusters per bud improved quality substantially. Thinning to two clusters did not reduce yield significantly. In the 1975 test, GA at 40 ppm applied as a foliar spray 10 days after full bloom significantly increased the soluble solids of berries, but did not increase vine yields.

### Harvesting and Storage

*Skin color and firmness of Golden Delicious apples.* Golden Delicious apples were harvested over 5 wk and assessed for skin color and firmness at harvest and after cold and CA storage. The more highly colored apples were found to be firmer at harvest and after storage than green fruits. However, highly colored fruits left to a late harvest date tended to lose this advantage of firmness. From the point of view of quality and storage, well-colored Golden Delicious apples from early harvests are recommended.

*Tissue mineral levels and breakdown of Spartan apples.* Spartan apples from British Columbia and Quebec were subjected to a storage trial and detailed analyses of fruit quality and mineral contents. Apples from Quebec developed much less breakdown in storage than did apples of a similar size from

British Columbia. Mineral contents of the flesh and peel appear to offer the best explanation for this difference. Quebec apples were slightly but significantly higher in calcium in the peel and flesh, but a more striking difference was the high magnesium and potassium in the flesh and peel of British Columbia apples. Because of these mineral contents, the ratio of calcium to other cations was much higher in Quebec apples. Other cations tend to reduce the effectiveness of calcium as a treatment for disorders of senescence.

*Growth regulator to reduce shatter of Patricia grapes.* Vine sprays of 12.5, 25, 50, and 100 ppm of naphthaleneacetic acid (NAA) were applied 8 days before harvest. The pull force required to remove individual berries was not affected by the treatment when measured immediately after harvest or on removal from cold storage after 5, 10, 15, or 20 days. However, bunches held at 20°C for 6 days showed a clear difference resulting from the NAA sprays. In bunches sprayed with 100 ppm NAA, loss of berry removal force during this "shelf-life" period was only one-third that of the unsprayed control.

*Sulfur dioxide atmosphere for grape storage.* Control of decay and moisture loss are two important requirements in cold storage of grapes. Results of tests indicated that Bath grapes, a labrusca-vinifera hybrid, can be stored successfully for 2.5–3 mo if SO<sub>2</sub> is used to control decay. The fruits were enclosed in polyethylene crate liners and SO<sub>2</sub> was provided by an enclosure containing sodium bisulfite, which releases SO<sub>2</sub> at a controlled rate in a humid atmosphere.

The condition, appearance, and flavor of treated fruits were good, whereas decay and moisture loss were excessive in untreated fruits. Benomyl did not control decay effectively, and sealed polyethylene liners retaining about 5% CO<sub>2</sub> were no better than perforated liners in which the CO<sub>2</sub> concentration was negligible.

*Carbon dioxide atmosphere for storage of Bartlett pears.* Bartlett pears respond well to CA storage but such facilities are not generally available because they provide a greater advantage when used for long-term storage of apples. A practical alternative is temporary storage in CA facilities for Bartlett pears



before they are packed and sorted for can-  
nery use. Treatments with a high concentra-  
tion of CO<sub>2</sub> for as little as 10 days followed  
by normal cold storage retarded ripening  
changes and reduced the tendency for core  
breakdown in fruits ripened after 2.5 mo in  
cold storage. Long exposure to more than 2%  
CO<sub>2</sub> sometimes injures pears but in these  
tests 16% CO<sub>2</sub> applied for 10 days caused no  
injury.

## SOILS

### Calcium Dips for Spartan Breakdown

Dipping of Spartan apples in calcium  
chloride solution plus Keltrol (Kelco Com-  
pany) thickener has been adopted by the  
fruit industry in British Columbia for the  
whole crop going into cold storage. The  
solution used commercially contains 4%

calcium chloride and 0.25% Keltrol. Keltrol  
is a commercial food thickener based on  
xanthane gum.

### Trickle Irrigation

No doubts remain that the trickle method  
of irrigation is acceptable for tree fruits, but  
only when the design is sound and the  
equipment functions properly. Intermittent  
flow, which aids in relieving blockage of  
emitters, irrigates about as well as the  
continuous-flow method under some condi-  
tions but provides less lateral spread of water  
in soil than does continuous flow.

### Soil Drainage

About 23% of the water applied to sandy  
loam in lysimeters reappeared as drainage  
and carried with it 48-70% of applied N,  
depending on the presence or absence of  
cover crops. In silt loam, drainage has just  
begun after two seasons.

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# Research Station

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## INTRODUCTION

The Research Station, Vancouver, is the national center for research on plant viruses and serves regional agriculture in problems of plant pathology and entomology.

During the year, little cherry disease became increasingly acute in the Okanagan Valley and threatened to destroy the sweet cherry industry there, as it had previously in the Kootenay region. Consequently, a major assault on this disease was undertaken, combining scientific manpower from the Research Stations in Vancouver, Summerland, and Vineland Station, the Post-Entry Quarantine Station in Sidney, and the British Columbia Department of Agriculture. The main thrust of this cooperative work has been to devise diagnostic methods for detecting the disease before the appearance of overt field symptoms and to identify its vector. Considerable progress in early diagnosis was made with the identification by electron microscopy of ultrastructures that are characteristic of the disease. This discovery led to the development of a rapid method for diagnosis of the disease by fluorescent ultraviolet microscopy. We hope that the search for the vector will be equally productive in the next year or two.

Requests for details of our research program or for reprints of this chapter should be made to individual scientists or addressed to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub  
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## VIRUS CHEMISTRY AND PHYSIOLOGY

### Physical and Chemical Properties of Viruses in vitro

The molecular weight of a spherical virus from saguaro cactus (SV) was estimated to be  $7.9 \times 10^6$ , calculated from its sedimentation coefficient of 118 S and its diffusion coefficient of  $1.22 \times 10^{-7} \text{ cm}^2/\text{s}$ . SV contained 17.2% RNA, calculated from its phosphorus content of 1.66% and the nucleotide composition of its nucleic acid content (29% guanylic acid, 24% adenylic acid, 21% cytidylic acid, and 27% uridylic acid). A single RNA component, a major protein component (90–95%), and two minor protein components were detected by electrophoresis in polyacrylamide gels, and their molecular weights were estimated at  $1.4 \times 10^6$ ,  $3.89 \times 10^4$ ,  $9.02 \times 10^4$ , and  $2.94 \times 10^4$ , respectively. At pHs 4, 5, 6, and 7, SV had three electrophoretic components, but at pH 8 it had only two. The components at pH 7 had similar amino acid compositions. SV dissociated at low levels of sodium dodecyl sulfate (SDS) (0.05% SDS at pH 7 and 0.10% at pH 5) and is probably held together by protein–RNA interactions. SV was not related serologically to sowbane mosaic, southern bean

mosaic, tobacco necrosis, carnation mottle, turnip crinkle, tomato bushy stunt, cucumber necrosis, or carnation ringspot viruses.

Polyacrylamide–SDS gel electrophoresis indicated that cauliflower mosaic virus (CIMV) particles contain two major structural polypeptides and possibly a minor one, with molecular weights of  $6.8 \times 10^4$ ,  $4.2 \times 10^4$ , and  $5.5 \times 10^4$ , respectively. Up to seven other minor bands produced by disrupted virus material were probably degradation products or stable aggregates of the structural polypeptides. The amino acid composition of CIMV protein differs from that of most other plant viruses in containing about 18% lysine. This unusually large content of a basic amino acid suggests that at least one polypeptide has a strong affinity for DNA.

### Virus Infection

Several compounds suppress disease symptoms caused by virus infections in plants. True inhibitors interfere with the infection process itself, whereas virus inactivators are inhibitory substances that denature or alter the virions directly. Naturally occurring inhibitors of virus establishment, which is the first phase in virus infection, are widespread in the plant order Centrospermae. These inhibitors are small proteins with molecular weights of about  $1.4 \times 10^4$ ; they contain



ε-amino groups of lysine, whose number and spacing are critical in acting as functional groups. There is good circumstantial evidence that carboxyl groups are also essential for biological activity. The molecular configuration of these inhibitors enables them to compete with the nucleic acid moiety of the virus for a limited number of pertinent receptor sites near the leaf surface. Representatives of this group of virus-inhibitory proteins probably occur also in species outside the Centrospermae.

High CO<sub>2</sub> concentrations in the atmosphere were found to affect drastically the response of hyperimmune hosts to virus infection. When two *Nicotiana* species were exposed to 1% CO<sub>2</sub> during the simulated daylight period, lesions induced by tobacco mosaic virus (TMV) or turnip mosaic virus (TuMV) were greatly reduced in size and number. In plants exposed to 1% CO<sub>2</sub> during the dark period, the lesions were small, and yellow instead of the usual brown. Lesions in plants exposed to 1% CO<sub>2</sub> continuously were also yellow. Yellow TMV lesions often contained a new type of virion aggregation called a zipper aggregate, which showed that variations in the environment influenced its formation.

To determine whether the CO<sub>2</sub> affected the establishment phase or the multiplication phase of the infection process, virus production was investigated in the systemic host *Nicotiana tabacum* L. Plants kept in air produced more than a hundred times as much TMV as did those kept in 1% CO<sub>2</sub>. The much lower concentration of particles was correlated with reduced viral RNA synthesis and therefore did not merely reflect an interference by the CO<sub>2</sub> with virion assembly. Immuno-osmophoric evidence suggested that viral protein synthesis was also affected. No viral-inhibitory substance was formed in the CO<sub>2</sub>-treated plants. These findings strongly support other evidence that TMV multiplication may depend on photorespiration.

### Ultrastructural Responses to Virus Infection

Free virus particles were observed in the cytoplasm and nuclei of mesophyll cells of *Dianthus barbatus* L. infected with carnation ringspot virus. Tubular structures were observed in the nuclei of *D. barbatus* and cowpea, *Vigna sinensis* (L.) Endl.; spherical inclusions 60–65 nm in diameter were found

in the nuclei of *D. barbatus* only. The tubules contained protein and sometimes preceded by a short time the appearance of virus particles. Their diameter of about 32 nm was only slightly larger than that of the virus particles, with which they were closely associated. The virus particles were frequently enclosed in a row within the tubules. The spherical inclusions in *D. barbatus* nuclei were embedded in what appeared to be a matrix of chromatin; they appeared to be neither virus particles nor nuclear membrane pores. The functions of the tubular structures and spherical inclusions are not known; it is unlikely that the tubules represent the site of viral synthesis.

Leaves from apple trees infected with apple chlorotic leaf spot virus and from trees showing some witches'-broom symptoms contained hexagonal tubular structures in their sieve tubes. However, because these structures were also present in leaves from indexed trees free from known viruses, they appear to be normal components of sieve tubes in apple leaves.

### Virus Transmission by Seed

Several forms of southern bean mosaic virus (SBMV), sedimenting at different rates, were observed when the virus was extracted from seed coats of brown or white beans at various stages of maturity. In extracts from immature, turgid, white seed coats, monomeric and dimeric sedimentation patterns were seen; in extracts from mature seed coats the monomer and a slower-sedimenting form of SBMV were detected. In extracts from immature brown seed coats, monomeric SBMV and a second form, sedimenting at a rate between monomer and dimer, were found; mature seed coats yielded the second form only.

Bioassays for the presence of pea seed-borne mosaic virus (PSbMV) in 264 seed lots of pea produced in Canada indicated that the virus is mainly confined to breeding lines. All 35 lines submitted by pea breeders were infected with the virus to varying degrees (6–80%). About 10% of 229 pedigree and commercial seed lots submitted were also infected, but the level of infection within lots was less than 2%. Phytosanitary procedures are strongly recommended to breeders for controlling the disease.

## Aster Yellows Disease

Callus tissue originating from the phloem of carrots infected with aster yellows contained mycoplasma-like bodies (MLBs) in the primary cultures only. In subsequent transfers the MLBs underwent gradual degeneration ending in their total disappearance within 80 days. Three ultrastructural changes were observed. After 30 days, MLBs lost their round shape and became filamentous and intensely staining. Subsequently, the bounding membranes ruptured and the MLBs disintegrated. After differentiation, which occurred earlier in infected than in healthy cultures, the new phloem tissue did not contain MLBs.

Polyribosomes were isolated by sucrose gradient centrifugation from tissue cultures from healthy carrots and carrots infected with aster yellows. Host polyribosome formation was reduced 40–50% during aster yellows infection. This decrease was directly proportional to the duration and intensity of the infection. Sonicated primary-infected tissue yielded higher levels of polysomes than did nonsonicated infected controls. Thus, it appears that a substantial amount of the translational process is carried out by the MLBs. After differentiation polyribosome levels returned to normal in the infected tissues.

## PLANT PATHOLOGY

### Virology

*Little cherry disease.* Five methods were tested for detecting little cherry disease before the appearance of fruit symptoms.

Electron microscopy revealed abnormal structures in phloem parenchyma and companion cells of midribs and petioles. The structures were consistently correlated with the disease in sweet and oriental flowering cherry. They were of two forms: elongated, flexuous rods about 12.0–12.5 nm in diameter, usually arranged in large aggregates; and vesicles about 75 nm in diameter, mostly spherical or ellipsoid, bounded by a double membrane, and containing fibrous strands radiating from an electron-dense center. The vesicles were often intermingled with the flexuous rods and were always attached to the inner surfaces of membranes that line large vacuoles in the cytoplasm.

Fluorescent microscopy revealed deposits on the walls of phloem cells of petioles and peduncles. These deposits became brilliant yellowish-white when stained with Acridine Orange. They were numerous in infected tissues but rare in healthy ones. The color was not typical of RNA. Staining with a mixture of Safranin – tannic acid – Orange G indicated that the deposit had properties of cell wall material other than those of lignin. This phenomenon was not evident in very young tissues and was not visible until the leaves were fully extended.

Pyrolysis – gas chromatography, histological staining, and thin-layer chromatography showed no diagnostic differences between healthy and infected material.

*Virus identification and characterization.* Serological comparisons of cherry rasp-leaf virus with a number of nematode-transmitted viruses showed that it is distinct from tomato ringspot virus but has some antigenic sites in common with it.

Poplar mosaic virus, which occurs throughout Canada and Europe, was shown to have filamentous particles mostly 670–690 nm long. In *Nicotiana clevelandii* A. Gray the particles were scattered throughout the cytoplasm of palisade, mesophyll, and parenchyma cells and were loosely aggregated adjacent to chloroplasts and mitochondria. The size and intracellular occurrence of the virus suggest that it belongs to the carlavirus group. The vector is unknown.

### Virus-Free Potatoes

One or more clones of 89 cultivars and seedlings, rendered virus-free since the program began in 1966, were grown in isolation plots and checked for potato viruses X (PVX), S (PVS), M, spindle tuber, and leaf roll. In the spring of 1975 tuber samples were sent on request to potato improvement agencies in six Canadian provinces, five states of the USA, Australia, and South Korea.

Seed from the virus-free program has been in general use by growers in the Pemberton and Cariboo districts since 1970. Tests are made annually to determine the extent of reinfection by PVX and PVS in fields planted with the grades Elite 3 and Foundation. In 1975 none contained more than 1.2% PVX or 5% PVS and, of 166 ha (411 ac) tested, 94.6% contained 0–2% infection ( $P = 0.05$ ).



Five virus-free clones of the cultivar Netted Gem, two from British Columbia selections and three from Idaho, each developed from a meristem tip culture, were identical in field trials. All possessed characteristics typical of the cultivar.

### Small Fruits

*Strawberry.* Several recent selections from the breeding program compared favorably with Totem in yield and various fruit qualities. Each has one or more special features that might, after further testing, justify consideration for cultivar status. Selection 70-17-12 (Totem × Olympus) seems particularly well adapted to the late fresh market. The fruit is firm and very bright and glossy red, and shows the lowest susceptibility to fruit rot, caused mainly by *Botrytis cinerea* Pers., of any other selection or cultivar that has been tested in the program. Selection 70-20R-15 (NY 844 × Totem) has also shown low susceptibility to fruit rot. Its fruit is particularly easy to harvest and therefore may be suited to mechanical harvesting. Selection 70-22-72 (Cheam × Valentine) produces early fruit of high quality suitable for the fresh market.

*Raspberry.* Virus-free raspberry plants were developed from source plants infected with raspberry bushy dwarf virus by propagating shoot tips after prolonged heat treatment at 32–36°C or 37–42°C. Small tip cuttings were excised periodically during treatment, dusted with rooting hormone, and planted in washed sand. As compared with plants grown at 32–36°C, those grown at 37–42°C produced many more axillary shoots, which rooted as cuttings twice as readily, and the virus was eliminated earlier. Of the cuttings taken from plants after 2 mo at the higher temperature, 80% rooted, and half of these were virus-free.

The sensitivity of raspberry cultivars to tomato ringspot virus was determined in field trials of graft-inoculated plants. Lloyd George and Avon were severely affected; Latham, Glen Clova, Meeker, and Matsqui showed an intermediate reaction; and Malting Jewel, Puyallup, and Canby were least affected.

The inheritance of resistance to *Didymella applanata* (Niessl) Sacc., a primary factor in causing raspberry dead bud disease, was determined to be quantitative and predominantly additive. The cultivar Haida was an

effective parent in the transmission of this resistance. The seedling 69-6-17, derived from Cuthbert, proved to be a valuable source of resistance to *Botrytis cinerea* Pers., the main cause of fruit rot.

*Blueberry and cranberry.* Registration was obtained for triforine for controlling mummy berry, a disease of highbush blueberry caused by *Monilinia vaccinii-corymbosi* (Reade) Honey, and this compound greatly reduced incidence of the disease in 1975. Tests have also shown that triforine is far more efficient than any other currently registered fungicide for controlling cotton ball, a disease of cranberry caused by *Monilinia oxycocci* (Wor.) Honey. Efficacy and residue data indicate that registration is warranted for use of triforine on cranberry.

Benomyl and triforine sprays failed to reduce the number of infections (cankers) on highbush blueberry caused by *Godronia cassandrae* Pk. f. *vaccinii* Groves (stat. conid. *Fusicoccum putrefaciens* Shear).

### Nematodes

*Pratylenchus penetrans* (Cobb) Filipjev & Stekh. and *Xiphinema bakeri* Williams, separately or together, considerably reduced cane growth and fruit yield of newly planted raspberries. The two together caused less mortality in transplants than did *P. penetrans* alone.

Transmission by *Paralongidorus maximus* (Bütschli) Siddiqi of 20 nematode-borne viruses was tested by three methods. (A) Infected plants, bait plants, and nematodes were grown together in the same pot of soil. (B) Nematodes were allowed to feed on infected plants; then they were extracted from the soil and transferred to bait plants. (C) After feeding on infected plants, nematodes were extracted from the soil, washed, crushed, and inoculated into indicator plants. Four viruses were recovered from the roots of bait plants in method A, but none in method B. In method C nine viruses were recovered directly from the nematodes, but only three of these were also recovered from the roots of bait plants. The other virus recovered from bait plants was not recovered from crushed nematodes.

These results show that *P. maximus* is not a specific vector of any of the 20 viruses, but that it has the capacity to transmit four of them under certain conditions. Recovery of only nine viruses from macerated nematodes

suggests selective destruction of the other 11 viruses.

## ENTOMOLOGY

### Vectors

*Little cherry disease.* Search for an efficient vector of the disease was continued in cooperation with entomologists at Summerland. Because electron microscopy showed no mycoplasma-like agent in diseased tissue, leafhopper surveys were mostly replaced by aphid and mite surveys. Tests with leafhoppers were restricted to five species: *Macrostelus fascifrons* (Stål), *Colladonus montanus* (Van Duzee), *C. geminatus* (Van Duzee), *Scaphytopius acutus* (Say), and *Fieberiella flori* (Stål). Five aphids, namely *Myzus persicae* (Sulz.), *M. cerasi* (F.), *Hyalopteris pruni* (Geoffroy), *Rhopalosiphum crasifoliae* (Fitch), and *Brachycaudus helichrysi* (Kltb.), and one species of mealybug, *Phenacoccus aceris* (Sign.), were also tested as vectors. More than 700 transfer tests were conducted.

To determine the season during which natural field infection occurs, 50 trees were exposed each month, from April to September, in infected orchards. These trees will be observed for 2 yr for symptom development.

*Morphology and fine structure.* Four aphid species were added to those already examined in a comparative study of mouthparts: *Cavariella aegopodii* (Scop.), *Myzus cerasi* (F.), *Cinara pinea* (Mord.), and *C. sp.* near *pseudotsugae* (Wils.). Improved micrographs were taken of some species examined earlier.

*Aphid species.* Fifty-eight species were added to the basic taxonomic list of aphids and hosts in British Columbia. Of these, 22 aphids were previously unknown in the province, 10 were new to science, and 26 were identifiable to genus only. The additions bring the number of known aphid species in British Columbia to 283. Aphids were collected from 162 plant species not on the original list.

*Aphid ecology.* Eleven European cultivars of fababeans and one broad bean cultivar, Broad Windsor, were bioassayed for resistance to the pea aphid, *Acyrtosiphon pisum* (Harris). There were differences in resistance between cultivars, but no cultivar had significant resistance.

### Pest Control

*Wireworms.* The European wireworm, *Agriotes obscurus* L., is making a strong comeback and remains a persistent problem 10 yr after the phasing out of organochlorine soil treatments. Some methods of chemical control were evaluated in 1975. Three techniques for applying various chemicals as granules to potatoes and sweet corn, where the wireworm population in untreated areas was 63/m<sup>2</sup>, were tested in each crop. A broadcast application of fonofos in potatoes and a furrow treatment in corn with fonofos and either of the still-unregistered organophosphates AC 92100 (Cyanamid) and N 2596 (Stauffer) controlled wireworms the best. The furrow treatments were effective at one-fifth the rate of the broadcast treatment.

*Leatherjackets.* Populations of the European crane fly, *Tipula paludosa* Meigen, whose larvae are the grassland pests known as leatherjackets, continued to decline. Part of the decline may be ascribed to biological control by at least one parasitic species of *Nosema* and four parasitic gregarines. The parasitic tachinid fly *Siphona geniculata* De Geer is now established over about 240 km<sup>2</sup> around the original release site, so that 500 adults could be collected for redistribution in the Fraser Valley and Delta. To add to the gene pool, 450 flies from Switzerland and Austria were released.

*Weeds.* On Vancouver Island some resurgence of the poisonous weed tansy ragwort, *Senecio jacobaea* L., occurred despite a fourfold increase in the cinnabar moth, *Tyria jacobaeae* (L.), in the spring. The weather did not favor the larvae in the summer and did favor strong regrowth of the weed in the fall. Two adult specimens of the flea beetle *Longitarsus jacobaeae* Watr. were recovered where several hundred had been released in 1971, 1972, and 1974. Larvae were also found in the roots of tansy ragwort.

Two European trypetid flies, *Urophora stylata* (F.) and *U. cardui* (L.), that cause galls in bull thistle and Canada thistle, respectively, were released in 1973. *U. stylata* appears to be well established at three sites; the establishment of *U. cardui* is doubtful. The European weevil *Ceutorhynchus litura* (F.) was placed in cages containing Canada thistle. Mines made by the larvae were found in stems and root collars.



*Root maggots.* Four types of brassica crops were grown in soil treated with various combinations of five granular insecticides and two herbicides. During the growing season sprays containing methomyl or *Bacillus thuringiensis* (Berliner) were also applied to the crops to gauge the efficacy of these combined treatments against aphids and caterpillars. The lowest numbers of pests overall were in plots treated with disulfoton granules and supplementary sprays of methomyl. Granules of the fairly new organophosphorous compound Counter (Cyanamid) were nearly as effective. In controlling caterpillars, the bacterial spray Dipel (Abbott) was only marginally better than methomyl. Against root maggots carbofuran and Counter were highly and uniformly effective. An unusual and disturbing observation was the presence of mature root maggots within the Brussels sprouts, 30 cm above the ground.

Populations of predators and parasites were estimated from nine species of carabids and five of staphylinids that were trapped in pits. Some of the carabids were unexpectedly numerous: *Bembidion lampros* (Hbst.), 34 580/ha; *Clivina fossor* (L.), 10 620/ha; *Calathus fuscipes* (Goeze), 5930/ha; and *Harpalus affinis* Schrk., 1980/ha. An effective staphylinid parasite of root maggot puparia, *Aleochara bilineata* Gyll., averaged more than 4940/ha. Narrow-band application of fairly short-lived insecticides should help to preserve large numbers of these beneficial insects.

*Potato pests.* Sixteen insecticides to control the aphid *Myzus persicae* (Sutzer) and the flea beetle *Epitrix tuberis* Gentner were evaluated. Each insecticide was applied singly at different rates, twelve at planting time as granules in bands, and four as sprays during the growing season. Five of the compounds applied as granules were also applied later as supplementary sprays. No treatment controlled both aphid populations and tuber damage by flea beetles. Five treatments significantly reduced damage by flea beetle larvae, but no treatment significantly reduced the numbers of aphids. Plots treated with fensulfothion, methidathion, and Bay 92114 (Bayer) had populations of aphids significantly higher than those in control plots. The same phenomenon was seen with fensulfothion and methidathion in 1974.

### Residue Chemistry

*Fungicide residues.* A study was made of the fungicide triforine (Cela W524; Celamerck GBMH and Co.), applied to highbush blueberries and to cranberries for control of infection from *Monilinia* spp. Based on the results, triforine is registered for use against mummy berry in highbush blueberries and is requested for use against cotton ball in cranberries.

*Carbamate residues.* The cause of unusually rapid degeneration of carbofuran in an Okanagan vineyard soil was found to be microbial. The organisms responsible for the breakdown were several species of actinomycete.

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PROGRAM STRUCTURE			July 1979
RESEARCH BRANCH CANADA AGRICULTURE			
AIM	OBJECTIVES	GOALS	
DEPARTMENTAL AIM To develop a viable and self-sustaining agricultural industry based on free trade and efficient agricultural practices.	FORAGE CROPS	1 To improve the efficiency of production and the quality of forage crops	<p>1 By 1978, to have developed the technology to make possible an increase in the unit yield of digestible, dry matter of forage crops by 10%, through the development of improved management practices, the development of superior varieties and increased seed production.</p> <p>2 By 1978, to have developed the technology to make possible an increase in the unit yield of digestible, dry matter of forage crops by 10%, through the development of improved management practices, the development of superior varieties and increased seed production.</p> <p>3 By 1978, to have determined the potential for successful biological control of twenty-five major weeds through the selection, establishment and assessment of suitable biotic agents.</p> <p>4 By 1978, to have identified and prescribed selected physiological schemes to develop tolerance to winter hardiness and to show how this information can be used to improve the efficiency of crop production.</p> <p>5 By 1978, to have increased the production potential of selected soils and to have improved soil management practices through the development of improved methods of irrigation, drainage and other crops through studies of selected soil reactions.</p>
	OLSEED CROPS	2 To improve the efficiency of production, adaptability and quality of oilseed crops and their products	<p>1 By 1978, to have provided new information and technology that will make possible a 5% increase in unit yield of rapeseed and mustard and an improvement in the quality of seed and oil.</p> <p>2 By 1977, to have provided new information and technology that will make possible a 10% increase in unit yield of sunflower seed while maintaining or improving quality of the seed and oil.</p> <p>3 By 1978, to have provided new information and technology that will make possible a 5% increase in unit yield of soybeans and an increase in their value as a crop in non-federal crop areas, while maintaining quality to meet market demand.</p> <p>4 By 1977, to have provided new information and technology that will make possible a 5% increase in unit yield of flax while maintaining or improving quality to meet market demand.</p> <p>5 By 1978, to have developed one or more management systems that control insect pests in rapeseed crops, without benefit cost reduction, and maintain environmental degradation.</p>
	HORTICULTURAL CROPS	3 To improve the efficiency of production and the quality of horticultural crops	<p>1 By 1978, to have developed new information and technology that will make possible an increase in unit yield of fruit crops by 10%, through the development of improved management practices, the development of superior varieties and increased seed production.</p> <p>2 By 1977, to have developed new information and technology that will make possible an increase in unit yield of berries by 10%, while achieving higher standards of fresh and processed quality through the development of improved cultivars and better management practices.</p> <p>3 By 1978, to have developed new information and technology that will make possible an increase in unit yield of vegetable crops by 5%, while achieving higher standards of fresh and processed quality through the development of improved cultivars and better management practices.</p> <p>4 By 1978, to have developed new information and technology that will make possible an increase in unit yield of potatoes by 5%, while achieving higher standards of fresh and processed quality through the development of improved cultivars and better management practices.</p> <p>5 By 1977, to have developed new information and technology that will make possible the production of 10 new crops of selected horticultural crops.</p> <p>6 By 1978, to determine the effectiveness of action, persistence, degradation and soil biotic compounds developed to control diseases and pests of crops and animals.</p> <p>7 By 1977, to provide the biochemical and ultrastructural basis for the understanding of plant infection by viruses and mycoplasmas, their movement in plants, and vector-host relationships.</p> <p>8 By 1978, to have developed the technology to make possible the identification of crop diseases in Eastern Canada, to have elucidated the host-parasite relationships and the effective use of nematodes for the integrated control of diseases of selected crops.</p>
	CEREAL CROPS	4 To increase the efficiency of production and the quality of cereal crops	<p>1 By 1978, to have provided new information and technology that will make possible an increase in unit yield of durum, winter and spring wheats by 5%, while maintaining the quality of each crop to meet market demands through the development of superior varieties and improved management practices.</p> <p>2 By 1978, to have provided new information and technology that will make possible an increase in unit yield of barley by 10%, while maintaining the quality to meet market demands, through the development of superior varieties and improved management practices.</p> <p>3 By 1978, to have provided new information and technology that will make possible an increase in unit yield of wheat by 10%, through the development of superior varieties and improved management practices.</p> <p>4 By 1977, to have provided new information and technology that will make possible an increase in unit yield of corn through the development of improved cultivars and better management practices.</p> <p>5 By 1978, to have provided the new information and technology that will make possible an increase in unit yield of water rye by 10%. Through the development of superior varieties and improved management practices.</p> <p>6 By 1978, to have developed assessment methods for determining the losses caused by pest in cereal plant diseases.</p> <p>7 By 1977, to have determined biological, biochemical and morphological factors of soil-borne pathogens primarily responsible for root rots, and to use the information for disease control.</p> <p>8 By 1978, to have developed environmentally safe and efficient methods for controlling selected weeds with herbicides, through studies of their mode of action, methods of application, and their persistence in the environment.</p> <p>9 By 1980, to have derived selected climatological and meteorological indices which will contribute to improved decisions in weather sensitive agricultural operations: to provide the information for the development of crop insurance programs, and to contribute to the interpretation of climate data for selected research programs.</p> <p>10 By 1978, to develop procedures for assessment and reclamation of "problem soils" by determining the interrelationships between physical properties and other factors affecting the productivity of these soils.</p>
	FIELD CROPS	5 To improve the efficiency of production and the quality of field crops such as tobacco, leaf peas, buckwheat, sugar beets, non-crop and others	<p>1 By 1978, to have provided new information and technology that will permit a better understanding of tobacco quality and make possible a 10% increase in unit yield of tobacco through the development of improved management practices, and the application of knowledge on quality characteristics.</p> <p>2 By 1978, to have provided new information and technology that will make possible a 10% increase in unit yield of leaf peas, while maintaining or improving quality to meet market demands, through the development of superior varieties and improved management practices.</p> <p>3 By 1977, to have provided new information and technology that will make possible a 10% increase in unit yield of buckwheat while maintaining or improving quality to meet market demand, through the development of superior varieties and improved management practices.</p> <p>4 By 1978, to have completed and published ecological studies of selected weeds, including their biology, ecology, host-parasite relationships, spatial occurrence, life cycles, reactions to herbicides, etc., other biological characteristics.</p> <p>5 By 1978, to have assessed the production and market potential of 10 new crops and to have demonstrated how to grow, protect and utilize 5 new crops previously identified as having potential.</p> <p>6 By 1979, to have provided new information and technology that will make possible a 5% increase in unit yield of sugar beets, through the development of superior varieties and improved management practices, through the development of superior varieties and improved management practices.</p>
	LAND AND WATER RESOURCES	11 To obtain a reliable inventory of Canadian soil, climate and water resources, and to evaluate the potential of these resources for agriculture and other uses	<p>1 By 1980, to have completed an inventory and interpreted the capability of soil resources in selected regions of Canada.</p> <p>2 By 1980, to have improved the basis for classification and mapping of soils through development of more reliable methods and criteria.</p>
	BIOSYSTEMATICS	12 To clarify the taxonomy of vascular plants, insects, arachnids, myriapods, nematodes and fungi occurring in Canada	<p>1 By 1980, to complete the taxonomy of selected groups of important vascular plants, particularly those relating to Canadian agriculture, which will assist plant breeders in developing new improved varieties to complete genetic surveys of selected areas, and to provide the information for the development of improved management practices.</p> <p>2 By 1980, to complete the taxonomy of selected groups of important insects, arachnids, myriapods and nematodes, particularly those relating to Canadian agriculture, to complete surveys and inventories of the groups occurring in selected geographical regions of Canada, and to develop a reliable national collection.</p> <p>3 By 1980, to have completed the taxonomy of fungi important in plant, animal and human environments, to complete surveys and inventories of the fungi occurring in selected geographical areas, and to develop and maintain the national collection of fungi and fungal cultures.</p>
	DAIRY CATTLE	13 To improve the efficiency of production and the quality of dairy products	<p>1 By 1978, to have synthesized a new high performance breed of dairy cattle, and to be using it in a cross-breeding program with Holsteins.</p> <p>2 By 1978, to have increased by 5% the yield of milk per unit digestible energy input.</p> <p>3 By 1978, to have solved selected problems in the production of disease resistant milk, with improved methods of selection, breeding and management, and to have developed procedures, methods which allow more efficient utilization of why.</p>
	BEEF CATTLE	14 To improve the efficiency of production and the quality of beef products	<p>1 By 1978, to have increased yield of beef per breeding cow by 10%, and yield of beef per unit digestible energy by 5% through a program of selection and crossbreeding.</p> <p>2 By 1978, to have increased calf yield per cow (7%) and per acre (10%) through multidisciplinary research of cow-calf systems, management, nutrition and other factors.</p> <p>3 By 1977, to have increased the efficiency of beef production by 5% of meat animals in the first year of improved meat quality through multidisciplinary research.</p> <p>4 By 1978, through an interdisciplinary and cross-disciplinary program primarily in industry and at universities, to develop improved methods of carcass handling and reduction: better utilization of carcasses and by-products, and improved methods of processing, and to develop improved methods of production and utilization of meat products, and to develop improved methods of processing and utilization of meat products.</p> <p>5 By 1980, to have achieved a better understanding of mechanisms controlling animal reproduction and to have developed practical procedures for increasing reproductive potential.</p> <p>6 By 1978, to have defined the potential hazard arising from certain naturally occurring toxins in important feed and food plants, toxins of microbiological origin in feeds, pesticides residues, and to have developed practical methods of producing domestic animals. (Supports all animal research.)</p>
	SHEEP	15 To improve the efficiency of production and the quality of products from sheep	<p>1 By 1978, to have increased lamb production per ewe by 15%, and growth rate of lambs by 10%.</p>
	SWINE	16 To improve the efficiency of swine production and the quality of products from swine	<p>1 By 1978, to have increased yield of pork per unit digestible energy by 5% while improving product quality.</p>
	POULTRY	17 To improve the efficiency of production and the quality of products from poultry	<p>1 By 1977, to have increased egg yield per hen housed by 5% and to have improved interior and shell quality.</p> <p>2 By 1978, to have increased the yield of poultry meat per unit of dietary energy input by 10%.</p>
	OTHER ANIMALS AND HONEY BEES	18 To improve the efficiency of production of other animals and bees and to improve the quality of their products	<p>1 By 1978, to have increased the productivity of honey bees by 2%, through phenomena chemistry, control of diseases and improved management practices.</p> <p>2 By 1978, to have defined selected nutritional requirements and physiological processes of fur animals which will increase production per unit by 10%.</p>
	ENVIRONMENTAL QUALITY	20 To identify, measure, establish the significance of environmental quality factors and pollutants affecting the utilization or quality of soil, plants, animals, food, air and water	<p>1 By 1978, to have analyzed existing animal and crop production management systems in order to determine the potential for improvement in environmental quality standards and energy conversion.</p> <p>2 By 1978, to have analyzed existing pesticide management systems in order to determine their compatibility with environmental quality standards and economic trends and to have developed improved methods of production and utilization of pesticides.</p> <p>3 By 1978, to have developed a model or models for predicting the maximum levels of plant nutrients which may be tolerated in agricultural soils without creating high water pollution using soil toxic, hydrological and climate parameters.</p> <p>4 By 1978, to have identified and measured the most important non-agricultural polluting agents, and to have developed practical methods of controlling these agents.</p>
	SERVICE GOALS		<p>1 To make available to Research Scientists and to the technicians of the Research Branch the support and facilities necessary for the development of new information and technology, and to make available to the public the information and technology developed by the Research Branch.</p> <p>2 To make available to the public the information and technology developed by the Research Branch, and to make available to the public the information and technology developed by the Research Branch.</p> <p>3 To make available to the public the information and technology developed by the Research Branch, and to make available to the public the information and technology developed by the Research Branch.</p> <p>4 To make available to the public the information and technology developed by the Research Branch, and to make available to the public the information and technology developed by the Research Branch.</p>
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This chart has been prepared using the new objective and goal structure adopted by the Research Branch in December 1978.





PROGRAM STRUCTURE  
ACTIVITIES OF RESEARCH ESTABLISHMENTS

July 1, 1976

OBJECTIVES ESTABLISHMENTS													Environmental and honey bees	Poultry
	Forage crops	Oilseed crops	Horticultural crops	Cereal crops	Field crops	Land and water resources	Biosystematics	Dairy cattle	Beef cattle	Sheep	Swine			
St. John's West	•		•							•				
Charlottetown	•		•	•	•			•	•					
Kentville	•	•	•	•	•							•		
Fredericton	•		•	•	•			•	•	•			•	
L'Assomption					•									
Lennoxville	•			•				•	•	•	•			
Sainte-Foy	•			•										
Saint-Jean			•											
Delhi					•									
Harrow		•	•	•	•									
Ottawa	•	•	•	•								•		
Vineland Station			•											
Animal Research Institute		•						•	•	•	•	•	•	•
Biosystematics Research Institute							•							
Chemistry and Biology Research Institute	•		•	•					•		•	•	•	•
Food Research Institute		•	•	•	•			•	•					
Soil Research Institute	•			•		•							•	
Research Institute, London			•	•									•	
Engineering Research Service	•	•	•	•	•			•	•	•	•		•	•
Ornamentals Research Service			•											
Statistical Research Service	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Brandon	•	•		•					•		•			
Morden		•	•	•	•									
Winnipeg		•		•										
Melfort	•	•		•	•				•		•			
Regina	•			•	•									
Saskatoon	•	•		•					•				•	
Swift Current	•			•					•					•
Beaverlodge	•	•		•					•				•	
Lacombe	•	•		•					•					
Lethbridge	•	•	•	•	•			•	•	•			•	•
Agassiz	•		•	•				•	•					•
Kamloops									•					
Sidney			•											
Summerland			•											
Vancouver	•		•	•										

This chart has been prepared using the new objective and goal structure adopted by the Research Branch in December 1975.





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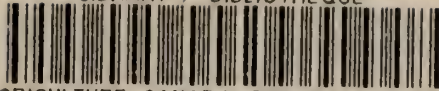
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