

RESEARCH BRANCH REPORT

❧ 1976-1978 ❧

RAPPORT DE LA DIRECTION DE LA RECHERCHE

AGRICULTURE CANADA

9 JAN 1980

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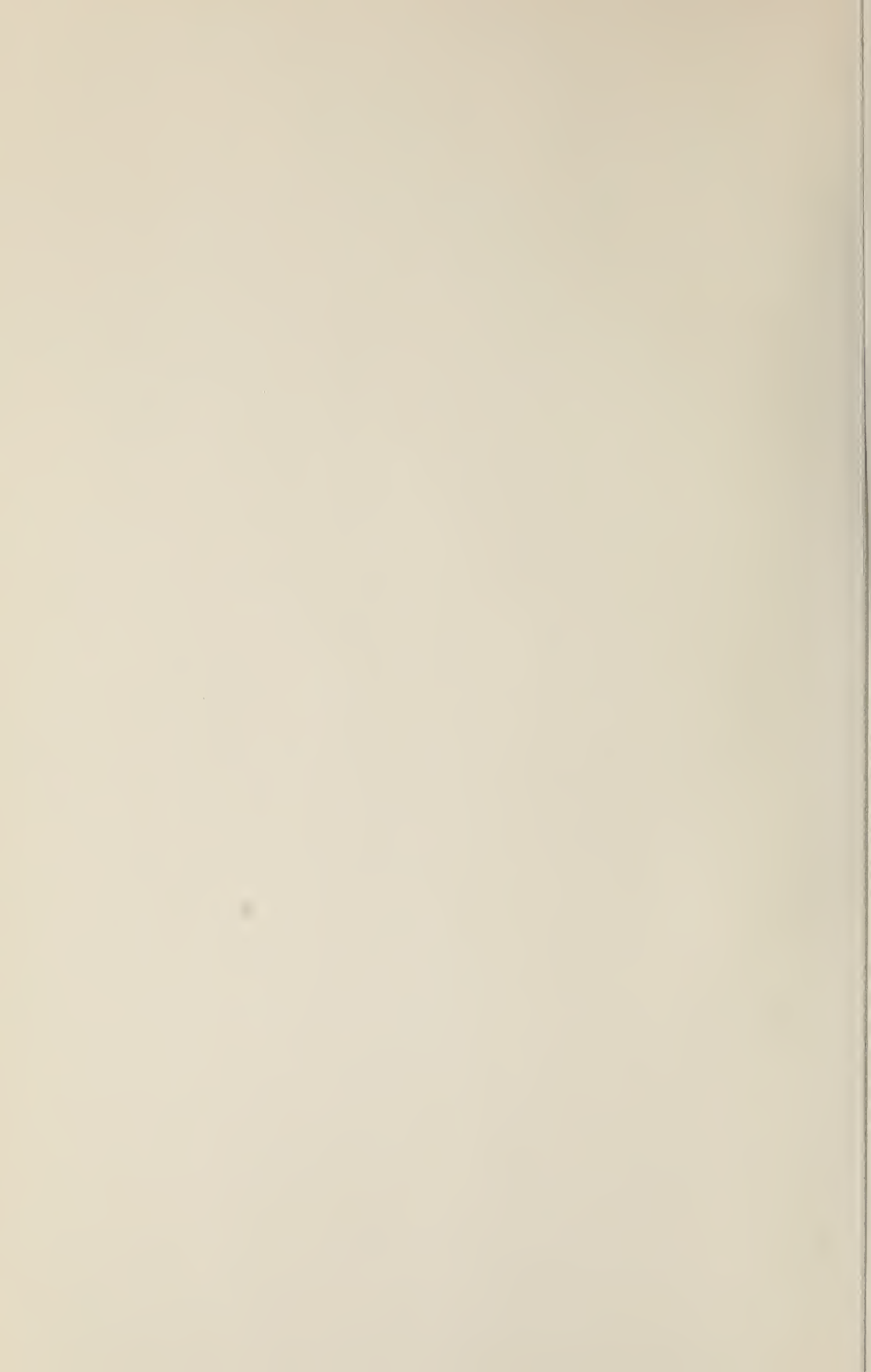
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Research Branch Report

1976-1978

Rapport de la Direction de la recherche

RESEARCH BRANCH
DIRECTION DE LA RECHERCHE

AGRICULTURE CANADA

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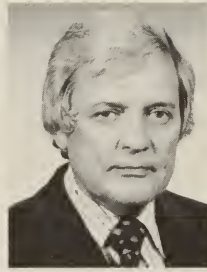
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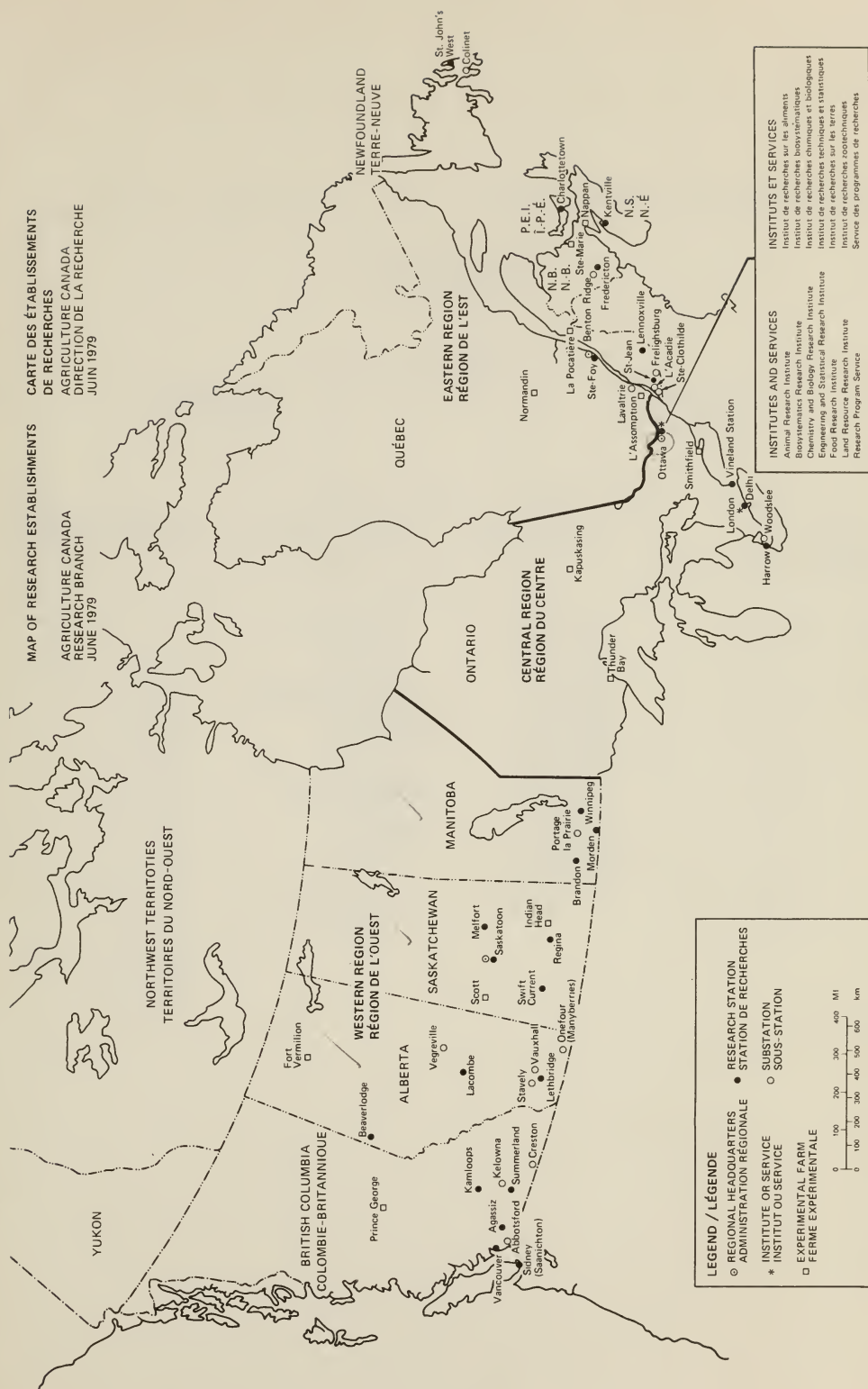
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Chief, Administration Section <i>Chef, Section de l'administration</i>	H. D. BRANNEN

MAP OF RESEARCH ESTABLISHMENTS

AGRICULTURE CANADA
RESEARCH BRANCH
JUNE 1979

CARTE DES ÉTABLISSEMENTS DE RECHERCHES

AGRICULTURE CANADA
DIRECTION DE LA RECHERCHE
JUIN 1979



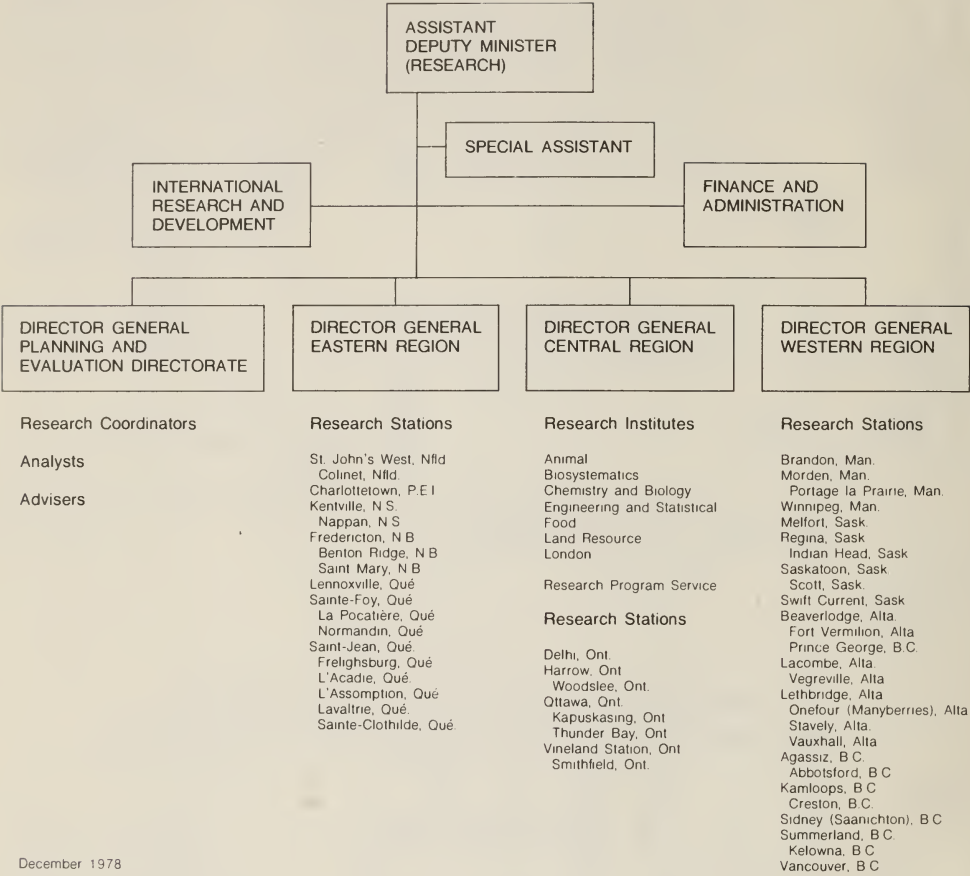
LEGEND / LÉGENDE

- REGIONAL HEADQUARTERS / ADMINISTRATION RÉGIONALE
- RESEARCH STATION / STATION DE RECHERCHES
- * INSTITUTE OR SERVICE / INSTITUT OU SERVICE
- EXPERIMENTAL FARM / FERME EXPÉRIMENTALE

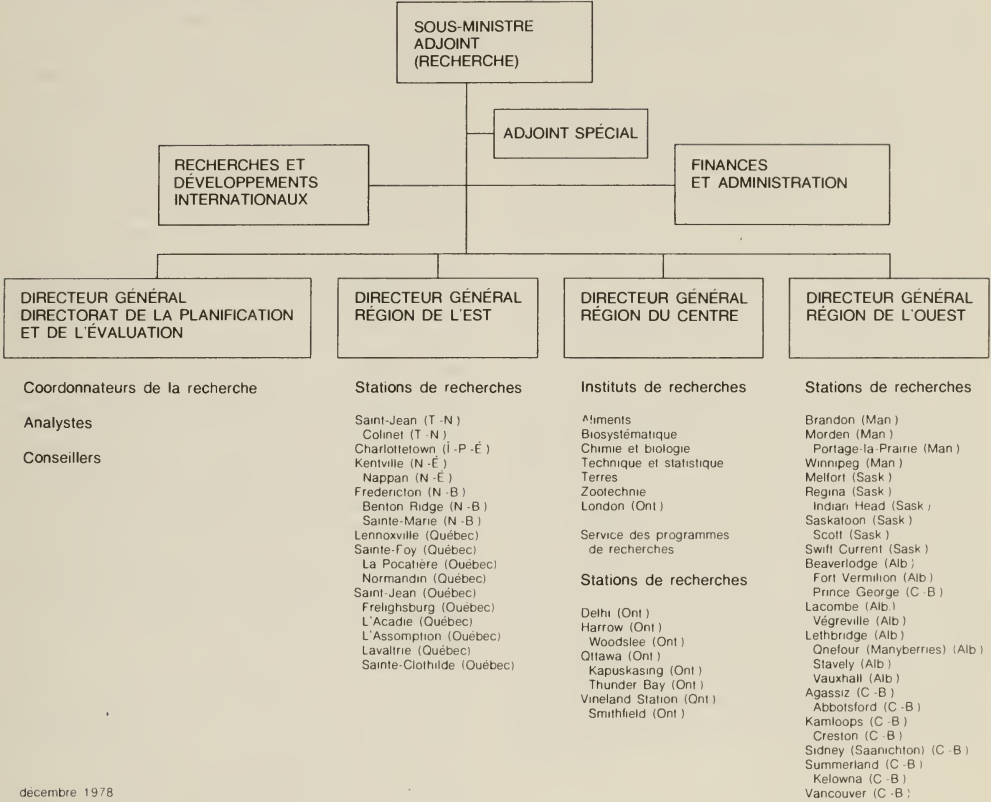
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INSTITUTES AND SERVICES	INSTITUTS ET SERVICES
Animal Research Institute	Institut de recherches animales
Plant Research Institute	Institut de recherches botaniques
Chemistry and Biology Research Institute	Institut de recherches chimiques et biologiques
Engineering and Statistical Research Institute	Institut de recherches techniques et statistiques
Food Research Institute	Institut de recherches sur les terres
Land Resource Research Institute	Institut de recherches zootechniques
Research Program Service	Service des programmes de recherches

ORGANIZATION OF THE RESEARCH BRANCH



ORGANISATION DE LA DIRECTION DE LA RECHERCHE



FOREWORD

The *Research Branch Report* is a compilation of reports from each research establishment of Agriculture Canada. The last issue of the Report was written for the year 1975. Although the present issue deals mainly with research activities for the years 1977 and 1978, for continuity the title shows the years 1976-1978. Henceforth we will be printing the *Research Branch Report* annually. Its purpose is to communicate with the scientific community.

In 1976, activities were reported in two new publications, with new formats, *Progress in Research 1976*, and *Professional Staff and Publications 1976*. *Progress in Research* will continue to be printed annually to review current goals and objectives and explain to the general reader our role in research.

On April 1, 1978, a major reorganization of the Research Branch became effective. It was the most extensive restructuring since the formation of the Branch in 1959. The important changes included the appointment of a new Assistant Deputy Minister for Research in the Department, the establishment of a new position of Senior Adviser for International Research and Development, and the transformation of the Branch's three divisions into the Eastern, Central, and Western regions, with headquarters in Quebec City, Ottawa, and Saskatoon, respectively. Each regional headquarters is headed by a director general, who is supported by a program specialist and a finance and administration section. The Planning and Evaluation Directorate was also restructured and

reorganized. Under a Director General the new P and E Directorate consists of six research coordinators, two program analysts, one contract analyst, and two special advisers.

The first few pages of the report present a description of the restructuring of the Research Branch. The reorganization brought about several changes in senior positions. Dr. E. J. LeRoux was appointed Assistant Deputy Minister; Drs. J. J. Cartier, W. B. Mountain, and A. A. Guitard were appointed directors general of the Eastern, Central, and Western regions, respectively; Dr. J. W. Morrison, Director General of the Planning and Evaluation Directorate; and Dr. T. H. Anstey, Senior Adviser, International Research and Development. In addition, Mr. P. Voisey became Director of the restructured Engineering and Statistical Research Institute; Dr. H. V. Morley, Director of the Research Institute at London, Ont.; and Dr. W. L. Pelton, Director of the Research Station at Swift Current, Sask. During 1978, Dr. E. D. Putt, Director, Research Station, Morden, Man.; Dr. J. R. Wright, Director, Research Station, Kentville, N.S.; Mr. D. G. Peterson, Special Assistant to the Assistant Deputy Minister; Dr. W. J. Pigden, Research Coordinator, Animals; and Dr. R. P. A. Sims, Program Analyst, retired after many years of service to the Branch.

E. J. LeRoux

AVANT-PROPOS

Le rapport de la Direction de la recherche est préparé à partir de l'ensemble des rapports provenant de tous les établissements de recherches d'Agriculture Canada. Le dernier rapport a été rédigé pour l'année 1975. Bien que le présent rapport fasse surtout état des recherches effectuées en 1977 et 1978, les années 1976-1978 apparaissent sur la page de couverture par simple souci de continuité. À l'avenir, nous publierons chaque année le rapport de la Direction de la recherche afin de garder un contact constant avec le monde scientifique.

On peut trouver les activités de l'année 1976 dans deux nouvelles publications présentées sous de nouveaux formats: *Essor des recherches en 1976* et *Cadres professionnels et publications en 1976*. *Essor des recherches* sera publié chaque année pour présenter les buts et les objectifs de la Direction et expliquer aux lecteurs notre rôle dans la recherche.

Au premier avril 1978, une importante restructuration de la Direction de la recherche a été effectuée. C'était la plus importante depuis la formation de la Direction en 1959. Les changements comportaient la nomination d'un sous-ministre adjoint, recherche, la création d'un poste de conseiller supérieur pour les programmes internationaux de recherches et de développements et la formation de trois régions administratives à l'est, au centre et à l'ouest du pays avec leur bureau régional à Québec, Ottawa et Saskatoon, respectivement. Chaque région est sous la responsabilité d'un directeur général aidé d'un spécialiste en programmes et d'une section des finances et de l'administration. Le Directorate de la planification et de l'évaluation a été également restructuré et réorganisé.

Outre le directeur général, le nouveau Directorate de la planification et de l'évaluation comprend six coordonnateurs de recherches, deux analystes de programmes, un analyste de contrats et deux conseillers spéciaux.

Les premières pages de ce rapport décrivent la nouvelle structure de la Direction de la recherche. La restructuration a apporté plusieurs changements dans les postes supérieurs: M. E.J. LeRoux, Ph.D., a été nommé sous-ministre adjoint; MM. J.J. Cartier, Ph.D., W.B. Mountain, Ph.D., et A.A. Guittard, Ph.D., ont été nommés directeurs généraux des régions de l'Est, du Centre et de l'Ouest, respectivement; M. J.W. Morrison, Ph.D., a été nommé directeur général du Directorate de la planification et de l'évaluation; M. T.H. Anstey, Ph.D., est devenu conseiller principal pour les programmes internationaux de recherches et de développements; M. P. Voisey est devenu directeur de l'Institut de recherches techniques et statistiques qui a été aussi réorganisé; M. H.V. Morley, Ph.D., est devenu directeur de l'Institut de recherches à London; et M. W.L. Pelton, Ph.D., a été nommé directeur de la station de recherches à Swift Current (Sask.). Au cours de l'année 1978, M. E.D. Putt, Ph.D., directeur à Morden (Man.), M. J.R. Wright, Ph.D., directeur à Kentville (N.-É.), M. D.G. Peterson, adjoint auprès du sous-ministre adjoint, M. W.J. Pigden, Ph.D., coordonnateur de la recherche, animaux, et M. R.P.A. Sims, Ph.D., analyste de programmes, ont pris leur retraite après plusieurs années de service à la Direction de la recherche.

E.J. LeRoux

Research Station St. John's West, Newfoundland

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INTRODUCTION

This report covers results of research work conducted at the St. John's West Research Station during 1977 and 1978. The Station's program emphasizes research on the control of potato wart disease, rutabaga clubroot disease, the golden nematode, and economic crop insects. Increasing effort is being directed to experimental peat soil studies on vegetable and forage production, drainage and cultivation techniques, together with the design and adaptation of mechanical equipment for cultivating, fertilizing, seeding, and harvesting peat soil crops.

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

H. W. R. Chancey
Director

ENTOMOLOGY

Cabbage maggot

The synthetic pyrethroid permethrin applied to the soil in 1977 as granules, granules plus drench, drenches, and as foliar sprays at 0.14 and 0.28 kg active ingredient per hectare gave from 2 to 34% control in a moderate infestation of root maggots in rutabagas. However, similar treatments on late cabbage gave adequate control in a moderate infestation where 50% of cabbages in the control plot died.

Field experiments conducted in 1978 at St. John's and Wooddale indicated that field populations of the cabbage maggot fly have developed a tolerance, or resistance, to the organophosphate insecticide fensulfothion at both locations. The recommended, and twice the recommended dosage inadequately controlled cabbage maggot attack in rutabagas. However, applications of four and eight times the recommended rate did give adequate protection, but were quite phytotoxic and caused extensive burning of the foliage. Resistance in adult flies could not be verified by the Toxicology Section, Research Institute, Agriculture Canada, London, Ont.

Lepidopterous caterpillars

Three pyrethroid insecticides, permethrin, fenvalerate, and cypermethrin, applied as single and double applications at 35 and 75 g active ingredient per hectare effectively controlled the imported cabbageworm, *Pieris rapae* (Linnaeus), purplebacked cabbageworm, *Evergestis pallidata* (Hufnagel), and diamondback moth, *Plutella xylostella* (Linnaeus), in a light infestation on early cabbage

and rape. All treatments were nearly as effective as two applications of a standard treatment of endosulfan at 3.2 kg active ingredient per hectare.

Leaf tier

This recently introduced insect is a pest of economic importance in native blueberry stands in eastern Newfoundland. Three pyrethroid insecticides, permethrin, fenvalerate, and cypermethrin, were evaluated and compared with azinphos-methyl to control this leaf tier, *Argyrotoza curvalana* (Kft.), on blueberries at Clarkes Beach.

All pyrethroid insecticide treatments at 0.035, 0.070, and 0.140 kg active ingredient per hectare gave satisfactory control of leaf tier larvae on blueberries and were equally as effective as azinphos-methyl at 0.56 and 0.84 kg active ingredient per hectare. Permethrin was slightly more effective than fenvalerate and cypermethrin.

PLANT BREEDING AND PATHOLOGY

Potato breeding for resistance to wart and golden nematode

Mirton Pearl has become firmly established as an acceptable commercial variety within the Province, and seed stocks are being multiplied at the Provincial Glenwood Seed Potato Farm.

Despite its susceptibility to wart disease, Arran Victory remains a popular variety. N433-21, resulting from a cross of Arran Victory and a wart resistant seedling, has

shown excellent cropping ability and resistance to wart disease. An application for the registration and licensing of this selection will be made in 1979 and it is expected that this variety should eventually replace Arran Victory.

Cysts have been found on the golden nematode pathotype A resistant variety Hudson, and have been identified as *Globodera pallida*. Resistance to several pathotypes of both nematode species (*G. pallida* and *G. rostochiensis*) is available in various breeding lines and crosses to incorporate this resistance along with wart resistance were successful. Atlantic has shown resistance to *G. rostochiensis* and to wart disease in tests in 1978.

Infectivity and germination in potato wart disease

Irrigation and temperature. A series of experiments were conducted to determine the influence of irrigation on infection. In the greenhouse it was found that extensive watering, using a commercial spray tube beside the plant in the second week of planting, induced the best level of infection. In a bench fitted with refrigeration coils and heating cable, results showed that infection increased almost linearly as temperature decreased from 18 to 10°C.

Tomato and other additional hosts. One hundred and twenty-five tomato cultivars proved susceptible to *S. endobioticum*. Tomato was explored as an assay tool for detection of the fungus and was sensitive to at least 10 resting sporangia per gram of soil. Infection increased with inoculum density but peaked when intersporangial distance was between 1.5 and 1.75 mm, and fell with increase beyond this level. Correlative work at Memorial University of Newfoundland showed that the tomatine content of tomato roots paralleled the level of infection and not the levels of inoculum density. Other species tested were of the genera *Datura*, *Capsicastrum*, *Physalis*, and *Schizanthus*; *Nicotiana* spp. were unaffected by *S. endobioticum*.

Breeding clubroot-resistant rutabagas

From advanced generations of a cross between Gelria summer turnip with York × Wilhelmsburger, roots were selected for uniformity of type. With a further generation of selection, it is anticipated that roots will be

commercially acceptable. Interspecific hybrids with the New Zealand variety York have been obtained and clubroot-resistant selections have been made.

The possibility of producing hybrid seed of rutabagas under field conditions, utilizing self incompatibility, introduced from summer turnip has been investigated. Preliminary studies indicate that not more than 25% hybrids were produced. Clubroot screening tests of oil seed rapes and rutabagas from North America and Europe were continued. No Canadian oil seed rapes were resistant to clubroot, but the European varieties Erle, Quinta, and Petranova appeared resistant. Of the rutabaga varieties tested, Niko, Merrick, and Criffel had more than 75% of plants free of infection.

PLANT SCIENCE

Field crops

Cabbage. Results of 2 yr work on mineral soil with the cultivar Houston Evergreen showed that early planting produced high yields with field-seeded cabbage. With transplants, time of planting was not critical. Yields in tonnes per hectare at the various planting times were as follows: May 19 (transplants = 78.9, field-seeded = 59.7); May 31 (transplants = 85.5, field-seeded = 47.4); and June 14 (transplants = 81.8, field-seeded = 31.2).

Direct-seeded lettuce. Preemergence application of sulfallate, chlorpropham, and pronamide were evaluated on mineral soil, but none of the treatments gave satisfactory weed control. However, both chlorpropham and pronamide gave excellent control of lady's-thumb, whereas sulfallate gave no control.

Cauliflower. Fertility trials on virgin peat with the cultivar Self-Blanche showed that although increasing the N level from 224 to 336 kg/ha increased marketable yield from 28.3 to 36.1 t/ha, there was no further increase with higher rates. Yields were increased slightly by increasing the K level from 185.9 to 205.8 kg/ha, but increasing the phosphorus level beyond 97.8 kg/ha had no effect.

Carrot. Over a 2 yr period on peat soils, 23 cultivars of carrots were evaluated for susceptibility to "sunburn." Cultivars which produced the highest yields of sunburn free

carrots were: Dess-Dan, 29.9 t/ha; Spartan Sweet, 29.1 t/ha; and Spartan Fancy, 28.5 t/ha.

Blueberry

Select clones. Rooted cuttings of the cultivars Augusta and Chignecto were planted in 1978 at the Avondale Blueberry Substation to determine if interplanting native stands with high yielding select clones would increase yields. Survival observations made on August 15 showed that 13.0% of Augusta and 30.2% of Chignecto had died, probably due to very dry weather.

Greenhouse crops

Tomato trials were completed to evaluate cultivars, various fertilizer schemes, and the effect of air-circulating fans on yields. Cultivars which performed best and their marketable yields in kilograms per plant were: Tuckcross 520, 4.63; Super M, 4.31; and F1 Hybrid Panase, 3.72.

Although the fertilizer program utilizing Mag Amp (7-40-6) and Osmocote (18-6-12) was not compared in the same experiment with the complete nutrient solution method described in Agric. Can. Publ. 1460, the latter gave better results. The incidence of blossom end rot was high using slow release fertilizer and virtually nonexistent using the complete nutrient solution method. Use of air-circulating fans did not increase yields in these trials.

SOIL SCIENCE

Peat soils

Fertility. In replicated trials with Wilhelmsburger and York turnips, results showed that Wilhelmsburger was the most efficient extractor of soil phosphorus. Further trials will determine maximum phosphorus requirements for this crop.

Drainage. The combined effect of ridges and mole drains between 7.5 m interval Norwegian and perforated pipe drains produced highest yields of carrots, potatoes, and turnips. Flat surface seeded crops on mole-drained intervals produced almost as well. There was good correlation between crop yields and soil aeration as determined by measuring soil oxygen content.

Machinery. A prototype articulated tractor for use on peat soils was designed, constructed, and field tested at the Colinet Peat Substation in 1978. The machine was manufactured by the Engineering and Statistical Research Institute, Ottawa, where it is now undergoing final alterations prior to field use.

Memorial University Engineering Faculty completed design work and preliminary field trials for the production of a combined seeder-ridger-packer to facilitate vegetable production on peat soils and is in the process of fabricating the machine. Also in the process of being fabricated is a narrow-width drainage ditcher suitable for use with a three-point hitch tractor mount.

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Research

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Miscellaneous

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Research Station

Charlottetown, Prince Edward Island

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Virus diseases (potato)

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INTRODUCTION

The Research Station at Charlottetown has Atlantic regional responsibility for research into the production of livestock feed crops, tobacco, and certain vegetables grown for processing. Research is also conducted on local problems with potatoes, cattle nutrition, and breeding, and on small fruits.

We regret to record the death in October 1977 of Keith E. LeLacheur who served for 25 yr with Agriculture Canada. He was widely recognized in the region for his research on tobacco and was primarily responsible for the successful establishment of tobacco growing in the region.

This report summarizes some of the results of research done in 1977 and 1978. More detailed results may be obtained from the publications listed as part of this report or by contacting the Research Station. Copies of this report and the publications 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

CEREAL AND PROTEIN CROPS

Breeding and testing

Barley. Atlanta barley, developed at the Research Station, Charlottetown, was licensed in 1977. It has high yield potential, good resistance to lodging, and good kernel weight. Summit, another two-rowed barley variety, has also been placed on the list of recommended varieties for the Atlantic region because of its good yield and lodging resistance.

Oats. The new oat varieties Sentinel and Laurent have been placed on the recommended list for the Atlantic region. Sentinel features good lodging resistance and considerable tolerance to barley yellow dwarf virus. Laurent has proven to be a very consistent, high-yielding variety. Several high-yielding, lodging resistant oat lines with exceptionally good kernel quality have been identified from the Quebec-Maritime breeding program.

Spring wheat. Applications for license of two new strains of spring wheat have been submitted. AW2-4 (Inia/Opal) has demonstrated similar yield to Opal but is 2 days earlier in maturity. MRO-1 (Opal* 4/Pompe) is resistant to powdery mildew, *Erysiphe graminis* DC. ex Méral f. sp. *tritici* Marchal, and has consistently yielded more than Opal when powdery mildew attacks occur. AW-4 (Kentville Selection* 6/Pompe), which also has resistance to powdery mildew,

is the most promising new strain in the testing program. Research has shown that a method of progressive selection in early generations can be used effectively in discarding inferior crosses, i.e. using yield of mid-parents, F_1 and F_2 generations.

Winter wheat. The most promising new line in the Maritime Winter Wheat Testing Program for the last 2 yr has been T1365-216, a hardy feed wheat strain developed at the Ottawa Research Station.

Winter rye. A license for the European variety Animo is expected in 1979. Agronomically, Animo is similar to Kustro, but is slightly higher yielding.

Field peas. Tara field peas and line MP 790 outyielded Century and Trapper, the currently recommended varieties. A 3-yr study of inoculation methods showed that soil implant inoculation gave better nodule formation and higher acetylene reduction activity but yields were not affected. This indicated that nitrogen fixation was not the factor limiting field pea yield under the conditions of this study.

Soybeans. Several lines of soybeans from the Ottawa breeding program mature earlier than Maple Arrow — the earliest cultivar currently recommended. Yields of up to 3000 kg/ha were obtained from early lines which had field moisture contents at harvest as low as 17%.

Management and nutrition

Intensive management of spring and winter wheat. Spring wheat yields were increased by multiple N applications when fungicides were used to control *E. graminis* and *Septoria nodorum* (Berk.) Berk. With winter wheat, the use of Cycocel (BASF) shortened the straw, reduced lodging, increased the severity of leaf diseases, and generally increased yields. Protein levels were increased from 12 to 15% by multiple N applications in both spring and winter wheat.

Ammonia losses from surface applied urea. A method was developed to measure NH_3 losses from urea applied to soil surfaces. Losses were small for early spring application but increased with later applications to 25% loss for July applications. Such observations are consistent with yield trials involving timothy and brome grass. Similar results were obtained with spring applications of urea and ammonium nitrate, but for summer applications better performance was obtained from ammonium nitrate than from urea.

Response to molybdenum on cereals. In field experiments, Mo applications had no effect on grain yield of wheat and barley. However, Mo applied as a foliar spray was found to be an effective means of increasing the Mo concentration of cereal tissues. In the case of suspected Mo deficiency in cereals, a foliar application of Mo at 0.2–0.3 kg/ha should correct the deficiency without increasing tissue concentrations to levels toxic to animals.

Plant physiology

Magnetic seed treatment. Magnetic seed treatment of some cereal varieties may result in a beneficial effect on yield. Volla barley responded to magnetic seed treatment with yield increases of 260–464 kg/ha. Stormont oats and Cal. 15 wheat responded slightly, while Laurent oats, Laurier barley, and Opal wheat did not respond.

Identification of hardiness in wheat. Polyacrylamide gel-electrophoresis of gliadin (alcohol-soluble fraction) of seed protein appears to be a useful method for selecting hardy strains of winter wheat. While hardy strains of winter wheat showed a characteristic band of gliadin on the electrophoretogram, it was seldom found in less hardy winter wheat or spring wheat strains.

A growth regulator on barley. Triaccontanol, a naturally occurring plant growth regulator which has been reported to increase yields of various crops, did not affect yield of barley under the moist climate of Prince Edward Island.

Diseases

In some years, the foliar fungal pathogen *Pyrenophora teres* Dreschs. occurs more frequently on barley than does *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. *Selenophoma donacis* (Pass.) Sprague & A. G. Johnson was reported on barley and wheat in the Maritime Provinces for the first time.

FORAGE CROPS

Management and nutrition

Winter survival. Viability assay of sample plants taken from various fields in January 1978 showed that most of the stress occurred while the overwintering plants maintained high levels of hardiness and before they commenced to break dormancy, thus they survived with little injury.

A number of methods were evaluated for sampling overwintering crops in frozen soil. A method using a portable gas-powered concrete cut-off saw equipped with a carbide disc was the most satisfactory. The extraction of one hard-frozen soil sample was completed by one man within 5 min.

Peroxidase of hardy alfalfa, *Medicago falcata* L., and common alfalfa, *M. sativa* L., was examined by polyacrylamide gel-electrophoresis. One-month-old plants of *M. falcata* grown in a greenhouse showed a characteristic peroxidase isozyme that was not detected in those of *M. sativa*. The particular isozyme, however, was produced in *M. sativa* when the plants were exposed to low temperatures.

A search was conducted for naturally occurring cryoprotectant organic chemicals that protect living tissues against freezing. Fructose polymers were identified as naturally occurring cryoprotectants in timothy, dandelion, and other hardy plant species. A foliar application of fructose polymers increased cold hardiness of alfalfa.

Harvest systems and nitrogen rates for Italian ryegrass. Lemtal Italian ryegrass (IRG) was grown on a sandy loam and/or on a fine sandy loam soil in 1974, 1975, and 1976. IRG was fertilized three times each

year with N at 40, 80, or 120 kg/ha per application and harvested at 3- to 6-wk intervals starting in July. Dry matter (DM) yield increased with the rate of applied N. Four-week harvest intervals generally resulted in the greatest DM yields ranging from 4.32 to 7.11 t/ha. The mean total N concentrations in IRG ranged from 2.40 to 3.68% and were approximately proportional to applied N. With longer regrowth intervals, total N concentrations were 0.12–0.56% less per week. Applied N did not influence the in vitro disappearance of DM (IVDDM), whereas longer regrowth intervals reduced IVDDM in 1975. The harvest system with a 4-wk regrowth interval and N at 80 kg/ha per application resulted in satisfactory DM, N, and digestible DM yields and appeared to be a suitable system for IRG grown as a summer annual.

Ensiling of timothy, brome grass, and orchard grass. The effects of two rates of nitrogen fertilization on the quality of silages made of primary growth and aftermath of timothy, brome grass, and orchard grass were determined in laboratory silos. Wilted and unwilted forage and unwilted forage that was treated with formic acid or formic acid plus formaldehyde were included. All grasses, and especially those fertilized with N at 132 kg/ha, were low in water-soluble carbohydrates. The addition of formic acid resulted in good quality silages with low pH's, ammonia-N, and fermentation acid contents. Formaldehyde further reduced ammonia-N in the silages. Silages from wilted and unwilted forages without preservatives had higher pH's, ammonia-N, and fermentation acid contents than those with preservatives, but most of these silages were of satisfactory quality. The quality of silages was influenced less by the rates of N or harvest dates than by the ensiling treatments.

Effect of applied Mo on Mo in forage crops. In experiments on alfalfa, red clover, and timothy it was found that the addition of Mo at about 0.2 kg/ha as a foliar spray or at 0.4 kg/ha applied to the soil alleviated a deficiency problem without causing tissue concentrations which would be toxic when fed to cattle. Residual effects at these levels of applied Mo should last from 2 to 3 yr from the crop sufficiency point of view.

Selenium levels in soils. A survey of forages grown in the Atlantic Provinces indicated

that Se was generally deficient, that is, less than 0.1 ppm, the amount needed to prevent Se deficiency problems in livestock. By adding Se to the soil at the rate of 2.24 kg/ha, the Se content of barley was increased to 0.1 ppm or more for 2 yr following Se application, while the Se content of timothy was above 0.1 ppm for the 3 yr of the experiment.

Corn management. Harvest date evaluations on forage corn over 2 yr indicated declining yields of all plant parts except ears after being frozen. The DM content of all plant parts increased with time, with leaves and plant tops drying the fastest. The lower one-third of stalks remained very wet (below 25% DM) long after frost. Nutrient contents, especially K, Ca, and Mg, declined rapidly after plants had been frozen, lowering feed quality. Little or no significant yield differences occurred with planting dates from mid-May through early June over 3 yr, but earlier plantings resulted in a maturity advantage at harvest. Planting corn in ridges on various planting dates over 2 yr did not improve rate or time for emergence, or yield or maturity at harvest. Four tillage treatments for corn production (fall plowing, spring plowing, spring disking, and no-till planting) compared over 3 yr indicated a 10% yield advantage for plowing over no-till planting. Spring plowing and spring disking were intermediate with a slight advantage to plowing.

Effect of atrazine residue carryover on crops grown in rotation with corn. Carryover in a fine sandy loam soil containing 3.3% organic matter of atrazine applied preemergence to corn in May 1977 at 1.13 kg active ingredient per hectare had no effect on dry matter yield of winter rye seeded prior to harvesting the corn, and of field peas, barley, alfalfa, red clover, and timothy seeded in May of the following year. Yields of all crops decreased progressively with increasing atrazine application rates. Field peas, barley, and alfalfa were least affected. Red clover and timothy yields were reduced by 18% at the rate of 2.25 kg active ingredient per hectare, and by 65 and 100%, respectively, at the rate of 4.5 kg active ingredient per hectare. Winter rye yield was reduced by 65 and 81% at the rates of 2.25 and 4.5 kg active ingredient per hectare, respectively.

Barnyard grass competition effects on silage corn yield. Delaying removal of barnyard grass, *Echinochloa crusgalli* L. Beauv., in a field which contained a heavy infestation for 2, 4, 6, or 8 wk after emergence of Pioneer 3992 silage corn resulted in yield losses of 20, 49, 61, and 62%, respectively, compared with plots kept free of barnyard grass all season. Early control, within 2 wk after corn emergence, was necessary to achieve maximum silage yields.

Insects and nematodes

Insect pests of forage legumes and grasses. Good control of the alfalfa blotch leafminer, *Agromyza frontella* (Rondani), was obtained with several insecticides at very low rates, but the effect of control on yield was not significant. Best control was obtained if insecticides were applied when adults were at their peak and just prior to egg hatch and early leaf mining. One week after the full bud stage of alfalfa growth was the optimum time to cut alfalfa infested with leafminers. The response of alfalfa leaves to this insect involves three stages as the infestation progresses: (1) physical destruction including a loss of capacity to absorb light; (2) catabolism; and (3) loss of foliage nutrients by exudation.

European skipper larvae, *Thymelicus lineola* (Ochsenheimer), caused economic losses in some timothy fields in 1977 and 1978. The larvae may be controlled with insecticides, but bactericides are the only products registered for use. A nucleopolyhedrosis virus which affects skipper larvae was widely distributed in Prince Edward Island in 1978.

Nematodes affect composition of forage from grass-legume swards. Studies with the root lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh., have shown that the nematode reduced yields of forage legumes significantly but had little or no effect on forage grasses even though reproduction of the nematode on the grasses was excellent. When legumes and grasses were grown in mixture, the effect of the nematode on total forage yield was less than when the legumes were grown alone but much greater than when the grasses were grown alone. Because of the additional stress from the grass growing in competition with the legumes, legume forage yield in legume-grass mixtures was affected more in the presence of nematodes than when the same legume was grown alone.

Root lesion nematodes and Fusarium on alfalfa. A field study was made of the effects of a residual nematicide (phenamiphos), a fumigant (methyl bromide), and fallowing on the number of root lesion nematodes, *P. penetrans*, forage yields of alfalfa, and the occurrence of *Fusarium* spp. fungi in plant roots and soil. Fallowing controlled nematodes initially; however, by the end of the second growing season, nematode numbers were as high as in plots which had grown a nematode susceptible crop. *Fusarium* in alfalfa roots and soil was not reduced by fallowing. Treatment with the nematicide reduced nematode numbers, increased forage yields in 2 of 4 yr, and reduced *Fusarium* infections of taproots. Soil fumigation resulted in the best control of nematodes and *Fusarium* and resulted in significantly higher forage yields for the 4 yr of study following fumigation, confirming that the potential yield of alfalfa was being reduced significantly; however, the study did not establish the relative contribution of root lesion nematodes and *Fusarium* spp. fungi to such reduction.

CATTLE

Early weaning of dairy calves

Studies confirmed that weaning of dairy calves at 3 wk is a useful alternative calf-rearing method. A relatively simple calf starter ration based on several grains was more acceptable than a complex mixture based on a number of grains and by-products. Calves weaned at 3 wk of age showed a growth response to crude protein contents of up to 21% of the starter ration. Calves weaned at 3, 5, or 7 wk of age digested dry matter equally during the first week after weaning with similar feed:gain ratios, indicating a rapid adaptation to dry feed even at 3 wk of age.

Fish silage as a protein source

Fish silage was acceptable as a supplementary source of dietary protein for calves weaned at 3 wk. Fish silage supplementation of calf and broiler diets up to time of slaughter did not impart a "fishy" flavor or odor to the meat. Also, feeding fish silage to lactating dairy cows did not impart any "fishy" flavor or odor to the milk.

Model of milk production based on Timothy

Data generated to date through the use of a five-part simulation model of a dairy farm in which timothy is the sole source of forage (see 1975 Research Report) suggest that under Lennoxville, Que., weather conditions, considering herds of 30 and 50 cows and hectarages between 19 and 56 that: (1) hay is a lower cost means of preserving timothy than is either wilted or direct-cut silage and leads to higher net returns; (2) the use of formic acid and bunker silos is more profitable than is the use of other available ensiling alternatives; (3) an approximate 0.8 ha of timothy per cow with the first cut taken about June 19 (average of 5 yr) is optimum; and (4) free stall barns, milking parlors, auto-detach milkers, and solid waste disposal systems are lower cost than are those including stanchion barns, liquid waste disposal, and manual detach milkers.

HORTICULTURAL CROPS

Potato management and nutrition

Seed tuber size, plant spacing, fertilizers, and planting date. Yields of Netted Gems and Red Pontiacs were not affected when either whole tubers averaging 57 g each, 113 g tubers cut in half, or 227 g tubers quartered were planted. However, the proportion of "B" size tubers (less than 113 g) was increased, and more "A" size tubers (greater than 113 g) were in the lower portion of the "A" size range at harvest with the 57 g seed tubers.

Reducing the in-row tuber planting distance of Kennebecs from 20 to 10 cm and of Red Pontiacs from 30 to 15 cm increased the yield of "B" size tubers with essentially no change in total yield. Kennebec "B" size yields were increased from 23 to 38% of the 34 t/ha yield by closer spacing. Increasing the in-row spacing of Netted Gems from 61 to 81 cm in a 2-yr study resulted in a total yield decrease of only 3% (27.9 to 27.0 t/ha).

Ammonium nitrate, diammonium phosphate, and urea produced equivalent yields when used at the normally recommended N rate (135 kg/ha) even though there was visual evidence that urea and diammonium phosphate may have restricted plant growth early in the season. At nitrogen rates of 202 kg/ha there was some lowering of yield with

the use of banded urea and diammonium phosphate. With proper placement and recommended rates, however, all three N sources can be banded. Broadcasting of fertilizer for potatoes to save time at planting resulted in no yield differences from N or K applications in a 2-yr study. Banding of P gave a 5% yield increase over broadcasting.

Delayed planting (mid-May to mid-June) significantly reduced total yields of potatoes over 2 yr. Late planting in combination with high rates of N reduced both yields and specific gravity. Tuber yields of Netted Gems planted from mid-May to early-June increased at a rate of about 0.5 t/ha a day between about the 60th and 108th day after planting in 1978. Yields were essentially the same on October 16 regardless of planting date since growth tended to cease after about 120 days.

Effect of metribuzin residue on crops grown in rotation. Carryover in a fine sandy loam soil containing 3.1% organic matter of metribuzin applied to potatoes in June 1977 caused only slight yield reductions in crops of winter rye seeded after harvest of the potatoes in 1977 and barley, wheat, oats, red clover, and timothy seeded in the spring of 1978. Residues from metribuzin applied at 0.5 and 1.0 kg active ingredient per hectare caused yield reductions of 4–7% for winter rye, wheat, oats, and red clover. Barley yields were reduced 6% at the 0.5 kg rate and 11% at the 1.0 kg rate of application. Timothy yields were reduced 8–13% at the rates of metribuzin used.

Quack grass competition effects on yield. Removal of quack grass, *Agropyron repens* L. Beauv., for 2, 4, or 6 wk after potato emergence gave yields of Netted Gems comparable to plots kept free of quack grass all season. When quack grass removal was delayed for 2, 4, or 6 wk after potato emergence, yields were reduced 29, 64, and 72%, respectively.

Effect of root lesion nematodes. The root lesion nematode, *P. penetrans*, interfered with water absorption by Sebago roots. Control of nematodes in the field with nematicides did not result in significant increases in tuber yields when soil moisture was adequate. However, when soil moisture was low, yields of Sebagos and Superiors were 40% greater in nematicide-treated plots than in check plots.

Effect of loss of topsoil and reduced soil organic matter content. Long term effects of soil erosion and intensive potato production on loss of topsoil and organic matter depletion projected from current trends on Prince Edward Island were simulated in the field by removal of the top 7.5 and 15 cm of a fine sandy loam soil. This reduced the organic matter content of the new Ap horizons to 2.9 and 2.1%, respectively, compared with 3.5% for the adjacent intact soil. Except for reductions in mineralizable N, soil fertility levels were unchanged. In 1977, when plants were under no moisture or heat stress, removal of the top 15 cm of soil reduced potato yields by 10% with N at 80 kg/ha but resulted in no yield reductions at N rates of 120 kg/ha or greater. For the minus 7.5 cm and intact soil treatments, maximum yields (35 t/ha) were achieved with N at 80 kg/ha. In 1978, with less than average rainfall during the growing season, removal of the top 7.5 and 15 cm of soil reduced potato yields at the N rate of 80 kg/ha by 9 and 31%, respectively. For the minus 15 cm treatment with N at 160 kg/ha, yields were 15% below those of the intact soil. Maximum yields on the minus 7.5 cm and intact soil treatments (32 t/ha) were achieved with N at 120 and 80 kg/ha respectively.

Machinery size for harvesting. With Kennebecs, 125 days of growth yielded the highest returns to management for all hectares up to 81 ha in a study of harvesting machinery complements. For areas < 26 ha, 26–57 ha, and 57–81 ha, optimum harvesters were one-row, two-row, and two-row with windrower, respectively, following 134 days of growth. A two-row harvester with windrower and 124 days were optimum for 57–81 ha.

Vegetable nutrition

Effects of N, P, K, and lime on pea yields. Broadcast applications of N, P, and K did not affect the yields of green peas significantly in experiments conducted at nine locations over a period of 3 yr. Yields varied from approximately 4–7 t/ha, and were not affected by applications of lime at 400 kg/ha in the row with the seed. Maturity was delayed slightly by added N and advanced slightly by added P.

Effect of added K on uptake of B. Applications of K did not affect substantially the uptake of B by cauliflower, Brussels sprouts, and peas in experiments conducted at 21 sites during 6 yr. As the rate of applied K increased, B uptake by all crops generally decreased; however, effects were not great.

Molybdenum requirement of vegetables on peat soils. In a greenhouse study, it was found that seed treatment with Mo or small quantities of Mo added to the peat were necessary for optimum yield of vegetable crops. For onions, cauliflower, and lettuce, the Mo seed treatment alone was sufficient, while carrots required additional Mo for optimum yields.

TOBACCO

Boron and chlorine studies

Field experiments conducted in Prince Edward Island showed that chlorine applications as high as 100 kg/ha had no harmful effects on tobacco. Applications of Cl at 33–50 kg/ha are essential for producing good quality tobacco. Applications of B at 8 kg/ha or higher seriously affected crop yields and produced poor quality tobacco.

Fungicides for root rot

Field tests on the use of fungicides added to the transplant water as a means of reducing the severity of tobacco root rot were completed. Use of fungicides in this manner would be of value only when the more susceptible tobacco cultivars are grown.

ENERGY USE

Energy use in crop production in Prince Edward Island

The ratio of output energy to input energy was calculated for seven major crops grown in Prince Edward Island. The input energy was based on standard and recommended practices for growing, harvesting, and storing the crops. The output energy was based on the digestible energy for each crop at the time of consumption. The output to input ratios were found to be 1.81 for cereals, 7.33 for hay, 13.02 for pasture, 1.60 for potatoes, 3.74 for corn silage, 0.56 for vegetables, and 0.29 for processing peas.

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Research Station Kentville, Nova Scotia

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Departures

E. W. CHIPMAN, B.Sc. (Agr.) Retired August 1978	Vegetable crops
D. CHISHOLM, B.Sc. Retired December 1978	Insecticide chemistry
F. R. FORSYTH, B.A., Ph.D. Retired March 1978	Postharvest physiology

C. R. MACLELLAN, M.C., C.D., B.Sc. (Agr.), M.A. Retired December 1978	Ecology of codling moth
D. J. SCHRODER, B.Sc. (Agr.), M.Sc., Ph.D. Resigned August 1978	Food microbiology
G. G. SMELTZER, B.Sc. (Agr.) Retired December 1978	Cereals and field crops
D. K. R. STEWART, B.Sc., B.A., M.Sc., Ph.D. Deceased July 1977	Fungicide chemistry
J. R. WRIGHT, B.Sc. (Agr.), M.S., Ph.D., F.C.I.C. Retired December 1978	Director
M. R. MALYK, B.Sc., M.Sc., M.L.S. Transferred December 1978	Librarian

¹Seconded from Data Processing Division.

INTRODUCTION

This publication summarizes the main research results of the Research Station at Kentville and the Experimental Farm at Nappan for 1977 and 1978. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km north of Kentville, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool, humid climate, and Podzol soils.

The construction at Kentville of a new office-laboratory complex for the federal and provincial departments of agriculture commenced in October 1978.

Significant program accomplishments include the introduction of the rhododendron Minas Maid, Chignecto lowbush blueberry, and the Micmac strawberry. The Nova Scotia lowbush blueberry select clone program has been advanced to commercial type plantings with the support of the New Crop Development Fund. Outstanding performances have been obtained from new soybean cultivars and new corn hybrids for grain and silage. Experiments have shown that rapeseed meals, when combined with fish meal, can replace all of the soybean meal used in chicken and turkey broiler diets. A commercial model of the Kentville-designed vegetable steam blancher is being manufactured for a local food processor. Formulations and processing parameters for flexible retortable pouch-packed apple and pear slices, cherries, and asparagus have been determined.

Evaluation trials at Nappan have led to an expansion of the area devoted to fall rye and field pea production. Nappan has also shown that alfalfa pellets may be substituted for grain in the ration of pregnant ewes, and that rumensin added to the feed of brood cows resulted in a significant saving in feed.

Dr. James R. Wright, Director of the Kentville Research Station and the Nappan Experimental Farm for the past 18 yr, retired in December 1978.

During the past 2 yr the Kentville Research Station has lost six scientists, one by resignation and five by retirement. Mr. E. W. Chipman, vegetable crops specialist for 32 yr, retired in August 1978. Mr. C. R. MacLellan of the Entomology Section retired in 1978 after 28 yr of service. In August 1978, Dr. D. J. Schroder resigned to accept the position of head of the Government of Alberta Food Technology Laboratory in Edmonton. Mr. D. Chisholm, of the Plant Pathology and Pesticide Residue Section for the past 35 yr, retired in December 1978. Dr. F. R. Forsyth, Head of the Plant Physiology Section, retired in February 1978 after serving 26 yr. Mr. G. G. Smeltzer, in charge of forage and cereal research for the past 25 yr, retired in December 1978. All of these scientists were highly regarded and will be greatly missed from the Station program.

Dr. D. K. R. Stewart died in July 1977 after a lengthy illness. His research in fungicide chemistry had received both national and international recognition.

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.

D. L. Craig
Acting Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush blueberries and cranberries

Tissue culture of lowbush blueberry stem internode sections. Stem internode sections of lowbush blueberry (*Vaccinium angustifolium*

Ait.) were cultured in vitro on medium containing plant growth regulators. Auxins, but not kinetin or gibberellic acid, promoted callus formation on the cut ends of explants; 2,4-dichlorophenoxyacetic acid (0.1 or 0.5 mg/L) was most effective. Callus formation was generally better in the dark than in light. There were differences in the amount and

friability of callus on internode sections taken from different lowbush blueberry clones. Explants were apparently nonpolar with respect to callus formation. Callus originated from both the cambial region and the pith, and consisted of large parenchyma cells with localized centers of meristematic activity. Internode sections cultured on high concentrations of 2,4-dichlorophenoxyacetic acid (2.5–10.0 mg/L) became swollen owing to cell division in the cambial region and enlargement of cortical cells.

Brunswick lowbush blueberry. Brunswick is the second clone to be named and released as a cultivar from the Kentville Station blueberry program. It is a midseason cultivar and has large attractive berries which may weigh up to 1.25 g each. It is adapted to areas where lowbush blueberries are presently cultivated.

Chignecto lowbush blueberry. Chignecto is the third clone to be named and released as a cultivar from the Kentville Station blueberry program. It is a midseason cultivar, somewhat less productive than Augusta and Brunswick, the two previously named cultivars. It is, however, more vigorous and easier to propagate.

Cultivar trials with the 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, respectively, 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. Depth of planting, soil pH, and prevention from frost-heaving the first winter are important factors in developing new stands of select clones or seedlings. The establishment of select clones and/or seedlings makes it possible to implement a greater degree of management coupled with superior plant material, resulting in increased and, hopefully, more consistent yields.

Italian ryegrass

Italian ryegrass (IRG) was fertilized three times each year with N at 40, 80, or 120 kg/ha per application and harvested at 3-, 4-, 5-, or 6-wk intervals starting in July. Dry matter (DM) yield increased with the rate of applied N. Four-week harvest intervals generally resulted in the greatest DM yields ranging from 4.32 to 7.11 t/ha. Droughty conditions

in 1975 reduced the growth and resulted in small DM yields, particularly on sandy loam. The mean total N concentrations of IRG ranged from 2.40 to 3.68% and were approximately proportional to applied N. Longer regrowth intervals decreased total N concentrations by 0.12–0.56% units per week. Applied N did not influence the in vitro disappearance of DM (IVDDM), whereas longer regrowth intervals reduced IVDDM in 1975. The harvest system with a 4-wk regrowth interval and N at 80 kg/ha per application resulted in satisfactory DM, N, and digestible DM yields and appeared to be a suitable system for IRG grown as a summer annual.

Strawberries

Micmac strawberry. Micmac strawberry (*Fragaria* × *ananassa* Duch.) is a mid-late selection from the cross Tioga × K61-87. In Nova Scotia, fruit yield, fruit size, firmness, appearance, and frozen quality of Micmac compare favorably with those of the standard cultivars Redcoat and Bounty. Micmac grows vigorously and is somewhat susceptible to common foliage and virus diseases. Resistance to red stele, verticillium wilt, and fruit rot appear to equal that of Redcoat and Bounty.

Cultivar trials. Results from cultivar trials conducted during the period 1971–1974 at Kentville, N.S., Fredericton, N.B., and Charlottetown, P.E.I., demonstrated the importance of conducting cultivar trials within each production area. Bounty performed consistently best at Kentville and yielded well at Charlottetown but not at Fredericton. Raritan, Veestar, and Vibrant performed quite well at all locations. Redcoat, the standard in Eastern Canada for many years, did not produce outstandingly well.

Effects of hilling and depth of plant setting on the incidence of multiple hearts and shape of sweet Spanish onion bulbs. Deeper planting or hilling sweet Spanish onion plants increased both elongation and decreased number of hearts (centers) in the mature bulbs.

Snap beans

Effect of nitrogen, phosphorus, and potassium on yields and nutrient levels in snap beans. Snap beans, *Phaseolus vulgaris* L.,

were grown on four commercial fields with fertilizer treatments consisting of three rates of N, of P, and of K in all combinations. Yields and levels of N, P, K, Ca, and Mg in leaf tissues were measured. Results indicated a reduction of foliar Ca from the addition of N fertilizer. No other consistent response pattern emerged.

Tobacco

Effects of 2-chloroethylphosphonic acid and nitrogen fertilizer on flue-cured tobacco growth and maturity. Ethephon at 1920 ppm advanced the date of harvesting and increased the early yield of mature leaves. Sulfur-coated urea (13% dissolution rate) utilized in the planting fertilizer decreased total fresh weight yields when compared with ammonium nitrate, urea, and sulfur-coated urea at the 36% dissolution rate.

Soils

Ammonium and nitrate nitrogen; their behavior in Nova Scotia's acid podzol soils. The application of NH_4NO_3 to a light sandy loam and a heavy silty clay loam revealed that, irrespective of whether soil was limed or unlimed, $\text{NH}_4\text{-N}$ was neither nitrified nor lost during winter but $\text{NO}_3\text{-N}$ was completely removed from the light soil and substantially reduced in the heavy. Under simulated summer weather much of the $\text{NH}_4\text{-N}$ was nitrified when either the sandy loam or the silty clay loam was limed and it was in the $\text{NO}_3\text{-N}$ form that most of the losses occurred, probably by denitrification.

PROTECTION OF CROPS AGAINST PESTS

Plant pathology

Tolerance of Venturia inaequalis to dodine in Nova Scotia. Isolates of *Venturia inaequalis* (Cke.) Wint. tolerant to dodine were detected following the failure of dodine to control scab in apple orchards in which it had been used successfully for many years; tolerance was confirmed by the response to dodine in artificial media of isolates of *V. inaequalis* from orchards in which dodine gave poor control of scab. The average tolerance of isolates from dodine-sprayed orchards was greater than that of isolates from orchards never exposed to dodine. The level of tolerance of isolates to dodine varied

within and among orchards and appeared to be shifting towards increased dodine tolerance.

Insect pests

Aphids on strawberries. Disulfoton applied to strawberries as a granular banded surface in-row treatment at rates of 1.68, 3.36, 6.72, and 13.44 kg active ingredient per hectare for control of aphids, *Aphis fabae* Scopoli, *Amphorophora agathonica* (Hottes), *Aulacorthum porosum* (Sanderson), produced $<0.01\text{--}0.13$ ppm sulfone and sulfoxide residues in fresh fruit in the first crop year and traces (<0.01 ppm) of the sulfone in the second crop year. Measurable residues of disulfoton metabolites remained in the soil 2 yr following application of the parent compound. There was no evidence of residue transfer with transplants from treated nursery stock to newly established plantations.

The application of 1.68 kg active ingredient per hectare in June and July provided better aphid control than a single application of 6.72 kg active ingredient per hectare applied in June. A split application of 3.36 kg active ingredient per hectare applied in June and July was as effective for complete season control as a single application of 13.44 kg active ingredient per hectare applied in June.

Apple leaf midge. Larvae of *Daisineura mali* (Kief.), the apple leaf midge, feed on the terminal leaves and suppress the growth of young trees. To date in Canada this pest occurs only in New Brunswick and was first noticed in 1964. Two generations occur per year. Adults of the overwintering generation emerge from pupae in the soil during the 2nd wk of June and egg-laying begins after a mating flight. The adults disappear in about 1 wk, by which time the eggs have begun to hatch and larval feeding has started. Larvae mature and drop from the tree during the 1st wk of July. Second generation adults emerge during the last half of July and may continue into early August in colder seasons. The second generation larvae drop from the leaves during the latter half of August and form puparia in the soil. No third generation has been noted. Traps were placed in infected orchards to determine the presence of parasitism and to obtain an estimate of mortality. Two species of parasites have been found and they are being compared with species attacking the midge in Europe to

evaluate the introduction of parasites for biological control.

Apple maggot. Six varieties of crab apples, Almey, *Malus sikkimensis*, Bailey, *Malus toringoides* Hughes, Dupont Flowering, Henrietta Crosby, and Morden 455, were found resistant to development of larvae of *Rhagoletis pomonella* (Walsh). Resistance was correlated with total phenol content but bioassays with an artificial diet suggested qualitative differences between susceptible and resistant varieties also occurred. Gallic, tannic, and *o*-coumaric acids, quercetin, naringenin, and *d*-catechin added to the diet at 1000 ppm prevented larval development.

The presence of α -glucosidase-like activity was shown in the gut of the adult apple maggot (Diptera: Tephritidae). Activity in the midgut was slightly higher than in the foregut and hydrolysis occurred faster at 37 than at 22°C. Hydrolysis of a number of α -glucoside sugars suggested the presence of α -glucosidase rather than invertase. Tests for proteases were negative.

The amount of injury by *Rhagoletis pomonella* (Walsh) in unsprayed apple orchards was not related to the number of female captures on Pherocon AM traps. No injury occurred until at least 3 wk after the first capture, which indicates that the first spray does not need to be applied within 7 days after first capture as presently recommended. Sprays will be necessary at low levels of adult prevalence to provide maggot-free fruit.

Codling moth. The populations of *Laspeyresia pomonella* (L.) on two cultivars in an insecticide-free apple orchard showed similar trends over a 12-yr period. Infestation of fruit was greater on the cultivar with the larger annual crop. Predation of eggs on the cultivar Delicious was greater than on the cultivar McIntosh. Mortality of neonate larvae was greater on McIntosh. Egg-to-egg survival ratios varied from 0.23 to 6.83. The average generation survival of egg to adult for the 12-yr period was near 10%, which confirms an earlier value established empirically.

Eye-spotted bud moth. The populations of *Spilonota ocellana* (D.&S.) on two cultivars in an insecticide-free orchard showed nearly identical trends over a 12-yr period. Egg populations reached maximum numbers when the orchard was 9 yr old and the ensuing larvae infested 33% of the clusters the following year. A marked decline in all

stages occurred when the orchard was 11–12 yr old and this was immediately followed by a second peak of less intensity on both cultivars. The only difference in mortality of the population on the two cultivars was found in neonate larvae. The average survival of egg to pupa for the 12-yr period was near 7%.

Field evaluation of synthetic sex pheromone attractants. Synthetic sex pheromones were evaluated in apple orchards against the pests *Spilonota ocellana* (D.&S.), *Archips argyrospilus* (Walker), *Choristoneura rosaceana* (Harris), and *Pandemis limitata* (Robinson). Significant correlations between spring larval counts and captures of males in summer in pheromone traps occurred only at moderate to high population levels. Correlations between captures of males in summer and fruit damage occurred only with *S. ocellana*. The attractants for *S. ocellana*, *A. argyrospilus*, and *C. rosaceana* appear satisfactory but that for *P. limitata*, possibly due to species identification uncertainty and low populations, requires further evaluation.

Onion thrips. Damage by the onion thrips, *Thrips tabaci* Lind., to the interior leaves of stored cabbage was reported for the first time in Canada. This occurred on cabbages held in storage in Nova Scotia and Prince Edward Island and the injury was characterized by rasped areas and hyperplastic galls.

Populations of major pests and their enemies on young and semidwarf apple trees. The population densities of several major apple pests and their natural enemies were studied in an insecticide-free young bearing orchard and in an older orchard of semidwarf trees on an integrated control program. In mature orchards of standard size trees, greater natural mortality occurs than that reported in this study. Over a 5-yr period most pests, with notable exceptions, increased rapidly under insecticide-free conditions whereas occasional numerical surges of certain pest species occurred under the mild insecticide program. Insect damage on fruit at harvest averaged 24% in the insecticide-free orchard and 8% in the integrated control orchard, which had 2.4 times more harvested fruit.

PESTICIDE RESIDUES AND DETERMINATION

Dihydrochlordene dicarboxylic acid residues in soil treated with high rates of aldrin. A hydrophilic residue of aldrin, dihydrochlordene dicarboxylic acid, was found to be present in a sandy loam soil collected over a 14-yr period after application of aldrin at two high rates. The residue was extracted from the soil, then methylated and determined using gas chromatography with an electron capture detector. The residue was found to decrease with time. An increase in residue detected with depth of the soil sample with time indicated that slow leaching as well as decomposition of this significant terminal residue of aldrin were taking place.

Effects of atrazine, cyanazine, and cyprazine on photosynthesis and growth of nine grasses. There were significant differences in levels of inhibition and subsequent recovery of NCE in maize and eight weedy panicoid grasses following limited root uptake of atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine), cyanazine [2-chloro-4-(1-cyano-1-methylethylamino)-6-ethylamino-1,3,5-triazine] and cyprazine (2-chloro-4-cyclopropylamino-6-isopropylamino-1,3,5-triazine). Rate of NCE recovery was positively correlated ($P = 0.05$) with growth of seedlings in nutrient solution containing the herbicides. Rates of NCE recovery >0.9 mg CO_2 per dm^2 per h/h reflected rapid rates of herbicide detoxification in the leaves and a significant tolerance to preplant incorporated and postemergence applications of atrazine, cyanazine, and cyprazine. In contrast, some species, e.g. large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and proso millet (*Panicum miliaceum* L.) treated with cyanazine demonstrated considerable tolerance to these treatments in spite of low NCE recovery rates, indicating that factors other than foliar detoxification may play an important role in the tolerance of some grasses to 2-chloro-1,3,5-triazine herbicides.

Ethylenebisdithiocarbamate and ethylenethiourea residues. In 1975, residues of ethylenebisdithiocarbamate (EBDC) in fresh apples harvested 42 days after receiving the last of nine sprays of the fungicides mancozeb and metiram were 1.70 and 0.50 ppm, respectively. With both fungicides, residues of ethylenethiourea (ETU) were at the

analytical sensitivity level of 0.01 ppm. On processing into apple products there was some conversion from EBDC to ETU. Canned apple juice and sauce from mancozeb-sprayed apples both contained 0.05 ppm ETU, while the level in dried apple pomace was 0.17 ppm. Similar levels were present in products prepared from metiram-spray apples. In 1976, with both fungicides, the EBDC fresh fruit residues were <1.0 ppm in apples receiving one, two, three, or four cover sprays and ETU was not detected except for a trace in the sample of apples receiving three cover sprays of mancozeb.

Glyphosate and its aminomethyl phosphonic acid metabolite detection. Glyphosate and its aminomethyl phosphonic acid metabolite were detected by using a one-dimensional thin-layer chromatographic method using microcrystalline cellulose or precoated MN-cellulose 300 sheets. Compounds were visualized using three spray reagents: ninhydrin, ninhydrin-copper nitrate, and ninhydrin Rhodamine B. The sensitivity of the method permits the detection of about 100 and 50 ng of glyphosate and metabolite, respectively, in spiked distilled water.

Organophosphorus and organochlorine residues. Bottom sediments from two streams draining agricultural land in New Brunswick were analyzed for organochlorine and organophosphorus insecticide residues. Most samples contained appreciable quantities of DDT plus metabolites (up to a total of 2.07 ppm), about one-third contained smaller quantities of endrin (up to 0.45 ppm), and approximately one-fifth contained dieldrin (up to 0.01 ppm). No other organochlorine and organophosphorus insecticides were detected.

3-Oxycarbofuran determination in soil. An electron-capture gas chromatographic method is described for the direct determination of 3-oxycarbofuran in soils. Soil samples were refluxed in 0.25 N HCl and the extracts partitioned with methylene chloride. The methylene chloride was evaporated and the 3-oxycarbofuran residues were taken up in hexane without derivatization and determined by electron-capture chromatography. Sensitivity was such that without clean-up, 0.1 ppm of 3-oxycarbofuran could be determined in soil.

Persistence of 2,4-D, 2,4,5-T, and dicamba in a dykeland soil. The rate of breakdown of

the herbicides 2,4-D, 2,4,5-T, and dicamba varies greatly depending on soil and climate. A 55-wk study was conducted to determine their persistence on a dykeland soil in a humid temperate climate. The residues were extracted from the soil, methylated, and determined using gas chromatography with electron-capture detection. More than 90% of the amounts of applied herbicide disappeared within 10 wk (with one exception). After 55 wk three treatments had residues of approximately 0.1% of the initial application and the rest had undetectable or trace (<0.1 ppm) residues.

Triazine herbicides, their action in a resistant and susceptible selection of lamb's-quarters. The uptake, translocation, and metabolism of ^{14}C -atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] was investigated in an atrazine-resistant and an atrazine-susceptible selection of lamb's-quarters (*Chenopodium album* L.). There were no differences between the two selections in foliar or root uptake of ^{14}C -atrazine, or in translocation and accumulation of ^{14}C -atrazine within the plants following root uptake. Both selections metabolized ^{14}C -atrazine by hydroxylation, *N*-dealkylation, and conjugation to peptides. Although ^{14}C -atrazine was detoxified more rapidly in roots of the resistant selection, this could not account for the large difference observed in tolerance. The atrazine-resistant selection was also resistant to a number of other 2-chloro-, 2-methylthio-, and 2-methoxy-s-triazine herbicides, and showed greater tolerance to other heterocyclic herbicides which inhibit photosynthesis than did the susceptible selection.

STORAGE

Controlling CO_2 egression from potato tubers. CO_2 permeability of thin, soft, edible films made by the application of aqueous nonionic polyoxyethylene adducts of fatty acids to product surface (potatoes) was substantially reduced by the addition of citric acid to the formulation. It was suggested that these films could serve as an effective means of controlling the internal atmosphere for some plant products.

Effects of harvest date on the condition after storage of McIntosh apples treated with ethephon and fenoprop. Trees of McIntosh

apples were sprayed with a combination of 300 ppm ethephon plus 6 ppm fenoprop before harvest. Fruits were harvested from treated and untreated trees at intervals from 4 to 15 days after spraying and were promptly stored at 0°C until 4 February. The criteria of quality, firmness, percentage malic acid, and incidence or core browning indicated that the ethephon plus fenoprop treatment resulted in more red color with less loss of storage life than did harvest of untreated fruit delayed until normal mid-harvest time for this cultivar. Clonal strains responded differently to treatment in firmness and in the incidence of core browning.

Prevention of poststorage greening in potatoes by application of surfactants and adjuvants. The addition of adjuvants to sprays of aqueous emulsions of Tween (polysorbate) surfactants reduced the concentration of the Tween required to prevent greening; thus they increased the practicality of using Tweens 60, 65, and 80, which are broadly accepted food additives. Conspicuous among adjuvants found were certain plant acids. These were lactic, glycolic, *d*-tartaric, L-ascorbic, glyoxylic, gluconic, α -ketoglutaric, D-isoscorbic, and citric acids. The principal mode of action of the adjuvants was to decrease the permeability of the adhering surfactant film towards CO_2 transfer. This action and its duration was a function of the Tween and its concentration, and the adjuvant and its concentration.

FOOD TECHNOLOGY

A new blanching system for the food processing industry. A new blanching system designed and built by Agriculture Canada (based on the individual quick blanch concept) has been tested extensively over several crop seasons. Results are given showing reductions in effluent load and energy usage as well as an increase in retention of nutrients as compared to conventional systems. The unit can blanch up to 180 kg of peas per hour using only 8.5 kg of steam per 100 kg of product and producing as little as 9 kg/100 kg of effluent. An increase in ascorbic acid retention of 20% over a conventional water blanch - water cool process was obtained for peas, while as much as 52% improvement was seen for broccoli. With the new process 85-90% of ascorbic acid is retained in the product.

Flexible retortable pouch processing with particular emphasis on an individual fruit pack for DND. Products superior to conventional canned products were produced from apples and pears by packaging in flexible retortable pouches for inclusion in an experimental ration pack for DND. Eighty-five grams of sliced vacuumized fruit pieces packaged in 15 mL of a 40% SS syrup in a 124 mm × 180 mm laminated pouch proved to be superior to all other packs from the point of view of product quality, seal integrity, headspace volume, and heat penetration characteristics. Details of heat penetration and process parameters are presented together with details of pH adjustments and microbiological evaluation.

Modification of the ultrastructure and rheology of rehydrated commercial wheat gluten. Electron microscopy and dynamic shear measurement were employed to study the effect of manipulating protein, starch lipid, and moisture levels of commercial vital wheat gluten. It was found that the ultrastructural and rheological properties of the wheat gluten could be altered by these manipulations. Up to a level of 3% added fat (based on gluten weight) a systematic decrease in magnitude of shear storage, loss moduli, and dynamic viscosity was noted. Neither type of liquid nor level seemed to cause a fundamental change in the nature of the viscoelastic character of the wheat gluten. It is suggested that protein-protein interaction is in some way hindered but not altered in nature.

The addition of starch to the gluten did not change the character of the viscoelastic response but caused an increase in magnitude of response. It would appear that starch level is related to a decreased availability of water which has been found critical to the response of the system and that starch granules increase orientation of protein while providing anchoring points for the protein fibrils and sheets.

Predicting storage behavior of prepeeled rutabaga by penetration testing. A puncture test was employed to evaluate the storage behavior of lye-peeled small whole rutabaga packaged in polyethylene. A limiting factor during storage was the development of a "new skin." Depending on experimental conditions this skin rendered the product unacceptable after the 14th day of storage. Time of storage, size of root, and thickness of

packaging material all had significant roles in the storage stability of the product. An equation based on multiple linear regression described the relationship between puncture force, root size, time of storage, and package thickness.

Production and processing of small, whole rutabaga. The feasibility of controlling root size in rutabaga was investigated over two crop seasons. Small roots suitable for processing could be produced almost exclusively or in combination with market-sized roots by varying within-row spacing and harvest date. The peeling process was accomplished by lye peeling. Yield was affected both by cultural practices and by peeling. The smaller the root, the greater the loss to peeling. The study indicates that it is possible to tailor root size to the requirement of the process and to produce an attractive prepeeled rutabaga product suitable for convenience food markets.

ANIMAL SCIENCE

Cattle

Feeding value for beef steers of corn silage as affected by harvest dates and frost. An experiment was conducted in three consecutive years with silage made of corn harvested at different dates before and after freezing. Yields of green and dry weight were recorded at each harvest. Individual whole plants and plant parts were evaluated for dry matter (DM), total nitrogen, total available carbohydrates, and in vitro digestibility of DM. Animal gains, feed consumption, and carcass grades were determined by feeding the silages to yearling Hereford steers and DM digestibility was determined with sheep. The total yield and contribution of the ear increased from the first to the second harvesting date. The in vitro digestibility of DM of the silages declined between the second and final harvests in all years as did animal gain in years 1 and 3. The in vitro digestibility appeared to underestimate the effect of frost on the in vivo digestibility of silage made with corn. When the silages were fed to steers, they consumed more dry matter per day from those harvested on the intermediate date than from either the early or late date. Higher carcass grades occurred when the steers were fed corn harvested at the intermediate dates. The results of these experiments

show clearly that corn which has been heavily frozen will lose dry matter and feeding value if left standing in the field for a period of time; however, corn harvested soon after freezing is not as seriously affected.

Relationship of forage maturity to digestibility and animal gain when silage is untreated or treated with formic acid. Four crops were compared as unwilted silage for beef cattle weight gain: (a) grass harvested 10 June, vegetative stage yield 3.29 t/ha of 74% digestible dry matter (DM) (in vitro); (b) similar grass, harvested 20 June, early head, yield 4.46 t/ha of 66% digestible DM; (c) similar grass, harvested 10 July, bloom stage, yield 5.96 t/ha of 56% digestible DM; (d) alfalfa-bromegrass, harvested 23 June, early head, full bud, yield 4.94 t/ha of 64% digestible DM. Formic acid (4.5 L/t) was applied to the forage stored in the bottom half of each of the four upright silos. The apparent digestibilities of the DM as determined with sheep for the four untreated silages were: (a) 74.4, (b) 64.7, (c) 55.2, and (d) 61.3%. Yearling steers fed the silages as the sole ration gained (a) 1.25, (b) 1.07, (c) 0.40, and (d) 0.72 kg/day; when supplemented with 1 kg barley per day, gains were (a) 1.24, (b) 1.17, (c) 0.51, and (d) 1.04 kg/day. The formic-acid-treated silage produced animal gains of (a) 1.17, (b) 1.06, (c) 0.78, and (d) 0.96 kg/day; when supplemented with 1 kg barley per day gains were (a) 1.31, (b) 1.08, (c) 0.79, (d) 1.06 kg/day. The greatest weight of beef cattle gain per tonne of DM was obtained with the a crop, but beef production per hectare was greatest from the grass crop harvested at the early head b stage of development. It was concluded that the production of over 1 t of beef gain per hectare per season is possible from a temperate climate grass crop, harvested in the vegetative stage of development.

Poultry

Effects of different proportions of rye to wheat in the grain component of broiler finisher diets on general performance. A total of 1520 commercial-type broiler chicks were used in two experiments to evaluate the effects on performance of feeding finisher diets containing 0, 5, 10, and 15% of the diet as ground rye as a replacement by weight for ground wheat. The finisher diets were fed approximately 3 wk commencing at 28 days of age. Biological data provide evidence that up to 10% of the ground wheat in broiler finisher diets can be replaced by an equal quantity of ground rye without an adverse effect on performance. Evidence indicates that feeding a finisher diet containing 15% ground rye resulted in inferior performance.

Feed texture and light treatment effects on the performance of chicken broilers. A total of 4800 broiler chicks from a commercial parent genotype was used in two experiments to evaluate effects of feeding finisher diets containing different levels of "fines." These experiments also included a comparison of incandescent continuous green lighting and white lighting with continuous and intermittent exposure at different intensities, including one treatment which was phased down to darkness at 21 days of age and continued to 49 days of age. Fines used in these diets were ground pellets having equivalent levels of protein, fat, and fiber. Performance of birds fed crumbled starters (1–28 days) and pelleted finishers (29–49 days) was superior to birds fed all-mash starters and finishers. As the proportion of fines in finisher diets increased, there was a significant decrease in body weights and monetary returns.

Performance under both intermittent white lighting vs. continuous white or green lighting had no differential impact with light intensity of 0.5 lx or 7 lx from 21 to 49 days of age. Broilers grown in darkness from 21 to 49 days performed well although body weights were reduced compared with birds grown in light. There was no evidence of an interaction between light and feed texture treatments.

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Diploid breeding and genetics of
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Weed control

Late blight of potato

Potato breeding and evaluation

Tuber-borne pathogens of potato

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Tuber-borne pathogens of potato

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Aphid-borne viruses

Potato quality and breeding

INTRODUCTION

The Fredericton Research Station is the Canadian center for research on the potato crop with a diverse, multidisciplinary program emphasizing breeding and genetics, pest management, soil and crop management, and harvesting and storage engineering. The Station serves also as the regional center in the Atlantic Provinces for research on the nutrition of ruminant animals as well as environmental impact studies of agricultural chemicals.

This report highlights research activities during 1977 and 1978. A more extensive and detailed synopsis is published annually in the Research Summary prepared for extension workers, crop specialists, and producers. Copies of the summary and related publications may be obtained by writing to the Research Station, Research Branch, Agriculture Canada, Box 20280, Fredericton, N.B. E3B 4Z7.

G. M. Weaver
Director

LIVESTOCK FEEDS AND ANIMAL NUTRITION

Feeding fermented colostrum and the effect of adding potassium sorbate

Streptococcus lactis cultures yielded a more acceptable colostrum for feeding to calves than *Lactobacillus plantarum* or a yogurt culture of *L. bulgaricus* and *S. thermophiles*. Colostrum fermented by *S. lactis* stabilized at about pH 4.3 and was adequately preserved except for growth of molds on the surface when stored during hot weather.

Addition of potassium sorbate, a mold inhibitor, to fermented colostrum or milk replacer increased the growth of calves and energy digestibility by a small amount. Calves fed whole milk; colostrum and *S. lactis*; or colostrum, *S. lactis*, and potassium sorbate (2 g/kg colostrum) for 21 days gained 5.1, 0.7, and 2.4 kg with the respective diets. Both colostrum diets were diluted with water to be isonitrogenous with the whole milk. A more pronounced improvement by the potassium sorbate was observed in the digestibility of nitrogen and its retention as percent of absorbed nitrogen. When potassium sorbate was compared with formaldehyde as additives to an unfermented commercial milk replacer for lambs, no differences in growth rate or efficiency were observed, indicating that the potassium sorbate was not exerting its effect directly on the calves or lambs.

Calves fed fermented colostrum which was diluted to be either isonitrogenous or isocaloric with whole milk gained respectively 25

and 20% less weight than a group fed whole milk. A group of calves fed fermented colostrum diluted to be isonitrogenous with whole milk and supplemented with lactose to make it isocaloric gained 25% less than the whole milk group. Thus, the lower weight gains measured in calves consuming fermented colostrum are not compensated for by addition of energy in the form of lactose.

Suboptimal protein levels in total mixed rations for dairy cows

Protein levels in total mixed rations must be related to the cow's appetite since such rations are fed ad libitum, whereas with conventional feeding methods the concentrate portion is fed according to the level of milk production. Rations too low in protein will reduce milk production, while excessive intakes of protein are expensive and reduce the efficiency of protein utilization. Total mixed rations composed of 60% grass silage and 40% concentrates on a dry matter basis and containing suboptimal (10%), recommended (13%), and high (16%) levels of protein were fed ad libitum to cows in early lactation. Total nitrogen intake per cow averaged 263, 377, and 510 g/day for the respective rations. Cows fed the 10% protein ration had reduced feed intakes and large body weight losses. Although milk production was unaffected by protein level, milk fat, milk protein, rumen ammonia nitrogen, and blood urea nitrogen increased in direct relation to the level of ration protein. The total mixed ration containing 13% protein was adequate for milk yields of over 20 kg daily.

Selenium and vitamin E supplementation for dairy cows

Forages and grains in the Atlantic region contain considerably less selenium than the 0.1 mg/kg of ration suggested for ruminants. Supplementation with selenium and vitamin E prior to calving has been proposed as a method of reducing the incidence of retained placenta in dairy cows. Due to the high incidence of retained placenta in the Research Station dairy herd, alternate cows were injected intramuscularly with 50 mg selenium as sodium selenite plus 680 IU of vitamin E as *d*-alpha-tocopheryl acetate approximately 20 days prior to calving. The number of retained placenta was less than 10% in both the treated and control groups and the incidence was unrelated to cow body weight, calf size, calf sex, or season of calving.

Ensiling potato vines

Experiments to assess the feasibility of ensiling potato vines for animal feed have shown that potato vines harvested prior to senescence contain a useful level of nutrients for ruminants; that they can be ensiled satisfactorily provided the moisture content is lowered; that sheep will readily consume a silage made from chopped potato vines mixed with 5% barley, 0.5% malted barley, and 20% hay or straw; and that the total glycoalkaloid level is not high enough to cause toxicity.

Based on these results, fresh, chopped potato vines were mixed with 5% barley and 16.7% chopped hay, ensiled in plastic bags, and fed to sheep over a 6-wk period. The dry matter digestibility (52.6%) and dry matter consumption (47 g/kg $W^{0.75}$) were similar to values expected for average quality grass silage. Five of the six sheep behaved normally throughout the experiment but the sixth started regurgitating rumen contents and scouring after 24 days on the silage. Total glycoalkaloid levels were determined to be low but the significance of pesticide residues has not as yet been determined.

Processing hay to feed with potatoes

Two of the most common feeds available for beef cattle in the Maritimes are timothy hay and cull potatoes. Often the timothy hay is not of the best quality. Studies were conducted to determine if processing hay by grinding and pelleting would increase intakes

and rates of gain of beef steers. Each steer was fed 12.5 kg of potatoes, 0.5 kg of a protein-mineral-vitamin supplement, and hay ad libitum. Steers fed long hay each consumed 2.9 kg of hay per day and gained 1.0 kg/day. Grinding and pelleting the hay, but not grinding alone, increased the intake of hay (4.01 kg) and rate of gain (1.32 kg) of the steers.

Similar steers were fed a daily ration of 12.5 kg of potatoes, 0.5 kg of supplement, and either a timothy or a ladino-timothy hay in chopped or ground-pelleted form. The ladino-timothy hay group gained 0.12 kg/day more than those fed the timothy hay (1.08 kg/day) regardless of the physical form of the hay. Grinding and pelleting resulted in an increase in rate of gain of only 0.08 kg/day compared with animals fed chopped hay. The daily intake of the pelleted hays averaged 44% more than the chopped hay but the efficiency of feed conversion to liveweight gain was considerably less.

Effects of low temperature on digestibility

Research at the University of Alberta has shown that ruminant animals kept in the cold do not digest their feed as completely as those kept warm. This was considered to be due to increased gut motility and a faster rate of passage of the fiber. Ground and pelleted forages have a faster rate of passage and lower digestibility than similar forages fed long or chopped. The potential depression of digestibility of pelleted forage by cold weather was therefore evaluated.

The digestibility of the hay was lower for animals in the frost-free barn (3–5°C) than for those in the heated lab (12°C) and lower still for those in the cold barn (0 to –18°C). The decline was about 1% unit for each 5° drop in temperature whether the forage was pelleted or chopped.

Paunch residue can be ensiled

Disposal of the undigested feed residue in the paunch of slaughtered cattle is a problem to many packing plants. An acceptable cattle feed can be made by cooking and dehydrating the residue but this is expensive. The possibility of disease transfer rules out feeding the fresh material directly. If the paunch residue could be ensiled and fed in this form it would avoid the cost of dehydration and the ensiling process would destroy most, if not all, potential pathogens.

Satisfactory fermentation and preservation can be obtained when the fresh paunch residue is mixed with chopped hay and ground barley. This silage was readily accepted by sheep and when a small amount of malted barley was added at ensiling the sheep ate as much dry matter per day from this silage as from corn silage. The silage made from paunch residue was low in digestibility however, and suitable only for maintenance rations.

Candle rapeseed meal in ruminant rations

Candle rapeseed meal (RSM) was found to be a fully satisfactory ingredient for ruminant rations. Candle RSM was produced from a new cultivar which has been bred to contain less crude fiber than earlier-released cultivars and fed to sheep in a digestibility trial and to lambs and steers in growth trials.

Candle RSM plus an equal amount of timothy hay was fed to mature wethers to determine the digestibility. Tower RSM plus timothy hay provided the control. The digestibility of dry matter, nitrogen, energy, organic matter, acid and neutral detergent fiber were all greater ($P > 0.05$) for Candle RSM compared to Tower RSM.

Both the lambs and steers fed diets containing Candle RSM grew more rapidly than did those fed Tower RSM. Differences were not significant and were partially accounted for by increased consumption.

Ammonium perchlorate as a feed additive

Russian reports of the growth-promoting effects of ammonium perchlorate (APC) in fattening beef steers were studied. APC was fed to beef steers and Holstein calves at 1.5–3.0 mg/kg of body weight. Control animals received no APC.

Beef steers grew at the same rate as the controls. In one test feed consumption was unaffected while in the other, the APC-fed steers consumed 3% less feed. The dairy calves appeared to grow more rapidly when fed APC but the increased growth was matched by increased feed consumption. No benefit was established for the incorporation of APC into conventional feeding programs.

Use of monensin and zeranol in beef cattle

The effects of monensin, a feed additive which is reported to improve feed efficiency, were studied using beef heifers fed long

timothy hay as the basal roughage for 78 days followed by corn silage for 118 days. Monensin improved the efficiency of conversion of roughage to live-weight gain by about 13% with both forages. When the hay was fed there was no change in rate of gain but when corn silage was fed there was an increase (1.11 vs. 0.97 kg/day) with the monensin-fed heifers.

Several anabolic ear implants approved for use in Canada are considered to be effective in promoting growth for 100–120 days but there is controversy concerning the ability of cattle to respond to a second implant after this time. The steers used in this experiment were all implanted with zeranol and half were reimplanted 117 days later. Following the second implant half of each group were fed on a high plane of nutrition (controls gained 1.11 kg/day) and half were restricted in feed (controls gained 0.80 kg/day). The reimplanted steers gained more but the response was greater for the steers on the high level of feeding (1.23 and 0.86 kg/day for high and restricted levels, respectively).

Heat-damaged forages in New Brunswick

The digestibility of protein in conserved forages may be reduced if heating occurs in the stored mass. Indigestible protein is increased during heating by chemical reactions of the Maillard type and is most likely to take place in a mass of forage having a 20–70% water content and an initial exposure to air. Forty-seven grower forage samples were dried at 40°C, ground, and the nitrogen content of the acid-detergent fiber and the total nitrogen content determined to estimate the digestibility of the protein.

Moderate heat damage was evident in 38% of the samples (digestible protein less than 58%) and 15% were severely heated (digestible protein less than 52%). Damaged samples were found in all types of conserved forage: hay, haylage, and silage. Since heating can be minimized by using good management in making hay, silage, and haylage, these data indicate the need for further improvements in forage conservation.

Production of cellulase by *Trichoderma viride*

The feeding quality of forages for livestock can be estimated by measuring the amount of dry matter dissolved when a sample of the feed is incubated with a solution containing

enzymes such as cellulase that can hydrolyze plant fiber. A simple method for culturing *Trichoderma viride* on forages and preparing extracts containing cellulase was developed. The crude extracts of *T. viride* mycelia and fermented wheat straw or timothy hay contained more cellulase activity than cultures grown on wheat bran. Extracts of *T. viride* cultures growing on timothy hay or wheat straw can be used instead of commercial preparations of *T. viride* cellulase for assessing the digestibility of forages.

Aphid control in grain with Pirimor (Pirimicarb)

Pirimor (Pirimicarb), a candidate grain aphicide, greatly reduced aphid numbers and the incidence and severity of barley yellow dwarf virus (BYDV) when applied to oats, wheat, and barley. Aphid predators (Coccinellidae) were not adversely affected by the Pirimor treatment. Grain yield response as a result of spraying was highly significant.

POTATO BREEDING

Jemseg, a new first early cultivar

Elite seed of the newly licensed cultivar Jemseg is available for distribution to selected seed and tablestock growers in the spring of 1979. Jemseg is an early-sizing, early-maturing cultivar that consistently outyields Warba in New Brunswick. Grower trials in southern Ontario have also shown that Jemseg will outyield Superior by a wide margin. Jemseg is moderately resistant to common scab, immune to virus X, and is resistant to virus S.

Yellow-fleshed cultivar development

In response to changing markets for Canadian seed potatoes, a program to introduce yellow flesh into breeding lines at Fredericton was initiated in 1975. Following field trials in New Brunswick and Prince Edward Island in 1977 and 1978, three yellow-fleshed seedlings (F73008, F74070, F74123) have been identified that exceed Kennebec in marketable seed yield. These lines will now undergo extensive trials in Atlantic Canada and in potential market countries.

Tetraploid-diploid crosses produce high-yielding progenies

South American diploid cultivated species (*Solanum phureja* or *S. stenotomum*) were crossed with haploids of *S. tuberosum* to produce highly heterozygous, vigorous diploid hybrids. Several diploid hybrids produce $2n$ male gametes and these were hybridized as male parents with well-adapted Canadian cultivars and breeding stocks. The resulting tetraploid ($4x-2x$) hybrid progenies exhibited considerable hybrid vigor. Six selected seedlings from a population of $4x-2x$ hybrids were compared with six cultivars in replicated field experiments in Manitoba, Ontario, New Brunswick, and Newfoundland in 1977 and 1978. Several $4x-2x$ hybrids outyielded most cultivars at most locations. Preliminary international trials have also indicated that the $4x-2x$ hybrids perform extremely well under greatly different environments.

Multivariate analysis of tetraploid-diploid hybrid families

Ten tetraploid-diploid ($4x-2x$) hybrid families were obtained by crossing five *S. tuberosum* parents with each of two diploid *S. phureja* \times *S. tuberosum* parents. The families together with $4x$ parents and cultivars were tested in field trials in 1976, 1977, and 1978. The $4x-2x$ progenies displayed later maturity and more vigor than the $4x$ parents and cultivars. They also showed a greater number of stems, a higher number of tubers per stem, and lower mean tuber weight than the $4x$ parents and cultivars. As a result, the progenies averaged 87 and 127% marketable and total yield, respectively, of the $4x$ parents and cultivars. The tubers of the progenies showed poorer appearance and deeper eyes than the $4x$ parents and cultivars. The only trait which was similar between the two groups was specific gravity. Data of eight traits were used in canonical analyses. The effects of $4x$ and $2x$ parents were clearly shown on the distributions of the $4x-2x$ families in the canonical diagrams. There was substantial canonical distance between the $4x-2x$ families and the $4x$ parents and cultivars. The results suggest that the hybrids should be backcrossed to $4x$ cultivars to generate new hybrids which are genetically closer to the present $4x$ *S. tuberosum* breeding population but still maintain a certain degree of superiority of some economic traits of the original hybrids. It may also be

necessary to develop more improved 2x parents in which yield, horticultural traits, and disease resistance are combined.

Multiple disease resistance breeding in Andigena

Long-day adapted Andigena clones have been evaluated in field exposure plots for resistance to PVY, common scab, late blight, and wart. PVY resistance was found in some 48% of the clones and additional testing has shown at least some of them to be immune. Scab resistance was found in 10% of the clones with 23% moderately resistant. Fourteen percent of the clones showed field resistance to late blight while 43% displayed moderate field resistance. Wart testing was confined to Newfoundland where 59% of the clones were found to be resistant.

Of 76 Andigena clones evaluated for combined resistance to all four diseases, none had resistance to all and only 3.9% had resistance to any three pathogens. Subsequently, a program was developed to combine resistance to the four diseases using a 2-yr cycle of hybridization, evaluation, and selection. Selected resistant clones were intercrossed, and modified tests used to evaluate each of the resulting seedlings to each of the four diseases. In the first cycle, of 236 seedlings evaluated, four (1.7%) were found to be resistant to all four diseases and 16.6% were resistant to three of them.

Evaluating group Tuberosum \times Andigena hybrids for cultivar development

Between 1975 and 1978, 68 Tuberosum \times Andigena hybrids were evaluated in a program to incorporate long-day adapted Andigena germ plasm into the cultivar development program. In the first (single-hill) field generation a random sample of 30 seedlings was evaluated from each hybridization. These same seedlings were grown and evaluated again in the succeeding year with their parents in 10-hill plots.

Hybrid seedlings were compared with each other and with their parents using canonical analysis of maturity, stolons, tuber appearance, tuber number, mean tuber weight, marketable yield, and specific gravity. Canonical distances were generally shorter between crosses and their Andigena parent, showing the greater influence of this germ plasm.

Individual selection in the single-hill generation plant resulted in large gains in marketable yield, number of marketable tubers, total yield, and in earlier maturity. Little or no selection response was noted for specific gravity and total tuber number. Comparatively larger selection gains were obtained with intergroup hybrids than are expected with hybrids within group Tuberosum.

Analysis of genotype-environment interactions of yield

Three methods were used to study genotype-environment interactions of potato yield. They were chosen to represent single (stability variance), two (genotypic stability parameters α , λ), and three (genotypic components v_1 , v_2 , and v_3) parameters for measurement of genotypic contributions to the genotype-environment interactions. Data for marketable yield and three yield components were collected: number of stems per plot, number of tubers per stem, and mean tuber weight of 30 genotypes. Significant differences were found for the stability variance and the genotypic stability parameters. The estimates of stability variance were highly correlated with the second genotypic stability parameter (λ). Both parameters showed a curvilinear relationship with v_1 and v_2 , suggesting that genotypes having moderate response to the environmental resources supporting the processes of stem formation and tuberization should be labeled as stable due to the small stability variance or, alternatively, as a highly predictable performer because of the small deviations from the linear response to the environments. The first genotypic stability parameter which measures the linear response of genotypes to the environments showed close association to v_3 , which measures the genotypic response of the tuber bulking process to the environments. The estimates of v_3 showed a moderately positive correlation with the mean marketable yield and were larger than those of v_1 and v_2 for most genotypes. Difficulty would be encountered in identifying high-yielding genotypes without sensitivity to the environmental factors which influence the process of tuber bulking for the formation of yield.

Interval estimate of expected response to selection

A method has been developed to obtain an interval estimate of expected response to selection based on the results of the progeny test.

Data on six traits for 465 seedlings of 25 hybrids evaluated in 1969, 1970, and 1971 were used to compare the efficiency of selection of three selection schemes on the Tuberosum breeding materials. Individual selection was the best of three selection schemes employed. Family selection gave smaller order responses. Selection for marketable yield and maturity resulted in the greatest deviation from the population mean while selection for specific gravity and appearance yielded the more precise results.

POTATO PATHOLOGY

Forecasting late blight outbreaks

An analysis of 25 yr of hourly weather data showed that the correlation between the time of disease outbreak and an index derived from temperature and various humidity values was highest when 75% relative humidity was used. Other factors found to affect the correlation were: the date in spring when data were first recorded, the numerical limit placed on the index derived from temperature and humidity, and the number of days when data were recorded previous to the date of disease outbreak. Regression curves developed from the data were used in 1978 to forecast blight outbreaks with good results. In 1979 the forecast method will be used as one of the criteria on which to base a weekly blight advisory bulletin to potato growers.

Effect of mechanical vine-pulling on development of late blight in tubers

The effect of mechanical vine pulling as a means of terminating growth of potatoes was evaluated to assess its impact on the development of late blight. Plots of cv. Green Mountain were inoculated with spores of the potato late blight fungus and, because of dry weather, plots were subsequently irrigated eight times to encourage late blight development. Disease readings at the time of vine pulling and chemical top killing (diquat at 0.82 kg/ha) showed that foliage in the sample rows was 80% infected with blight.

Disease was assessed on the tubers approximately 6 wk after harvest with 1.9% of the tubers from the chemical treatment infected with blight and 1.3% of the tubers from the mechanical treatment infected. Consequently, vine pulling appears to be comparable with chemical top killing in controlling the spread of late blight to the potato tubers.

Differential inhibition of spore germination in *Phytophthora infestans*

Further study of the differential behavior of sporangia and zoospores of *P. infestans* following treatment with varying levels of actinomycin D, 5-fluorouracil, and cycloheximide indicated that the continued translation of a preformed stable messenger RNA is a necessary requirement for the formation and release of zoospores during indirect germination. The pattern of inhibition produced by these compounds on the zoospores themselves also suggested that their subsequent germination and development may depend upon renewed transcription activity as well.

RNA metabolism in *Phytophthora infestans* during sporogenesis

An autoradiographic analysis of label uptake by the RNA components isolated from ^{14}C -uridine-treated sporangia of *P. infestans* in 2.5% polyacrylamide gels showed the presence of RNA species with molecular weights of 2×10^6 and 0.8×10^6 daltons. The addition of actinomycin D (25 $\mu\text{g/mL}$) to sporangia undergoing indirect germination at 13°C in the presence of labeled uridine led to a 40–50% inhibition of label uptake and incorporation when compared to the control mixtures. Coupled with the absence of demonstrable levels of intact polysomes, as determined by conventional methods, these results point to a rapid turnover in ribosomal RNA during sporogenesis.

Induction of common scab symptoms in aseptically grown tubers

A thermostable, freely dialyzable low molecular weight substance was isolated from scab lesions in both field-grown and aseptically cultured potato tubers and purified routinely by column chromatography using Sephadex LH-20. The material eluted from the column was used to induce common scab in healthy tubers cultured under aseptic conditions. Provisionally named thaxtomin,

this phytotoxic principle satisfied all of the basic criteria of a vivotoxin.

Miniature plant indexing for virus diseases

A significant saving of space has resulted from use of miniature plants in eye indexing of seed potatoes. Sets are scooped out with a 10 mm scoop fashioned from stainless steel sheet, rather than the standard 30 mm melon scoop. They are then placed in 45 mm pots (soil) or plastic-paks (peat-perlite mix), on a low fertilizer and water regimen. Small but well-proportioned plants develop. Excellent symptoms of leaf roll, as well as mild and rugose mosaic, have been obtained. Leaves of these miniature plants have proved satisfactory in serological tests for PVS and PVX.

Field resistance to potato virus Y and potato leaf roll virus classified by cluster analysis

Data from 5 yr of field exposure trials have been subjected to cluster analysis to classify potato cultivars into four categories of resistance or susceptibility to PVY; and four categories with respect to PLRV. Resistance to the two viruses segregates independently. This method of classification is being applied to selection of seedlings in the potato breeding program.

Epidemiology and control of potato leaf roll virus in the cultivar Netted Gem

Spread of PLRV to healthy plants of cv. Netted Gem was monitored in the field by removal of cuttings which were then cultured in the greenhouse for symptom expression. Virus spread followed closely upon heavy flights of the aphid *Myzus persicae* caught in yellow pan traps during the 2nd and 3rd wk of August; and in most instances tubers became infected. When no mass flights of *M. persicae* were detected, spread of PLRV occurred later in August, and in many instances virus did not reach the tubers by harvest.

Treatments which hastened maturity reduced the level of tuber infections: green-sprouting; close spacing; early planting; use of low N and P, but high K fertilizer ratios. The insecticide methamidophos also exercised some control; and fewer infections occurred in plots in the central portions, as opposed to the fringe areas of the field.

Potato spindle tuber viroid

The infectivity of the potato spindle tuber viroid (PSTV) was followed at weekly intervals up to 14 wk after inoculation of cv. Netted Gem. The viroid was assayed on *Scopolia sinensis* leaves from extracts of roots, lower and upper stems, and middle and apical leaves. PSTV was detected from the middle leaves and roots as early as 1 wk after inoculation; however, in most plant parts, the highest infectivity was observed 4–8 wk after inoculation, after which it declined. Infectivity was also highest in extracts from the mature leaves in the middle of the plant and lowest in roots and tuber extracts.

Methods to store the infectious viroid in freeze-dried form were evaluated. PSTV survived up to 6 yr in freeze-dried tomato leaves stored at room temperature with no loss of infectivity during storage. The freeze-dried material was suitable for long-distance shipping as freeze-dried leaf powder and for concentrating viroid for purification purposes.

Piperonyl butoxide, two mineral, and two vegetable oils were tested for their effect on local lesion symptom expression in *Scopolia sinensis* plants inoculated with PSTV. Piperonyl butoxide strongly inhibited local lesions, while sesame oil acted as a modest inhibitor. In tests with potato, piperonyl butoxide at a concentration of 1% prevented infection in sprayed leaves up to 5 days, whereas sesame oil at a concentration of up to 4% failed to prevent infection. Inhibition with piperonyl butoxide was observed in several potato cultivars.

Local lesion indicator for potato virus A

Intact and detached leaves of *Physalis floridana* produced local lesions when inoculated mechanically with crude sap from potato plants infected with potato virus A. The local lesions appeared in 6–9 days and were circular with a light brown center and dark brown border. The local lesion development was optimum at low intensity of 2–3 klx at temperatures of 18–25°C.

Two other species, *P. angulata* and *P. pubescens* were found to be local lesion hosts for PVA. The plants of *P. angulata* have long and smooth leaves and are preferred over the other two species.

Disease-indexed stem cutting (DISC) potato program

Disease-indexed stem cuttings (DISC) have been used to establish seed stocks known to be free from bacterial ring rot and the latent and visible viruses. Each nuclear stock plant is indexed to ensure freedom from tuber-borne diseases, before the cuttings from that plant are used. To date, there has been no reinfection or recontamination in any multiplication plot by bacterial ring rot or the following tuber-borne diseases: black-leg; silver scurf; verticillium wilt; or skin spot. In addition, only the occasional tuber has become slightly recontaminated with black scurf (sclerotia of *Rhizoctonia solani*). Superficial pinkeye (*Pseudomonas fluorescens*) lesions appeared on Kennebec, Sebago, and Netted Gem Pre-Elite tubers but none of the infected tubers rotted or produced abnormal plants or infected daughter tubers when used as seed. *Erwinia* soft rot bacteria were isolated from three tubers in samples of Elite II seed, but no black-leg type symptoms have been observed in the plots. Pocket rot (*Phoma exigua* var. *exigua*) and black dot (*Colletotrichum coccoides*) were present in the seed stocks (Elite I, II, and III) at low levels in Sebago, Kennebec, Netted Gem, and Red Pontiac, but there was no correlation between the levels of colonization of the stems and the incidence on the tubers with either disease.

All seed lots have remained free from PVX. With PVS we have detected reinfection in Red Pontiac and Netted Gem to a maximum of 19% in Elite III Gems.

POTATO ENTOMOLOGY

Aphid overwintering

Although the overwintering hosts of holocyclic populations of potato-infesting aphids have been known for some time, such populations of *Myzus persicae* (Sulzer), the main vector of potato leaf roll virus, were seldom found in New Brunswick on *Prunus nigra*, a recorded winter host. In our search for the anholocyclic strain of *M. persicae* in sheltered places we found not only this species but also two other potato-infesting aphids, *Macrosiphum euphorbiae* (Thomas) and *Aulacorthum solani* (Kltb.), colonizing potted plants and bedding plants in glasshouses, plastic houses, and department stores. In

1977, of 66 retail outlets surveyed in New Brunswick around the end of May, only 14 had potato-infesting aphids on their plants. But eight of these were located in the potato-growing area of the province, some in mall corridors, others in sidewalk displays. Often these infested plants were within full view and easy flying distance of emerging potatoes. In most cases the aphid-infested plants had originated from distributors in other parts of the province or from other provinces.

POTATO PHYSIOLOGY AND CROP MANAGEMENT

Relationship of stem number to yield in Kennebec

Differences in yield of Kennebec due to varying stem numbers per plant were studied by measuring changes in leaf area and dry weight throughout the season. Initially, the dry weight yield of tubers was related to leaf area but, following maximum leaf area development, this relationship no longer held. The final yield was shown to depend mainly on the net assimilation rate late in the season. The assimilation rate was controlled by the sink demands of the developing tubers and these in turn were influenced by tuber number. Tuber number and yields were increased as the number of stems increased.

Effects of transplanting and chitting on growth and development in Netted Gem

Early emergence and yield were consistently and significantly greater for transplants than those of plants grown from either chitted or unchitted seed. Tuberization was also advanced substantially. Higher relative growth rates were associated with later emergence so that the rate for plants growing from unchitted seed was greater than that for plants growing from chitted seed which, in turn, was superior to that of the transplants. This pattern was maintained through the season. Consequently, small advantages in time of emergence, such as that obtained with a short period of chitting, were not accompanied by significant yield differences. Canopy size decreased as emergence was delayed and canopy size differences were determined largely by the amount of branching. As emergence was delayed and canopy size decreased, the net assimilation rate was found to increase.

Influence of planting and emergence dates on tuber development in Netted Gem

Plantings in mid-May, late May, and mid-June were compared over a 5-yr period. The mean period from planting to emergence and from planting to tuberization was shortened as planting was delayed each spring. This was related to warmer soil and air temperatures coincident with later planting. However, the length of the period from emergence to tuberization was unchanged by planting date. Tuberization occurred about 18 days after emergence. If tuberization was delayed past the middle of July, there was a substantial reduction in the tuber development rate. It is important, therefore, that Netted Gems be planted early enough to ensure emergence by June 25 at the latest. The earlier tuberization occurs, the higher the mean tuber development rate during the critical growth months of July and August.

Canopy size effects on growth and tuber development

Three potato cultivars which normally produce small-, medium-, and large-sized canopies, respectively, but with similar tuber yields, were compared. Differences in total and tuber dry weight throughout the season were slight compared to differences in leaf and stem growth. The branching capacity of the cultivars was the major determinant of canopy size. As canopy size increased, the initial tuber growth rate immediately following tuberization decreased. Thus, in the two smaller cultivars, the early tuber growth rate was more critical in determining yield than was the case in the large canopied cultivar. As expected, the net assimilation rate increased as canopy size decreased. The evidence indicated that the demands of the developing tubers exerted the greatest influence on the net assimilation rate.

ENVIRONMENTAL QUALITY

Ethylenethiourea (ETU)

Although a number of gas chromatographic methods for determining ethylenethiourea (ETU) in foods and crops have been developed, most have not been subjected to any degree of collaborative testing. In an effort to ascertain the relative viability of our procedure, a collaborative evaluation involving analysis of tomato juice fortified

with ETU was undertaken. Statistical evaluation of the results from eight collaborators indicated a mean average of 93.7% recovery from spiked samples. The procedure proved reliable and much less time consuming than other methods in the literature. It was subsequently adopted for routine use by a number of participating labs.

Our previous residue studies indicated that the direct absorption of ETU from soil or foliage by potato tubers is minimal (0.1–0.2 ppm) and the normal use of ethylenbis(dithiocarbamate) fungicides is unlikely to result in any illegal ETU residues or to constitute a potential health hazard. We have recently examined tubers from plants treated simultaneously with a top killer (diquat at 0.56 kg/ha) and a dithiocarbamate (mancozeb at 1.80 kg/ha) spray at harvest time. Our analytical results indicate that, although some diquat was translocated, the tubers from these plants had ETU residues no greater than those observed on normal treatment with the dithiocarbamate spray alone.

Derivatization of pesticide sulfoxides for gas chromatographic analysis

Pesticides containing a sulfide group readily undergo oxidation to their sulfoxide and sulfone analogs, metabolites which normally also exhibit some pesticidal activity and must be considered in residue studies. Generally, sulfoxides do not gas chromatograph well but our previous studies have demonstrated the utility of their reaction with trifluoroacetic anhydride to give volatile α -trifluoroacetylated derivatives of the corresponding sulfides (Pummerer reaction).

To ascertain its relative generality several interesting variations on this reaction were further explored. Thus, the first example of a reaction sequence involving functionalization of an allylic methyl group, proceeding via an additive Pummerer rearranged intermediate was demonstrated. This novel reaction provided ready access to a number of previously unavailable 2-oxymethyl analogs of the highly active and widely used systemic fungicide carboxin (5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide). Examination of the transformation of 4-methylsulfinyl-3,5-xyleneol (mesurol phenol sulfoxide) to a bis(trifluoroacetyl) catechol analog, yielded a 2,5-dienone intermediate, and a potential

pathway to ring-hydroxylated mesurol analogs.

Determination of diquat residues in potato tubers

A new rapid gas chromatographic method utilizing sodium borohydride reduction and a nitrogen-phosphorus specific detector for the routine analysis of diquat (top killer) residues in potato tubers was developed. A total of 102 duplicate samples of treated and untreated potato tubers were analyzed for diquat by the new method. Diquat residues in the tubers varied with the foliar treatment but no correlation regarding the amount of eventual tuber rot was established. Translocation of diquat to the tubers following application to the stalks remaining after roto beating of the vines was much less than from the normal application of diquat to the whole plant.

BLUEBERRY PESTS

Control of blueberry maggot

Recent surveys have shown a marked increase in the prevalence of the blueberry maggot, *Rhagoletis mendax* Cn., and this is related to a general relaxation in control programs. The removal of calcium arsenate

dust as a registered control product for blueberry has created a serious problem, particularly in New Brunswick where many of the fields are small and growers rely on power dusters for applying insecticides. The changeover to sprays has been more rapid in Nova Scotia where Guthion sprays have been applied by aircraft for several years. However, in 1978 a coordinated aerial spray with Guthion was carried out on about 100 ha in southwestern New Brunswick and a major infestation was brought under control.

In small plot trials, excellent control of maggots was obtained with two applications of Guthion 2.4 SC and Cygon 4E at 0.33 kg active ingredient per hectare and Zolone EC at 0.5 kg active ingredient per hectare. In another trial, single applications at the same rates also gave good control.

Control of leaf-tier on blueberry

Excellent control of the blueberry leaf-tier, *Argyrotoza curvalana* Kft., was obtained in small plot trials with single applications of Guthion WP at the rate of 0.5 kg active ingredient per hectare or the synthetic pyrethroid Ambush 50 EC at the rate of 70 g active ingredient per hectare. Timing of application appears to be important, with maximum control being obtained when larvae are in the last instar about June 15.

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Zootchnie

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INTRODUCTION

Les recherches poursuivies à cette station sont fonction du type d'agriculture de la région, soit la partie sud-est du Québec. Elles sont axées sur les productions animales, notamment les bovins, les porcs et les moutons, et sur les productions fourragères. Ce rapport résume quelques expériences terminées au cours des années 1977 et 1978.

Il est agréable de noter que le personnel scientifique a augmenté pendant cette période. En effet, messieurs G. Barnett, L. Guilbault et D. Petitclerc se sont joints à l'équipe à l'été 1978.

On peut obtenir de plus amples renseignements en écrivant à: Station de recherches, Agriculture Canada, C.P. 90, Lennoxville, Québec, J1M 1Z3.

C. S. Bernard
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ZOOTECNIE

Bovins laitiers

Systèmes de production laitière. On a étudié, pendant 3 ans, la productivité de 40 vaches laitières selon quatre systèmes d'alimentation et de régie. Les animaux des systèmes A et B étaient au pâturage en été dont la durée était en moyenne 135 jours. En hiver, les vaches du système A recevaient du foin de graminées, alors que celles du système B recevaient de l'ensilage de maïs et 3 kg de foin par tête et par jour. Les vaches de ces deux systèmes consommaient de la moulée selon leur production de gras dans un rapport 1:4. Les vaches des systèmes C et D demeuraient à l'étable durant toute l'année et recevaient de l'ensilage de maïs et de l'ensilage de mil-luzerne dans une proportion 50:50 sur base de matière sèche. Le groupe C recevait de la moulée selon les mêmes normes que les groupes A et B, alors que le groupe D recevait de la moulée mélangée au fourrage à raison de 40% de la matière sèche.

Les rendements annuels en lait corrigés à 4% de gras étaient respectivement 5009, 5829, 5852 et 4909 kg par vache pour les systèmes A, B, C et D. C'est au début de la période d'hivernement de 230 jours que les vaches du système A accusaient une diminution de rendement. La qualité du foin de graminée pouvait en être la cause. Le nombre de jours en lactation était de 277 pour les vaches du système A tandis qu'il était de 306 pour celles des autres systèmes.

Production de lait aux pâturages. On a comparé la productivité d'un pâturage semé en trèfle ladino et mil à celle d'un pâturage

semé en mil. Dix vaches Holstein paissaient sur 3,24 ha de chacun des types de pâturage du 29 mai au 7 octobre, au cours des étés 1975, 1976 et 1977. Les pâturages ladino-mil ont été fertilisés aux doses suivantes: 123 kg/ha de P_2O_5 et 264 kg/ha de K_2O . Les pâturages de mil ont reçu environ les mêmes quantités de P_2O_5 et K_2O . De plus, on y a appliqué 165 kg/ha de N.

Les pâturages de mil ont produit au total 8677 kg de matière sèche (M.S.) par hectare contenant 11,41% de protéines. Seize pourcent de trèfle blanc se retrouvait dans leur gazon. Les pâturages ladino-mil avait un rendement de 6574 kg de M.S. par hectare d'une herbe contenant 11,78% de protéine. Le trèfle ladino contribuait aux rendements dans une proportion de 37%.

La production laitière s'est chiffré à 8486 kg de lait à l'hectare sur les pâturages de mil, comparé à 7808 kg/ha sur les pâturages ladino-mil. La production quotidienne de lait a été semblable sur chacun des pâturages et se chiffrant à 23,85 kg de lait par vache. Cependant, si on ajuste cette production de façon à la rendre comparable en tenant compte de la courbe de lactation, on constate qu'une vache paissant sur les pâturages ladino-mil a produit en moyenne 19,48 kg de lait par jour comparé à 17,83 kg sur les pâturages de mil.

Valeur alimentaire du mil dans la production de lait. On a servi, à 24 vaches noires et blanches de 100 jours de lactation, du foin de mil coupé avant épiaison (12% PB et 34% ADF) avec un concentré (18% PB) dans des proportions de 100:0, 85:15, 70:30, 55:45.

Les vaches à ces quatre traitements alimentaires ont accusé les performances suivantes: matière sèche consommée en pourcentage du poids vif, 2,84; 3,10; 3,49 et 3,70% ($P < 0,01$); consommation quotidienne de M.S., 15,1; 16,8; 18,6 et 19,4 kg ($P < 0,01$); et rendement quotidien en lait corrigé à 4%, 16,7; 20,7; 23,1 et 21,0 kg ($P < 0,01$). La digestibilité des quatre rations était, pour la M.S., 65,6; 65,6; 66,9 et 66,8%; pour le N, 62,5; 63,7; 65,2 et 65,3%; pour l'énergie brute, 70,3; 70,3; 68,4 et 67,8%; et pour l'ADF, 71,8; 69,7; 68,7 et 65,6% ($P < 0,05$). Les vaches aux rations 100:00 et 85:15 ont produit un lait contenant un pourcentage moindre de solides totaux, de solides non gras et de protéines que les vaches des deux autres rations. On a enregistré une baisse du dosage butyreux dans le lait des vaches à la ration 55:45. On en conclut qu'une alimentation au mil seul est suffisante pour un rendement laitier de 16 kg/jour, alors qu'une ration qui contient 9 kg de concentré (le traitement 55:45) augmente le rendement à 21 kg.

Induction à la lactation: effet sur la première lactation. Cinquante-deux génisses Holstein ont été réparties dans les quatre traitements suivants: saillies à l'âge de 12 mois (N-12); induction à la lactation à l'âge de 12 mois et saillies (I-12); saillies à l'âge de 18 mois (N-18); et induction à la lactation à l'âge de 18 mois et saillies (I-18). L'induction à la lactation a été faite à partir d'injection d'un mélange de 17β -estradiol et de progestérone. Les injections ont débutées au jour 3 de l'oestrus et ont été faites deux fois par jour pendant sept jours. On a commencé la traite au jour 21 après le début des injections. Les génisses ont produit du lait durant la phase d'induction pendant un minimum de 220 jours et on les a tarées au moins 90 jours avant la date prévue du premier vêlage.

Les âges (mois) et poids (kilogrammes) moyens au vêlage ont été respectivement 22 et 459 pour le N-12; 25 et 475 pour le I-12; 28 et 508 pour le N-18; 30 et 517 pour le I-18. Pour la lactation qui a débuté au premier vêlage, les vaches se sont classées d'après leur rendement, de la façon suivante: 105,4% pour le N-12; 78,4% pour le I-12; 108,1% pour le N-18 et 109,0% pour le I-18.

Les productions laitières (305 jours) des vaches induites à l'âge de 12 mois n'ont été que de 84% de celles des vaches régies

normalement avec vêlage à la suite d'une saillie à 12 mois. Les lactations des vaches du traitement I-12 ont été 58 jours plus courtes que celles des trois autres traitements. On n'a pas enregistré de différences entre les deux groupes dont le traitement a été appliqué à l'âge de 18 mois.

Bovins de boucherie

Addition de poudre de lait écrémé au lait entier dans une ration pour veaux d'abattage. On a comparé trois aliments d'allaitement, soit du lait entier contenant 0, 2,5 et 5% de lait écrémé (DSM) pour l'alimentation de veaux d'abattage. Soixante veaux noirs et blancs ont servi à cette expérience. Ils ont été abattus aux poids vifs de 92 et 154 kg. Les veaux au lait entier ont consommé 436 kg de lait pour atteindre le poids de 92 kg, ceux nourris au lait avec 2,5% DSM ont consommé 311 kg de lait et 14 kg de DSM pour atteindre le même poids. Lorsque l'abattage avait lieu au poids de 154 kg, les veaux au lait entier en consommaient 1239 kg, alors que ceux au lait avec 2,5% de DSM consommaient 1074 kg de lait et 44 kg de DSM. L'addition de DSM au lait entier a amélioré le gain journalier; il a été, par ordre des trois régimes alimentaires, de 0,63; 0,73 et 0,77 kg respectivement, pour l'abattage à 92 kg, et de 0,82; 0,91 et 0,95 kg respectivement pour l'abattage à 154 kg. Il en est de même pour la conversion alimentaire qui se situe à 1,30; 1,20 et 1,20 kg respectivement lorsque l'abattage est à 92 kg, et à 1,56; 1,63 et 1,63 kg respectivement lorsque l'abattage est à 454 kg. De plus, l'addition de DSM au lait entier a donné des carcasses dont les muscles étaient plus pâles.

Le tourteau de colza et la levure dans la moulée pour veau d'abattage. Nous avons expérimenté une moulée pour veau d'abattage contenant du tourteau de soya et du tourteau de colza dans les proportions de 100:0, 50:50 et 0:100. Chacune des trois moulées contenait soit 0, soit 0,1% de levure. Vingt-quatre veaux noirs et blancs ont servi à cette expérience à partir de l'âge de 3 jours jusqu'à l'abattage au poids vif de 155 kg. Les moulées à base de soya comparées aux moulées à base de colza ont donné respectivement les performances suivantes: rendement des carcasses, 53,7 et 54,7; le gain journalier, 0,84 et 0,83 kg; la consommation totale de moulée, 292,3 kg et 293,5 kg; et le taux de conversion alimentaire, 2,78 et 2,81.

Les veaux recevant de la levure avaient une chair plus pâle et un thymus d'un poids plus élevé que les autres. Il en ressort que le tourteau de colza peut remplacer tout le tourteau de soya dans la moulée pour veaux d'abattage.

L'orge humide pour les bouvillons laitiers. Nous avons utilisé 32 bouvillons Holstein pesant 369 kg pour évaluer la valeur alimentaire de l'orge humide. Une partie de l'orge humide qui contenait de 21 à 23% d'humidité a été ensilée dans un silo de ciment tandis que l'autre partie a été placée en tas dans une grange et traitée à deux reprises avec 0,5 et 0,25% respectivement de paraformaldéhyde ou avec 1% d'acides organiques (80% propionique, 15% acétique et 5% benzoïque). L'orge sèche a été récoltée dans les mêmes champs que l'orge humide. Au moment de la récolte l'orge sèche contenait 13,4% d'humidité.

En plus de l'orge, qui était distribuée à volonté, les animaux recevaient de l'ensilage d'herbe à raison de 10% de leur poids vif.

L'orge ensilée ou traitée avec le paraformaldéhyde contenait plus de N ($P < 0,05$) que l'orge sèche ou traitée avec les acides organiques. Les différents traitements appliqués à l'orge n'ont pas eu d'effet significatif sur le gain journalier, la consommation alimentaire, l'efficacité alimentaire, surface de l'oeil de longe et sur le gras de la 12^{ième} côte. Cependant, le rendement à l'abattage était significativement plus élevé ($P < 0,05$) pour les bouvillons alimentés avec l'orge sèche ou ensilée que celui des bouvillons alimentés avec l'orge traitée avec du paraformaldéhyde ou des acides organiques.

Taux plasmatiques des stéroïdes lors de grossesses uni- ou multi-foetales se terminant soit par un vêlage soit par un avortement. Les taux plasmatiques de progestérone et d'oestrogènes ont été mesurés chez les bovins de boucherie ayant présenté des grossesses multi-foetales qui se sont terminées soit par un vêlage soit par un avortement, à la suite d'injections de PMSG. Chez les vaches qui ont vêlé, celles portant plus d'un embryon ont eu des taux de progestérone et d'oestradiol-17 β significativement plus élevés que celles ayant eu une grossesse unifoetale. Chez les vaches ayant eu une ovulation multiple et ayant avorté pendant la grossesse, la progestérone était initialement très élevée et diminuait par la suite de façon importante, annonçant en quelque sorte l'avortement qui

pouvait survenir à une date beaucoup plus tardive. L'oestradiol-17 β était basse et la montée que l'on observait normalement avec le déroulement de la grossesse était toujours absente. Ces résultats indiquent donc que chez les vaches qui vont avorter, il semble y avoir un facteur présent au début de la grossesse, qui empêche le maintien du taux de progestérone; de plus, ils suggèrent que, quoiqu'il soit en quantité plus faible que l'oestrone, l'oestradiol-17 β est un indice plus sensible de l'état physiologique de l'animal.

Porcs

Performance de reproduction de la truie alimentée avec du tourteau de colza cv. Tower durant la gestation et la lactation. Nous avons utilisé 64 truies pour étudier l'effet du tourteau de colza cv. Tower sur la reproduction et sur les niveaux de triiodothyronine (T3) et de tétraiodothyronine (T4). Les truies ont été alimentées avec des rations isoprotéiques contenant 0 ou 10% de tourteau de colza (RSM) lorsqu'elles ont été diagnostiquées gestantes. L'addition de RSM à la ration n'a pas affecté significativement ($P < 0,05$) le nombre de porcelets ainsi que le poids des porcelets à la naissance et au sevrage. L'apparition du premier oestrus après le sevrage, qui se faisait à 28 jours, et le taux d'ovulation ont été semblables dans les deux cas étudiés. Le poids de la glande thyroïde n'a pas été affecté par les traitements. Le taux de captation de la 3,5,3'-triiodothyronine (T3) par des éponges de résine était plus bas ($P < 0,05$), au 110^{ième} jour de gestation, pour les truies alimentées avec 10% de RSM. Cependant, le RSM n'a pas affecté les taux de T3 et T4 au moment du sevrage et 3 jours après le premier estrus post-partum. Les niveaux de T3 et T4 ont variés significativement entre les différents stages indépendamment du régime alimentaire.

Moutons

Morphologie des follicules ovariens de brebis avec ovulation simple ou double au moment de l'oestrus. On a identifié et marqué à l'encre de Chine, les quatre plus gros follicules de 30 brebis, 12 h après le début de l'oestrus. Sept jours plus tard on a abattu les brebis et déterminé l'origine et le taux d'ovulation. Après avoir classé les brebis selon le taux d'ovulation observé après le

marquage, nous avons constaté que les brebis à ovulation multiple avaient à l'oestrus, un deuxième plus gros follicule plus grand que les brebis à ovulation simple. Le plus grand follicule identifié au temps de l'oestrus était de même grandeur chez toutes les brebis mais chez les brebis à ovulation simple il se développait en des corps jaunes qui étaient 15% plus lourds que ceux des brebis à ovulation multiple. Chez les brebis à ovulation multiple, il y avait une différence de 1,8 mm entre le diamètre des deux plus gros follicules. Ils ont produit cependant des corps jaunes de poids identiques.

PRODUCTIONS VEGETALES

Sols

Evaluation des dommages par érosion pour deux différentes méthodes de culture du maïs, tillage contre no tillage. Sur une période de 4 ans, on a comparé l'efficacité de la méthode de culture du maïs ensilage sans travail du sol "no tillage" (NT) avec la méthode conventionnelle avec travail de sol "tillage" (T) sur les quantités de sol érodé (kilogrammes par hectare), le volume d'eau ruisselée (mètre cube par hectare) et sur les éléments fertilisants $N-NO_3$, P et K entraînés au bas d'une pente de 10%.

Dans l'ensemble, les quantités totales de sol érodé ont été de l'ordre de 50 800 kg/ha sur les parcelles de culture du maïs (T) comparativement à seulement 3935 kg/ha dans le cas du maïs (NT) soit un apport de 13:1. Les rendements du maïs n'ont donné aucune différence significative entre les deux systèmes de culture. La présence du chaume de graminées a favorisé l'infiltration d'eau dans le sol et a réduit considérablement l'eau de ruissellement dans une proportion de 2,5 à 1. En effet, il y a eu une perte nette d'eau de 902 m³/ha sur les parcelles de maïs (T) entraînant avec elle des quantités appréciables d'éléments fertilisants. Ainsi, les pertes en $N-NO_3$ et en P soluble pour le maïs (T) ont été de 1,2 et 1,5 fois plus grandes respectivement. Le K a été l'élément le plus entraîné par l'eau d'écoulement superficiel avec des quantités annuelles moyennes de 6 kg/ha pour le maïs (T) et de 2 kg/ha pour le maïs (NT). Tout compte fait, cette méthode culturale sans travail du sol réduit considérablement l'érosion du sol et le délavage des éléments fertilisants dans les champs de maïs.

pH du sol et Mg. Une bonne partie des sols du Québec sont pauvres en Mg et leur réponse au Mg vaut la peine d'être examinée. A cette fin, nous nous sommes servis du loam de Coaticook chaulé pour obtenir des pH de 5,0; 6,5 et 7,5. Nous avons appliqué du Mg aux doses de 0, 25, 50, 100 et 200 kg/ha et nous avons récolté neuf coupes de luzerne cultivées en serre. On notera que les pH du sol à la fin de l'expérience s'étaient fixés à 4,9; 6,0 et 7,0.

En sol non chaulé, le Mg n'a pas pu accroître les rendements de luzerne à cause des quantités trop grandes de Al et Mn dans le sol de pH 4,9. En sol de pH 6,0, les rendements de luzerne ont augmenté à la suite d'application de Mg à 25 kg/ha et des doses plus élevées n'ont pas augmenté davantage la productivité de la luzerne. A pH 7,0, les rendements de luzerne se sont accrues avec les doses de Mg jusqu'à la dose maximum.

La teneur en Mg de cette légumineuse s'est augmentée proportionnellement aux doses de Mg, mais on constate que le contenu en Mg de la luzerne cultivée en sol acide a toujours été plus élevé que celui de la même légumineuse cultivée en sol de pH 6,0 ou 7,0. Selon Griffith, les chercheurs d'Ohio ont établi que la teneur adéquate en Mg se situe entre 0,31 et 1,0%. Cette teneur a été atteinte à la dose de 100 kg/ha dans le sol de pH 6,0 et à 200 kg/ha dans le sol de pH 7,0. Le contenu en Mg des sols a été affecté par le chaulage de la même manière que la teneur de luzerne.

Effet des régimes de fauche et de la fumure azotée sur la production du mil, du brome et de l'alpiste roseau. On a cultivé, en même temps, du mil, du brome et de l'alpiste roseau au cours d'une expérience destinée à évaluer la productivité et la qualité de ces espèces fourragères récoltées comme pâturage, ensilage, foin hâtif ou tardif. De plus, l'expérience comportait une comparaison de cinq doses d'engrais azotés soit: 0, 37, 75, 150 et 300 kg/ha. Les rendements saisonniers n'ont pas changé significativement quand les dates de la première coupe avaient lieu plus tard que la mi-juin. La fauche hâtive n'a pas affecté la population de graminées, mais la dose de N à 300 kg/ha a diminué la production de mil et brome. Ces parcelles de mil à forte fumure azotée étaient infestées de chiendent. Le pourcentage de digestibilité *in vitro* a chuté du niveau de 70 au début de juin à 55%, à la mi-juillet. La digestibilité du

brome s'est avérée la plus élevée, tandis que celle de l'alpiste s'est classée la plus basse. L'apport de N au sol a provoqué une diminution de 2 à 10 unités de digestibilité à chacune des coupes chez chacune des espèces de graminées et a propulsé la teneur en protéine de 3 à 8 unités. L'application de N

jusqu'à la dose de 150 kg/ha a eu pour effet de favoriser la croissance, tandis que les doses excédentaires ont causé une absorption exagérée de N chez la cellule végétale et un accroissement drastique de N-NO₃ dans le sol.

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

INTRODUCTION

Les programmes de recherche de la station se sont de plus en plus consolidés et des progrès appréciables ont été réalisés.

Nous déplorons la décès de notre dynamique technicien en physiologie des graminées fourragères monsieur André Roy. Nous en conservons un excellent souvenir surtout à cause de son acharnement au travail et de sa jovialité.

Ce rapport présente un résumé des principales réalisations des équipes de recherche à Sainte-Foy, La Pocatière et Normandin durant les années 1977 et 1978. Pour des comptes rendus plus détaillés, veuillez vous adresser à: Station de recherches, Agriculture Canada, 2560 boulevard Hochelaga, Sainte-Foy, Québec G1V 2J6.

Le Directeur
S. J. Bourget

LES PLANTES

La luzerne

Amélioration. Le projet d'amélioration de la luzerne en vue de développer des cultivars à plus haut rendement et possédant une plus grande résistance au froid, aux maladies et aux nématodes se poursuit. La sélection pour une meilleure fixation symbiotique de l'azote a débuté. Les résultats d'un essai constitué des diverses sélections pratiquées pour la survie à l'hiver, la résistance au froid et une combinaison des deux facteurs indiquent, à ce stade, que la survie est augmentée de 15% par la sélection pour la survie à l'hiver et d'un autre 5% par la sélection pour la résistance au froid. Trois variétés expérimentales sont sous évaluation dans différents sites à travers la province. L'une d'entre elles est dans les essais préliminaires et présente une bonne amélioration de la survie à l'hiver. Le travail en vue de déterminer la valeur de la sélection visuelle en comparaison avec la méthode traditionnelle basée sur le rendement se poursuit en coopération avec les stations d'Ottawa et Lennoxville, et les fermes expérimentales de Kapuskasing et de Normandin. De façon générale, la concordance de choix entre les observateurs d'une même station a été plus grande que celle obtenue entre les stations.

Maladies. Le tamisage de populations se poursuit pour la résistance aux flétrissures bactérienne (*Corynebacterium insidiosum* (McCull) H.R. Jens.) et fusarienne (*Fusarium oxysporum* f. sp. *medicaginis* (Schlecht.) Weimer), à la tache leptosphaerulienne (*Leptosphaerulina briosina* (Poll.) Graham &

Luttrell) et au nématode cécidogène (*Meloidogyne hapla* Chitwood). Les croisements effectués entre plants sélectionnés des cultivars Europe et Saranac AR pour leur résistance au *Fusarium* montrent un rendement supérieur aux cultivars d'origine. Deux cent quarante nouveaux plants résistants au *Fusarium* ont été sélectionnés des cultivars Saranac AR, Angus et Iroquois. Des 400 plantes résistances à la flétrissure fusarienne identifiées dans quatre cultivars, 30 se sont révélées résistances au *Leptosphaerulina* et 60 à la tige noire (*Phoma medicaginis* Malbr. & Roum.). En un cycle de sélection, le pourcentage de plants résistants à l'anthracnose (*Colletotrichum destructivum* O'Gara) dans le cultivar Europe a été accru de 5 à 50% environ.

Endomycorrhizes. Deux espèces de champignons endomycorhizateurs de la luzerne ont été isolés. Un *Glomus* (probablement *caledonium* (Nicol. & Gerd.) Trappe & Gerd.) a fait l'objet de synthèses d'endomycorrhizes sur la luzerne. Sa spécificité envers la luzerne est certaine. Sa multiplication permettra des expériences visant à démontrer son efficacité en combinaison avec le *Rhizobium meliloti* Dangeard. Le *Gigaspora calospora* (Nicol. & Gerd.) Gerd. & Trappe est moins spécifique, quoique compatible avec la luzerne.

Fixation symbiotique de l'azote. Nous avons démontré que les inoculants de la luzerne composés de plus de deux souches de *R. meliloti* sont moins efficaces que les inoculants composés d'une ou de deux souches. Dans une étude sur les formulations liquides d'inoculants à base de *Rhizobium* nous avons trouvé que le lactosérum (petit

lait de fromage) possède les bonnes caractéristiques nutritives pour le *Rhizobium* et que ce milieu permet d'obtenir un inoculant à très forte dose en cellules. Le *R. meliloti* protège la luzerne contre la flétrissure bactérienne causée par *Corynebacterium insidiosum*, et ralentit le développement de certains champignons phytopathogènes chez cette plante. Dans ce dernier cas, la répression n'est pas due à la production d'antifongiques par le *Rhizobium*, mais à un phénomène nutritionnel où le *Rhizobium* l'emporte sur les champignons. De plus, nous avons isolé un actinomycète qui exerce une réaction de synergisme sur *R. meliloti* et qui inhibe le *Fusarium oxysporum* Schlecht f. sp. *medicaginis* (Weimer) dans la rhizosphère de la luzerne; cet actinomycète peut être bénéfiquement utilisé dans un programme de contrôle biologique de certains champignons pathogènes chez la luzerne ou comme agent protecteur du *Rhizobium* dans les inoculants et dans les sols où la nodulation ne réussit pas.

Le trèfle rouge

On a sélectionné des plants des cultivars Dollard et Hungaropoli qui ont survécu à trois hivers en champ. Des polycross issus de ces sélections ont été constitués et seront évalués pour leur résistance au pourridié fusarien. Dans les essais de régie, les traitements de trois et quatre coupes annuelles ont affecté la survie à l'hiver.

Les graminées

Rendement de la fléole, de la luzerne et du trèfle rouge semés séparément ou en mélange. Après 6 ans d'expérimentation, à St-Augustin, La Pocatière et Normandin, la luzerne, l'association luzerne-fléole et la fléole recevant 150 kg de N par hectare ont offert un rendement de m.s. identique d'environ 8000 kg/ha. La fléole cependant a maintenu une production plus uniforme que les légumineuses au cours des années. L'association luzerne-fléole s'est avérée de beaucoup plus stable et productive que l'association trèfle rouge-fléole. Le trèfle rouge a dû être réensemencé régulièrement à tous les 2 ans et à trois reprises à péri durant l'hiver suivant le semis.

Régie d'automne de la fléole. Il ne semble pas y avoir de période critique pour le récolte de la fléole des prés à l'automne. Des deuxièmes coupes faites entre le 21 août et le 2 octobre après une première coupe à l'épiaison ou à la floraison n'ont pas affecté la

survie de la fléole après 2 ans à Normandin. Le rendement a varié, selon les traitements, entre 6300 et 8000 kg de m.s. par hectare. Une première coupe à l'épiaison et une deuxième vers le 25 septembre ont fourni les rendements plus élevés.

Etablissement de la fléole avec du raygrass comme plante-abri. La fléole s'est établie très facilement et le raygrass s'est révélé une très bonne plante-abri. Des taux de semis du raygrass de 15 et 25 kg/ha ont permis d'obtenir des rendements de 4767 et 6492 kg/ha respectivement à La Pocatière durant l'année d'établissement. Cependant l'année suivant le semis, la fléole a donné, sous les mêmes taux respectifs de semis du raygrass, des rendements de 5605 et 6243 kg/ha. L'effet de la densité du semis du raygrass sur le rendement de la fléole a disparu à la deuxième année de production. On a obtenu un rendement moyen de 6350 kg de fourrages par hectare pendant 4 ans.

Fertilisation azotée du brome. De 1973 à 1976, le rendement du brome est passé de 4447 kg/ha à 10 308 kg/ha lorsque la dose annuelle d'azote a varié de 0 à 448 kg/ha. Dans le même temps, la teneur moyenne en protéine brute du fourrage atteignait 20,8% à la première coupe sous la dose d'azote la plus élevée.

Inventaire écologique. Par un inventaire écologique dans des pâturages de la région de Québec on a identifié les principales mauvaises herbes et espèces spontanées et on a mesuré leur influence sur la qualité des herbages. Le pissenlit, le plantain, la céraiste vulgaire, la marguerite blanche, la renoncule âcre et les stellaires sont apparues les mauvaises herbes les plus communes. Règle générale, les pourcentages de protéines et de digestibilité des herbages étaient plus élevés lorsque la proportion de légumineuses et de pissenlit était plus grande. Les graminées naturelles spontanées (chiendent, fétuques et agrostides) ont eu peu d'effet sur la teneur en protéines mais ont contribué à réduire l'indice de la valeur nutritive. Certaines autres mauvaises herbes (carex scirpes et renoncule âcre) lorsqu'abondantes ont contribué à réduire la teneur en protéines et l'IVN des herbes des pâturages.

Amélioration de la fléole. On a poursuivi la sélection de la fléole en pépinières pour déceler du matériel qui permettrait d'augmenter le rendement en matière sèche, la

teneur en protéine et la digestibilité de l'espèce. Un polycross de plants individuels sélectionnés a été établi pour produire de la semence et étudier les progénitures.

LES CEREALES

Régie des mauvaises herbes. Après des applications répétées d'herbicides, l'étude des populations de mauvaises herbes a démontré qu'il y avait diversification si l'herbicide était non sélectif et une diminution de la diversité floristique avec les herbicides sélectifs. Les différences floristiques sont dépendantes des pratiques culturales et non des traitements herbicides car leurs effets résiduels sont négligeables d'une année à l'autre.

L'hypothèse voulant que chaque niche écologique a le potentiel d'être occupée par une plante, de préférence une plante désirable, a été étudié par l'effet des modes (volée et en rangée), taux (50, 100 et 200 kg/ha) et dates de semis (hâtif et tardif). Il semble que le semis à la volée ait désavantagé la céréale et favorisé les mauvaises herbes par rapport au semis en rangée. Il y a une diminution sensible des mauvaises herbes avec l'augmentation du taux de semis avec un plafonnement de la densité de la céréale à 100 kg/ha.

L'étude de l'influence du régime hydrique sur la compétition des mauvaises herbes et le rendement des céréales en fonction de deux dates de semis semble indiquer que ces deux facteurs sont autant influencés par la date de semis que par le régime hydrique. En semis hâtif, l'irrigation n'a pas eu d'effet sur la densité de la céréale mais a doublé les populations de mauvaises herbes alors qu'en semis tardif le recouvrement de mauvaises herbes a été le même.

Enfin, l'effet compétitif des mauvaises herbes dans les céréales est surtout fonction de la phytomasse produite mais le cycle vital, la forme de croissance et les combinaisons bispécifiques sont également importants.

Le blé. La lignée Laval 19 a très bien fait en 1977 et en 1978 et sera considérée pour homologation en 1979 malgré une maturité légèrement plus tardive qu'Opal. Son grain roux très foncé est un marqueur idéal pour le différencier des blés panifiables. L'application de chaux sur sols sableux acides augmente les rendements du blé alors qu'une

fertilisation au magnésium donne des résultats erratiques sur les mêmes sols préalablement chaulés. L'application fractionnée d'azote sur les cultivars Opal et Glenlea ont permis de constater des baisses de rendements chez Glenlea mais variables avec les doses chez Opal.

La sélection de génotypes résistants au nanisme jaune (BYDV) dans les populations massales en est à l'évaluation des méthodes. Le tamis et un système de flotation semble être prometteurs et adaptables pour la sélection massale.

L'orge. Quelque 110 croisements ont été réalisés en 1977 et 1978 pour répondre aux divers objectifs tels l'adaptation, la résistance au nanisme jaune, à l'acidité du sol et à l'helminthosporiose. Quelque 20 000 plants individuels F_6 ont donné naissance à 1700 lignées F_7 , certaines de ces lignées ont eu des rendements supérieurs de 10% à Laurier et sont réévaluées cette année. Des quatre lignées évaluées en 1977 et des deux en 1978 en essais coopératifs, aucune ne sera considérée pour homologation à cause de leur paille faible malgré des rendements supérieurs aux témoins.

L'avoine. Quelque 242 croisements ont été réalisés en 1977 et 1978 pour répondre aux objectifs d'adaptation, de résistance au nanisme jaune (BYDV), à la septoriose et au mauvais drainage et d'amélioration des caractéristiques agronomiques comme la verse, le pourcentage d'écale et la hauteur de la paille. En 1978, quelques croisements ont été réalisés sur des génotypes d'avoine d'hiver ayant survécu à l'hiver 1977-78. Quelques 30 000 plants F_6 ont été sélectionnés pour la paille courte et forte et l'absence de symptômes de BYDV et sèmes en préobservations l'année suivante. Quelque 3500 de ces lignées, dont certaines avaient des rendements supérieurs de 10% à Laurent avec les pailles fortes, ont donné naissance à 300 lignées réévaluées cette année à plusieurs stations. Des huit lignées en 1977 et des huit en 1978 évaluées en essais coopératifs, plusieurs seront considérées pour homologation car elles ont toutes de très bons rendements avec les pailles fortes et certaines sont résistantes au nanisme jaune.

SURVIVANCE A L'HIVER

Influence du climat. Les résultats de cinq années d'étude dans le champ montrent une corrélation étroite entre la résistance au gel de la luzerne (LT₅₀), la teneur en proline libre des collets et l'abaissement de la température. La résistance au gel et la teneur en proline commencent à augmenter lors des premiers gels en septembre (entre le 20 et le 30 octobre normalement), et atteignent un maximum généralement entre le 15 et le 30 octobre. Le printemps suivant, la durée du désendurcissement est de 4 à 5 semaines, ce qui permet à la plante d'éviter les effets nocifs d'un gel tardif à cette saison. A la différence des expériences en laboratoire (conditions contrôlées et constantes), l'augmentation de la proline dans les cultures en champ précède celle de la résistance au gel. La matière sèche augmente de 75% ainsi que les sucres totaux, mais ceux-ci ne montrent pas de corrélation significative avec la résistance au gel et la proline. La réponse de trois variétés, Rambler, Saranac et Caliverde, à tous ces facteurs correspond à leur capacité à s'endurcir. L'humidité des sols argileux mesurée par gravimétrie a varié de 45 à 65% de la capacité maximale de rétention durant la saison automnale. Dans une expérience sur l'effet de la glace et de l'humidité du sol sur la survie à l'hiver de la luzerne, la glace est apparue comme le facteur le plus déterminant et le plus nocif. Cependant, sur des parcelles bien drainées, la présence de la glace a très peu affecté la survie de la plante. La présence de la glace a très peu affecté la température du sol qui n'a pas été inférieure à -7,5°C au cours de la saison hivernale.

Physiologie de la résistance. La sécheresse peut induire l'endurcissement à la gelée du blé d'hiver (cv. Kharkov) sans abaissement de la température, et sans qu'il y ait augmentation du degré d'insaturation des acides gras. Tant à 1°C qu'à 20°C, la résistance à la gelée a augmenté, tandis que le pourcentage de l'acide linoléique diminuait, chez les plantes soumises à la sécheresse (10% de la rétention d'eau maximale du sol) comparativement aux témoins (40%). Les effets du froid et de la sécheresse sont additifs. Des expériences sur l'influence de la sécheresse sur la résistance à la gelée de la luzerne ont donné des résultats analogues. La résistance à la gelée de plantes cultivées en pots de plastique est moindre que celle de plantes

cultivées en pots de tourbe. L'aération des racines semble donc également jouer un rôle.

Le BASF 13-338, un dérivé de la pyridazine, inhibe la photosynthèse sans affecter la respiration du blé d'hiver à basse température. Cette inhibition, plutôt que l'inhibition simultanée de l'accumulation de l'acide linoléique, est probablement la cause de l'inhibition de l'endurcissement à la gelée par ce composé.

Des expériences où la photosynthèse a été limitée au cours de l'endurcissement du blé d'hiver à basse température, en faisant varier la photopériode, en soumettant les plantes à l'obscurité, en coupant les feuilles, ou en les traitant avec le BASF 13-338, montrent que la lumière est nécessaire à l'endurcissement et à l'accumulation de l'acide linoléique, mais non au maintien de la résistance à la gelée et d'un haut niveau d'acide linoléique au froid pendant plusieurs semaines. L'endurcissement partiel obtenu à l'obscurité peut être éliminé par préétiolement des plantes à 20°C et à l'obscurité pendant 48 h avant l'endurcissement des plantes. Le BASF 13-338 fait tomber rapidement la résistance à la gelée acquise avant le traitement. L'effet de ce composé sur la résistance à la gelée ne se limite donc pas à l'inhibition de la photosynthèse.

Biochimie de la résistance. Un nouveau test pour mesurer l'endurcissement au froid des plantes a été mis au point. L'action du gel sur les membranes cellulaires induit la libération des phosphatases acides du tissu dans le milieu liquide externe. La quantité d'enzymes ainsi libérée est directement proportionnelle aux dommages membranaires causés par le froid. Ce test mesure donc un facteur unique de l'action du gel, la destruction des membranes, qui est directement relié aux mécanismes de dommages et d'endurcissement au gel, ce qui en fait une méthode précieuse pour l'étude des mécanismes physiologiques de la résistance au froid. Ce test a été appliqué à la mesure de la viabilité des cultures de blé et de luzerne échantillonnées dans le champ en hiver.

Quelques protéines-¹⁴C synthétisées par les plantes en voie d'endurcissement résistent beaucoup mieux à l'hydrolyse par les protéases de la sève du blé d'hiver que celles de plantes non endurcies. Il semble donc qu'il y ait des changements aux niveaux biochimique et biophysique dans certaines protéines au cours de l'endurcissement du blé.

Chez les mitochondries du cultivar rustique Kharkov, les dommages causés par des températures sous-léthales se réparent en dix jours. Chez le cultivar tendre Champlain ces mitochondries exigent plus de 14 jours pour revenir à leur état initial. Ceci contribue à leur reprise tardive.

La teneur en stérols totaux des collets et racines du blé d'hiver cv. Kharkov augmente fortement au froid. Il y a cependant peu de changements dans les proportions des stérols et des groupes de lipides contenant des stérols. Le rapport stérols/phospholipides tend à baisser le premier mois pour réaugmenter ensuite.

LES SOLS

Fertilité

Engrais minéraux. Une étude a été faite en serre sur les effets du phosphore, du potassium et du soufre sur les rendements de la luzerne sur les sols St-André et Kamouraska. Seul l'apport de soufre a permis d'augmenter les rendements de façon significative sur le sol Kamouraska. Une augmentation de rendement de 28%, pour cinq coupes, a été observée entre le traitement maximal de soufre (34 kg/ha) et le témoin. Une faible tendance à la hausse a été notée cependant en augmentant les doses de soufre sur le sol St-André.

L'application de chaux à 0, 4,5, 9 et 18 t/ha et de Mg à 0 et 27 kg/ha sur huit sols du Québec a permis de constater que le magnésium n'avait pas d'effet tandis que la chaux avait un effet marqué sur les rendements du blé. Selon les sols et les applications, des augmentations de rendement de 41 à 250% par rapport au témoin ont été enregistrées. Les rendements maximum ont été obtenus avec une dose de 18 t/ha de chaux sur les sols des séries St-André, De l'Anse, Platon et Beaurivage, avec un apport de 9 t/ha sur les sols des séries Achigan, St-Onésime, et Villeroy et à une dose de 4,5 t/ha sur le sol de la série Des Originaux.

Fumiers. La valeur fertilisante des fumiers de bovins et de porcs au moment de l'épandage a été analysée dans vingt fermes et seize porcheries du Québec. Le fumier de bovins est de meilleure qualité car il renferme 2,4 fois plus de N, 1,5 fois plus de P et 3,8 fois plus de K que celui de porc. Il en résulte que si on se réfère aux valeurs du fumier frais, la

quantité de N sera sous-estimée, tandis que celles de P et K seront surestimées pour le fumier de bovins, et les quantités de N et K seront sous-estimées pour le fumier de porc. Ceci est important si on veut assurer une fertilisation adéquate des plantes.

Complexe échangeable. Les sols des basses terres sont formés sur des dépôts marins riches en argile. Ils appartiennent souvent à l'ordre gleysolique. Dans les horizons Ap de onze profils, l'argile totale et surtout l'argile fine peuvent mieux expliquer la capacité d'échange que la matière organique ou les mesures de surface spécifique du sol. Par contre, dans les horizons Bg et Cg, c'est la surface spécifique du sol qui est le mieux reliée à la capacité d'échange. Des analyses de régression ont montré que la CEC de la matière organique passait de 56,5 à 223 meq/100 g de la surface à la profondeur, tandis que la CEC de l'argile fine diminuait de 57,5 à 50,7% meq/100 g de la surface vers la profondeur.

Pédogenèse

Gleysols. L'analyse minéralogique par diffraction des rayons X, ainsi que des mesures de surface spécifique et de capacité d'échange pour le sol et la fraction argileuse ont permis de mettre en évidence l'évolution de ces sols. Les minéraux primaires, illite et chlorite, sont altérés en minéraux gonflants, surtout la smectite et dans une moindre mesure en vermiculite. Il y a également libération de produits alumino-siliciques amorphes qui peuvent représenter jusqu'à 15% de la fraction argileuse. La distribution des minéraux argileux ainsi que les rapports quarts/feldspaths semblent indiquer des phénomènes de translocation des particules fines vers les horizons Bg sous l'influence du drainage interne de ces sols.

Podzols. L'ion Al^{3+} a une influence sur les propriétés d'échange des horizons B podzoliques. Les quantités d'Al extractibles sont fonction de la nature des solutions de chlorure ($Ba^{2+} > Ca^{2+} > NH_4^{+} > K^{+} > Mg^{2+} > Na^{+}$) et de leur concentration. Les capacités d'échange cationique augmentent avec les quantités d'Al extrait, probablement parce que ceci augmente l'accessibilité des sites pour les ions échangeables. La nature amorphe des composés alumineux dissouts est mise en évidence par des mesures potentiométriques et chimiques.

Dans les horizons B podzoliques, la datation de la matière organique indique des âges variant de moderne à 2000 ans. Ceci est assez faible et est attribué au turnover rapide de la matière organique.

Propriétés physiques

Dans trois séries de sols mal drainés, Ste-Rosalie, Kamouraska et Normandin, il existe une relation entre le contenu en argile et la porosité totale des sols. Cependant la distribution du volume poreux en pores grossiers, moyens et fins est différente dans le sol Ste-Rosalie par rapport aux autres sols. Dans le premier, il n'y a que très peu de pores moyens et la porosité totale augmente en profondeur. Dans les sols Kamouraska et Normandin, les pores fins augmentent en profondeur mais il y a un pourcentage élevé de pores moyens. La porosité totale diminue en profondeur dans le sol Kamouraska et elle passe par un minimum dans le sol Normandin. Les classes de pores et leur distribution sont reliées au développement des profils et les résultats ne permettent pas d'expliquer entièrement les valeurs de conductivité hydraulique.

FERME EXPÉRIMENTALE LA POCATIÈRE

Les plantes fourragères

Régie du semis. On a déterminé que la période du début à la mi-mai et celle de la fin juillet au début d'août sont les plus propices à la réussite optimale des semis de luzerne. Un taux de semis de 11-13 kg/ha est suffisant. Les variétés hâtives produisent généralement plus les premières années de récolte, mais elles sont dépassées par les tardives lors des années subséquentes. Les effets des taux et des dates de semis sont bien visibles l'année du semis et celle d'après, mais difficile à percevoir de façon continue par la suite.

L'enrobage de la semence ne favorise pas sous nos conditions une meilleure implantation de la luzerne ensemencée sur de bons sols cultivés conventionnellement.

Nous avons jusqu'à maintenant démontré qu'il est possible de ressemer les plantes fourragères sans labourer. Malgré des progrès intéressants nous n'avons pas encore réussi à mettre au point cette méthode. Il nous faudra apprendre à mieux connaître et

comprendre ses exigences. Le problème majeur de cette technique est l'obtention sur une base continue de succès valables.

La production de fourrage à partir d'une association graminées-légumineuses fait souvent ressortir l'importante contribution de la légumineuse au rendement total.

Régie de coupe. La persistance du trèfle rouge est nettement influencée par le mode de récolte. Cette plante réagit assez fortement soit à l'intensité de la fauche (nombre ou fréquence des coupes) ou au moment d'intervention (stade de développement). La période ou le moment d'intervention pour la première coupe semble moins important que pour la deuxième. Et nos résultats obtenus sur sols lourds laissent entrevoir que le trèfle rouge cultivé en conditions naturelles supporte difficilement une intensité de récolte dépassant deux à trois coupes.

Chiendent. Le glyphosate (Monsanto) ne peut servir à réprimer le chiendent dans les plantes fourragères puisque la plupart des légumineuses et des graminées sont plus ou aussi sensibles que le chiendent à ce produit. Appliqué même immédiatement après la coupe du trèfle et de la luzerne, le glyphosate a abaissé le rendement à la coupe suivante. Les dommages étaient cependant disparus à la deuxième coupe après le traitement.

La destruction du chiendent avant les semis en août a beaucoup favorisé l'implantation de la luzerne et du trèfle rouge. Cependant, la biomasse totale à la première coupe n'a pas été influencée par la répression du chiendent. A la deuxième coupe, la biomasse totale, composée presque exclusivement de légumineuses, a été élevée en l'absence du chiendent.

Méthode de travail du sol en monoculture. Après 5 ans de monoculture d'orge, l'envahissement du chiendent a été influencé par les méthodes de préparation du sol et les dates de semis. L'envahissement le plus faible a été obtenu avec un labour et un passage d'une herse à disque à l'automne suivis au printemps par le passage d'une herse à dents avant le semis. En l'absence de hersage au printemps, le chiendent a augmenté avec le retard de la date de semis. Lorsqu'on a employé seulement la herse à disque à l'automne, le chiendent a augmenté par rapport à l'emploi du labour et de la herse à dents. Il est cependant possible de

réprimer le chiendent en employant du glyphosate après la récolte.

Interférence due au chiendent. En moyenne, on a obtenu 1600 kg/ha d'augmentation du rendement de l'orge soit en employant de l'azote soit en réprimant le chiendent. Lorsqu'on a réprimé le chiendent, l'augmentation en rendement de l'orge a été de 2470 kg/ha avec 50 kg/ha d'azote et de 3170 kg/ha avec 100 kg/ha d'azote. De même, sans chiendent l'emploi du mcpa a contribué à augmenter le rendement de l'orge de 26% tandis qu'en présence de chiendent l'augmentation n'a été que de 12%.

Les pommes de terre

Irrigation. En 1978, un apport de 2,5 cm d'eau par semaine a augmenté le rendement de 58,8% lorsqu'on avait pas appliqué d'azote et de 82,5% lorsqu'on en avait appliqué 80 kg/ha. Avec 160 et 220 kg/ha d'azote, le rendement a été augmenté de 130% par l'irrigation. La proportion de petits tubercules a été réduite et celle des très gros a été augmentée par l'irrigation. Le poids spécifique a passé de 1057 à 1066 avec l'irrigation sur le loam St-André et de 1053 à 1071 sur le loam St-Pacôme. Le rendement final a été en relation directe avec la surface foliaire du début d'août seulement lorsqu'on a irrigué.

Les défanants. On a étudié l'effet de l'éthrel sur l'efficacité du diquat et du dinosèbe. Ajouter 2 L d'éthrel au diquat a fait augmenter le degré de défanage à 83,7% (68,7% sans éthrel). Le degré de défanage avec le dinosèbe est passé de 6,2% sans éthrel à 22,5% avec éthrel. De plus avec le traitement diquat & éthrel, la proportion de très gros tubercules a été réduite de 66% alors qu'elle a été réduite de 20% avec le diquat seul.

FERME EXPÉRIMENTALE NORMANDIN

Les plantes fourragères

Graminées en semis pur et en mélange. Le brome Saratoga, la fléole Climax et leur association binaire à la luzerne Saranac ou le trèfle rouge Lakeland ont été exploités durant 3 ans sous un régime de deux fauches annuelles. Le brome et la fléole ont produit une quantité égale de matière sèche (m.s.), soit 5810 kg/ha. L'association de l'une ou

l'autre de ces graminées à la luzerne a rapporté 5200 kg de m.s. par hectare, soit 340 kg de plus qu'avec le trèfle rouge. On a obtenu 964 kg de protéine brute (P.B.) par hectare du mélange brome-luzerne, soit 7% de plus que l'association fléole-luzerne. La teneur plus élevée en P.B. chez le brome (14,46%) que chez la fléole (12,80%), (moyenne des deux coupes), s'est traduite par une production respective de 842 et 743 kg de P.B. par hectare. La composition en fibres brutes des deux graminées était d'environ 28,4% suivies des mélanges à base de luzerne (27,6%) et de trèfle rouge au cours de l'essai et la graminée des mélanges binaires a avantageusement suppléé à la carence de la légumineuse associée. La production de la fléole a été mieux répartie sur une base annuelle que celle du brome.

Vérification de semences de luzerne. Avec trois semis différés dans le temps, avec et sans fumure minérale, on a évalué l'efficacité de la semence de luzerne enrobée (Prillcote, Oseco Ltd) en comparaison d'une semence inoculée des mêmes variétés. Les paramètres étudiés, soit la germination, les stades de croissance, le rendement et la persistance ont été comparables à l'intérieur de chaque variété. Sous les conditions de l'essai, il n'y avait pas avantage d'utiliser la semence enrobée; une fumure de base et de maintien a cependant contribué à une augmentation du rendement des deux types de semence.

Le genre *Vicia* (gourganès)

Epreuves de cultivars. Après 5 années d'essai, les rendements moyens en gousses vertes et en grains verts sont respectivement de 16 476 et 6567 kg/ha pour le cultivar Baie St-Paul, 16 625 et 4429 kg/ha pour Vainqueur, 17 507 et 5380 kg/ha pour Grosse de Windsor. Les moyennes de 4 ans de Triple Blanche et La Rapide pour ces deux caractères de rendement ont été respectivement de 15 926 et 4260, 21 088 et 6570 kg/ha. Express Early et les cultivars en disjonction GI-N et TR-N, après 3 années d'évaluation, ont produit respectivement 20 726 et 7185, 19 134 et 7936, 19 202 et 7231 kg/ha de gousses vertes et de grains verts. Après 2 ans d'épreuve, la Mammouth Résistante a rapporté 19 350 kg/ha de gousses vertes et 5344 kg/ha de grains verts.

Régie de la plantation. Les résultats de 4 ans obtenus du rechaussage des cultivars

Baie St-Paul, Grosse de Windsor et Vainqueur, lorsque les plants atteignaient 10 et 25 cm de hauteur, permettent de conclure que cette méthode ne contribue pas à l'obtention de rendements, en gousses vertes et en grains verts, plus élevés que dans un semis conventionnel. De plus, le billonnage est un procédé qui augmente les coûts de production.

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MINISTÈRE DE L'AGRICULTURE DU QUÉBEC

Protection des vergers

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INTRODUCTION

La Station de recherches de Saint-Jean, spécialisée notamment dans les cultures fruitières et légumières, s'occupe aussi de la culture du maïs grain et du tabac. L'équipe de chercheurs et le personnel de support concentrent leurs efforts dans les domaines de la production et de la protection de ces cultures. La création de nouveaux cultivars de pommes ainsi que de nouvelles racines souches de pommiers résistantes à nos conditions climatiques demeure d'envergure nationale. La régie des cultures horticoles en sols organiques est aussi d'intérêt national, grâce à une étroite collaboration des chercheurs des divers Instituts d'Ottawa ainsi que des Stations de recherches de l'Est du Canada.

Depuis 1975, date du dernier Rapport publié sous le format présent, les responsabilités de la Station ont augmenté par le fusionnement de la Ferme expérimentale de L'Assomption et de son programme sur le tabac.

Quelques-unes des réalisations importantes décrites dans ce rapport sont:

- (a) l'évaluation de cultivars et systèmes de production de la pomme;
- (b) les essais de piégeage et de lutte intégrée dans les vergers, ainsi que l'évaluation des pyrèthrinoïdes de synthèse;
- (c) les applications à doses massives de fongicides contre la tavelure du pommier;
- (d) l'excès de fertilisation (fumure) dans les sols organiques;
- (e) les nouveaux cultivars de petits pois;
- (f) la réaction au milieu et les moyens de contrôler les espèces d'escargots importées d'Europe;
- (g) l'introduction d'une nouvelle espèce de crucifère *Brassica napoleracea*;
- (h) l'évaluation de méthodes culturales et de préparation du sol dans la production du maïs;
- (i) l'inventaire des populations de nématodes dans les champs de tabac du Québec.

Ce rapport contient les résultats des recherches poursuivies en 1977 et 1978. On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport ou des renseignements supplémentaires en adressant sa demande directement aux chercheurs ou à la Station comme suit: Station de Recherches, Agriculture Canada, Casier postal 457, Saint-Jean, Québec J3B 6Z8.

Jean-Jacques Jasmin
Directeur

ARBRES FRUITIERS

Gestion des pommeraies

Cultivars. Le cultivar à lambourdes de la lignée Mor Spur Mac a donné un rendement supérieur aux autres lignées de type McIntosh et a atteint dans sa septième année après la plantation une production de 2000 minots à l'hectare pour les arbres entraînés de plein vent, soit une augmentation de 100% sur la sixième année de plantation. Le cultivar à lambourdes Hardisur a donné un rendement supérieur aux autres lignées de type Red Delicious. Les cultivars Spartan, Jersey-mac et Summerred greffés sur M.7 et plantés en 1974, ont produit en quatrième année, une moyenne de 1 minot par arbre. Cette production hâtive et abondante de fruits de qualité,

supporte les recommandations pour la valeur commerciale de ces cultivars.

Sous nos conditions, le porte-greffe O-3 semble légèrement plus nanisant que M.26. Tous deux, cependant, semblent avoir la même résistance au froid et supporter des températures très basses sans dégâts majeurs. Sous des températures extrêmes de -45°C , tous les porte-greffes testés ont subi des dégâts irréparables.

À La Pocatière, des essais de cultivars de pommier ont indiqué que les meilleurs rendements sont obtenus par Lobo, suivie de Melba, Lindel, Imperial, McIntosh, Melred, Golden Delicious et Cortland.

Régulateurs de croissance. L'emploi de régulateurs de croissance (Alar, Promalin et Acide Gibberellique) ne semble pas affecter

la fermeté des fruits, mais réduit le rendement total et produit un allongement du fruit qui n'est pas toujours à son avantage. Ces régulateurs de croissance ont un effet rémanent qui permet à l'arbre, l'année suivante, de produire des fruits plus fermes, plus allongés et des rendements accrus de 0,44 à 4,11 fois plus que les témoins chez les lignées Red Delicious.

Densité et taille. Deux ans après sa taille de formation, une première récolte du cultivar Spartan greffé sur M.9 et taillé en cloche avec une densité de 2988 pommiers/ha, a rapporté un bénéfice net de \$1256 à l'hectare alors que les autres systèmes ou les autres densités demeuraient déficitaires. Ces premiers résultats de récolte indiquent l'importance de ce type de taille des pommiers ainsi que de leur densité de plantation.

Protection des pommeraies

Insectes. Les pyréthrinoides de synthèse se sont avérées être de bons insecticides contre la mouche de la pomme, *Rhagoletis pomonella* (Walsh), la noctuelle du fruit vert, *Orthosia hibisci* Gn., la punaise terne, *Lygus lineolaris* (P. de B.), la pyrale, *Carpocapsa pomonella* (L.), la petite pyrale, *Grapholitha prunivora* (Walsh) et les tordeuses, *Lepidoptera* (partim).

Des essais de piégeage et de lutte intégrée ont été conduits dans 10 vergers commerciaux et deux vergers négligés. Les résultats obtenus permettent d'établir, pour chaque verger, un bilan comprenant les données phénologiques de développement des pommiers, les relevés météorologiques, la cumulation des degrés-jours, l'époque et le nombre de captures de cinq ravageurs ainsi que les pourcentages de pommes attaquées par ces insectes en regard des insecticides appliqués. Ce bilan indique aussi la possibilité de réduire de 20% le nombre des applications insecticides. Les agronomes régionaux ont décidé d'utiliser ces données pour leurs recommandations futures.

La lutte contre le puceron lanigère, *Eriosoma lanigerum* (Hausm.) a démontré que le Pirimor (périmecarb) et la Lannate L (methomyl) sont les deux meilleurs insecticides contre cet ennemi des pommiers. Une espèce de cécidomye a été trouvée en grand nombre dans des colonies d'*Aphis pomi*. Les populations de pucerons ont été maintenues en-dessous du seuil de tolérance durant toute la

saison de végétation grâce à l'action prédatrice de ce cécidomyie, ne nécessitant ainsi aucune intervention insecticide.

Maladies. Un projet d'hybridation en vue de la sélection de cultivars résistants à la tavelure du pommier, *Ventura inaequalis* (Cke) est en cours depuis 1971; nous avons en pépinière des centaines d'arbres de différents âges qui sont résistants à cette maladie, et qui sont présentement évalués pour leurs caractères horticoles et/ou pour leurs qualités cidrières, leur résistance à certains insectes et au mildiou.

Des essais fongicides contre la tavelure par l'emploi à doses massives de Captafol au stade du ballon blanc se sont avérés très prometteurs. Des études de rémanence ont indiqué que ce produit disparaît rapidement du bouquet floral et de la pousse végétative. A la fin de la saison, le fruit contient 1,6 ppm de captafol dans la pelure, 0,07 ppm dans la chair sous la pelure, 0,02 ppm dans la chair plus à l'intérieur du fruit et 0,04 ppm dans le coeur.

Rémanence des insecticides. Des analyses de sols pratiquées sur des échantillons provenant de différents vergers commerciaux révèlent la présence de DDT et de DDE dans tous les cas. Quoiqu'appliqués en grande quantité au cours de la saison, les organophosphorés tel le Cygon, le Guthion, le Phosalone, l'Imidan, ne sont pas retracés dans les échantillons de sol prélevés, indiquant une dégradation rapide de ces insecticides.

PETITS FRUITS

Gestion du bleuët

Le cultivar Blueray donne les meilleurs rendements de bleuët en corymbe suivi de Bluecrop, Berkeley, Coville, Jersey et Bluetta. Des clones de bleuët nain en provenance de la Station de Recherches de Kentville sont présentement multipliés en vue de les évaluer sous nos conditions. Une collection de bleuëts en corymbe indigène, ramassée en 1978, est présentement multipliée en vue de son évaluation éventuelle portant sur la rusticité et la productivité.

Gestion du framboisier

Le courbage des tiges de framboisier pour prévenir les dommages de l'hiver est avantageux pour les cultivars tendres tel Newburg

et Carnival. Il ne semble avoir aucun effet positif et a même des effets négatifs pour les cultivars rustiques à tiges flexibles tel Boyne.

Protection du framboisier

L'anthronome du fraisier, *Anthonomus signatus* Say, se retrouve sur le framboisier dès la formation des premiers boutons floraux, et dans certains cas, plus de 50% de ces boutons sont attaqués. La punaise terne se rencontre également à l'état adulte ou larvaire. La pégomie du framboisier, *Pegomyia rubivora* (Coq.), apparaît sur les jeunes pousses des framboisiers. Les recommandations de lutte insecticide présentement utilisées ne sont pas efficaces.

Dans les essais de lutte dirigée à la fois contre l'anthronome et la punaise terne dans les fraisières, les insecticides Belmark, Gardona, Ambush, Basudin et Guthion ont donné de très bons résultats.

GESTION DES SOLS ORGANIQUES

Affaissement

L'arpentage a révélé que les sols organiques drainés s'affaissent dans la région sud-ouest du Québec à un taux annuel de 0,9 cm et que ce taux augmente à 3,2 cm si le sol est en cultures sarclées. Les causes de cet affaissement sont multiples et nous avons évalué que la perte de C sous forme de CO_2 et de carbone organique en solution est probablement beaucoup plus importante qu'on ne le pensait. Ces pertes de CO_2 sont nécessairement influencées par la température du sol ainsi que le mouvement de l'oxygène dans le sol.

Les oligo-éléments ont une action indirecte sur l'affaissement de ces sols en encourageant ou en intoxicant la vie microbienne du sol. Il faut, cependant, atteindre des niveaux supérieurs à 5000 ppm de Ca, B, Mo, Zn et Mn avant que l'évolution du CO_2 ne soit diminuée.

Persistance des pesticides

Les méthodes d'extraction du fonofos ont démontré que le stade de décomposition du sol, sa teneur en fibre, son pH ainsi que les façons culturales pratiquées durant la saison ont une influence sur le taux de recouvrement. Il a été également démontré que dans les sols acides et moins décomposés, le

méthanol est un mauvais solvant d'extraction. Les mélanges acetone/hexane 50:50 s'avèrent un meilleur solvant de même que le mélange méthanol/chloroforme 10:90 qui est cependant difficile d'emploi à cause de sa densité plus grande que celle de l'eau.

Fertilité (amendement)

L'action limitative du cuivre dans la production de carottes en sol organique vierge a été confirmée. Le bore vient en deuxième comme agent limitatif. Cette action dépressive est accentuée en présence de quantités recommandées d'autres oligo-éléments ou d'éléments majeurs.

Le rapport $\text{Ca}(\text{OH})_2/\text{Na}_2\text{CO}_3$ doit être très élevé pour assurer un rendement maximum. Nous avons observé des cas de toxicité causée par le sodium lorsque le rapport n'était pas suffisant et que le pH approchait 7,0.

L'azote sous forme de $(\text{NH}_4)\text{SO}_4$ à 160 kg/ha a un effet dépressif sur l'oignon. L'urée a également un effet dépressif lorsqu'appliqué à 160 kg N par hectare. Les rendements maximums ont été obtenus avec des applications de 80 kg/ha d'azote sous forme de NH_4NO_3 .

Une enquête faite chez les producteurs a révélé qu'une grande proportion de cultures reçoit des doses beaucoup trop fortes d'engrais chimique. Les niveaux de fertilité dans le sol sont si élevés, dans certains cas, qu'ils approchent le palier de la toxicité.

LEGUMES

Production

Cultivars de légumes de conserve. La récolte mécanique des cultivars de haricots mis à l'essai nous a donné moins de 5% de fèves brisées ou laissées sur le champ. Les rendements se sont échelonnés entre 8,3 t/ha pour la Splendorgold à 11,9 t/ha pour la BBL 73-103 avec au moment de la récolte, un classement de grosseur acceptable pour la mise en conserve.

Les cultivars hâtifs de pois ont été récoltés entre 90 et 100 degrés au tendromètre et la variété Caméo 1220 U.T. a donné 2,8 t/ha avec 80% de pois dans les trois premières catégories tandis que le cultivar Accord a donné un rendement de 2,6 t/ha avec 60% de pois dans les trois premières catégories. Les meilleurs rendements furent obtenus avec le cultivar semi-hâtif Krite 1307 U.T. qui a

donné 5,1 t/ha avec 85% de pois dans les trois premières catégories. Les cultivars tardifs Charger, Rally, Canner 68-273 et Canner 69-315 ont produit entre 4 et 5 t/ha avec une plus forte proportion de pois dans les catégories 4 et 5.

Cultivars et production de légumes en sol organique. Les cultivars Fawn Preview, Gladiator, Canada Maple, Spartan Sleeper et Harvestmore ont donné des rendements supérieurs d'oignons classés No. 1.

La production de mini-carotte en sol organique compte-tenu des conditions climatiques et d'une croissance très rapide, semble possible, mais il est difficile de dépasser 65% de produit vendable en frais (cello). Durant les mois de juillet et août, la période de croissance ne doit pas dépasser 66 à 70 jours pour être rentable, sinon la longueur et le diamètre au collet deviennent vite des facteurs de rejet. Le semoir NIBEX bien calibré et utilisé à basse vitesse, donne un semis très uniforme, mais le contrôle de la profondeur du semis demeure difficile en sol organique.

Protection

Les quatre pyrèthréinoïdes synthétiques, Ripcord, Selecron, Belmark et Ambush se sont avérées plus efficaces que les produits homologués Dipel, Monitor et Lannate contre la fausse-arpenteuse du chou *Trichoplusia ni* (Hübner) et la piéride du chou *Pieris rapae* (L.).

Le produit Thimet s'est avéré efficace contre l'escargot *Helix aspersa* Müller alors que carbofuran, methamidophos, permethrine, methomyl, Perma-Guard et carbaryl n'ont montré aucune activité contre cette espèce d'escargot qui apparaît occasionnellement dans nos jardins. Des essais sur la survie de ces escargots à l'hiver canadien ont démontré qu'*Helix pomatia* L. avait survécu aux conditions hivernales de 1977, mais les spécimens sont morts peu de temps après avoir été ramenés en laboratoire. *Helix aspersa* Müller n'a pas survécu dans les cages en plein champ, mais deux spécimens sur 25 étaient encore vivants dans des cages localisées le long des fondations d'une bâtisse chauffée. Ces deux escargots sont encore vivants et ont pondu une masse d'oeufs en laboratoire. Les oeufs retrouvés dans les cages de plein champ ou le long de la fondation d'une bâtisse chauffée n'ont pas éclos.

Contrairement à certaines assertions, les hormones présentes dans le feuillage de la carotte au moment de sa montée en fleurs ne provoquent aucun effet sur l'oviposition de la femelle du charançon de la carotte.

CRUCIFERES

La hernie (*Plasmodiophora brassicae* Wor.)

Des échantillons pris à travers le Canada nous ont permis de caractériser les différentes races de hernie présentes dans certaines localités.

Des techniques ont été développées dans le but d'obtenir des parcelles expérimentales ne contenant qu'une seule race de hernie. Ces parcelles permettront de vérifier en plein champ la résistance de certains cultivars.

Des techniques permettant une infection maximale, 30 jours après le semis et sous conditions contrôlées, ont été mises au point. Des travaux sont en cours dans le but de séparer les spores, de différentes grosseurs, à l'aide d'une solution de sucrose et de la centrifugation avant de les exposer à une teinture fluorescente permettant les techniques microscopiques d'examen sur la viabilité de ces spores.

Résistance à la hernie

Une nouvelle technique permettant d'identifier les chromosomes somatiques de chaque chou individuellement a été développée en se basant principalement sur les cellules nucléaires localisées dans l'ovaire du jeune pistil.

Un rétrocroisement sur le F₁ triploïde provenant du croisement entre *Brassica oleracea* L. et *B. napus* L. a produit une plante dont le nombre des chromosomes est de $2n = 18$, mais où les chromosomes 1 et 7 du chou ont été substitués par deux chromosomes plus petits venant de la navette. Cet échange chromosomique a introduit la résistance dans cette nouvelle plante qui portera le nom de *Brassica napoleracea*.

Cultivars de crucifères

Choux. Les cultivars recommandés pour l'usinage et la transformation sont: Safe Keeper hyb, pour le marché frais Quick Green Storage, Houston Ever Green et Storage Green.

Choux-fleur. Les cultivars recommandés sont Whiteton, Idol Original, Burpeana, Super Snow Ball, Imperial 10-6 et Extra

Early Snow Ball; les cultivars Super Junior et tout spécialement Delira possèdent une tête plus petite qui permet une présentation spéciale à l'état frais. Les cultivars Roberna et tout spécialement Lagon à grosse tête pourraient se prêter mieux à l'usinage et à la transformation.

Choux de Bruxelles. Le cultivar Jade Cross E est beaucoup supérieur sous nos conditions aux autres cultivars; il est, cependant, recommandable d'essayer entre autre Crenel (hyb), Valient et Long Island Improved.

Brocoli. Les cultivars les plus recommandables sont: Premium Crop, Green Hornet, f. Dandy, G. Comet, Southern Comet, Spartan Early et Royal Sluid 73367.

MAÏS

Production

Le cultivar N.K.442 de maïs grain a donné des rendements supérieurs lorsque semé dans un terrain labouré à l'automne et hersé au printemps ou lorsque le labour et le hersage sont faits au printemps. Des rendements inférieurs ont été obtenus lorsque le maïs est semé dans un sol non préparé avec labour et hersage à l'automne ou lorsque le maïs est semé sur sillon butté.

Protection

Dans des conditions d'infestation artificielle (20 oeufs de la pyrale du maïs par plant), deux applications d'Ambush 1G ont donné moins de 5% d'épis touchés par l'insecte (ce pourcentage est le seuil de tolérance au Québec pour le maïs vendu à l'état frais).

Des courbes de LD-50 ont été établies pour Ambush, Ripcord, Belmark et Dylox. Les pyrèthrinoïdes de synthèse se sont avérées plus efficaces que le Dylox. Le Dylox, techniquement pur, était deux fois plus efficace que la formule commerciales (SP et EC), à la même concentration.

TABAC

Génétique

Lignées de tabac à cigare. L'évaluation de lignées ainsi que de cultivars se continue et des croisements ont été effectués entre différentes lignées qui possèdent des caractères agronomiques avantageux. Des techniques

de production de plant haploïde à partir de culture d'anther sont aussi à l'essai.

Lignées de tabac jaune. Virginia 115 et Strain 76-C-16 sont les deux meilleures lignées pour le rendement, la qualité et le revenu brut.

Production

Edrageonnage. L'évaluation de produits chimiques permettant d'éliminer le développement des drageons sur le tabac à cigarette ou sur le tabac à cigare a révélé que le nombre et le poids des drageons est de beaucoup réduit par ces traitements. Une deuxième application de produit, 10 à 12 jours après la première, n'est pas économiquement rentable.

Fertilisation (fumure). Des applications d'azote accroissent le rendement et abaissent la qualité du tabac à cigarette. Le phosphore n'a que peu ou pas d'influence sur les paramètres étudiés. Le potassium accroît le rendement et la qualité, par contre des doses excessives de potassium peuvent diminuer la qualité.

Protection

Mauvaises herbes. Les herbicides évalués n'ont démontré aucune sélectivité sur le tabac et le contrôle des herbes ne persiste jamais plus de 4 semaines après la transplantation. Les binages et les hersages sont importants et les herbicides qui ont le plus d'effet sont le chloramben, le pebulate, le fluchloradin et diphenamid. Les systèmes de production doivent s'adapter aux types de cultures, aux types de terrain et aux producteurs. Ces herbicides ont une influence sur la qualité du tabac.

Nématodes. Le Telone C-17 semble être efficace contre le *Pratylenchus penetrans* (Cobb) Filipj et Stekh., mais a un certain effet sur la qualité des tabacs. Une enquête indique que les populations de nématodes sont relativement faibles dans les champs de tabac du Québec; il est donc recommandé d'agir avec prudence et de ne fumiguer que dans les cas précis où les populations sont définitivement très élevées. Le coût de la fumigation et la perte de qualité ne rendent cette opération rentable que dans les cas de concentration dépassant 1700 nématodes par kilogramme de sol.

Insectes. Chez les diverses espèces de vers gris qui attaquent le tabac, seul *Euxoa*

scandens (Riley) et *Euxoa messoria* (Harr.) sont d'importance économique. La migration des larves de *E. messoria* vers le tabac a lieu du 9 au 30 juin. Le maximum des populations des différents âges larvaires d'*E. scandens* a été déterminé par élevage en insectarium.

Un virus de type polyédrie cytoplasmique (CPV) a été isolé et des populations d'*E. scandens* et d'*E. messoria* ont été infectées avec ce virus. Parallèlement, les premiers essais sur la pathogénicité d'un virus de type polyédrie nucléaire (NPV) d'*Agrotis C-nigrum* ont débuté en laboratoire.

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INTRODUCTION

Programs at the Delhi Station concern flue-cured tobacco production with emphasis on improving the quality of Canadian tobacco from the standpoints of usability by manufacturers, both domestic and foreign, and consumer health. Research on nutrition, on control of insects, diseases, and nematodes, and on seedling production and crop management have resulted in improved production practices. Two new cultivars (76N-3, 76C-16) have been developed and recommended for licensing in 1979. A program funded by Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers Council was initiated at the Delhi Station in 1978 to conduct research on energy use in curing and on mechanization of harvesting and handling of tobacco.

Detailed information on research results can be obtained by contacting individual scientists at: Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9.

C. F. Marks
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SOIL SCIENCE

Fertilization

Application of 4-30-8 fertilizer resulted in lower soluble salts in the muck than did the regular 2-16-6 seedbed fertilizer. This new 4-30-8 formulation is low in sulfate and chloride and will be recommended for the 1979 season at 25 kg/100 m². Urea or urea and NH₄⁺-N in various combinations as the source of N in complete fertilizers resulted in similar yield and quality of flue-cured tobacco to those of the regular source of N, 75% NH₄⁺-N plus 25% NO₃⁻-N.

PLANT SCIENCE

Seedbed culture

Improvement in field survival of seedlings from successive pullings from seedbeds was related to seedling hardiness and proportion of retained root. Increasing density of seedlings delayed flowering and reduced agronomic indices. Seedbeds of muck and lime-amended peat with intermixed perlite or vermiculite were equivalent or superior to muck alone relative to germination and seedling growth and subsequent maturity and agronomic indices in the field. Todd cell culture via direct seeding was superior to seedbed culture in uniformity, survival, time to flowering, and yield.

Topping and spacing

Yields of Delhi 76 and Virginia 115 increased progressively as plants were topped to a height of 10, 13, 16, or 19 leaves but price and total alkaloids tended to decrease. When plants were spaced at 51 cm × 107 cm or 61 cm × 107 cm, the yields were lower with the wider spacing for both varieties. The narrow spacing reduced the quality of Virginia 115 more than Delhi 76. Size of tip leaves increased with each three-leaf decrease in topping height with both varieties at both spacings: lamina weight tended to increase with increase in height of topping regardless of variety or spacing.

Inhibition of axillary bud growth

Axillary bud growth, stimulated by topping, must be controlled to produce leaf of acceptable yield and quality. Straight-chain fatty alcohols of either C₁₀ or C₈₋₁₀ formulations were most effective in inhibiting bud development when applied at mid-bud stage and 5-7 days later.

Ripening agents

Field sprays of ethephon (2-chlorethyl phosphonic acid) at 4.2-7.0 L/ha using three fine nozzles per row at 414-453 kPa gave best results when applied in warm weather to upper leaves mature in both age and color development. Introduction of ethylene gas into kilns reduced yellowing time by 10-15 h. Levels less than 200 ppm were effective and levels up to 2000 ppm caused no damage.

Curing

Over-yellowing for 24 h was superior to normal yellowing time in the upper three primings. A slow rate of initial drying in color fixing was of more benefit in lower than in upper primings. Reduction of the upper temperature limit in final drying from 77 to 54.5°C increased total curing time but did not affect quality.

CHEMISTRY

Pyrolysis-Gas chromatography of alkaloids

Pyrolysis-gas chromatography was adapted for the rapid determination of alkaloids in tobacco. The technique was particularly useful where nornicotine, an undesirable alkaloid, had to be determined and should be a useful tool for plant breeders.

Estimation of chemical parameters by infrared reflectance spectroscopy

An InfraAlyzer was used to estimate total alkaloids such as nicotine, reducing sugars, and total nitrogen in tobacco lamina samples. The technique can also be applied to the estimation of other chemical parameters that are indicators of tobacco quality.

Effect of sheeting on chemistry of tobacco and smoke

Tobacco sheets made by the PCL method (Ajax Co., Montreal) were examined for changes in the chemical composition of tobacco and smoke. Water-soluble leaf components such as nicotine, reducing sugars, and total nitrogen were considerably reduced in sheets derived from leaves from the lower, middle, or upper plant positions or from a blend of leaves from all plant positions. Structural, polymeric, or mineral leaf components such as cellulose, lignin, fiber, and ash were changed very little. Tar, nicotine, and nitromethane extractables in the particulate phase and aldehydes in the gas phase of smoke were reduced in proportion to the decline in water-soluble leaf components.

Method for determination of phenolic constituents

The major phenolic constituents in flue-cured tobacco were separated for the first time in a single chromatographic procedure

using high-performance reversed-phase liquid chromatography. The gradient system employs methanol and 0.1 M KH_2PO_4 mixtures with a μ -bondapak C18 column.

Effect of rates of N fertilization on phenolic constituents of tobacco

A comparison was made of four rates of N fertilization (0, 22.4, 44.5, and 67.2 kg/ha) on the levels of phenolic constituents of flue-cured tobacco. Chlorogenic acid, neochlorogenic acid, 4-*O*-caffeoylquinic acid, total chlorogenic acid, rutin, and scopolin were found to be inversely related to the amount of N. The largest differences in these phenolic constituents were observed between zero and normal N fertilization (22.4 kg/ha). Scopoletin was the only phenolic constituent which tended to increase with increasing N rates.

Method for determination of nonvolatile organic and fatty acids

A procedure using sulfuric acid in absolute methanol was used to simultaneously extract and esterify the nonvolatile organic and fatty acids in flue-cured tobacco. The methyl esters are then partitioned into chloroform and analyzed by gas-liquid chromatography.

GENETICS AND PLANT BREEDING

Variety development and evaluation

A new variety, Delhi 76, was developed by treating seed of Delhi 34 with cobalt-60 and selecting the progeny for increased yield and reduced ground sucker growth. The variety was amenable to easy curing and produced leaves of good texture and color with a favorable balance of chemical constituents. Approximately 15% of the Ontario crop and over 60% of the Quebec crop was planted to Delhi 76 in 1977-1978.

Breeding pale yellow type tobacco

U.S. Tobacco Introduction, T.I. 1372, which has a dominant pale yellow gene, was crossed with some Canadian and U.S. varieties to develop strains adaptable to field chopping and sheet production. The plant tended to yellow within a short time after topping allowing earlier field chopping and reducing yellowing time by at least 24 h after field chopping.

Interspecific hybridization studies

A stable breeding line 76N-3 was developed from a *Nicotiana tabacum* L. and *N. rustica* cross using *N. tabacum* as a recurring parent. The line exhibited rapid early growth, desirable agronomic, physical, and chemical characteristics, and produced cured leaf of better quality than Virginia 115. It has been proposed as a new flue-cured tobacco cultivar for Canada.

Black root rot immunity

A black root rot immune line 76C-16 has been developed and recommended for licensing as a variety to be grown on problem farms in Prince Edward Island. Except for a slightly reduced yield and excessive leaf turnover, the line exhibited desirable agronomic, physical, and chemical characteristics, and produced cured leaves of outstanding quality.

Correlation studies

Agronomic characteristics positively associated with yield were negatively correlated with leaf total alkaloids and lamina weight, and with smoke total particulate matter, wet tar, and alkaloids on a per cigarette basis. Conversely, grade index and average length of the three top leaves, which were in negative association with yield, exhibited a positive relationship with leaf total alkaloids and smoke characteristics. Leaf total alkaloids and lamina weight were the most important characters influencing smoke TPM.

PLANT PATHOLOGY

Black root rot

Cross grafting indicated that resistance of tobacco to black root rot is restricted to the root. Corn as compared with rye in the third tobacco rotation reduced lesions and increased tobacco growth in a field heavily infested with *Thielaviopsis basicola* (Berk. & Br.) Ferr.

Weather fleck

Ethylene diurea "EDU" (previously DPX 4891) reduced weather fleck by 50-90% depending on method and date of application. EDU was compatible with the sucker control chemical "Delete" and had no

undesirable effect on tobacco leaf and smoke qualities. Residues in the cured leaf were negligible.

Pole rot

Deficiency of K, P, or Mg in tobacco did not influence pole rot infection. Pollen grains of tobacco, corn, rye, and pine increased the germination of *Rhizopus arrhizus* Fischer sporangiospores and the length of the germ tubes.

Tobacco stunting

Nematodes, fungi, soil conditions, toxins, and soil enzymes were investigated as potential causes of undefined stunting in tobacco. The problem appears to be due to an interaction of several factors; however, higher rates of nematocides with some fungicidal properties reduced the severity of the problem.

ENTOMOLOGY

Cutworms

A total of 989 insect parasites, including eight species of Hymenoptera and four of Diptera, were reared from 6750 darksided cutworm larvae collected from tobacco fields. Nine species were recorded for the first time in North America. *Copidosoma bakeri* (Howard), *Arenetra rufipes vernalis* Walley, and *Enicospilus* spp. are the most important parasites of the darksided cutworm in Ontario.

Residues of chlorpyrifos, leptophos, and trichlorfon were not detected in any cured leaf samples regardless of formulation or method and number of applications employed. Residues of carbaryl and endosulfan were detected in all such samples and ranged from 0.4 to 4.0 ppm, and from 11.5 to 30 ppm, respectively, depending on number of applications and interval between treatment and harvest.

Hornworms

Tobacco yields were negatively related to tomato hornworm infestation levels. No qualitative differences were apparent when compared with tobacco from insect-free plots.

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MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade Name

Ethylene diurea (EDU)
Delete

Manufacturer

DuPont of Canada Ltd.
Proctor and Gamble

Research Station Harrow, Ontario

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Departures

G. H. FRIESEN, B.Sc., M.Sc., Ph.D. Transferred; Research Station, Morden, Man., December 31, 1978	Head of Section; Weed science
P. W. JOHNSON, B.S.A., M.Sc., Ph.D. Transferred; Research Station, Vineland Station, Ont., July 2, 1977	Plant parasitic nematodes
F. G. VON STRYK, Dipl. Chem., Ph.D. Retired September 6, 1977	Pesticide chemistry
L. O. VAARTAJA, B.S., M.A., Ph.D. Retired December 30, 1977	Soybean and white bean diseases

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INTRODUCTION

The Research Station at Harrow serves southwestern Ontario where favorable climatic conditions permit an intensive and diversified agriculture. Variation in timing of rainfall creates problems with moisture supply and the excess rainfall late in 1977 interfered with planting of winter wheat and the harvest of crops. The 1978 summer season was dry and reduced yield compared to normal production. Our programs of research 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, winter wheat, and Burley tobacco. Crop improvement is achieved by breeding new varieties with superior characteristics, improving insect, disease, and weed control practices; and by improving soil and crop management practices.

This report summarizes results attained in 1977 and 1978. Request for further information or reprints of publications should be directed to: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

J. M. Fulton
Director

FIELD CROPS

Burley tobacco

Harvesting. Experimental two-row stalk cutters performed best at 4.7 km/h which resulted in a time saving of 85–90% in the cutting operation during harvesting. With proper adjustment, better quality tobacco was harvested with the cutters than with conventional hand harvesting.

Corn

Breeding. In 1977, two Harrow hybrids, 753 and 761, were released to United Cooperatives of Ontario and Otto Pick and Sons Ltd. to be sold as Co-op S315 and Pickseed 8858, respectively. These hybrids have yielded 12 and 16% higher than comparable check hybrids. In 1978, Harrow 762 was released to Maple Leaf Mills Ltd. It has yielded 8% above check hybrids of similar maturity and standability.

Diseases. Within a group of cultivars of similar yield and maturation period, good correlations were obtained between ear growth rate in the early stages and eventual stalk rot in October. These correlations apparently reflect differences in hormone balance within the plant during the season. Effects on ear growth are soon apparent; effects on root and stem physiology become more apparent later.

Insects. A 5-yr study of the ecology and economic importance of a bivoltine strain of the European corn borer in grain corn showed that when plots of corn were planted 10–12 days apart the first generation of the borer deposited more eggs in the early planting, but the second generation favored the late planting. In chemically treated plots established to examine the effect of each generation and the two generations combined on yields of corn, it was found that the second generation was always more destructive than the first. When two sets of plots were harvested 1 mo apart, the late-harvested corn suffered an additional loss of ears during fall storms because of bored stalks and shanks. It was concluded that corn growers should use resistant hybrids to reduce injury by the first generation, and to plant and harvest as soon as feasible to decrease injury by the second generation. There are no commercial hybrids resistant to the second generation.

Corn rootworm populations with an average of 2.1 larvae per plant at sites in Kent and Lambton counties with corn on the same land in consecutive years reduced yield by about 1% per larva in 1977 and 1978. Western rootworms comprised about 20% of adult populations in Kent and Lambton counties and 76% in Essex county in 1978. Larval mortalities resulting from the application of 1.0 kg of carbofuran 10% or of phorate 10% granular per hectare at planting

time were 62% in 1977 and 4% in 1978. Dry soil conditions probably reduced rootworm populations and the efficacy of soil insecticides in 1978. Numbers of adults that were caught and counted in yellow sticky traps, in cages, and on check plots were similar; the averages were 2.9 per sticky trap, 2.5 per cage, and 2.5 per check plot at various sites in 1978.

Rotation. Analyses of long-term rotation data indicate that soil compaction, which may result from continuous corn culture on heavy clay soils, is associated with reduced soil moisture and with reduced potassium nutrition, even where ample K reserves are known to exist in the soil, or are provided by fertilizer input. Soil compaction, soil moisture, and K level in the leaves accounts for most of the yield difference between continuous corn with fertilizer and comparable corn grown on a legume-containing rotation.

Compaction associated with continuous corn resulted in an average of 44% total soil pore space in comparison with 52% porosity measured over a 13-yr period within corn plots that followed 2 yr of alfalfa in a 4-yr rotation. The K content of corn leaves was 1.56% from fertilized continuous corn compared with 2.50% K in corn leaves from the alfalfa rotation. The increased soil porosity and the increased K content was also related to corn yield of 6.81 t/ha on rotation corn compared with 5.33 t/ha on continuous corn.

Soil fertility. A reliable and rapid technique has been developed to measure the flux of nitrous oxide (N_2O) from soils under natural field conditions. Results so far indicate considerable fluctuation in rates from site to site and day to day.

It was found on corn plots fertilized with N at 0–336 kg/ha that there was a strong correlation between N_2O emission and fertilizer rate. In this study ammonium nitrate had been broadcast over the soil and incorporated by discing. The time of sampling was 39–43 days after treatment. The average rate of loss of N for the most heavily fertilized corn was 0.01 kg/ha per day.

Weed competition. Weed competition in corn and soybeans cannot be eliminated in a heavy weed infestation by cultivation for up to 8 wk. However, weeds present in corn for no longer than 2 wk after emergence do not reduce yields. An economic advantage can be obtained in corn by spraying and cultivating

weeds even up to 6 wk versus no control at all; for soybeans the time parameter is 4 wk.

Weed control. Herbicide evaluation research has resulted in four chemical treatments (bentazon, pendimethalin, metolachlor, and atrazine/metolachlor) being recommended for weed control in corn.

Economics

Tile drainage. Comprehensive computer models for analysis of tile drainage investments have been developed. A study on the economic feasibility of increasing crop productivity in Ontario and Quebec by drainage improvement has found that the average crop yield increases obtained under experimental conditions would make tile drainage of land to be used for production of grain corn, soybeans, and wheat a profitable investment proposition. An application to experimental data relating grain corn yield to tile drain spacing on a Brookston clay loam soil indicated that best economic returns resulted with tile drain systems having 12 m spacings between laterals even though higher corn yields were obtained from closer spacings. A model suitable for counseling farmers on individual drainage investments has been developed and is currently available to the industry through the Ontario Ministry of Agriculture and Food.

Soybeans

Breeding. Improved lines suitable as parental material have been selected for resistance or tolerance to phytophthora rot, powdery mildew, and soybean mosaic virus. The lines have also been evaluated for physiological traits such as photosynthetic rate and chlorophyll content.

Pathology. Races 7 and 9 of *Phytophthora megasperma* Drechs. var. *sojae* Hildebrand have been identified at the Woodslee Substation. The percentage plant loss of varieties grown at Woodslee has ranged from 8 to 4%. A technique for evaluating tolerance in the greenhouse has been developed which permits preliminary evaluation of varieties.

Physiology. In a test of 12 cultivars of similar maturity, there was a significant positive correlation between yield and photosynthetic rate per unit leaf area during pod-filling (August) but not during July. Yield was not correlated significantly with leaf chlorophyll concentration, specific leaf

weight (dry weight per centimetre squared), and photosynthetic rate per unit of chlorophyll in either period.

Weed control. As a result of herbicide evaluation research, butralin, chloramben plus metribuzin, diethatyl, metolachlor, and profluralin have reached the recommended category in soybeans.

White beans

Anthracnose. Surveys indicate that the delta race of *Colletotrichum lindemuthianum*, first seen in 1976, has persisted in southwestern Ontario, but the disease incidence decreased somewhat in the dry weather of 1978 and as the result of a seed treatment program.

The fungus developed sclerotium-like structures (SLS) in the presence of benomyl at 500 μ g/ml. Desiccated SLS survived for at least 7 mo and germinated myceliogenically at the onset of favorable conditions. The SLS were demonstrated to be structurally identical to sclerotia, hitherto unknown in this fungus, and served to prolong the overwintering phase. Conidia from SLS were pathogenic.

Bacterial blight. Thirty-nine strains of the blight bacteria (*Xanthomonas campestris* pv. *phaseoli* (Smith 1897) Dye 1978) were isolated from Huron and Kent county bean fields. About equal proportions were common and fuscous blight producers; 27 were virulent, 8 were weak, and 4 were intermediate on cv. Seafarer. In field evaluations, 2 resistant and 11 tolerant lines were recognized.

Breeding. Fleetwood, a new variety developed at the Station, was released in 1978. This variety is a tall bush type. It is resistant to the alpha, beta, and gamma races of bean anthracnose caused by *Colletotrichum lindemuthianum* and to the Type and NY15 strains of bean common mosaic virus. In trials across southern Ontario during 1973-1976, Fleetwood matured approximately 10 days later than Seafarer. The average seed yield of Fleetwood in these tests was 32% higher than Seafarer, 25% higher than Sanilac, and 13% higher than Kentwood. Average grams per 100 seeds for Fleetwood, Seafarer, Sanilac, and Kentwood was 17.1, 18.0, 16.6, and 20.4, respectively. Cooking tests indicate that Fleetwood quality is satisfactory and equal to Seafarer, Sanilac, and Kentwood.

Virus diseases. Severe outbreaks of virus disease on white bean were observed in several 1978 Select plots near Chatham, Ont. Two of the more severely affected plots had approximately 35 and 80% of plants infected. Yield loss was estimated to be about 26 and 40%, respectively. Symptoms of the virus complex include mosaic, black root, and bud blight. Components of the complex include tobacco ringspot virus and bean common mosaic virus.

Winter wheat

Breeding. Winter wheat strains resistant to wheat spindle streak mosaic have been developed. Many lines show much less disease than Fredrick. Other strains have been developed with emphasis on high yield, winter hardiness, increased lysine for nutritional value, earliness, and resistance to powdery mildew and leaf rust.

Canada thistle control. Control of Canada thistle of up to 90% can be achieved by late summer glyphosate application to thistle shoots regrowing in wheat stubble. Even at this level of control eventual reestablishment of patches from escaped plants would be anticipated. Treatment of regrowth in stubble with glyphosate appears to give more consistent results than application to regrowth following a shallow postharvest discing.

HORTICULTURAL CROPS

Field vegetables

Baby carrots

In anticipation of a potential baby carrot production industry in Ontario a cultural system was tested and developed for baby carrots. Machinery for seeding, detopping, and harvesting with a bed system of producing carrots was developed and tested in collaboration with the Engineering and Statistical Research Institute. The baby carrot cultivars that are now recommended from results of studies of agronomic and organoleptic characters include Amstel, Amsterdam Minicor, and Sweetheart. These studies are now complete and the production system is ready for use.

Crucifer crops

Insect control by pathogens. Laboratory and field tests on control of leaf-eating pests of crucifer crops in 1977 and 1978 indicated

that low dosages (one-quarter of full rate) of permethrin and *Bacillus thuringiensis* or viruses were more effective when used in mixtures than when used alone against the cabbage looper and cabbageworm. Effectiveness of the low-dosage mixtures was similar to, or exceeded that of, permethrin or methomyl, respectively, used alone at the full rate indicating a method of reducing the quantity of chemical required for control.

Cucumbers

Aphid control. Melon aphids were well controlled by recommended materials and some experimental materials including foliar sprays and systemics applied at planting time. The complex of natural predators of melon aphids was identified and their period of effective activity determined.

Breeding and testing. Rigid selection for the best agronomic traits in the parent inbreds and their combining ability as potential new, white-spine gynoecious picklers resulted in the designation of four new F_1 hybrids for off-station trials in 1979. Meeting all requirements for productivity, fresh quality, and salt-stock cure, these test hybrids are also highly tolerant to angular leaf spot, *Pseudomonas lachrymans* (Sm. & Bryan) Carsner, and to cucumber mosaic virus, and resistant to scab, *Cladosporium cucumerinum* Ell. & Arth. On the basis of their reaction to field infection, the need for angular leaf spot tolerance in both inbred parents of F_1 hybrids was confirmed.

Economics of machine harvesting. A general-purpose computer model for evaluation of crop mechanization systems has been developed and applied to pickling cucumber production. Machine harvesting will reduce production costs per hectare but because of reduced crop sales per hectare will result in lower profitability and productivity per unit area when compared with hand harvesting. Increasing the harvester efficiency in cucumber recovery and increasing the quantity and quality of cucumbers present at the time of once-over harvest could increase crop sales and profit per hectare.

Weed competition. The critical period for weed control in pickling cucumbers was found to be 24–36 days after emergence and for transplanted tomatoes 24–36 days after transplanting. Weed growth can reduce cucumber yields by 50–90% and tomato yields

by 35–80% depending on the duration of competition. Grades of cucumbers were also adversely affected by weed competition. The reduction in cucumber yields resulting from 1 weed per metre of row was not significantly different from that resulting from 2, 4, or 6 weeds per metre of row, suggesting compensatory growth of the surviving weeds. Annual grasses were shown to be just as competitive in cucumbers and tomatoes as some of the common broad-leaved weeds.

Peppers

Forecasting borer damage. Linear equations were developed for forecasting the percentage of pepper fruits damaged by European corn borer larvae from light trap moth catches 3–5 wk earlier. These were tested by weekly counts in 1978 and gave six acceptable forecasts and one serious over-forecast, which could be partly attributed to dry weather reducing adult survival and larval establishment in fruits. When improved, these forecasts will be useful to growers anxious to minimize control costs.

Insect control. Granular sidedress application of carbofuran provided effective control of corn borer and pepper maggot. The best foliar treatment for these pests plus green peach aphid was acephate, followed by Selocron (Ciba-Geigy) and Belmark (Shell).

Potatoes

Relation of insect control and yields. Yields of potatoes increased in direct proportion to the degree of insect control which was regulated by various rates of systemic insecticide applied at planting time. Results over 2 yr demonstrated that Dacamox (Diamond Shamrock) was most efficient at 1.0 kg/ha.

Weed control in snap beans

Preplanting incorporated treatments of trifluralin, fluchloralin, or profluralin protected snap beans from injury resulting from preemergence treatments of metobromuron and, to some extent, linuron. Dinitramine, however, did not offer such protection.

Sweet corn

Insect control. Minimum effective rates of insecticide were established for corn borer control and the timing of spray applications related to the level of moth activity. Insecticides were specified which controlled aphids and fall armyworm as well as the corn borer.

Natural incidence of infection by microsporidian parasites (*Nosema* spp.) reached 17 and 10% among adults of the corn borer captured in light traps in 1977 and 1978, respectively. Application of *Nosema pyraustae* to field plots of sweet corn resulted in infection of 33–68% of larval populations. Preliminary laboratory tests indicate that *N. pyraustae* is highly infective for corn borer larvae.

Tomatoes

Pesticide residues. In cooperative work with CBRI it was shown that while conventional spray schedules of ethylenebisdithiocarbamate (EBDC) fungicides generally resulted in legally tolerable residues of EBDC, nonpermissible residues of the degradation product ethylenethiourea (ETU) frequently occurred. Residues of both materials in processed juice were considerably reduced by a hot acid treatment or by a cold hypochlorite wash of the fruit.

Seed bed preparation. Research with seed bed preparation methods has shown that tomatoes can be seeded directly on clay soil with successful results provided that raised beds are prepared for this purpose the preceding fall and that pregerminated seeding techniques are used. When such a program is followed tomato yields similar to yields from conventionally transplanted tomatoes can be achieved with an approximate 10-day delay in maturity. The most serious limitation to direct seeding of tomatoes is the absence of a reliable method of chemical weed control on untilled soil.

Soil fertility. Examination of the relationship between tomato yield, soil test level for K^+ , and the necessary rate of fertilization has confirmed the existing soil test calibration presently used for this crop in Ontario. Soil levels above the range 100–150 ppm K^+ or additional fertilizer K^+ at these levels failed to improve yield or quality of fruit.

Weed control. Dinitroaniline-type herbicides (dinitramine, trifluralin, ethalfluralin, or profluralin) applied preplanting incorporated, followed by metribuzin applied postemergence about 3 wk after transplanting, were the most effective weed control treatments for transplanted tomatoes.

Weed control with charcoal protection. A charcoal:vermiculite mixture applied above plug-mix direct-seeded tomatoes successfully

protected them from injury from metribuzin applied as a preemergence treatment and permitted satisfactory weed control, previously unattainable with available herbicides. With charcoal protection, application of metribuzin at 0.6 kg/ha caused no reduction in the number of plugs with plants (98% of control) or the number of plants per plug (96% of control). At this rate of metribuzin, fresh weight per plant in protected plugs was 83% of the control weight. Although this plant weight reduction was not significant, it may reflect uptake of low doses of unadsorbed metribuzin by seedlings, especially since at lower rates of metribuzin plant weight averaged 94% of the control. Preemergence application of metribuzin at 0.6 kg/ha provided 76–80% control of annual broadleaf weeds and the addition of napropamide at 4.0 kg/ha or diphenamid at 6.7 kg/ha increased the control of annual grass weeds. In grower trials, protection of seeded tomatoes from metribuzin afforded by the charcoal over the plug-mix was sufficient to provide yields equivalent to the weeded diphenamid control treatment although some initial injury was observed where metribuzin was applied.

Weed ecology. Five species of *Amaranthus* (pigweeds) have been identified as common weeds in field crops, vegetable crops, and tree fruits in southwestern Ontario. Three of these species, which are morphologically quite similar, are particularly abundant in cultivated fields. Green pigweed, *Amaranthus powellii* S. Wats., originally a western species, was found to be as common as, if not more common than, redroot pigweed, *A. retroflexus* L. Smooth pigweed, *A. hybridus* L., is also considerably more abundant than had been realized.

Yellow nut sedge development and control. Yellow nut sedge, a perennial weed, produces tubers when the plant is exposed to short daylengths. This formation begins the latter part of July in the Harrow area. One plant, when set out in the spring, has been found to produce over 300 additional shoots and some 3000 tubers by the fall. These tubers will overwinter in the soil and will sprout to reinfest the field over the next 3–4 yr. The length of time required for a plant of any age to be induced to form tubers can be as short as 1 wk with maximal tuber formation occurring when the plant is exposed to

short daylengths for a 2-wk period at an age of 6–8 wk.

Control of the weed may be accomplished by the use of incorporated metolachlor or by an application of glyphosate prior to tuber formation. Suppression of the weed may be obtained when incident light is reduced by 50%, as would occur under a crop canopy. Eradication of the problem can only be achieved culturally when the field is kept barren after the latter part of July until frost. Any tissue regrowing during this time will produce tubers.

Greenhouse vegetables

Cucumber

Breeding and testing. All 135 cultivars and/or strains of European seedless cucumbers tested for their reaction to local isolates of cucumber mosaic virus (CMV) were highly susceptible. Breeding to develop a variety with CMV tolerance and resistance to powdery mildew, *Sphaerotheca fuliginea* (Schlect. ex. Fr.) Poll., became complicated as one of the three recessive genes for powdery mildew resistance is linked to the *D* gene for dull fruit. Backcrossing was begun to break the *D* linkage.

Powdery mildew. Good control is obtained by carefully timed sprays of pycnospores of the parasitic fungus *Ampelomyces quisqualis* interspersed with water sprays. This control agent is compatible with some experimental fungicides.

Tomatoes

Biological control of insects. Four common native parasites of the vegetable leafminer were reared. *Diglyphus begini* had the shortest life cycle and has been successful in small greenhouse tests.

Chemical pest control. The synthetic pyrethroid permethrin is very toxic to whitefly and leafminer adults. Residues on tomato fruit are always less than 200 ppm, and tomato foliage with a higher level of residues remains toxic to insects for 3 wk.

Fusarium foot and root rot. The pathogen is designated as *F. oxysporum* f. sp. *radicis-lycopersici* n. f. sp. Jarvis Shoemaker, pathogenically distinct from *F. oxysporum* f. sp. *lycopersici*. A survey of cultural practices in 119 greenhouses (80 ha) in Essex county

indicated that the source of irrigation water and the presence of straw mulch, both probably affecting soil temperature, were major factors in predisposing crops to this low temperature disease. The severity of the disease was negatively correlated with planting date. Several hundred seedlings have been screened for Dr. E. A. Kerr's breeding program at the Horticultural Institute of Ontario, Simcoe, and a number show promising resistance. No chemical treatment has yet been found that is effective in controlling the disease in Ontario conditions. A biological control system has been evolved in pot work but has so far been less successful in ground-beds. The reasons for this are being investigated.

Wilt. Greenhouse tomato plants affected by fusarium wilt tend to be associated with other wilted plants, especially within rows. The spread of surviving disease inoculum through tillage and planting operations appears the most likely reason for this pattern. Recovery from the disease is possible where conditions favor formation of adventitious roots.

Tree fruits

Apple

Control of codling moth by granulosis virus. Injury to apples by codling moth was reduced by 44–91% by application of granulosis virus in orchard tests in three Canadian locations. These results and the high efficacy of the virus in laboratory tests suggest the potential value of this pathogen in integrated pest management.

Apricot breeding

A new cultivar named Harcot formerly tested as HW401 was introduced in 1977. This is a very early, attractive, medium to large, high-quality variety best suited for the fresh market. It has a high level of cold hardiness combined with adequate resistance to bacterial spot (*Xanthomonas pruni* (E.F. Sm.) Dows.), brown rot (*Monilia fructicola* (Wint.) Honey), and perennial canker (*Leucostoma* spp.). Several selections now fruiting in regional trials, especially HW405, HW407, HW410, and HW425, offer sufficient promise that further releases are expected soon.

Nectarine breeding

In 1973 a major program was undertaken to intercross the best of the California cultivars with the hardiest and best of the Canadian and American cultivars developed in the northeastern states and Ontario. In 1978, 19 very promising selections were made which ripened from August 11 to September 11. These selections combine the larger size, firmer flesh, and better quality of the California varieties with the greater hardiness and disease tolerance (*X. pruni*, *M. fructicola*) of those from eastern North America. They are undergoing further hardiness and other pomological tests and the best will be propagated in 1979 for regional trials in 1981.

Peaches

Bacterial spot. Orchard experiments showed that both oxytetracycline-HCl and streptomycin sulfate (100 mg/L) significantly reduced defoliation and/or leaf infection due to bacterial spot (*Xanthomonas campestris* pathovar *pruni* (Smith 1903) Dye 1978). Fruit infection was also similarly reduced but data for streptomycin were limited by low incidence. Schedules of eight weekly sprays commencing about shuck fall were as effective as extended sprays. Residues of oxytetracycline were not detected in harvested fruits. Oxytetracycline-resistant strains of pv. *pruni* were not found. In monitoring trials from spring until harvest, epiphytic populations of pv. *pruni* appeared earlier and were 10- to 100-fold higher until 6 wk before harvest on susceptible cvs. Babygold-5 and Olinda than on resistant cvs. Madison and Loring. A selective medium devised was useful in monitoring pv. *pruni*.

Breeding. A new cultivar named Harland was introduced in 1978 at the request of fruit growers and government pomologists in New Zealand. The name Harland was chosen to denote its Harrow origin and New Zealand as the place of its intended culture. Harland has been extensively tested in Canada and the United States but its performance in North America has been inferior to Harbinger, another Harrow introduction introduced in 1971 which matures at the same time. Harland has performed well in New Zealand, however, especially south of Auckland. Harland combines very early maturity with good color and quality for the early season and may help fill an important gap in the

New Zealand ripening sequence. It is not recommended for Ontario. Several very promising mid- to late-season selections for the fresh market, particularly HW231, HW234, HW232, HW235, and HW225, are now being entered into regional trials because in addition to possessing cold hardiness comparable or superior to Redhaven, they also have good size, appearance, flesh firmness, and eating quality combined with adequate resistance to bacterial spot (*X. pruni*) and brown rot (*M. fructicola*).

Crown gall. A commercial product being an axenic culture of the antagonistic bacterium, *Agrobacterium radiobacter* (Beijerinck & van Delden 1902) Conn 1942 strain #84, in peat medium, gave significant control of crown gall (*A. radiobacter* pv. *tumefaciens* (Smith & Townsend 1907) Kerr et al. 1978) in peach and sweet cherry nurseries. Biotype-2 stone fruit crown gall strains are common in Ontario. Five strains were resistant in vitro to the bacteriocin produced by the antagonist but were still subject to biological control in greenhouse tests.

Peach X-disease. In 1977, 50% of 148 orchards in Essex and Kent counties were affected by X-disease. Typically less than 2% of trees were infected in an orchard. Most of the popular cultivars and usually mature trees were subject to the disease.

Peach X-disease vectors. Two additional leafhopper vectors, *Norvellina seminuda* Osb. and *Gyponana* sp., have been confirmed by trapping in the outbreak area since the last report. Vector flight activity extended from May to early November, since some species had two generations per year. It was most pronounced in peach orchards after insecticide spraying ceased at harvest. Some vector species rarely entered orchards and were probably important only in transmitting the disease in the wild reservoir host.

Pesticide interception. Four experimental hedgerows in peach differed in interception of captan. Oblique fan, canted oblique fan, and modified central leader hedgerows reduced captan loss by spray drift 14% compared to 61% lost by the open center hedgerow. Leaf residues decreased as tree canopy volume increased. Oblique fan and modified central leader hedgerows were 41% and 20% more efficient at intercepting captan than open center. Pesticide rates for hedgerow culture are more accurate and precise based

on the target, e.g. tree canopy volume, than on land area.

Weed control. Excellent weed control was provided in nurseries of peach, apricot, and pear by spring treatments of simazine (granular) or simazine plus napropamide to areas free of emerged weeds. Simazine alone provided better broadleaf weed control than the combination containing a lower rate of simazine plus napropamide but grasses were controlled by the latter treatment. The use of a lower rate of simazine also reduces the possibility of soil residues which could affect succeeding crops. No tree injury was observed.

Hydroxysimazine, a nonphytotoxic metabolite of simazine, showed prolonged persistence in soil following repeated applications of simazine in peach orchards.

Pears

Breeding. Two fire-blight-resistant pear selections, HW604 and HW605, were advanced to station and grower trials. HW604 is an early-ripening selection for the early fresh market, and HW605 is a late-ripening pear with good storage life for the winter market. Inheritance of fire blight resistance was found to be polygenic with 42% of the total phenotypic variation due to additive gene action. It was also demonstrated that it is possible to predict resistance of mature field-grown pear seedlings on the basis of tests conducted in the greenhouse on young seedlings 6 mo after germination.

Trials of Old Home \times Farmingdale dwarf and semidwarf pear rootstock clones and Quince A have been established in station and grower trials.

Fire blight. This disease, caused by *Erwinia amylovora* (Burr.) Winsl. et al., was controlled in pears with foliar applications of streptomycin after periods of rainfall between blossoming and 30 days before picking. In experimental plots twig blight was reduced by 84–95% and in a commercial orchard situation the disease was reduced by 80% during a serious fire blight epiphytotic.

Fire blight bacteria were not found in the healthy overwintering buds of apple and pear trees except for two apple buds which were excised from healthy branches of trees with disease symptoms. These buds represented less than 0.3% of all assayed buds. On the other hand, overwintering cankers on branches and limbs yielded numerous bacteria throughout the winter season in the assay. Small twigs, less than 0.5 cm in diameter, cannot be neglected as a source of spring inoculum for the fire blight organism.

Flavor analysis. The flavor constituents of several pear cultivars were characterized by gas and liquid chromatography. Bartlett, the main processing cultivar, had a larger and greater number of higher boiling compounds and higher quantities of decadienoate esters (character impact compounds) than other cultivars. Chromatographic analysis of fruit extracts may provide an objective evaluation of fruit flavor.

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Departures

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J. M. MOLNAR, B.S.A., M.Sc., Ph.D. Transferred August 1977	Head of Section; Floriculture
J. F. SEITZER, Ing. Agr., M.Sc., Ph.D. Resigned July 1978	Soybean breeding

J. M. WAUTHY, B.Sc. (Agr.)
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1977-1979 Cytogenetics

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Population dynamics

INTRODUCTION

Since the last issue of this report, the research programs and service functions of the Ottawa Research Station have expanded considerably with the take-over of the former Ornamentals Research Service and the management of the entire Central Experimental Farm. The research programs are concerned with the development of improved cultivars of cereals, corn, soybeans, forage grasses, and legumes, many facets of ornamentals research, and studies of honey bee behavior and pathology. Supporting research is being conducted in genetics and cytology, plant physiology and pathology, remote sensing, and entomology. The Canadian Plant Gene Resources Office and Landscape Architecture are also our programs.

The Experimental Farms at Kapuskasing and Thunder Bay continue to conduct experiments on crop production and provide information for northeastern Quebec and northwestern Ontario, respectively.

Drs. L. S. Donovan and V. R. Wallen were elected to Honorary Life Memberships in the Canadian Seed Growers Association for their outstanding contributions to the Canadian seed industry.

This report summarizes some of the more important research results from the Station in 1977-1978. Further information can be obtained from the publications listed at the end of this report.

Reprints of the research publications and copies of this report are available on request from the Ottawa Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Tibor Rajhathy
Director

CEREAL CROPS

Oats

Breeding. Cultivars bred and released by this station continue to perform well in Canada. Scott and Sentinel are top-yielding cultivars in Ontario and Scott is gaining popularity in Quebec. Sentinel combines high yield with lodging and red-leaf resistance and its grain possesses the highest protein content of any recommended cultivar. Foot-hill was released to forage producers in Alberta in 1978 and performance reports have been favorable. The breeding of dwarf, lodging-resistant grain-type cultivars capable of producing high yields under conditions of high fertility may soon be possible because of the discovery, isolation, and blending of genes governing dwarfing and long floral stems (peduncles). The dwarfing gene (D) was produced by mutation by R. I. H. McKenzie, Winnipeg Research Station, and the gene(s) producing long peduncles (LP) in the presence of D was discovered and isolated by V. D. Burrows, Ottawa Research Station from a strain of dormoats. The LP gene raises the yield of the dwarf by ensuring the emergence of the panicle from the leaf

sheath thus overcoming a floret sterility problem associated with trapped flowers in the leaf sheath of normal dwarfs.

The dormoat crop breeding inventory now includes high protein and high fat, daylength sensitive and insensitive, tall and short, grain and forage-type dormoats. Superior strains have been isolated in each category and they are being evaluated at several locations in Canada and by scientists in many foreign countries. Large-scale experimentation of dormoats on selected Canadian farms has been initiated and various techniques are being evaluated to manage dormoats.

Physiology and morphogenetics. Microchemical methods using fluorescent dyes which are specific for reacting with storage lipids have been used to screen large numbers of oats and barley seeds for lipid content. The endosperm half of 1500 seeds was assayed for lipid content and the embryo containing half of each seed was grown to maturity to obtain seed of selected seedlings. This is a rapid selection technique which offers great promise to increase the effectiveness of selection.

Diseases. The septoria leaf blotch and black stem disease *S. avenae* Frank f. sp. *avenae* has been important in Eastern Canada for many years. An adult plant growth room testing procedure to simulate conditions favorable for the spread of the disease in nature has been used with some success to differentiate several resistant cultivars and lines. A genetic study is also being carried out using a hybrid between CI 8175 (resistant) and OA 338 (susceptible) and preliminary data indicates that resistance is transferable and dominant.

Wheat

Breeding. Fredrick, released by this station in 1971, continues as the leading soft white winter wheat in Ontario. A survey of producers conducted by the University of Guelph and the Ontario Wheat Producers Marketing Board showed that 82% were growing Fredrick, 9% Yorkstar, 6% Genesee, and 2% Talbot.

Among the new candidate cultivars in the Ontario Cooperative winter wheat test, ORS lines 0-45-2 and 0-45-4 ranked first and second in the test for yield in 1977 and second and first respectively in 1978. Both have better pastry quality than Fredrick and are slightly shorter than Yorkstar. Their weakness is low hectolitre weight, similar to Yorkstar.

After 12 yr of research, the hybrid winter wheat program was terminated in 1978. Many cytoplasmic male sterile lines and many restorer lines were bred but only a few of the latter gave nearly complete restoration. Several high-yielding hybrid combinations were discovered. Problems included the lack of either bread or pastry quality in most of the material and the question of isolation distances. The need for possibly 1.6 km of isolation from other wheats made it questionable whether seed for hybrid wheat could be produced in Ontario.

A combining ability test of hybrids between 8 cytoplasmic male sterile (cms) females and 10 pollen restorer males showed wide differences in yield and pollen restoration. The soft white pastry quality females cms American Banner, cms Yorkstar and cms Fredrick were difficult to restore. On the other hand, cms Mironovskaya 808 was outstanding for ease of restoration and also it showed combining ability for high yield.

Diseases. ORS has begun a program to determine the prevalence and severity of common diseases of soft white winter wheat in Ontario. Snow mold caused severe damage to crops throughout eastern and central Ontario in the spring of 1978. Losses ranged from trace to total in fields that were plowed under. In most fields surveyed damage was attributed to infection by *Fusarium* and *Typhula* species.

Barley

Breeding. The new cultivar Massey, released in 1978, was the highest yielding six-rowed, feed barley in Ontario and is resistant to smut, mildew, and scald. Emphasis is being placed on breeding naked-seeded barley of high protein content. The high protein cultivar Hiproly was found to be a poor parent to use when attempting to increase the yield of protein per hectare. Hiproly has a low kernel yield which is negatively correlated with protein content. Hooded, forage-type barley strains have been isolated and their yields of forage and protein compare favorably with other cereals.

A program to select for extreme responses of barley to photoperiod has been initiated using the progeny from hybrids between insensitive (Olli and Mari) and highly sensitive (selections from Middle East) cultivars. Transgressive segregation occurred in both directions. Strains which head in 22 days after sowing on a 16 h photoperiod have been isolated and may be useful in northern breeding programs.

Diseases. Spot blotch (*Cochliobolus sativus* (Ito and Kurib) Drechsl. ex Dastur) of barley has been prevalent in some years in the Ottawa area. Disease loss tests have shown that it can cause average losses of 20% and as much as 40% in very susceptible cultivars such as Vanier. The cultivar Beacon was found to be quite tolerant to natural spot blotch development. Even though leaf infection was plentiful little or no yield reduction occurred. Studies on inoculum potential in the field showed that viable spores were present on overwintered straw throughout the winter and the following spring after the new crop had emerged. A new method of differentiating spot blotch resistant cultivars has been devised which utilizes an extended period of foliage wetness. Susceptible cultivars develop severe spot blotch with a relatively short wet period (24 h) while

resistant ones develop little disease over an extended period (96 h).

Physiology. At present, cereal pollen cannot be stored for extended periods of time without loss in viability. Experiments were begun in 1978 to evaluate inert fluorocarbon as a liquid medium to store barley anthers and pollen. Mature barley anthers were immersed in the fluorocarbon at varying temperatures from -20°C to $+20^{\circ}\text{C}$ for up to 24 h. After storage, the anthers were removed from the preservative and placed on mature stigmas. Seed set in several trials indicated that barley pollen can maintain viability during storage in a fluorocarbon medium.

CROP LOSS ASSESSMENT

Methodology

Bacterial blight of field beans. The effectiveness of the select seed program, an integrated management program, combined with aerial infrared photographic techniques to monitor the success of the program can now be demonstrated over the 10-yr period 1968–1977. Initially, in the early stages of the program, 1968 and 1970, 4.63 and 6.56% of the crop was infected in the test area of Hensall. By 1972, the infected area had declined to 0.688% and by 1973 and 1974 the infected area was too small to measure. From 1975 to 1977 the infected area continued to be well below the 1% level. As well, losses from 1968 and 1970 were \$140 370 and \$260 720, respectively. Losses from blight in 1976 and 1977 were less than \$10 000. Losses in 1978 were the lowest on record.

Anthrachnose of field beans. Following the discovery of anthracnose and the identity of the delta strain of bean anthracnose, extensive surveys in 1977 revealed over 60 pedigreed fields to be infected with either the delta or lambda strain. During the winter of 1977–1978, cooperative seed treatments were established at Ottawa, Ridgetown, and Guelph using fungicides containing benomyl provided by Chipman and Ciba-Geigy companies. These fungicides were very effective in laboratory and greenhouse trials and fortunately were registered and used to treat most pedigreed seed stocks in 1978. The results of the 1978 survey revealed no fields

with anthracnose. This is an excellent example of Research Branch, provincial, and university cooperation in solving a serious problem of Ontario bean growers.

Aerial photography for forage legume identification and quantification. With sufficient ground truth data, the forage legumes (chiefly alfalfa and clover) and grasses were characterized and quantitatively measured from infrared color photographs (scale 1:6000) of hay fields in Vernon and Carp area comprising about 132 km². Damage due to winterkill (1977–1978) of these crops was also estimated by comparing 1977 and 1978 fall (September) photographs of selected fields.

Soybean bacterial blight. The natural occurrence of this disease in soybean breeding areas at Ottawa was confirmed by isolation and pathogenicity tests of the causal organism, *Pseudomonas glycinea* Coerper. Field plot experiments suggested that the distribution of this disease is likely to occur in a random fashion. At a low severity level, measured in terms of percent leaf area covered by lesions, no significant yield loss of three soybean varieties (Maple Arrow, Maple Presto, and Evans) was noted in 1978.

Measurement of winter injury in alfalfa by remote sensing techniques. A method was developed to measure void areas and subsequent canopy development patterns in alfalfa plots and fields as affected by winter injury. The method utilizes aerial infrared photography, taken sequentially throughout the growing season, or year to year as well, followed by electronic measurements of the photographs. The method demonstrates that strong canopy recovery takes place throughout the growing season and a considerable amount of the damage is not permanent.

CYTOGENETICS

Experimental haploidy and somatic cell genetics

Brassica spp. The frequency of embryogenesis in cultured anthers of *B. campestris*, *B. napus*, and *B. oleracea* was stimulated by elevated culture temperature treatments. The optimal temperature and duration of treatment required for maximum embryo yield varied among the three species. Several

hundred plants were regenerated from anther-derived embryos. Haploids were identified at frequencies of approximately 25% in *B. napus* and *B. oleracea* and 75% in *B. campestris*.

The efficiency of the anther culture method was demonstrated by comparing segregation and recombination frequencies for seed coat color and fatty acid composition between plants derived from F_1 anther cultures and conventional F_2 populations. In *B. campestris*, recombinants containing low erucic acid levels and yellow seed coats were detected amongst the anther-derived plants. Analysis of cotyledons of anther-derived *B. campestris* embryos revealed fatty acid compositions similar to that of seeds thereby permitting efficient, nondestructive selection for fatty acid composition at the embryo culture level.

Cereals. Wheat anther culture studies have been continued with the objective of identifying critical factors influencing the induction of microspore-derived callus. A range of donor growth conditions, donor genotypes, anther stages, spike pretreatments, culture media, culture environments, and technical procedures such as whole spike culture in liquid were evaluated. Development of multicellular structures within the anthers was occasionally detected but significant correlations could not be established.

Delayed pollination of rye with lethally X-rayed pollen in combination with heat shocks did not result in the production of haploid embryos.

An enzymatic method was developed to prepare high yields of stable protoplasts from nonhardened and hardened seedlings of winter wheat and rye. Isolated protoplasts of nonhardened rye seedlings were subjected to freezing tests. The protoplasts exhibited the same responses to the resulting stresses of intra- and extra-cellular ice formation as found in the intact plants.

Flax. High frequencies of shoot regeneration were induced in cultured haploid flax stem explants. Physiological stage of the donor plants, culture temperature and culture medium composition influenced shoot regeneration frequency. Rooting frequency of regenerated shoots was in the range of 25–50%.

Mutagenesis experiments involving X-irradiation of haploid stem explant cultures were undertaken. The frequency of albino shoot

induction was affected by a number of conditions including preculture exposure of the donor plants, pretreatment explant culture, and posttreatment maintenance at low temperatures. The highest frequency of albino mutants obtained was 0.54%. Progenies derived from crosses using haploids as the maternal parent consisted of diploids, aneuploids, and triploids. Further study showed that haploids from haplo-diplo twins could be utilized for transfer of genetic characteristics.

Nicotiana. Callus and cell suspension cultures of normal and chlorophyll deficient mutants of *N. rustica* and *N. tabacum* were initiated. Viable protoplasts were isolated from the cultures of both species and were induced to undergo cell division, colony formation, and morphogenesis. Fusion experiments were performed with theoretically complimenting chlorophyll-deficient protoplasts of the two species. Green colonies were subsequently detected in the protoplast cultures. These colonies were isolated and induced to undergo shoot differentiation.

Bromegrass cytogenetics

Quadrivalent plus trivalent frequencies in colchicine-induced octoploids of *Bromus inermis* Leyss. are twice those seen in commercial cultivars suggesting a difference based on polyploid nature or other chromosome pairing mechanisms such as pairing sites or chiasma localization. The Co generation was reduced in vigor as compared to the allotetraploid cytotype. A feulgen karyotype developed for $8x$ *B. inermis* characterized several structural differences between the A and B genomes. Trivalent frequencies in a spontaneous haplo-triploid (AAB) revealed considerable homoeology between the A and B genomes but no evidence of large structural differences.

Multivalent frequencies in $8x$ *B. pumpe-lianus* Scribn., $8x$ *B. inermis* and F_1 hybrids are equivalent and suggest that these species have the same genomic structure.

ENTOMOLOGY

Population dynamics and pest management

Alfalfa weevil. Detailed analysis of life table data from four geographic locations showed that population trends of the alfalfa weevil *Hypera postica* (Gyll.), are now

regulated throughout Ontario by the fungus *Entomophthora phytonomi* Arthur. This agent, not previously recognized from the insect, was first discovered in the Quinte area during 1973 and is now known from a wide area of northeastern North America. It attacks the larvae and cocooned stages, causing disease epizootics that, at times, virtually annihilate the population. However, it is overcompensating in its action and this imposes population oscillations that periodically exceed the economic threshold. Other biotic agents including the parasitoids, *Bathyplectes curculionis* (Thom.) and *Tetrastichus incertus* (Ratz.) act in a density-independent manner and fail to dampen these fluctuations. A heat unit model has been developed for predicting weevil activity on first-cut alfalfa. This shows that egg hatch peaks in the spring following the accumulation of 302°D_{48} , that larval attack reaches its maximum between 450 and 470°D_{48} , and that pupation occurs at 650°D_{48} . When used in concert with trend forecasting from the life tables and sequential decision sampling to pinpoint economic pockets of infestation, these data have permitted the development of a viable grower alert system and Farm Radio Advisory for the dairy-intensive Quinte area. A sampling plan with preset error limits has been designed for estimating the magnitude of adult infestations. It is based on vacuum samples of the foliage and ground litter, and uses a half ft^2 (465 cm^2) as the sample unit. For typical infestations during the oviposition period in early spring, estimates with reasonable precision may be obtained by taking 60 randomly selected units from a field, at a total cost of 6 man-hours. For estimates of newly emerged adults in early summer, not more than 20 units are required.

Cereal leaf beetle. Surveys during the past 3 yr have demonstrated that the parasitoid *Tetrastichus julis* (Walker) has become the principal factor governing population levels of the cereal leaf beetle, *Oulema melanopus* (L.), throughout southern Ontario. Although numbers of the beetle have remained low, some progress has been made towards a detailed understanding of its population dynamics. Cohort studies for one generation at Ottawa showed that within-generation survival was less than 3%. Highest rates of mortality occurred in first-stage larvae, due to rainfall, and in pupal cells following earlier

attack by *T. julis*. Hibernation studies showed that adult survival varied with the type of habitat; 26, 16, and 10% overwintered successfully in sparse woods, dense woods, and stubble fields, respectively. Emergence rates of *T. julis* and a second parasitoid, *Diaparsis carinifer* (Thom.), were 92 and 63%, respectively, from overwintered host cocoons in grain stubble. From laboratory studies, it was determined that thermal requirements, with 7°C as developmental zero, were 105, 41, 36, 43, 46, and 282°D , respectively, for the eggs, the four larval instars, and the pupae. Accumulated heat units during development of the beetle in field plots did not differ significantly from those expected.

Honey bees

Behavior. Replacement queen rearing begins almost immediately after a honeybee colony loses its queen. Although larvae of suitable age for queen rearing are normally present for 5–6 days after the disappearance of the queen, most queen cells are initiated during the 1st day of queenlessness. Fewer cells are built on each successive day. This reduction is caused by pheromones produced by the developing queens. Experiments showed that the inhibitory activity of a sealed queen cell is less than that of a caged adult queen, but greater than that of synthetic-9-oxo-*trans*-2-decenoic acid. 9-Hydroxy-*trans*-2-decenoic acid had no effect on queen cell production.

Because worker bees recognize and remember certain individual characteristics of their queen, it is usually difficult to exchange queens between colonies. However, the replacement of old queens with young ones may be accomplished by introducing queen pupae into colonies. The success rate is 90% if the old queens are removed prior to the introduction of queen cells, 50% if the colonies are temporarily divided, and 15% if the resident queens are not removed beforehand.

Pathology. Growth of *Ascosphaera apis*, the causal organism of chalkbrood disease of bees, was studied in culture and in enzootically infected hives. In culture, growth and sporulation was improved by holding the media at temperatures suboptimal for bee development and by the addition of honey monosaccharides, trehalose, pollen, or pollen extracts. In hives, the numbers of infected

larvae were higher in overwintered colonies, old brood combs, and unmedicated colonies than in fresh packages, new combs, and colonies that were fed the fungistat thiabendazole. Viable fungal cultures were isolated from the gut of adult bees, from the tissues of apparently healthy larvae, and from pollen of diseased colonies but not from healthy pupae, honey, fresh nectar, or larval food from diseased colonies.

Remains of larvae killed by American foulbrood disease, *Bacillus larvae*, were more acidic and contained more glycogen and proteolytic enzymes than did those of larvae killed by chalkbrood disease. The latter appeared to die from starvation due to pathogen growth rather than from elaboration of toxic compounds.

FORAGE CROPS

Grasses

Orchardgrass. The program has concentrated on winter-hardiness, high forage and seed yields, and increased resistance to rust. The variety *Juno* which has a high yield and good seed quality was released to SeCan. The cultivar Kay has proved to excel in yield and hardiness in Alberta and Manitoba. Over 124 ha of seed production has been planted in the spring of 1978. There may be an export demand for this cultivar in Japan once the supply of seed has been stabilized. A reselection for forage and seed yield and greatly increased rust resistance, in the late maturing Rideau cultivar, has reached the syn₂ seed stage. The new synthetic will be entered in all the three Eastern Canadian provincial tests. A new superior synthetic of Kay genotype was entered in the Ontario list for the first time in 1978.

Timothy. The breeding program consists of providing cultivars of varying dates of maturity, increased forage and seed productivity, and selection for increasing percentage of digestibility utilizing the in vitro system of analysis on selections. The new early strain 009 has outyielded Clair timothy, at four or five locations in the Maritimes. We have 100 kg of breeder seed now, and expect 1000 kg of seed by the fall of 1979. A recently licensed mid-early cultivar Basho is increasing greatly in utilization; over 1700 kg of foundation seed went to the trade and provincial seed growers released by the

forage seed project. Bounty, a late cultivar, was released to SeCan for seed increase. Syn₂ seed has been produced from two high-digestibility genotypes from Champ and Gagetown sources. When 500 plants of the broad-leaved Labelle strain were analyzed by the in vitro method a variation from 56.4 to 75.0% was obtained. The top 11 and bottom 11 plants were set up for retesting in the greenhouse to confirm the previous data in a replicated test.

Bromegrass. The major goal in the brome-grass breeding program was increased seed production of a southern-type brome. The new cultivar Tempo has yielded twice the seed production of the standard Saratoga. On a farm in Manitoba, a 26 ha field gave 627 kg/ha which was exceptionally high for brome-grass in 1977. Pedigreed seed is being increased in Western Canada and also in Western USA.

Alfalfa

The three objectives in alfalfa breeding are resistance to *Phytophthora* root rot, increased protein content, and increased efficiency of nitrogen fixation.

Phytophthora-resistant selections have been identified in a wide variety of germ-plasm sources and they are evaluated for other agronomic qualities. Experimental synthetics have been formed for regional yield testing. High-protein selections have also been combined in a series of experimental synthetics. These are being grown to measure progress resulting from one selection cycle. Studies of nitrogen-fixation efficiency of individual plants from different cultivars showed wide variability. Selfed and crossed progenies of selections with high and low efficiency are being evaluated to measure the potential for improvement of this characteristic by breeding and to study the relationships between nitrogen fixation efficiency and other agronomic characteristics.

A 2-yr study showed that potato leafhopper infestations reduce yields of direct seeded alfalfa by about 50% in the year of seeding. Protein content is also reduced. Insecticides effectively control leafhopper populations.

Breeding methods. Forage yield of 180 F₁ alfalfa hybrids between Iroquois and Thor recorded over 3 yr indicated a low average heterosis of 1.2%, being negative in 1976, 2.4% in 1977, and 0 in 1978. Over the 3-yr average, 102 F₁ were arithmetically above

the parental mean and 76 were below. The F_1 families were distributed about the parental mean in each year as follows: 78 above and 97 below in 1976, 111 above and 63 below in 1977, 84 above and 84 below in 1978. The expression of heterosis varies with years and would appear to be sensitive to the genotype \times environment interaction. The number of F_1 selected as being significantly superior to the parental mean at the 5% level were as follows: 9 in 1976, 32 in 1977, and 15 in 1978. Thor was consistently superior to Iroquois: 18.2, 6.9, and 3.1% each year, respectively. Seed production, measured on the second cut in 1978, indicated an average yield of 608 kg/ha, no heterosis, wide differences between F_1 progenies, and minor differences between the two parents. Several F_1 appear promising for both forage and seed production.

Corn

Breeding. Eleven new experimental hybrids qualified for licensing in provincial corn committee tests and seed production and marketing rights have been allotted to commercial companies. One of these, OX532, with a heat unit requirement of 2150 is the earliest-maturing hybrid developed in this program. It is currently considered to be at, or near the limit, where early maturity and an acceptable yield can be combined into one hybrid. Germplasm that will permit some extension of this limit is available, but the increments of improvement will be small and slow to achieve.

The principal breeding effort is directed to improvement of stalk quality and root strength in currently used early-maturing inbreds that are deficient in these characters. This is a long-range project where lines developed from the Iowa stiff stalk synthetics are used as the nonrecurrent parent in backcrossing programs. The first such improved lines will occur in some hybrids entered in the Ontario Corn Committee trials in 1980.

Five inbred lines developed out of corn borer resistant synthetics No. 5 and 6 have shown acceptable agronomic qualities and are currently being tested in various hybrid combinations.

A collection of inbred lines having the ability to grow at an above-average rate in the cool early part of the growing season has begun. The best of these have come from

northwest Europe. These along with others developed here will be tested to determine those likely to be most suitable for use as nonrecurrent parents in backcrossing programs similar to those currently being carried out to improve stalk quality and root strength.

Agronomic practices. Soybeans, sunflowers, and sorghum cultivars have been grown in various mixtures with corn hybrids to determine the possibility of improving the yield and/or quality of silage. Soybeans in all combinations of mixed and separate rows in association with either an early- or late-maturing corn hybrid failed to add any significant amount of dry matter to the total yield. The corn component of the mixture actually yielded considerably less than it did seeded alone. Mixtures of corn and sunflowers did not perform well. Mammoth Russian, Valley, and P.G.R. 102 cultivars of sunflowers were grown in association with two corn hybrids at three population densities. Corn alone at each population level outyielded by a considerable margin each comparable mixture with sunflowers over a 3-yr period. Digestibility of the forage averaged 69% for the corn hybrids and only 48% for the sunflowers. Mixtures of corn and sorghum appear more promising. Two forage sorghums were grown in mixed and separate row mixtures with two corn hybrids. Mixtures either in the same row or in separate rows yielded significantly more than either the comparable corn or sorghum alone. Further studies of corn and sorghum mixtures are planned.

Soybeans

Breeding. The cultivar Maple Arrow was licensed in 1976 and placed on the recommended list of cultivars for the 2500 to 2700 heat unit areas in Ontario. It has since been very well accepted by growers in eastern and central Ontario. The line BD21117 (proposed name: Maple Presto) has been recommended for licensing by the Ontario and Manitoba Oilseed Crop Committees. It matures in about 100 days, that is, 12–16 days earlier than Portage, the earliest cultivar presently licensed. The line is insensitive to the long days of northern regions and its reproductive development is unaffected by night temperatures as low as 10°C. The line offers the potential for soybean production in areas with as few as 2000 heat units.

Two dominant genes have been identified which permit normal flower and seed development at night temperatures as low as 10–12°C. These genes are most common in soybean strains developed in Sweden and have been transferred to a number of promising Ottawa lines such as BD21117.

The inheritance of insensitivity to long days is being studied but the exact method of inheritance has not been established. Insensitivity is being transferred by backcrossing to the cultivars Harosoy 63, Maple Arrow, and Evans. The fourth backcross to Harosoy 63 has been completed.

Strains which carry the lowest pods higher off the ground than existing cultivars have been identified. High podded F₂ plants were selected in 1978 from progeny of the second backcross to Maple Arrow and BD21117. Small-seeded lines for the Japanese natto market have been developed and tested. They have adequate maturity and seed size (less than 6 mm diameter) but yields are 75–85% of comparable check cultivars.

Agronomy. The new short-season soybean cultivars respond very well to cross-seeded planting patterns. In a preliminary experiment Maple Arrow was seeded in rows 18, 36, 54, 72, and 90 cm apart and overseeded at right angles with rows at the same spacings. Yield responses were regularly better in the overseeded patterns compared to seeding in one direction only. In a pattern of rows 18 cm apart crossed with rows 72 cm apart the yield increase was 30% compared to the yield of rows 18 cm apart not overseeded.

Pathology

Over two consecutive years, susceptible alfalfa cultivars suffered 60% yield and 36% stand losses, as compared to 27 and 11%, respectively, for cultivars resistant to *Phytophthora* root rot in the field. Most resistant cultivars screened were Agate, Apollo, and WL-318. Plants showing resistance were used for self- and cross-pollination to produce F₁ seeds. These progenies showed satisfactory resistance to *Phytophthora megasperma* Drechs. both in growth chamber and field.

Quantitative chemotaxis of zoospores of *P. megasperma* towards primary roots of alfalfa demonstrated a close relationship between spore accumulation and susceptibility. The accumulated spore layer on roots of the most susceptible cultivar (Saranac) averaged

93.8 μ compared to 14.4 μ on roots of the most resistant cultivar (Agate).

P. megasperma caused 20% preemergence damping-off in susceptible cultivars, and 2% in resistant ones; 87 and 35% postemergence damping-off, respectively. Losses were much reduced when plants were older. The seedling stage of plants is the most critical period for disease development. On a highly susceptible alfalfa cultivar lowest zoospore concentration induced disease slower and less severely; highest zoospore concentration induced disease faster and more severely.

ORNAMENTALS

Floriculture

Investigations on effects of plant growth regulators were continued. Use of a substituted oxathiin for disbudding of chrysanthemums gave positive, but as yet, no commercially applicable results.

Acetylcholine effects on ethylene synthesis and a substituted benzothiadiazole and ethylene effects on plant cell permeability were determined as well as the effect of plant growth regulators on liposome fluidity and permeability. Some factors of flower quality and senescence were determined, i.e. lignin content and synthesis in rose stems, and pyrophosphatases and senescence of roses, carnations, and chrysanthemums.

Growing chrysanthemums at split, low temperature during the dark period showed that a potential saving of energy may be thus obtained without any significant changes in plant and flower quality. Seeds of *Impatiens* germinated best at 25°C, continuous light, and pre-treatment with gibberellin or 15°C temperature. Starburst, a long-day plant, grew more compact and flowered best at 15°C. Liquid suspension cultures of *Lilium* were established, *Begonia* peduncles and *Impatiens* leaf segments were used to produce callus, roots or buds.

Pest control

An integrated program to control greenhouse whitefly on poinsettia was developed by selecting plants resistant to the pest using a selective insecticide (Altosid), the parasite *Encarsia formosa*, and trap plants drenched with insecticide Orthene and fungicide Truban, thus reducing the number of blackened

scales (parasitized hosts) to as low as 0.17 per leaf.

An integrated control program for the two-spotted mite of roses was continued. The predacious mite *Phytoseiulus persimilis* could not control the pest mite over a 6-mo period, thus requiring a selective acaricide. Pesticide-resistant aphids, sow bugs, and mildew need to be controlled by methods innocuous to natural enemies.

The efficacy, persistence, and phytotoxicity of six new, experimental pesticides were determined.

Pathology

Work on biological control of soil-borne pathogens continued. Adding *Trichoderma viride* Pers. or a *Streptomyces* sp., or both, to soilless mixtures infected with *Pythium splendens* Braun delayed blackleg in geranium for 22–28 days. Steamed soil with the two organisms added to soilless mixtures protected against the disease directly proportional to quantity of soil added. Large additions of spore-mycelium mixtures of *T. viride* and *Streptomyces* sp. to sterile mixtures infected with *Pythium aphanidermatum* Edsen gave up to 90% control of sudden wilting in poinsettia. This protection was greatest at pH of 7.0.

Some fungicides for control of damping-off in bedding plants were phytotoxic in several soilless growing mixtures. Dexon and Terrachlor alone or combined reduced germination of geranium seeds in soilless, but not in soil sand peat mixtures. Truban was toxic to petunia, *Impatiens*, and salvia in soilless mixtures; it and Benomyl were less toxic to geranium. *Rosa rugosa* Thunb. hybrid 'Martin Frobisher', considered resistant to black-spot (*Diplocarpon rosae* Wolf.), was severely infected in 1977. The fungus was a new race capable of infecting *R. rugosa*, but not the common garden rose cultivars. The race isolated from garden rose at Ottawa was not pathogenic on *R. rugosa*. A race, severely infecting *R. rugosa* and garden rose, was isolated from *R. carolina* L. *Pythium aphanidermatum* Edsen caused a sudden wilting of poinsettia plants from California, the first report of the fungus on this host. *Phialophora cinerescens* Wollenw. causing a serious disease in carnation was isolated for the first time in Canada from plants in a greenhouse near Milton, Ont. Turfgrass from several locations in eastern Ontario and western

Quebec was found infected with *Cochliobolus sativus* (Ito & Kurib.) Drechsl. *Pythium aphanidermatum* Edsen and *Curvularia lunata* (Wakker) Boed. were found on turfgrass.

Plant breeding

Rosa, one *rugosa* and one *kordesii* hybrid, and four *rugosa* × *chinensis* hybrids as genetic stock have been released. Hardy, everblooming climbers and hardy, yellow roses are under development. The flowering characteristics of winterhardy roses were elucidated. *Philadelphus*, two cvs. Snowbelle and Buckley's Quill were released. *Weigela*, two hardy, low attractive, freely flowering seedlings are tested. Long flowering seedlings with free bloom and attractive flowers and shrubs were obtained. Plants with purple or variegated leaves are being selected. Improvements in bud hardiness and length of flowering of *Forsythia* are being made.

Arboretum and plant evaluation

Plants were maintained and improved by additions of rhododendron and other plant material. Annual plant testing was continued evaluating cvs. of: Tagetes, Impatiens, Petunia, Begonia, Salvia, Coleus, Celosia, Verbena, Cosmos, Lobelia, Nicotiana, Phlox, and other species and cvs. from 62 different genera.

Turfgrass

Poa annua L., often the major, invasive species of golf greens, was collected across Canada. About half of the plants, the best being from Ottawa area, were perennial or semiperennial types with good growth spread. Seed from some 20 clones produced plants similar to previous generations in growth habit, but varying with environment and time in leaf width and length, stem length, and buds per stem. Some lines had fair heat tolerance, comparable to perennial ryegrass and bentgrass, and good growth of roots. Several *Poa* and bentgrass lines showed resistance to *Helminthosporium sativum*.

Testing of new turfgrass cvs. to establish performance ratings are required for licensing. An appraisal scheme was prepared and accepted and a summary of results circulated to the seed trade. Bluegrass cvs. Majestic, Bristol, Touchdown, and Nugget; fescue cv. Polar, and PP15E and ryegrass cvs. Derby,

Manhattan, and Citation were best introductions.

A method to grow sod in soilless culture producing four crops per season was developed.

PLANT GENE RESOURCES

Plant gene information

Descriptions for over 2100 stocks of barley, tomato, alfalfa, wheat, and oats have been obtained to date by the Plant Gene Resources Office. Computer information banks have been created for each of the first three crops and a query service to locate stocks or cultivars with certain specific traits or a combination of traits is available to breeders and other plant workers.

Conservation

The Plant Gene Resources Office is participating in the program of the International Board for Plant Genetic Resources to organize an international network of base collection centers for cooperative genetic preservation. Under this program it is responsible for the preservation of international base collections of *Pennisetum* millets and oats. The Plant Gene Resources Office has 91 m³ of seed storage space at present: 27 with temperature (+4°C) and humidity (20% RH) control; and 64 with temperature (-20°C) control only and where seed is preserved in sealed containers. Seed of over 30 000 stocks is preserved in these facilities.

Exchanges

Activities of the Plant Gene Resources Office in connection with exchange of genetic stocks and cultivars in 1976-1978 involved 951 such exchanges with individuals in at least 50 countries for a total of over 35 000 accessions.

Newsletter

The PGRC Newsletter started in 1976 is issued semiannually and it has a mailing list of 500 individuals in Canada and 115 in 25 foreign countries. It reports informally on activities and programs in Canada and elsewhere in connection with plant gene resources.

EXPERIMENTAL FARM, KAPUSKASING, ONT.

Forage management

In 1975, a legume management trial was established by using Iroquois alfalfa and Leo birdsfoot trefoil and in 1976 treatments were initiated. Plots of both species were randomly cut at the early flower and at the pod setting stages. Other plots were harvested at the second and last cycle from August 10 to September 28 at weekly intervals. First-cut dry matter yields of birdsfoot trefoil were 2647, 1909, and 3492 kg/ha when the previous year's second and final cut was harvested on August 10, August 24, and August 28, respectively. Dry matter yields of alfalfa on the first cut averaged 3213 kg/ha when the previous year's second cut was taken in August and increased to 3500 kg/ha when the second cut was taken in late September. After 3 yr of data under the growing conditions of the Clay Belt, Iroquois alfalfa yielded about 1000 kg/ha more than Leo birdsfoot trefoil in the first 2 yr of production, but in the third harvest year, both species yielded similarly for the entire growing season.

Cereal management

Keystone barley, Garry and Hinoat oats, and Century peas were sown alone and in mixtures for three consecutive years to determine the best yielding formula for grain and protein per hectare. A 3-yr average grain yield of 4718 kg/ha was achieved with a pure seeding of Keystone barley followed very closely at 4528 kg/ha by a 50/50 mixture of Keystone barley and Century peas. The next five best yielding mixtures all contained between 50 and 33% Keystone barley. At the bottom of the list for grain yield was Century peas at 2749 kg/ha. A seeding of 50/50 Keystone barley and Century peas produced a grain mixture of 90% barley and only 10% peas whereas a seeding of 50% Keystone barley and 50% either Garry or Hinoat oats yielded a mixture with 65% barley and 35% oats. A grain yield mixture of about 85% oats and 15% peas was obtained with a 50/50 seeding. A three-way equal seeding of Keystone barley, Garry oats, and Century peas yielded 56% barley, 35% oats, and only 9% peas. If Hinoat oats was substituted for Garry in the three-way mixture of barley, oats, and peas, the amount

of barley in the mixture produced increased from 56% to over 62% with only 25% oats and a little more than 12% peas. Century peas yielded 26.1% crude protein followed by a 50/50 mixture of peas and Hinoats at 18.6% and a pure seeding of Hinoats at 16.6%. Total crude protein production was highest at 717 kg/ha with a pure seeding of Century peas followed by a mixture of 50% barley and 50% peas at 648 kg/ha.

EXPERIMENTAL FARM, THUNDER BAY, ONT.

Crop management

Productivity of alfalfa and birdsfoot trefoil managed under two- and three-cut harvest systems. Pure stands of alfalfa and birdsfoot trefoil adequately fertilized with P and K in the early spring and fall differed significantly in total seasonal dry matter production as between species and frequency of clipping. On coarse-textured soils, alfalfa compared favorably with birdsfoot trefoil in seasonal productivity when managed under a three-cut system in which clippings were harvested on June 24, July 2, September 7. In this instance alfalfa (dry matter basis) averaged 10 292 kg/ha, compared to 10 343 kg/ha for birdsfoot trefoil over a 2-yr period. Under a two-cut system, in which legumes were harvested on June 24 and again in early August, birdsfoot trefoil produced 33% more dry matter than alfalfa with average yields of 11 722 and 8788 kg/ha, respectively, recorded. While the forage quality of both species improved with more frequent clipping, there was evidence of stand reductions when harvesting was completed throughout the last 2 wk of August and the 1st wk of September. In this study, birdsfoot trefoil was particularly susceptible to removal of top growth in late August and early September, the critical fall harvest period.

Species for early and late pasture. Reed canarygrass and brome grown in pure stand and fertilized with N at (168 kg/ha as a split application), stockpiled 25% more forage by the end of May than simple mixtures of the same species with birdsfoot trefoil. By contrast, tall fescue failed to exhibit satisfactory potential as an early- or late-producing species, ranking inferior to other grasses with and without birdsfoot trefoil on all cutting dates. Pure stand seedings of birdsfoot trefoil

excelled in dry matter production by mid-July, surpassing mixtures in which it was used with the three grass species. By midseason birdsfoot trefoil had produced 76% of its total seasonal production. Prior to the first fall frost in mid-September simple pasture mixtures containing birdsfoot trefoil with brome or reed canarygrass, or brome and reed canarygrass sown in pure stand, exhibited excellent potential on coarse-textured soils of northwest Ontario. Acceptable yield performance of all grasses requires adequate N fertilization in conjunction with P and K. The use of N increased yields on an average of 280% by May 27, 149% at second clipping on July 14, and 191% on final harvest on September 8. Over a 2-yr period nitrogen increased forage yields on an average of 189% over all harvest dates.

Prillcoated legume seed. A comparison of alfalfa and birdsfoot trefoil forage stands produced from the use of coated and non-coated seed, with and without fresh inoculant, has shown there is no yield advantage to be derived from the seeding of prillcoated seed on soils favorable to the production of such crops. Over the past 2-yr period, legumes grown from noncoated seed treated with inoculant produced superior plant stands with an average dry matter yield over all treatments of 6959 kg/ha. Prillcoated seed treated with fresh inoculant produced 1st-yr stands averaging 6435 kg/ha compared to 5926 kg/ha where noninoculated coated seed was used. Irrespective of seed treatment, Leo trefoil produced significantly higher yields over W.L. 215 alfalfa.

Sixty isolates of *P. megasperma* were isolated from Ontario and Quebec and were classified: (1) small spored form, (2) large spored form, (3) large spored form having a limited fruiting capacity, producing oogonia in the presence of other *Phytophthora* species.

Introductions

Promising introductions identified in the period 1976-1978 included: a very vigorous *Lotus uliginosus* from the USSR which was more productive than Empire, a *Medicago sativa* from the Netherlands which had superior resistance to the alfalfa leaf miner, and a *Sylphium perfoliatum* which is comparable to alfalfa in protein production and is extremely persistent. About 115 alfalfa plants collected from old fields in eastern Ontario were crossed to Iroquois and Thor. The F₁

hybrids were tested at four locations including Ottawa and visual estimates of yield were taken by two observers at each location. At the same four locations 26 synthetics resulting from allele selections are now being tested.

Seed of a strain of cicer milkvetch, *Astragalus cicer*, and of tetraploid red clover, *Trifolium pratense*, have been further increased during the period 1976-1978 to provide adequate amounts of breeder seed should licensing occur.

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INTRODUCTION

Effective pest management programs have been developed for apple and peach, and many Ontario growers are using these programs. Similar work is progressing favorably for pears and also for carrots. During the last 2 yr the apple leafminer has developed to a level of economic importance. Means of determining its presence and providing effective control have been developed.

Tomato ringspot virus continued to be a problem on Seibel grapes. Studies have shown that the nematode vector cannot be eliminated by fumigation of grape soils and that other means of disease control are essential.

A model, which uses early season weather data, was developed that predicts severity of virus disease in the pepper crop at harvest time. The warning is sufficiently early that the grower can decide whether or not to grow peppers.

X-Disease has been a continuing problem in peach orchards. Small amounts (< 1 g) of oxytetracycline per diseased tree, injected after harvest, are sufficient to return the tree to full productivity for at least 1 yr. A practical technique for treating the trees was also established.

A mechanical harvester for peach and apple was developed under contract. With proper tree conformation and orchard design it offers a practical and economic means of harvesting these crops.

Two apple cultivars, Sandel and Moira, were released by the Smithfield Experimental Farm (S.E.F.). The latter is resistant to apple scab. Rootstock tests showed that O-8 has dwarfing characteristics similar to MM-106 but that it has greater winterhardiness. S.E.F. also released Earlrouge, a high-yielding fresh-market tomato cultivar.

For more information on our research projects or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0.

A. J. McGinnis
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PESTICIDES

Application

Evaluation of sprayer coverage. Apple trees (cv. McIntosh) 4.6 m high were sprayed with the experimental sprayer at four volume median diameters (VMD) and four rates per hectare using a fluorescent dye tracer. Visual coverage rating increased with application rate but decreased with increasing VMD. The coefficients of variability of coverage were constant (40%) for all VMD's and for the rates 440, 880, and 1350 L/ha, but was higher (54%) for the 225 L/ha application rate. The percentage of undersprayed samples reached a minimum of about 20% at approximately 200 μ m VMD and 450 L/ha. Newly hatched larvae of oriental fruit moth were exposed to phosmet residual deposits produced by different numbers and sizes of droplets of WP suspensions. Mortalities were recorded 20 h after 3-, 5-, and 8-min exposures. For any area covered, small droplets gave higher kill than large droplets with

active ingredient at 4 g/L. For 70% control, coverage must exceed 4% of foliage surface with active ingredient at 4 g/L and 15% with active ingredient at 1 g/L.

Development of an air cushion spray boom. A contract was established to assess the potential of a novel sprayer system. The boom was used in Ontario on several row crops as well as oats and peanuts, and the pesticide residues were analyzed. In the west, the boom's performance at standard and high speeds was assessed on the basis of deposit uniformity and drift. Its performance was sufficiently encouraging that further development and preliminary commercial production is being funded.

Chemistry

Persistence of permethrin on fruit foliage. Dissipation of permethrin from peach leaves, though applied at a low rate, was significantly slower than that of phosmet or azinphosmethyl. The isomers (*cis* and *trans*)

of permethrin, determined by gas chromatography, dissipated at almost identical rates, and dissipation of deposits on apple and pear leaves was almost identical with that obtained with peach leaves.

Preventing pesticide hydrolysis in the spray tank. Many O-P and carbamate pesticides decompose after prolonged exposure to alkaline conditions in the spray tank. A simple and practical method of protecting the pesticides from hydrolysis during spray applications has been established. Either $\text{NH}_4\text{H}_2\text{PO}_4$ or KH_2PO_4 added to natural alkaline waters at 0.5 g/L will stabilize the pH of the water at 6.7 ± 0.3 regardless of original pH. The pH of waters tested in the Holland Marsh and Niagara Peninsula ranged from 7.6 to 9.7.

INSECTS AND MITES

Pest management

Pest management in apple orchards. In 1977 seasonal pest control was obtained in an experimental apple orchard under a pest management program with four insecticide, two miticide, and four fungicide sprays. At harvest, total fruit damage due to all pests was less than 1%. In an experimental apple orchard in 1978 three insecticide sprays (phosmet 50% WP at 2.3 kg/ha) on June 6 and Aug. 3 and Ambush 25% WP (Chipman) (0.63 kg/ha) on July 4 gave excellent control of all pests. The European red mite was controlled with one plictran (1.1 kg/ha) spray on June 6. A prebloom application of Difolatan 4.8F (Chevron) (22.5 L/ha) followed by Cyprex 65% WP (0.34 kg/ha) on July 4 and Polyram 80W (8.4 kg/ha) on Aug. 3 gave good control of apple scab at harvest (0.6% injury).

Pest management in pear orchards. Preliminary studies showed that one application of Ambush 25% WP (0.4 kg/ha) at petal fall gave good pear psylla control in 1977 but was not as effective in 1978. In both years two sprays of azinphosmethyl 2E (2.2 L/ha), one at petal fall and another in late June, were required to give similar control. In 1977 the numbers of predators, particularly the anthocorids, increased after application of the insecticides to levels that appeared to regulate the psylla population. In 1978 predators increased in numbers very late in

the season and were not as effective in regulating psylla numbers.

Pest management in peach orchards. During the years 1976, 1977, and 1978 the dates of any individual spray application varied by as much as 3 wk. Numbers of oriental fruit moth were progressively higher from 1976 to 1978. Excellent control was achieved in 1976 and 1977 but in 1978 some difficulties were encountered in the late season varieties. These areas may require additional monitoring to make adjustments in timing of sprays. In 1977 the program was extended into the Fonthill and Essex-Kent areas of Ontario. Control, achieved by using the management program, was excellent in both areas in 1977 and 1978.

Carrot rust fly control. In both 1977 and 1978 the carrot rust fly was monitored in the Holland Marsh. Adult activity was measured by placing adhesive traps in sheltered sites, heavily infested areas, and on various commercial farms about the marsh. This procedure has permitted extension personnel to advise more accurately when sprays should be applied to control second-generation flies and to recommend with confidence fewer sprays in characteristic low-risk areas. Individually monitored farms have often required zero, one, or two sprays, whereas five to seven would normally be applied in the high-risk areas.

Ecology

Development of Lithocolletis blancardella (Fab.) and Apanteles ornigis (Weed). Under constant laboratory conditions, temperature thresholds for development of overwintering pupae were estimated for *L. blancardella* and for its parasite *A. ornigis*. Degree-day accumulations in the field were calculated by using daily maximum and minimum temperatures recorded from either the pupal habitat or a Stevenson Screen. Degree-days in the pupal habitat accumulated from January 1 above 5.7°C for *L. blancardella* and above 11.3°C for *A. ornigis* were more accurate than Stevenson Screen degree-day accumulations for predicting first emergence. After emergence, however, seasonal development was best related to Stevenson Screen degree-days accumulated from April 1 above 6.7°C for *L. blancardella* and above 10.4°C for *A. ornigis*.

Simulation model of European red mite. A simulation model was described for the population dynamics of the European red mite, *Panonychus ulmi* (Koch). The model depends upon the following relationships: (a) development rate is dependent on effective daily temperature; (b) each population component can be divided into distinct daily age classes; (c) movement of individuals from each population component to the next depends on a log-normal probability distribution, which in turn is related to effective temperature. Predictions made for 1976, 1977, and 1978 adequately described actual population curves as determined from daily orchard sampling.

Chemical control

Evaluation of new acaricides and insecticides. The newer acaricides Fusilade (fentri-fanil) (Chipman), malonoben (GCP5126) (Gulf), XE333 (Chevron), CM12301 (Celamerck GmbH), and DPX3792 (Dupont) compared favorably in both laboratory and field tests with the organotin compounds Plictran and Vendex. There were, however, indications of cross-resistance from dicofol to XE333 in a dicofol-resistant laboratory strain. The compounds XE333, CM12301, and DPX3792 showed low toxicity to a laboratory strain of *Amblyseius fallacis* (Garnan) and to the Stigmaeid, *Zetzellia mali* (Ewing). The compounds Lannate (methomyl), Vydate (oxamyl), Zardex (Zoecon Co.), and Zolone (phosalone) were highly toxic to *A. fallacis*. The pyrethroid Ambush was highly toxic to *A. fallacis*, and more toxic than phosmet, azinphosmethyl, or Zolone to the erythraeid mite *Balaustium putmani* Smiley.

Tentiform leafminer adults from five orchards in various apple-growing areas across southern Ontario were found highly resistant (ca. 100-fold resistance) to most organophosphorous insecticides. All strains were highly susceptible to the synthetic pyrethroid permethrin.

NEMATODES

Host-parasite relationships

Infectivity of Pratylenchus penetrans on Du Puits alfalfa. The dense root-hair zone of alfalfa roots was preferred for penetration by females, males, and third-stage larvae. A lesion initially appeared water-soaked,

became yellow and elliptical as the nematode entered the cortex, and dark brown cells later appeared centrally as the nematode fed. At 20°C females entered roots earlier, faster, and in greater numbers than did males or larvae. Females entered roots at temperatures from 5 to 35°C with maximum entry between 10 and 30°C; males and larvae entered roots only between 10 and 30°C with maximum entry at 20°C.

Pathotypes of Pratylenchus penetrans. Variant females of *P. penetrans* had either a smooth or crenate tail terminus. Single crenate-tailed females on pea seedlings suppressed growth. Similarly four crenate-tailed females per seedling of radish and onion inhibited growth. Only crenate-tailed females reproduced and only on radish and pea; both variants were equally infective on the three crops.

Nematode injury to potential crops for southwestern Ontario. Initial densities of 1.8, 2.6, 3.7, 5.1, and 14.7 *P. penetrans* per gram of soil caused no difference in growth of nine crop cultivars. The nematode reproduced well on dormoats and two corn and sorghum cultivars, poorly on two millet cultivars, and very poorly on Valencia and Spanish peanuts. The same cultivars were subjected to *Meloidogyne hapla* at a population density of three larvae per gram of soil. Valencia peanuts, Spanish peanuts, lupine, and mint were good hosts; both chickory and mung beans were poor hosts; and Jerusalem artichoke was a nonhost.

Saprophagous nematodes in mushroom production. Mushroom yields in an experimental mushroom house were not consistently reduced by high densities of saprophagous nematodes. A positive correlation between nematode population at the time of casing and mushroom yield during the primary flushes was noted in some experiments. In others, high nematode populations at the end of the crop were correlated with reduced yields.

Control

Fumigation for control of dagger nematodes in grape soils. Loam and clay loam grape soils, fumigated with Vorlex (Morton; 80% 1,3-dichloropropene) applied broadcast 20–25 cm deep at 112 and 224 L/ha and planted with healthy grapevines continued to harbor dagger nematodes. In the loam soil,

dagger nematodes were undetectable at planting, present in low numbers by late summer, and only increased slightly over the next two seasons. In the other soil, nematode numbers were reduced to one-tenth of the control at planting, declined further by late summer, but recovered over two subsequent seasons to the initial numbers. Nematodes were found at all depths with sampling down to 90 cm. The results indicate that the nematode cannot be eradicated by conventional soil fumigation and that some other means of controlling spread of the virus is essential.

Chemical control of Pratylenchus penetrans on fruit tree understocks. Oxamyl (foliar spray with active ingredient at 1.12 kg/450 L water per hectare), aldicarb (granular, with active ingredient at 6.7 kg/ha), and carbofuran (granular, with active ingredient at 6.7 kg/ha) were used safely and reduced nematode numbers in roots of apple, apricot, cherry, peach, pear, and plum understocks. The systemic chemicals aldicarb and oxamyl also provided good control of aphids and mites. Pear was the best nematode host. Apple, apricot, cherry, plum, and one peach cultivar (Rutgers Redleaf) were poor hosts.

PLANT DISEASES

Fruit crops

Virus diseases of grapes. Peach rosette mosaic virus (PRMV), responsible for the rosette mosaic disease in peaches and the "decline" of Concord grapes, consists of two nucleoprotein components. The virus contains two RNA species with molecular weights of 2.5×10^6 and 2.2×10^6 daltons. Both RNA's are needed for infection thus indicating that PRMV has a genome divided between two RNA species.

The grape Joannes-Seyve virus infected 24 out of 40 grape cultivars and rootstocks tested for susceptibility by grafting inoculation. Most of the rootstocks (7/9), Labrusca-type cultivars (10/16), and French hybrids (6/10) were susceptible to the virus. In contrast, most of the *Vitis vinifera* cultivars were resistant.

Control of peach X-disease. Remission of X-disease symptoms and restoration of fruiting occurred in Redhaven and Loring peach trees after postharvest treatment with 100–2400 mg of oxytetracycline-HCl per tree.

Extent of symptom remission in trees was similar at all dosages. The percentage of symptomless trees in the 1st, 2nd, and 3rd yr after a single treatment at different dosages ranged from 60–100%, 20–100%, and 0–33%, respectively. Oxytetracycline was not detected in fruit and no phytotoxicity was evident.

Infection relative to apple scab spore density. Inoculation of apple foliage with *Venturia inaequalis* using 10, 100, 1000, and 10 000 conidia per square centimetre gave respectively 8, 25, 53, and 61% leaf surface infection. A therapeutic treatment with fenarimol reduced the infected areas to respectively 0, 0, 3, and 17%, demonstrating reduced efficacy at the high inoculum levels. Similarly, the inoculation of Montmorency tart cherries with *Monilinia fructicola* using 1500, 15 000, and 150 000 conidia per square centimetre gave respectively 55, 90, and 97% infection. Prophylactic surface deposits of captan necessary to reduce infection by 50% (ED50) were 0.03, 0.07, and $0.43 \mu\text{g}/\text{cm}^2$. In contrast, the ED50 values for benomyl and procymidone were not affected by inoculum density. These results assist in explaining the apparent failure of fungicides under severe epiphytotic conditions.

Vegetable crops

Virus diseases in peppers. Organic mulches such as straw, sawdust, wood chips, and corncobs reduced the incidence of aphid-transmitted virus disease in pepper plants relative to peppers in bare soil. Straw, the most effective mulch, reduced the virus incidence by 60%. Virus incidence was reduced by 45% with sawdust, by 35% with wood chip, and by only 12% with corncob mulches. Present results suggest that straw and sawdust mulches may offer a practical method of reducing aphid populations and virus incidence in peppers and perhaps in other vegetable crops.

A predictive model that permits advance warning of virus disease incidence in peppers at the end of August was developed for the Niagara Peninsula. The incidence agreed closely with predictions from a simple regression equation based on accumulated degree-days plus bright sunshine hours in April for the period 1970–1977. Risk years for these diseases can be accurately forecast for this region in advance of spring planting. The

model may prove generally applicable in other pepper-growing areas by calculating regression of local virus incidence from regional meteorological records.

Pea root rot. Fusarium solani (Mart.) App. & Wr. f. *pisi* (F.R. Jones) Snyder & Hansen was the organism most commonly associated with pea root in Ontario. *F. oxysporum* Schlecht. f. *pisi* (Linford) Snyder & Hansen, *Pythium* spp., *Rhizoctonia solani* Kuhn, and *Ascochyta pisi* Lib. were also involved but were encountered less frequently. These fungi varied in their virulence to peas (*Pisum sativum* L.): *Pythium* spp. and *R. solani* caused preemergence damping-off, *F. solani* f. *pisi* and *A. pisi* severe root necrosis, and *F. oxysporum* f. *pisi* severe wilting. In the laboratory, root rot incidence was slight on peas grown in a mixture of equal parts of soil from a field showing severe disease and from one with just a trace. Disease suppression was observed only on the first crop of peas.

MECHANIZATION

Contract research

A harvester for peaches and apples for processing. The physical-biological characteristics of several varieties of peaches and apples, as related to mechanical harvesting, were established. The effects of pruning methods, growth regulators, and machine thinning on harvesting efficiency were assessed. Several types of catching surfaces were evaluated, and an air-inflated surface was developed. A modified cherry harvester was used to assess fruit damage levels at several points between the point of detachment and the bin. Based on the results of all tests, a harvester was designed to suit Ontario orchards. Subsequent trials indicate that peaches so harvested, when graded by the processor, were of similar quality to hand-harvested fruit. Limited trials were carried out in apple orchards. This work was done at the University of Guelph.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Vegetables

Tomato breeding. The cultivar Earlirouge was released as a high-yielding fresh-market type with a possible use as a hand-picked

juice processing cultivar. It is as early as New Yorker with 25% larger fruit. Earlirouge contains the *og^c* gene, is free of blotch and yellow top, and has better fruit storage on the vine, foliage cover, and internal structure than other early varieties. This variety in field seeding trials had the highest germination, total yield, and early yield.

Viscosity of tomato juice measured with the Ottawa texture-measuring system (OTMS). The OTMS, fitted with a 11.25 kg strain gauge and a back extrusion cell, is being used to measure tomato juice viscosity. Preliminary work suggests that subtle differences in viscosity can be distinguished and that these are reproducible. Different features of the chart-recorded curve (e.g., initial and peaks, slopes, "chatter" during downstroke) appear to be related to specific viscosity characteristics, such as serum viscosity and pulp particle size.

Fruits

New apple cultivars. Sandel (T-3916) was released in 1978. The fruit is medium to large, oblong conic in shape, slightly to moderately ribbed, with 70% bright lively red overcolor. Flesh is yellow, slightly coarse, crisp, juicy, subacid in flavor, and mildly aromatic. Harvested in mid-October, it stores up to 10 mo. This selection is not scab resistant.

Moira (O-548) is a good quality apple resistant to apple scab. The fruit is medium to large, round to slightly conic, with an 80–90% wash of medium to dark lively red. Flesh is cream, slightly coarse, tender, moderately acid, juicy, with a pleasant flavor. It is harvested in early October and stores well for a period of 4 mo.

O-8, a hardy rootstock in the MM 106 rootstock size range. Under test since 1971 at Ottawa and Smithfield, McIntosh and Quinte on O-8 in 1978 had average trunk circumferences of 40.4 and 40.3 cm, respectively. Comparable values for McIntosh and Quinte on MM 106 were 38.1 and 39.1 cm. Cumulative yield results for McIntosh and Quinte on O-8 were 331.3 and 214.7 kg/tree and on MM 106 were 293.7 and 193.8 kg/tree, respectively. Results indicate that O-8 could be an alternative to MM 106 where winter-hardiness of rootstock is a factor.

Aids in apple juice extraction. Rice hulls, shredded bleached paper, and a processed

wood product (Sylvacel) proved the most satisfactory of several organic and inorganic materials tested. Used in various combinations at rates totaling 2–3%, they increased juice yield on pressing and facilitated the removal of the pressed cake, without downgrading juice flavor. Juice yield could be increased further—up to 80% compared with normal yields of around 70%—using “hot mash” treatment. This involved the addition of commercial enzyme preparations to the crushed apples and holding at slightly elevated temperatures for up to 1 h before pressing.

Effect of apple crop management and storage on juice recovery. Firmness, maturity, and storage of apples were major factors determining juice yield and quality. Orchard management practices (tree-picked vs. wind-falls, treated or not treated with Ethrel, minimal spray and pruning program vs. normal care) influenced juice extraction properties, probably by means of their effect on fruit firmness and maturity. With longer storage time, fruit firmness, juice yield, and acid content decreased while soluble solids and moisture content remained fairly constant. Juice recovery was not closely related to fruit moisture content. At similar fruit firmness values, juice recovery was higher with McIntosh than with Richared Delicious or Northern Spy.

Hedgerow plantings of apple. A sickle-bar mower has been used annually at full bloom since 1975 to maintain row width of McIntosh on seedling and *Malus robusta* 5 rootstocks planted in 1970. The indiscriminant mechanical pruning has increased total yield by not removing as many flower buds as the standard pruning technique. The delayed mechanical pruning reduced the amount of vegetative regrowth and fruit size compared to dormant pruning. Sickle-bar pruning lends itself to a system of harvesting a proportion of well-colored fruit for the fresh market and then shaking the remainder from the center of the tree for juice.

Artificial propagation of parasites. Two developments combine to eliminate needs for host insects in laboratory propagation of *Itopectis conquisitor* (Say): (1) The development of an artificial host—an encapsulated medium for in vitro oviposition, eclosion, and larval development of a parasitoid. The first adult parasitoid so reared was a male. This represents a breakthrough in culturing parasitic insects, though more work is needed to make the technique fruitful. (2) Two concocted artificial diets—one liquid, the other candied—developed to feed adult *I. conquisitor* have allowed equal fecundity to the usual diet, which included primarily exuded host blood. Advantages gained by these developments will include convenience, efficacy, economy of space and materials, and manageability for proper insect husbandry to produce parasitoids of highest quality.

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A. F. FORTIN,¹⁴ B.Sc. (Agr.), Ph.D.

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H. A. ROBERTSON, B.Sc., Ph.D., C. Chem., F.R.I.C.,
F.R.S.E.

N. K. SARKAR, B.Sc., M.Sc., D.Sc.

Program Chairman; Artificial
rearing and sow nutrition

Carcass evaluation

Sow nutrition and reproduction

Female reproductive physiology

Protein synthesis

Poultry Breeding Program

J. S. GAVORA, Ing., C.Sc.	Program Chairman; Genetics of disease resistance
J. R. CHAMBERS, ¹⁶ B.Sc., M.Sc., Ph.D.	Quantitative genetics, meat production
R. W. FAIRFUL, ¹⁷ B.Sc., M.Sc., Ph.D.	Quantitative genetics, egg production
R. S. GOWE, B.S.A., M.S., Ph.D.	Quantitative genetics, egg production
A. A. GRUNDER, ¹⁸ B.S.A., M.Sc., Ph.D.	Biochemical genetics
K. G. HOLLANDS, B.A., B.S.A., M.S.A.	Physiological genetics
C. P. W. TSANG, B.Sc., M.Sc., Ph.D.	Metabolism and assay of hormones

Poultry Nutrition Program

I. R. SIBBALD, B.Sc. (Agr.), M.Sc., Ph.D.	Program Chairman; Avian energetics and feedingstuff evaluation
N. A. G. CAVE, B.Sc., M.Sc., Ph.D.	Amino acids and proteins, broiler breeder nutrition and management
J. D. CIPERA, Ing., M.S.A., Ph.D.	Biochemistry of egg shell formation
R. M. G. HAMILTON, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition and physiology, egg shell quality

Pesticide Residues Program

T. S. FOSTER, B.Sc., M.Sc., Ph.D.	Program Chairman; Pesticide metabolism and residues
M. H. AKHTAR, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues

Waste Utilization Program

N. K. PATNI, B.Ch.E., M.Sc., Ph.D.	Program Chairman; Livestock waste utilization and farm pollution abatement
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Departures

A. J. DAGENAIS, ¹⁹ C.P.A. Transferred to Research Station, Lacombe, Alta., November 1978	Administrative Officer, Personnel
J. A. B. EMSLEY, B.Sc., Ph.D. Resigned October 1978	Quantitative genetics, economic traits in poultry
B. J. FERGUSON, B.A. Transferred to Finance and Administration Branch, July 1977	Administrative Officer, Personnel

C. G. HICKMAN, ²⁰ B.S.A., M.S., Ph.D. On leave at Animal Production and Health Division, FAO, Rome, Italy, December 1977	Dairy cattle breeding
S. K. HO, B.Sc., Ph.D. Transferred to Plant Products Division, Food Production and Marketing Branch, March 1978	Availability of chelated trace minerals
H. W. HULAN, B.Sc., M.Sc., Ph.D. Transferred to Research Station, Kentville, N.S., June 1977	Lipid nutrition and metabolism
W. G. HUNSAKER, B.S.A., M.S.A., Ph.D. Retired December 1978	Environmental and behavioral physiology, chronobiology
G. P. KAVANAGH Retired December 1978	Computer systems and programming
E. E. LISTER, B.Sc., M.Sc., Ph.D. Transferred to Central Region, Research Branch, March 1978	Deputy Director
G. A. LODGE, B.Sc., Ph.D. Resigned August 1978	Swine muscle development, energy and protein metabolism
G. B. MATTHEWS Transferred to Central Region, Research Branch, February 1978	Chief, Administration and Resources
H. F. PETERS, B.S.A., M.S., Ph.D. Retired June 1977	Sheep breeding and management
D. B. SNYDER, B.Sc. Resigned September 1977	A/Resources Advisor
J. F. STANDISH, B.Sc., M.Sc., Ph.D. Transferred to Plant Products Division, Food Production and Marketing Branch, September 1977	Dairy cattle nutrition, forages and mineral requirements
F. A. VANDENHEUVAL, B.Sc., M.Sc., Ph.D., D.I.C., F.C.I.C. Retired December 1977	Identification and assay of steroid hormones
D. S. WALSH, B.A. Retired December 1977	Dairy cattle nutrition, hormones of energy metabolism

VISITING SCIENTISTS

I. GRANCIU, Ing., Ph.D. Res. Inst. Cattle Breeding, Ilfov, Romania	Dairy cattle breeding and quantitative genetics
D. M. PEDROSO, Lic. Chem. Nat. Cent. Sci. Res., Havana, Cuba	Lipid metabolism and analysis
G. SALYI, D.V.M. Cent. Vet. Inst., Budapest, Hungary	Trace mineral nutrition and toxicology
C. P. SEET, B.Sc., M.Sc. Malaysian Agr. Res. and Develop. Inst., Serdang, Malaysia	Poultry breeding and selection

National Research Council postdoctorate fellows

R. J. DWYER, B.Sc., M.Sc., Ph.D.

1977-79

Hormone production by the
embryo

R. J. BOILA, B.S.A., M.Sc., Ph.D.

1978-79

Nonprotein nitrogen sources and
ruminant function

Graduate students

J. A. CARNEGIE, B.Sc., M.Sc.

Reproductive physiology

D. V. GILL, B.Sc.

Reproductive physiology

¹Appointed August 1978.

²Appointed September 1978.

³Seconded from Data Processing Division, Finance and Administration Branch.

⁴Seconded from Libraries Division, Finance and Administration Branch.

⁵Appointed February 1977.

⁶Appointed August 1978.

⁷Appointed September 1977.

⁸Appointed December 1977.

⁹Appointed December 1977.

¹⁰Appointed July 1978.

¹¹Appointed July 1977, seconded to Experimental Farm, Kapuskasing, Ont.

¹²Appointed November 1978.

¹³Appointed June 1978.

¹⁴Appointed May 1977.

¹⁵On transfer of work at Department of Animal Production, Edinburgh School of Agriculture, Edinburgh, Scotland, September 1977 to September 1978.

¹⁶Appointed December 1977.

¹⁷Appointed December 1978.

¹⁸On transfer of work at Department of Poultry Science, Pennsylvania State University, University Park, Pennsylvania, August 1977 to August 1978.

¹⁹Appointed December 1977.

²⁰On transfer of work at Département de génétique animale, Centre national de recherches zootechniques, Jouy-en-Josas, France, September 1976 to September 1977.

INTRODUCTION

The Animal Research Institute makes a major contribution to the dairy cattle, sheep, swine, and poultry research objectives of the Research Branch, Agriculture Canada. It also contributes to the oilseed crops and environment quality programs. The Institute is the main Canadian center for breeding research with dairy cattle, sheep, and poultry and it has major research programs in dairy cattle and swine nutrition, trace mineral and beef nutrition, rapeseed oil nutrition, pesticide residues, and animal waste management and utilization.

The Institute research program teams are composed of scientists with a broad range of scientific disciplines.

In 1978, the program structure was slightly modified to strengthen the multidisciplinary nature. To expand the emphasis on livestock reproductive productivity in the dairy cattle, sheep, swine, and poultry programs, scientists of the Reproductive Physiology Program were formally assigned to the Swine Production, Dairy Cattle Breeding and Production, Sheep Production, and Poultry Breeding programs. This new arrangement recognizes their significant contribution to these programs. The Reproductive Physiology Program as a separate program was disbanded and research results from this program are now reported under the various species programs. The large component of common research direction of both the Beef Cattle Nutrition and the Trace Mineral Nutrition programs led to their amalgamation. The new Trace Mineral and Beef Cattle Nutrition Program will expand applied research in these two areas.

The addition of staff in the areas of rumen microbiology, meat quality, meat bird genetics, and male reproductive physiology has permitted research in these fields to be initiated or diversified. The health of Institute flocks and herds is now being closely monitored by the staff veterinarian, resulting in more accurate research data.

The terms of reference of the Rapeseed Oil Nutrition Program have been broadened to include the field of agricultural toxicants, and particularly mycotoxins in feedstuffs and animal tissues.

The development of specialized facilities for animal research continued at the Institute's Greenbelt Farm. A building was completed for housing a large minimal-disease swine herd for the Swine Production Program. The facility will allow research on all ages of animals under one roof. It is ventilated with filtered air under positive pressure (FAPP); manure from growing and adult animals is processed in oxidation ditches. The construction of a small animals building allows studies using laboratory animals as the experimental model for a number of research programs. Construction is now well underway for an isolation barn and a research feed mill. The former will allow physical separation for any livestock requiring special health treatment or short-term isolation from the main animal population. The feed mill will fill a major need in permitting the accurate preparation of both large and small volumes of various research diets. In 1978, planning proceeded on the office/laboratory building for the Institute's scientific, technical, and administrative staff. Architectural drawings and specifications are almost completed for this project.

This report records only the highlights of our accomplishments for 1977 and 1978; more detailed information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available on request from the Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

RAPESEED OIL NUTRITION PROGRAM

Studies with swine and poultry

The results of three separate feeding experiments using 318 Yorkshire boars and 186 gilts have shown that rapeseed oil included in their diets at 20% by weight does not show any deleterious effects. Boars fed diets containing corn oil or soybean oil gave similar growth performance and incidence of myocardial necrosis as those fed diets containing rapeseed oil, irrespective of the erucic acid (22:1) level (1–24%). Contrary to results using male rats, rapeseed oil did not significantly increase the incidence of myocardial lesions in boars.

The cardiac lipids of boars fed either corn oil or rapeseed oil with 23% 22:1 were analyzed. Compared to the rat, much less 22:1 was incorporated into the heart and liver lipids. Small differences were observed in two major cardiac phospholipids between boars fed corn and rapeseed oil. Erucic acid was found to be highest in the ethanolamine phosphoglycerides, in particular the alkenyl acyl-phosphoglyceride.

Significant changes were also observed in the hearts of chicks fed rapeseed oils. There was evidence of severe lipid and 22:1 accumulation when diets were rich in 22:1. The pathological results, however, showed no evidence of myocardial lesions specific to feeding rapeseed oil.

Studies with rats

Several new varieties of low erucic acid rapeseed (LEAR) oils were tested and found to give a significantly higher incidence of heart lesions in male Sprague-Dawley rats than those fed other vegetable oils. Female rats of the same strain were much less affected and did not show a difference in lesion incidence between oils. There was evidence of strain differences. The Sprague-Dawley rat is very susceptible to the formation of heart lesions, unlike the Chester Beatty rat, which was observed to have a low incidence of heart lesions and showed no specific response to rapeseed oils irrespective of the level of 22:1. Increasing the level of fat in the diet of the Sprague-Dawley rat significantly increased the incidence of heart lesions. There was no evidence to indicate that rats fed LEAR oils showed alterations in the

electrocardiogram that could be correlated to myocardial lesions.

A study was completed to determine whether cardiopathogenic agents could be removed from rapeseed oil and soybean oil by purifying the triglycerides using molecular distillation and adsorption chromatography. The pathological results provide no evidence that molecular distillation alone or a combination of both methods removes cardiopathogenic compound(s) from either oil. The feeding trial and pathological examination were carried out at each of two independent locations, and no significant differences were observed between the results of the two establishments.

A statistical analysis was carried out on published results of 23 experiments involving over 2200 male rats at four independent laboratories. The results suggest that the observed incidence of heart lesions was correlated to several dietary fatty acids. The following fatty acids were negatively correlated to heart lesions: palmitic, stearic, and linoleic. On the other hand, linolenic, oleic, and erucic acids were positively correlated. The saturated fatty acids and linolenic acid, however, accounted for most of the variation. Studies are in progress to provide evidence that a specific balance of dietary fatty acids is the cause of myocardial lesions in the Sprague-Dawley rat.

Research on mycotoxins

In addition to overt cases of fungal poisoning, scientific evidence is accumulating that many less dramatic effects should also be of concern, such as, the potential human health hazard of mycotoxins in the food system and the decrease in livestock productivity expressed as reduced weight gains, enhanced susceptibility to trauma, and reduced effectiveness of acquired immunity. Several mycotoxins are of particular concern to food regulatory agencies since they are highly toxic or carcinogenic or both.

There is very little information in Canada on the economics of mycotoxicoses and associated problems of animal and human health. Research at the Institute has been initiated with the objective of determining the incidence of mycotoxins in feedstuffs and their effects on Canadian livestock production and meat products. In general, although some methods are available for screening certain mycotoxins in feedstuffs, many of

these methods do not analyze for those mycotoxins typically found in feeds from the colder Canadian climate. In addition, these analytical methods are primarily for use with feedstuffs and not meat products.

Initial studies will develop rapid, sensitive methods of analysis for the mycotoxin, zearalenone, which occurs frequently, particularly in southern Ontario, in feedstuffs, food samples, and animal tissues. In addition, research will determine the factors that affect absorption, distribution, and elimination of zearalenone administered orally to pigs.

DAIRY CATTLE BREEDING AND PRODUCTION PROGRAM

National cooperative dairy cattle breeding project

The pureline foundation phase of this project has been completed and performance results are now available on a wide variety of traits including milk production, growth, reproduction, and survival. The first cycle of the crossbreeding phase will end in April 1979. Most crossbred females are now less than 2 yr of age.

In the project, milk production is recorded weekly for the Holstein-based H line, the Ayrshire-based synthetic A line, and the C line crossbreds of the H and A lines. The foundation purelines differ in average milk yield, with the H line cows producing more than 1000 kg above the average for A line cows but with the A line having higher percentages of butterfat and protein. The number of completed first lactations for crossbred cows is not yet large enough to allow meaningful comparisons, whereas growth, reproduction, survival, and disease data is now available for C line heifers.

For young stock in the crossbreeding phase, preliminary results for body weights from birth through 574 days of age show negligible effects of year and season of birth. Birth weights of H line heifers are 7 kg larger than for A line heifers (40 vs. 33 kg); C line heifers from H line dams are similar in weight to H line heifers while those from A line dams are intermediate between A and H lines. C line daughters of H line dams generally grow at a similar rate to H line heifers. There appears to be a slightly slower growth of C line daughters of A line dams (17 kg less at 462 days), while A line heifers

are lighter throughout the growth period (28 kg less than C line daughters of A line dams at 462 days). Average weights of H and C line heifers at 462 days ranged between 341 and 395 kg across the five cooperating stations while the range for A line heifers was 324 to 337 kg. The similarity of growth rate between C line and H line heifers indicates heterosis for growth and is consistent with published results of other research with both beef and dairy cattle.

Project heifers are bred at first heat after 350 days of age, though prior heats are recorded. In the analysis of heifer reproduction data in the crossbreeding phase, C line heifers sired by H line sires had a significantly earlier age at first heat (321 days) than either the H line heifers (335 days), the C line heifers sired by A line sires (340 days), or the A line heifers (345 days). The breeding groups maintained nearly the same order for average age at first calving (669, 674, 673, and 683 days, respectively). C line daughters of A line sires required the fewest inseminations per conception (1.54) while the C line daughters of H line sires and the A line heifers required the greatest, 1.73 and 1.72, respectively. The H line heifers became pregnant after an average of 1.63 inseminations. The growth pattern of the groups reported for weights through 462 days of age continued to weights at first freshening. Among the groups, the H line and the A line sired C line heifers were the largest (456 and 463 kg), the A line heifers the smallest (394 kg), and the H line sired C line heifers intermediate (426 kg).

Calf and heifer survival are important components of the replacement rate in a dairy population. C line heifer calves had slightly lower mortality from birth to 9 wk than calves of the A or H lines. Early calf mortality accounts for more than half of the losses to 574 days of age. The lower losses for calves and heifers of the C line were maintained through 1 yr of age. The H and C lines were similar for total losses to 574 days with both being less than the A line.

Field test of Finnish Ayrshires

Proven Finnish and Canadian Ayrshire bulls were compared to Canadian Ayrshire herds. Macdonald College, the University of Guelph, the Animal Research Institute, and artificial breeding units in Ontario and Quebec cooperated in making test matings in

1972. Meat production was evaluated on a sample of male progeny from matings in Quebec. No significant differences were observed between Canadian and Finnish sires in growth rate, feed efficiency, and carcass quality of their sons. An analysis of conformation data revealed that daughters of Canadian proven bulls generally were superior in type classification to daughters of Finnish Ayrshire sires.

Bull progeny tests in France

Eight Research Branch Holstein bulls are being progeny tested for milk and butterfat production of their daughters and growth performance and carcass quality of their sons in cooperation with the Institut National de la Recherche Agronomique in France. Progeny from matings made from November 1976 to April 1977 were 10–15 mo old as of December 1978. Nearly 60 sons of these bulls and of other Black and White bulls in use in France are to be evaluated for growth and feed efficiency from 5 to 9 mo of age. They will be finished in a feedlot and slaughtered at about 16 mo of age for carcass evaluation. Progeny tests for growth, feed efficiency, and carcass traits of males will be compared among the Research Branch Holstein bulls and the other Black and White bulls involved in the experiment.

Breeding studies using record of production data

Estimates of genetic progress for milk and butterfat production in the Canadian dairy cattle population have been obtained from results of recent dairy sire evaluations. Genetic trends over the period 1958–1975 for milk and butterfat production were 1.32 and 1.62 breed class average (BCA) for the Ayrshire, 1.50 and 0.88 BCA for the Guernsey, 0.72 and 0.80 BCA for the Holstein, and 0.60 and 0.54 BCA for the Jersey, respectively. The results of this study suggest that from 1958 through 1975 the average annual genetic gain in milk production in dairy breeds was less than 1% of the current average yield over the breeds.

Some of the assumptions underlying the current Canadian cow evaluation method are no longer valid because of the increased rate of genetic progress and the existence of substantial genetic differences between herds in the Canadian dairy population. A method has been developed at A.R.I. to circumvent

this problem and to make use of all available pedigree information in the estimation of cow breeding values.

If the mates of dairy sires being progeny tested differ in average genetic merit, it can bias the genetic evaluation of sires. A method has been developed to eliminate this bias by adjusting the first lactation record of each daughter of a sire by the estimated genetic value of her dam.

Pilot genetic studies with mice

In two random-bred populations of mice, selection conducted for 17 generations resulted in lines with characteristic nursing ability or adult weight or both traits. Comparisons of lines within each population revealed that selection for nursing ability improved that trait while selection for adult weight was effective in improving both nursing ability and adult weight, although fertility declined. For the two populations, estimated realized heritabilities were 0.16 ± 0.05 and 0.11 ± 0.06 for nursing ability, 0.40 ± 0.02 and 0.43 ± 0.03 for adult weight, while the realized genetic correlations between nursing ability and adult weight were 0.70 ± 0.07 and 0.73 ± 0.08 , respectively. The genetic correlation was partitioned into direct and maternal genetic covariance components.

Examination of the relationship between preweaning body weight of a cross-fostered litter of standard size and number of young born alive in each line suggests that as the number of young born alive increases, milk production tends to increase. Examination of DNA, RNA, and protein in mammary glands indicated that milk yield was related more to cell number than to cell size of the tissue.

Maternal recognition of pregnancy and hormone synthesis by the conceptus

In a study of maternal recognition of pregnancy, sheep embryos were used. In *in vitro* metabolism experiments, sheep embryos at day 12, 15, and 21 were found to produce prostaglandin $F_{2\alpha}$ from arachidonate. Cultured endometrial cells, obtained from a pregnant uterus at the same stages, produced prostaglandin E_2 compared to the nonpregnant uterus, which does not metabolize arachidonate. This difference constitutes the earliest maternal recognition of pregnancy yet observed.

Studies in vitro on steroid transformation by the early sheep conceptus indicate estrogen synthesis by day 35, but it may begin earlier. Androgen formation appears at least 1 wk earlier. In a related study, evidence has been obtained for *de novo* synthesis of progesterone by the day 21 sheep conceptus.

DAIRY CATTLE NUTRITION PROGRAM

Composition of urea-treated silage

The inclusion of urea in corn silage, at the time of ensiling, has been suggested as an efficient and convenient means of providing nonprotein nitrogen (NPN) for lactating dairy cows. The protein and free amino acid patterns in corn ensiled with and without added urea have been examined. A 38% urea solution (Urasil; Canadian Industries Ltd.) was added to freshly cut corn to provide 0.6% urea on a wet basis. Urasil was metered into the blower during filling of a 4.3×17.1 m concrete tower silo. A similar silo was filled with untreated silage. Samples for analysis were obtained during the first 20 days of silage fermentation. Samples on day 0 were obtained from the exit of the blower into the silo and on subsequent days from holes bored in the wooden silo doors 2 m above the ground.

Approximately one-third of the added urea was degraded to ammonia by urease present in fresh corn. Urease activity had disappeared after the 2nd day of fermentation in the silo. The ammonia concentration of urea silage was approximately 0.5% on a dry matter basis. The fermentation of urea-treated silage produced higher concentrations of acetic and lactic acid than the control silage.

The crude protein ($N \times 6.25$) of corn was increased from 9% to 19% by the inclusion of urea. The true protein content of urea-treated silage remained at 5% throughout the fermentation. The free amino acid content of untreated silage increased from 0.3% to 0.9% during fermentation. During this time free amino acids in urea-treated silage increased from 0.4% to 2.5% of the silage dry matter. Isoleucine, glycine, threonine, lysine, and valine were among those that increased most in urea-treated silage. Urea addition to silage appears to result in increased true protein either by sparing protein breakdown or by

increased microbial protein synthesis or both. Fermentation also resulted in greater free amino acid concentrations when urea was added. These effects together are probably the reason for the benefits derived from urea addition to silage.

Performance of cows fed urea-treated silages

Urea-treated corn silage as a protein source was compared to soybean meal or urea fed in the concentrate in an experiment with 32 lactating Holstein cows. Three diets were formulated to provide 12–13% crude protein (CP) either from the urea silage, urea (3%) mixed with concentrate, or soybean meal mixed with concentrate. A negative control group (9.4% CP) had no supplemental protein or NPN. Concentrate (40% of dry matter, DM, intake) and corn silage (60% of DM intake) were mixed just prior to feeding each day and were fed ad lib. from at least the 10th week of lactation. The average daily milk production during weeks 27–30 of lactation was significantly greater for cows receiving the urea or soybean meal diets than those on the negative control (19.5, 17.8, 17.6, and 13.1 kg for urea silage, soybean meal concentrate, urea concentrate, and negative control group, respectively). Although there was slightly better production by cows receiving the urea silage than those on the urea and soybean meal concentrates, these differences were not significant. Milk persistency for the four groups, expressed as 27- to 30-wk production as a percentage of peak production, was 76, 70, 69, and 52%. The negative control group was significantly lower than the other three. Urea silage again showed a slight advantage over the urea and soybean meal concentrate groups.

The total mean daily feed intake (DM) for the negative control group (13.5 kg) was significantly lower as compared to the urea silage (17.1 kg), soybean meal concentrate (16.1 kg), or the urea concentrate (15.9 kg) groups. The slightly greater DM intake of the urea silage group may account for their somewhat increased production over the other two groups. Animals receiving the negative control diet lost body weight during the experiment while animals on the other treatments all gained weight.

The replacement of soybean meal in the concentrate by urea in the silage was calculated to provide a saving of \$13.00/t of

complete feed. For an animal consuming 17 kg of feed per day this is a saving of 22¢/day or \$67 for a 305-day lactation. Such savings make the addition of urea to corn silage appear very favorable.

Alfalfa silage as a main source of proteins for dairy cattle

Four groups of 60 cows kept year round under complete confinement in a loose-housing barn were fed complete diets consisting of 60% roughage and 40% concentrate. For two of the groups (treatment 1) the roughage component consisted of 11% mixed hay, 26% wilted grass-legume silage, and 63% corn silage, and the concentrate was a 21% crude protein concentrate containing 1.5% urea. The other two groups (treatment 2) were fed a forage mixture consisting of corn silage and formic acid treated direct-cut alfalfa silage apportioned weekly on the basis of nitrogen analyses in such a way that the crude protein content of the mixture was 14%. The grain-mineral mix fed to the latter groups contained 12.5% crude protein.

Dry matter consumption of the cows fed treatment 1 was 11% higher than for those fed treatment 2 (18.1 vs. 16.2 kg/day); since complete feeds were used, the same difference in energy digestibility coefficient (63 vs. 65%) partly explains the improved efficiency of utilization of energy observed on the alfalfa silage diet.

Observations on the health of cows in the four groups showed that, contrary to a popular belief, the feeding of alfalfa silage as a large proportion of the diet had no significant effect on the incidence of metabolic diseases in the herd. Analysis of reproduction data showed an average of over 60% conception at the first service for a total services-to-conception ratio of 1.52 for treatment 1 and 1.57 for treatment 2. The values are well within the accepted limits in the dairy industry.

The experiment indicates that it is possible to utilize alfalfa silage as a major source of proteins for dairy cattle, thereby eliminating the need to feed expensive protein supplements. It is also demonstrated that hay can be eliminated in the feeding of dairy cows. The elimination of hay may cause a decrease in dry matter intake by the cows, but does not cause a decrease in milk production.

Preruminant calf nutrition

A low pressure (LP) method was developed for dispersing high levels of fat into milk replacers. Under *in vitro* conditions the procedure yielded a strong curd, an important factor in the very young calf for efficient utilization of nutrients and good health. In experiments with calves (0-28 days of age), it was found that when high levels of fat (40% DM) were fed, the calves performed well when the fat was dispersed by the LP method but not when the usual commercial homogenization technique was employed. The LP method produces a fat globule size that apparently allows both effective lipase activity in the gastrointestinal tract and the casein absorbed on the fat to interact for strong curd formation.

In vitro studies were conducted on the effectiveness of calf gastrointestinal lipases on various fat substrates. Pancreatic lipase was effective in hydrolyzing all triglycerides tested but had lowest activity on the tallows commonly used in commercial milk replacers. Pregastric esterase (PGE), the lipase active in the calf stomach, was highly active in hydrolyzing butterfat, coconut oil, and tributyrin; had medium activity for corn, cottonseed, safflower, and olive oils; and had poor activity for lards and various grades of tallow. Lecithin, as an emulsifier, promoted PGE activity as did several dietary proteins; Ca^{++} had no effect. Optimum PGE activity was at pH 6.1 and was significantly lower at pH 4.0, the pH values in the stomach at zero time and 3 h after feeding, respectively. Some of the bile salts normally found in ruminant bile markedly inhibited PGE lipolytic activity. These *in vitro* studies indicated that lard and tallow, the commercial fats used in calf milk replacers, are poorly digested by PGE in the stomach of the very young calf. These fats, however, could be digested by pancreatic lipase in the small intestine if they were occluded in the stomach clot and released slowly so as not to overwhelm the pancreatic lipase, which is in short supply for the first 2 wk postpartum.

Protein degradation in the rumen

A new colorimetric method for the determination of the degradation of soybean meal proteins was developed. Proteins in soybean meal were converted to highly colored diazonium derivatives. After incubation with rumen organisms, the undigested soybean

protein was solubilized and determined colorimetrically. The method measures only the diazotized protein in the presence of other feed proteins and microbial proteins, thus offering many advantages over existing methods. This approach is expected to lead to better evaluation of the amount of feed protein bypassing rumen degradation.

The physical, chemical, and biochemical parameters that determine the rate and extent of degradation of dietary proteins in the rumen are being studied. The major proteases and peptidases of rumen bacteria are being isolated and their properties investigated. These studies are aimed at finding possible ways of controlling the rate and extent of protein breakdown in the rumen and of making more intact dietary protein available to the ruminant.

Rumen microbial growth

The concentration of ATP of microbial cells and their energy charge (EC) value ($EC = [ATP] + \frac{1}{2} [ADP]/[ATP] + [ADP] + [AMP]$) have been used to assess growth conditions in various ecosystems. Maximum benefit will be derived by the ruminant when conditions are optimum for growth of the rumen ecosystem.

Adenine nucleotide concentrations, energy charge, cell counts, and volatile fatty acid concentrations were determined in the rumen contents of two rumen-fistulated cows fed a low-quality diet (LQD) or a high-quality diet (HQD). The concentration of ATP was highest on the HQD (43.0 vs. 17.3 nmol/mL rumen fluid). Total rumen microorganisms were also more numerous on the HQD (14.8×10^{10} vs. 1.2×10^{10} /mL). The concentrations of ADP and AMP were lower on the HQD (6.8 and 3.4 nmol/mL rumen fluid) than on the LQD (10.6 and 5.0 nmol/mL). The energy charge was highest for the HQD (0.871 vs. 0.685). Adenine nucleotides in rumen microorganism and energy charge relate to diet quality and the adequacy of the diet to support optimal microbial growth.

TRACE MINERAL AND BEEF CATTLE NUTRITION PROGRAM

Manganese and bone formation in lambs

In previous experiments, a deficiency of manganese in pregnant ewes resulted in the birth of manganese-deficient lambs with

twisted forelegs, despite the fact that the process of calcification of the lamb skeleton was normal. Studies showed that the efficiency of mucopolysaccharide metabolism in the organic matrix of bones was severely impaired in manganese-deficient lambs, resulting in abnormalities in the formation of cartilage. It was also found that these lambs have lower levels of uronic acid and increased levels of basic amino acids in the epiphyseal cartilage.

Trace mineral metabolism and chelation

Using sheep equipped with a rumen fistula and a duodenal reentrant cannula, it was found that in the rumen, chelation with nitrilotriacetic acid (NTA) increased solubilities of zinc, manganese and iron, but not copper. The solubilities were highest 2 h after feeding and increased with increasing dosage of NTA. In the duodenum, however, only the solubility of iron was increased by the NTA dosing, resulting in more iron being available for absorption from the small intestine. This indicated that NTA might be a good chelating agent for dietary iron and could be useful in improving iron availability for ruminants consuming feedstuffs with low iron solubility.

When sheep were fed a diet containing excessive amounts of zinc and iron, intraruminal dosing with NTA resulted in a decreased apparent absorption and an increased urinary secretion of both metals. The NTA, therefore, could also be used in prevention of zinc and iron intoxication of sheep. There was no harmful effect of NTA dosing on rumen microbial activity as measured by the concentration of volatile fatty acids in rumen fluid and by the quantity of nitrogen, originating from feed and rumen microflora, flowing into the small intestine.

In another experiment, sheep equipped with rumen fistula were maintained on a diet that was suboptimal in concentration of zinc and manganese. Using radioisotopes of manganese and zinc, it was found that dosing sheep with NTA decreased uptake of both radioisotopes by rumen bacteria and protozoa and increased apparent absorption from the gastrointestinal tract. There was no increase, however, in the concentration of the radioisotopes in soft tissues, such as liver, and it is doubtful therefore that NTA had any effect on the overall manganese and zinc metabolism in sheep.

Seasonal variation of a vitamin D metabolite in the blood of beef cattle

At the Kapuskasing Experimental Farm in northern Ontario the summer levels of 25-hydroxyvitamin D₃ (25-OHD₃), a metabolite of vitamin D, in the blood of beef cattle were more than double those measured in winter. The data indicated an increase in plasma 25-OHD₃ levels at the end of May, which paralleled the increased availability of ultra-violet radiation. It is apparent that in cattle at high latitude, the dermal synthesis of vitamin D is much more important than the dietary intake of provitamin D from silage or grass. There is evidence that endogenous photoproduction of large amounts of vitamin D in summer may be stored in tissues and then used for metabolism, thus protecting the animals against vitamin D deficiency in winter. Based on plasma 25-OHD₃ levels, the half-life of a massive intramuscular dose of vitamin D is approximately 4 wk.

Economic systems of beef production in the Northern Claybelt area of Ontario

Forty-eight Shorthorn × Hereford steers at the Kapuskasing Experimental Farm were overwintered on four direct-cut formic acid treated silage diets. The four treatments were early-cut silage, early-cut silage and high-moisture barley (1:1 on a dry matter basis), mid-cut silage, and late-cut silage. For the four diets, the average daily gains were 0.93, 1.10, 0.89, and 0.50 kg, respectively, and feed efficiencies were 7.93, 7.06, 9.38, and 13.01 kg intake per kilogram gain, respectively. The steers fed the silage plus barley were marketed after 154 days; had a dressing percentage of 59.0; and graded 9% A1, 66% A2, and 25% A3. The large percentage of A2 and A3 carcasses was due to overfatness. The steers fed the early- and mid-cut silages were marketed after 168 days and had a dressing percentage of 56.1 and 54.7, respectively. The carcasses from these two groups graded 50% A1 and 50% A2, and 59% A1 and 41% A2, respectively.

The results show that silage of excellent quality can be made from grass in the Northern Claybelt and that there is a benefit in animal performance in early cutting of grass for silage. The improved gain, feed efficiency, and dressing percentage, however, show the advantage of some supplementary grain in the ration.

PESTICIDE RESIDUES PROGRAM

Methoxychlor

The metabolism of methoxychlor was studied in chickens. Metabolism proceeds via demethylation, which results in metabolites that are readily eliminated in the excreta. Low concentrations of residues were detected in tissues and organs after the hens had been returned to a noncontaminated diet for 7 days.

Lindane

In a cooperative study with the Chemistry and Biology Research Institute, a metabolic pathway for lindane was postulated as a result of *in vitro* studies with chicken liver enzyme preparations. A total of 17 metabolites were identified.

Atrazine

In a cooperative project with the Chemistry and Biology Research Institute, a metabolic pathway for atrazine was postulated after *in vivo* studies in the laying hen and *in vitro* studies with chicken liver enzyme preparations. Detection and identification of the herbicide and three metabolites permitted postulation that metabolism in the chicken proceeds mainly by partial *N*-dealkylation accompanied by hydrolysis. Metabolism studies were extended to goose, pig, and sheep liver enzyme preparations. Some species differences were noted.

Tetrachlorvinphos

Tetrachlorvinphos and its major metabolite, 2,4,5-trichlorophenacyl chloride, were stable in acidic and neutral solutions but degraded under alkaline conditions. A metabolic pathway was postulated for the insecticide and its major metabolites as a result of *in vitro* studies with chicken liver enzyme preparations. Five metabolites were positively identified. The primary step was glutathione-dependent demethylation, followed by hydrolysis and further metabolism to conjugated polar compounds, which can be readily excreted. Similar studies were carried out with preparations from goose, sheep, pig, and cow. Species differences were noted with goose liver preparations in which isomerization of the insecticide occurred in addition to the metabolism observed in the other species.

Approximately 67% of an administered dose was eliminated via the excreta of the laying hen in 24 h, whereas about 35% was excreted in the urine of the lactating cow in this time. Metabolites were detected and identified in eggs, organs, tissues, and fat from chickens but not in milk from cows fed the insecticide.

Trichlorfon

Trichlorfon was degraded in buffered aqueous solutions. The primary metabolite dichlorvos, a potent insecticide, was further degraded to other water-soluble metabolites. In vitro studies with enzyme preparations from chicken liver resulted in five metabolites, which were identified and suggest a complex metabolic pathway.

Synthetic pyrethroids

An investigation of the metabolism of fenvalerate in farm animals has commenced. Both in vivo and in vitro approaches will be used. Possible metabolites have been synthesized, purified, and characterized.

SWINE PRODUCTION PROGRAM

Development and maintenance of a minimal disease herd for intensive research

Construction was completed on a new swine facility for intensive research and a minimal disease herd established. The new facility is windowless and is protected against disease entry by a filtered-air positive-pressure (FAPP) ventilation system and a strict routine for entrance of staff and materials. Research results from this facility will not be subject to the variability introduced by subclinical disease and environmental fluctuations.

Fifty Yorkshire litters were introduced into the facility by hysterectomy and reared artificially with 85% survival to 8 wk of age. Piglets averaged 18.9 kg at 8 wk of age and achieved 90 kg market weight in an average of 148 days. Frozen Landrace semen is being used on the Yorkshire females to establish a crossbred sow herd for research use. To the end of 1978 there has been no evidence of rhinitis, virus pneumonia, or internal or external parasites, and the incidence of postweaning scours is negligible.

Energy/protein requirements for pregnancy in the once-bred gilt

Gilts bred at first estrus were fed a standard sow ration at either 1.8 or 0.45 kg/day from day 100 of gestation or 1.4 or 0.45 kg/day from day 85 of gestation. All gilts were slaughtered within 96 h postpartum and their carcasses evaluated as to quality and acceptability. In the first instance gilts averaged litter size of 10.6 and 9.0 liveborn pigs per litter with average birth weights of 1.13 and 1.28 kg, respectively. In the second instance gilts averaged 9.7 and 9.6 liveborn pigs per litter with average birth weights of 1.01 and 0.96 kg, respectively. Carcasses from bred gilts, although graded Sow 1, were not markedly different from unbred gilts following the same regime; however, the meat tended to be tougher than that from conventional market pigs.

Artificial rearing of zero-weaned piglets

The concept of zero weaning and artificially rearing piglets under farm conditions using a gamma-globulin supplemented milk replacer to provide passive disease immunity was field tested under a research contract. In the first experiment 104 pigs were zero weaned over a 6-wk period with a survival rate to 56 days of 51% and poor performance. In a second trial all sows farrowed within 2 days and survival to 56 days was 86% with improved performance. Duration of the immunoglobulin administration beyond 10 days of age did not significantly affect survival. In a third experiment all gilts farrowed within 7 days and survival to 56 days was 96% with a further improvement in performance. These experiments have emphasized the fact that a successful artificial rearing system must be based on batch farrowing to facilitate all-in all-out operation of the rearing unit. Placing newly born piglets in with older piglets only results in reduced survival, as evidenced by the first experiment.

Nutrition of the early-bred gilt

Fifty-four gilts were fed three levels of soybean oil and soybean protein added to a basal diet in a factorial experiment to determine their effects on puberty (first estrus), at which time the gilts were bred and the experimental diets discontinued. The gilts were penned and fed individually for the growing, gestation, and lactation periods and

then either marketed as once-bred gilts or rebred as sows. Two other groups of gilts acted as unbred controls and as conventional market weight (90 kg) controls. Puberty averaged 172 days; dietary treatment differences were not significant. Fewer piglets ($P < 0.05$) were born to gilts fed the lowest protein level. The body weight of the once-bred gilts at weaning was slightly less than that immediately after farrowing; their carcasses were not as heavy and less fatty than those of the unbred controls. Loin and ham roasts were tested by a panel for flavor, juiciness, and tenderness. The amount of liquid fat (percentage of total) obtained on roasting was related directly to the level of oil included in the sow's prepuberal diets.

The linoleic acid content of the shoulder fat was higher ($P < 0.01$) in gilts fed the 20% oil diet than those fed the 0% oil, and also higher in their 3-wk old piglets. Of 23 sows, 17 were rebred 5–8 days postweaning; overall embryo mortality at 30 days reached 40%.

Fatty acid composition of the pig uterus, fetus, and belly fat

The fatty acid composition of fat from the uterus and fetuses from gilts killed 30 days after breeding at puberty (first estrus) was not altered by the addition of 20% soybean oil to the basal diet (0% added oil) given to the gilts for an average of 61 days before being bred. Differences ($P < 0.01$) in linoleic and linolenic acid content were evident in belly fat samples taken from the gilts. While the belly fat contained linolenic acid at $1.9 \pm 0.06\%$ compared with $5.5 \pm 0.9\%$ for the 20% oil diet, arachidonic acid was not formed as it was in the uterus and fetuses.

Effect of pregnancy on body composition and energy balance of the gilt

The energy cost of pregnancy was calculated by comparing energy balances for 20 pregnant and 20 nonpregnant gilts given the same feed allowance. Treatments consisted of an initial slaughter group, and pregnant (P) and nonpregnant (NP) groups slaughtered at 56 and 112 days of gestation. Body weight (W) was recorded at each slaughter time. Chemical analyses were conducted on carcass, viscera, liver, blood, uterus, and when applicable, fetuses, placenta, and uterine fluid. The study was divided between winter and summer periods. Daily maintenance cost (energy intake less

energy retention) per kilogram $W^{0.75}$ was 450 kJ for both P and NP gilts in summer and 660 kJ and 640 kJ for P and NP gilts in winter, respectively. There was no evidence of pregnancy anabolism for energy; only a 3% increase in the maintenance energy requirement for the winter study.

Fat deposition, mobilization, and utilization in neonatal pigs

A study to determine the patterns of fat and protein deposition in neonatal pigs from birth to 4 wk of age revealed that total body fat increased from 1.1% at birth to 12.4% at 2 wk and 15.4% at 4 wk of age. Protein deposition was greater than that of fat during the 1st wk of life but the latter exceeded protein deposition from the 2nd wk of life. Fatty acid composition of backfat reflected the fatty acid composition of sow's milk, indicating that neonatal adipose tissue possibly does not synthesize fatty acids. A low concentration of blood ketone bodies suggested a very low mobilization of fat from adipose tissue during early life. A subsequent experiment, designed to divert the surplus energy of sow's milk from fat deposition to additional protein synthesis, showed that a synthetic milk supplement high in protein (24%) and low in fat (5%) made available to piglets from 2 to 29 days of age resulted in a significant gain in liveweight at 20, 35, and 165 days of age. More protein than fat was found in the carcass at 20 days. Male pigs that received milk supplement reached 90 kg body weight 9 days earlier than the males that did not receive it and 14 days earlier than the females that received the milk supplement.

Cellular growth and effect of nutritional stress on growth

Continued work on cellular growth, growth of pigs after an initial period of growth restriction imposed during the period of most active hyperplasia (5–35 days of age), showed increasing differences (divergent growth) in absolute liveweight and kidney, liver, and gastrocnemius muscle weights compared to those not subjected to growth restriction despite the fact that the rate of gain in liveweight and tissue weights was higher during the early recovery phase. Muscle appeared to be most severely affected and kidney the least by growth restriction.

Investigation of sex differences in the rate of growth of the liver and gastrocnemius muscle of pigs slaughtered on the basis of weight, age, or total feed intake showed that boars were heavier and had larger livers than gilts; greater amounts of total DNA, RNA, and protein in the liver tissue; and a higher RNA:DNA ratio. However, the protein:DNA ratio was not significantly higher. No sex differences were found in gastrocnemius muscle weight, total DNA, RNA, and protein; and RNA:DNA and protein:DNA ratios.

Ruler and ultrasonic measurements of backfat in pork carcasses

Two hundred and fifty-six hot carcasses selected on the rail in a commercial abattoir were used to compare ruler and ultrasonic measurement of dorsal fat thickness at different locations over the back of pork carcasses. Back fat thickness was measured ultrasonically over the last rib on the midline and 2.5 and 5.0 cm off the midline, and at these three locations for four positions posterior and five positions anterior to the last rib at 5 cm intervals. Ruler measurements of backfat thickness were taken at the same 10 midline positions. The correlation between ruler and ultrasonic measurements varied from 0.82 to 0.93 depending on position, with the ultrasonic value consistently lower than the corresponding ruler value. The relationship between backfat thickness and hot carcass weight was positive and linear.

Slaughter weight and carcass characteristics

Thirty-two Yorkshire pigs, 16 gilts and 16 barrows, were slaughtered at four liveweights (85, 92, 103, and 112 kg) to determine the effect of slaughter weight on selected carcass traits. Dressing percentage was not affected by slaughter weight or sex. Weight of untrimmed and trimmed cuts increased ($P \leq 0.01$) with increasing carcass weight as did the weight of trimmings necessary to meet the requirements of the retail trade. The weight of four untrimmed cuts as a percentage of the chilled left side remained unchanged as did the weight of the trimmed ham loin and shoulder. Fat thickness at the loin was highly and at the shoulder poorly correlated with percent yield of trimmed cuts.

Control of parturition in the pig

The use of prostaglandin $F_{2\alpha}$ to induce parturition and facilitate batch farrowing was investigated and field tested. When administered on day 111, 112, or 113 of gestation, 63% of sows farrowed during the working day immediately following treatment. Parturition time, litter size, birth weight, number of piglets weaned, growth to weaning, and subsequent reproductive performance of the sows was normal.

SHEEP PRODUCTION PROGRAM

Development of new strains

Analysis was completed of lamb growth data obtained from the testing of progeny from Suffolk, Finnish Landrace, Ile de France, and East Friesian rams (breeds making important contributions to the synthetic strains being developed) mated to Suffolk, Shropshire, and Ottawa MM ewes and from the evaluation of crossbred ewes in backcrosses with their own breeds of sires. Growth rates of the crossbred and backcross progeny did not differ significantly among the four breeds of rams (approximately 3.4 kg difference in 140-day weights between first-ranked Suffolk and fourth-ranked East Friesian). On the other hand, as a breed of sires of crossbred dams, the East Friesian excelled with progeny surpassing those of the fourth place Suffolk by 8.9 kg for 140-day weight. As a breed of dam for crossbred lambs, the Suffolk ewes had progeny that were significantly heavier at 140 days than those of the other two ewe breeds used in these studies. The Ottawa MM however, surpassed the Suffolk and Shropshire as breed of dam of crossbred dams.

Intensive rearing of lambs

Studies continued on ways to decrease milk replacer (MR) costs of artificial rearing. Compared to lamb MR (24% protein - 24% fat), feeding less expensive vealer (20% protein - 20% fat) or cow milk reduced lamb gains by approximately 15-17% and marginally decreased lamb survival. The substantially better lamb performance with lamb MR, however, may not be sufficient to offset the increased cost as lamb MR currently costs about 40% more than good vealer. Preliminary summaries indicate that reducing either fat or protein from 24% to 20% reduced lamb

performance. When feeding lamb MR, it was also found that delaying weaning from MR from 21 to 28 days of age increased lamb weights at 70 days of age by about 1.2 kg; the extra week of MR feeding required about 3 kg dry MR per lamb so the increase in lamb performance was not enough to offset the additional MR cost.

Reproductive physiology

Controlled breeding. Results have shown that control and synchronization of estrus and ovulation with progestagen impregnated sponge pessaries is very effective. Because the vaginal sponge treatment for estrus synchronization is not registered for use in Canada, studies of alternative methods of estrus synchronization are under way. Preliminary results indicate prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is an effective estrus synchronizing agent when injected into ewes, providing they are cycling, and that fertility after synchronization with $PGF_{2\alpha}$ is equal to unsynchronized, naturally mated ewes or vaginal sponge synchronized ewes. Other studies have indicated that ear implants impregnated with a synthetic progestagen are also effective for synchronizing estrus and that fertility of implant synchronized ewes is equivalent to vaginal sponge synchronized ewes.

Prepubertal gilts, treated with hormones to induce ovulation, were used as an experimental model to study the interrelationships and role of follicular determinants in the process of ovulation. Results indicate that ovarian synthesis of prostaglandins is a necessary prerequisite in the sequence of events leading to follicle rupture and ovulation. The results do not support a mediatory role for prostaglandins in oocyte maturation and development of luteal function.

A study of factors affecting resumption of cyclic activity in ewes during the early postpartum period indicates that only a small portion of control ewes have resumed cyclic activity by 35 days postpartum. Gonadotropin releasing hormone is unable to induce early resumption of activity. In contrast, treatment with vaginal sponges plus pregnant mare's serum gonadotrophin (PMSG) induces resumption of cyclic activity by 35 days postpartum.

Studies using various light regimens indicate that an abrupt change (from 18 h light: 6 h dark to 10 h light: 14 h dark and vice versa every 4 mo for an 8-mo breeding

interval) is more effective in inducing cyclic activity than light regimens that are either contracted (weekly light changes simulating natural circannual changes but contracted to an 8-mo period) or constant (10 h light: 14 h dark).

A pregnancy test for sheep, based on the presence or absence of placental lactogen in maternal blood 60 days after the last day of exposure to a breeding ram, has been successfully developed.

Artificial insemination. Artificial insemination (AI) is being developed as an alternate method of breeding sheep to exploit the reproductive potential of superior rams. Studies have concentrated on processing and storage procedures for fresh and frozen semen, reducing sperm number requirement at insemination, and defining effective AI requirements for breeding synchronized ewes. Since initiating research 3 yr ago, over 2200 ewes have been inseminated with either diluted fresh or frozen semen, establishing capabilities that compare favorably with other establishments. The results show that AI using fresh semen, stored for up to 12 h, provides a 65–70% lambing rate in synchronized adult ewes. Fertility can be maintained by reducing the sperm numbers inseminated from 450 million to 225 million. Frozen semen conception rates are presently about 50% lower than those of fresh semen. Recent studies indicate that PMSG improves fertility of synchronized ewes bred by AI and that dosage can be reduced from 500 IU to 250 IU.

POULTRY BREEDING PROGRAM

Selection studies

Results of a long-term selection study with Leghorns were evaluated in an experiment testing in parallel two unselected control strains, six strains that have been under selection for high egg production and economically important related traits for up to 27 generations and all 30 possible reciprocal crosses of the selected strains. Under low-stress housing in individual laying cages, in which the strains are normally kept at ARI, the average hen-housed egg production up to 497 days of age was 204, 253, and 269 eggs for the control strains, selected strains, and

strain crosses, respectively. Under the high-stress environment of group cages, the corresponding performances were 198, 239, and 257 eggs. The differences between the control and the selected strains (49 and 41 eggs in the individual and group cages, respectively) represent the average genetic gain achieved by selection. The differences between the strain crosses and the pure selected strains (16 and 18 eggs in the two environments) represent the average heterosis. Thus the heterotic effects added 33 or 44% to the genetic gain from selection and the increased performance of the hybrids was more pronounced under the high-stress environment.

Another test compared the above selected strains to strains derived from them and selected for resistance to Marek's disease in addition to selection for the above production traits. Under Marek's disease vaccination, the long-term selected strains and their crosses produced, up to 497 days of age, on the average five eggs more than the resistance-selected strains. The best cross of the resistance-selected strains produced 262 eggs without vaccination, which was comparable to the 266 eggs produced by the best vaccinated cross of the long-term selected strains. In general, the ARI strains in these experiments were performing at levels similar to the better of two commercial stock tested in parallel.

Initial experimental work in a new research program on genetic aspects of obesity in the modern broiler chicken compared the performance of contemporary commercial broilers with that of chickens genetically corresponding to performance levels of broilers of 10 and 20 yr ago. The test showed that the large genetic improvement achieved by the industry was mainly in terms of growth rate. The 45-day body weights were 1750, 1120, and 760 g for the contemporary, "10 yr ago," and "20 yr ago" broilers, respectively. Much smaller genetic improvement, if any, was seen in feed conversion. This can be at least partly explained by a large proportion of high-energy fat deposited in the carcass of the modern broiler.

Genetic resistance to disease

There is an increasing tendency among poultry breeders to prevent disease problems by disease eradication. There is a concern, however, that progeny of hens from which diseases were eradicated might be highly

susceptible to disease when reared in conventional housing conditions. A study of this problem using six genetic strains of chickens showed that with the exception of one strain, no differences were found between the performances of progeny from specific pathogen-free and from conventionally housed dams. However, in this study, the adventitious exposure with Marek's disease virus, adenoviruses, and *Mycoplasma* occurred relatively late.

Marek's disease is a highly infectious lymphoproliferative disease of chickens caused by a herpes virus. Involvement of a major histocompatibility locus in resistance to Marek's disease tumors was demonstrated using lines of chickens developed at ARI. The birds with allele B^{21} , which earlier was shown to be associated with resistance to Marek's disease virus, also were more resistant to the Marek's disease tumor transplant JMV.

Lymphoid leukemia, an egg-transmitted lymphoproliferative disease caused by a virus, was another disease studied. Surveys of ARI Leghorn strains showed that the frequency of hens positive for lymphoid leukemia virus was higher in unselected controls than in high egg-production selected strains. This indicated that the disease, even in its subclinical form, is negatively influencing egg production, which results in elimination of positive birds in strains under selection. There was also evidence that infection with the virus reduces general viability. It was known that besides the existence of the above exogenous viruses of lymphoid leukemia, some chickens of experimental inbred lines are capable of spontaneous production of an endogenous, nonpathogenic lymphoid leukemia-type virus. Work with ARI stocks of chickens showed that production of the endogenous virus occurs in both inbred and noninbred birds, thus suggesting that the endogenous virus probably also exists in many commercial egg-production stocks. A possible negative effect of the endogenous virus on egg production was suggested by the data.

The above research on disease resistance was conducted in cooperation with the Animal Diseases Research Institute in Ottawa, University of Alberta in Edmonton, and USDA Regional Poultry Research Laboratory in East Lansing, Mich.

Degenerative myopathy (green muscle disease) of turkeys is a syndrome wherein

tissue of the deep pectoral muscle initially breaks down to form a greenish lesion followed by the loss of the affected muscle tissue. No disease organism has been yet associated with this condition. Three generations of selection have not increased the incidence of the disease in the ARI flock, but it would appear that the severity of the lesion has increased with selection. Tests indicated birds fed corn- or wheat-based diets do not express the disease differentially. Two codominant alleles of the enzyme adenosine deaminase (ADA^A and ADA^B) were identified in red blood cell lysates of chickens and turkeys. The allelic frequencies were $ADA^A = 0.85$ and $ADA^B = 0.15$ in the turkey flock while these frequencies were reversed in the chicken studies. No association was found between the frequency of these alleles and the incidence of degenerative myopathy in turkeys. The blood levels of the enzyme creatine phosphokinase, when used to identify affected live birds, successfully identified 82% of the affected females while incorrectly including only 4% of the unaffected females. It is of some concern that 10 adults (both sexes) of broiler chicken stocks kept at ARI have been diagnosed positive for the degenerative myopathy.

Egg shell quality

Studies to find genetic variation in physiological traits related to egg shell quality were started by investigating multiple molecular forms of enzymes in the oviduct of White Leghorn hens. Zone electrophoresis revealed five carbonic anhydrase isozymes and five esterase isozymes in the magnum, isthmus, and uterus of laying hens. No association with shell quality was observed.

Calcium and calcium-binding protein levels of hen sera were studied in cooperation with the Pennsylvania State University in University Park, Pennsylvania. The nondiffusible (protein-bound) and diffusible calcium levels were higher in sera of thick than in sera of thin shell layers when blood was sampled 2.5 h after oviposition. Of the two calcium-binding proteins identified, namely albumin and vitellogenin, the latter had the greater binding capacity. Vitellogenin was found in greater quantities in thick than in thin shell layers. Thus the thick shell layers possessed more protein bound to the greater quantities of nondiffusible calcium.

POULTRY NUTRITION PROGRAM

Laying-hen nutrition

Changing the ratio of sodium plus potassium to chloride in diets of White Leghorn hens of three strains had significant effects on body weight, feed intake and efficiency, egg production and weight, albumen height, blood pH, pO_2 and bicarbonate, plasma sodium, chloride, phosphorus, magnesium, and protein. Blood pCO_2 , plasma potassium and calcium, and egg shell strength were unchanged. There was no relationship ($r < 0.2$) between blood pH or bicarbonate and shell strength.

Reducing available phosphorus (0.52–0.27%) and substituting 25-hydroxy-vitamin D_3 for vitamin D_3 (326, 640, 920, ICU/kg) in the diet had no effects on the body weights, feed intakes and efficiencies, egg production and yield, mortality, interior egg quality, or shell strength when fed to two strains of White Leghorn hens; there were strain differences. Dietary phosphorus influenced serum phosphorus levels but had little effect on serum calcium or duodenal calcium binding protein activity of one strain.

A laying-hen diet supplemented with ammonium sulphate (0, 10, 20, 30 g/kg) was fed to pullets and force-molted hens. Pullets did not change their feed intake but hens increased intake to compensate for diet dilution. Level and source of ammonium sulphate had no effect on feed per dozen, egg production and yield, mortality, egg and shell weight, percent shell, specific gravity, or blood spots.

Providing energy, protein, and calcium in physical forms that permitted diet selection by two strains of hens had no effect on total feed, energy, protein or calcium intakes, feed efficiency, interior or shell quality, but had negative effects on egg production and yield. Strain influenced egg production and yield.

Egg formation

The pH, pCO_2 , pO_2 , and bicarbonate levels in blood of White Leghorn hens were independent of time after oviposition, strain, age, or ability to produce egg shells of high or low strength.

Intravenous injections of ^{14}C -labeled bicarbonate, acetate, D-glucose, glycine, L-leucine, and palmitic acid into laying hens at the time of rapid shell formation, 10–12 h after

oviposition, showed that bicarbonate, acetate, and glucose contributed the highest; glycine and leucine intermediate; and palmitic acid the lowest level of activity in the shell of the first egg laid postinjection. All compounds contributed higher levels of activity than bicarbonate to the shells of second and subsequent eggs laid after injection. An appreciable quantity of activity from glucose was found in the albumen of the first egg; whereas, with the other compounds little activity was obtained in the albumen until the second egg postinjection.

Gross energy of eggs

The gross energy (GE) contents of whole eggs, including shells, were measured using eggs from hens of three strains. The dry matter (percent) and GE (kilojoules per gram) differed between strains. The variation in GE per egg was largely associated with egg size.

Growth restriction of broiler breeder stock

Dietary ammonium sulphate (13.8 and 27.6 g/kg) reduced feed intake and weight gain when fed to meat-type replacement pullets from 0 to 12 wk of age. Subsequent egg production was slightly, but not significantly, higher than for control birds full fed (0–6 wk) and then fed on alternate days (7–20 wk). Savings in feed were offset by increased mortality associated with the food-grade ammonium sulfate.

Voluntary feed consumption of chicks was measured following intraperitoneal injection or dietary supplementation with a series of 15 nonesterified fatty acids. Medium-chain acids, uneven C-number acids, and arachidonic acid significantly reduced feed intake, having metabolic effects in addition to any influence on palatability when included in the diet. Dose–response relationships were measured for selected acids.

Metabolizable energy

The true metabolizable energy (TME) values of fats varied according to the compositions of the diets with which they were fed and tended to decrease as the level of dietary inclusion increased. Age of the assay bird had little effect on the TME values of four diets. The TME values of feedingstuffs including cultivars of rapeseed, fractions of rapeseed prepared by five procedures, and fats were measured. It is usual to freeze-dry excreta but

oven-drying at 65, 80, and 95°C did not alter the TME values of two feedingstuffs.

Biological availability of amino acids

A simple, rapid bioassay for true available amino acids (TAAA) was developed. It is an extension of the TME assay and may be conducted simultaneously using the same samples of feed and excreta. A correction for metabolic and endogenous amino acid excretion is important. It eliminates variation associated with differences in feed input. The TAAA values of soybean meal, wheat, oats (2 samples), corn, and barley were measured.

A chick growth assay showed the availability of lysine in barley and oats to range from 66 to 89, average 78%, and from 78 to 100, average 90%, respectively.

Rate of passage of feed

When certain feedingstuffs were placed in the crops of starved roosters, the residues were not completely voided within 24 h. Consequently, when such feedingstuffs are subjected to TME or TAAA assays, the excreta collection period must be adjusted to ensure that all residues are voided.

A procedure was developed to measure the mean retention times of feed residues in full-fed birds. It is based on the excretion rates of stained feed particles.

WASTE UTILIZATION PROGRAM

Pollutant transport to subsurface and surface water

A 4-yr field study at the Institute's Greenbelt Farm was completed to determine the quality of and pollutant transport to (a) subsurface tile drainage water from the use of livestock manures for crop production in large and small fields, and (b) surface stream drainage water in an intensively cropped 600 ha watershed where large quantities of manure are incorporated into land every year. The study was a part of Agriculture Canada's contribution to the Great Lakes Water Quality Agreement, and was 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.

Water flow rates were measured and selected samples were tested for temperature, pH, dissolved oxygen, specific conductivity, nitrogen (total Kjeldahl, ammonia, and nitrate), total phosphorus (filtered and unfiltered), potassium, residue (total, nonfilterable and volatile nonfilterable), coliforms (fecal and total), fecal streptococci, heterotrophic bacteria (standard plate counts) at 20 and 35°C, and the herbicide atrazine.

Results for subsurface tile drainage indicated that heavy applications of manure over a period of 5–10 yr can lead to high concentrations of nitrate nitrogen in tile effluent. Under a corn crop on a fine-textured soil with a previous history of low rates of nitrogen application, manure applications of N at 500 kg/ha per year (split between spring and fall applications) for four successive years did not lead to unacceptable deterioration in water quality. About 50–85% of the N, P, and K in the manure applied to the fields could not be accounted for by crop uptake and removal in tile effluent. Bacteriological quality of tile effluent was comparable for the manured and chemically fertilized fields. Atrazine and

desethyl atrazine removed in the tile effluent was insignificant compared to the amount applied on fields.

Results for surface stream drainage indicated that the quality of water leaving the intensively cropped and manured watershed was better than or close to acceptable quality for surface water supplies. This was attributed to management factors associated with cropping and manure handling. Annual losses of sediment, N, P, and K were found to be comparable to losses reported for other regions of Ontario.

Groundwater nutrient content

In a long-term study in cooperation with the Engineering and Statistical Research Institute and the Land Resource Research Institute, groundwater samples obtained from piezometers in manured fields and in the vicinity of manure storages were examined for nutrients. Nitrate nitrogen concentration was high in groundwater beneath heavily manured coarse-textured soil. Low levels of all nutrients were found in the vicinity of below-grade liquid manure and above-grade solid manure storages.

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V. DESROCHES, B.Ph.A., B.L.S.	Librarian, Entomology
J. E. H. MARTIN	Head, National Identification Service, Zoology
P. M. LECLAIR	Head, National Identification Service, Botany

Coleoptera, Lepidoptera, and Trichoptera

J. M. CAMPBELL, B.S., M.S., Ph.D.	Head of Section; Staphylinidae (rove beetles)
S. A. ALLYSON, B.Sc.	Lepidopterous larvae
D. E. BRIGHT, B.S., M.S., Ph.D.	Scolytidae (bark beetles), Curculionidae (weevils)
E. C. BECKER, B.S., M.S., Ph.D.	Elateridae (click beetles, wireworms)
J. D. LAFONTAINE, B.A.	Noctuidae (cutworm moths)
E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C.	Pyrilidae (pyralid moths)
A. MUTUURA, B.Sc., Ph.D.	Tortricidae (leafroller moths)
F. SCHMID, Lic. ès Sc. Nat., D. ès Sc. Nat.	Trichoptera (caddisflies)
A. SMETANA, M.U.D.R., Cand. Sc. Biol.	Aquatic beetles, Staphylinidae (rove beetles)

Diptera and Hemiptera

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K. G. A. HAMILTON, B.S.A., M.Sc., Ph.D.	Cicadellidae (leafhoppers), Cercopidae (spittlebugs)
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J. R. VOCKEROTH, B.A., M.A., D.Phil.

Chironomidae (nonbiting midges)
 Simuliidae (black flies),
 Nycteribiidae and Streblidae (bat flies)
 Aphidoidea (aphids, plant lice),
 Psyllidae (psyllids), Coccoidae (scale insects), Thysanoptera (thrips), Psocoptera (psocids, booklice), Collembola (springtails)
 Tabanidae (horse flies and deer flies), dipterous larvae
 Syrphidae (flower flies),
 Scatophagidae (dung flies)

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Head of Section; Reproductive biology and behavior of cutworm moths
 Hoplolaimidae (spiral nematodes), Tylenchorhynchidae (stylet nematodes), Aphelenchoidea (foliar nematodes)
 Insect hemocytology
 Criconematidae (ring nematodes), Paratylenchidae (pin nematodes), Hemicycliophoridae (sheath nematodes)
 Chemical taxonomy of insects: polymorphic enzymes
 Comparative morphology, Tingidae (lace bugs), Aradidae (flat bugs)
 Heteroderidae (cyst nematodes), Meloidogynidae (root-knot nematodes), Tylenchidae (spear-bearing nematodes)
 Comparative micromorphology of insect eggs

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 Symphyta (sawflies)
 Acari (mites and ticks)
 Ichneumonidae (ichneumon wasps), Braconidae (braconid wasps)

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Proctotrupeoidea (proctotrupid wasps), Bethyloidea (bethylid wasps), Sphecoidea (digger wasps), Evanioidea (ensign wasps)

Braconidae (braconid wasps)

Acari (mites)

Chalcidoidea (chalcid wasps),

Cynipoidea (cynipid wasps)

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

Head of Section; Ascocarpic parasites of cereals

Zoosporic parasites of vegetable crops

Conidial parasites of forage crops

Ascocarpic parasites of fruit crops

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

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

Conidial molds of wood and insects

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

Mycotoxin fungi

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

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

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

Mushrooms

L. K. WERESUB, B.A., M.A., Ph.D.

Basidiocarpic humus-formers and crop psychrophils

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

Head of Section; Cultivated crops, *Medicago*

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Grass flora of Canada

I. J. BASSETT, B.A.

Hay-fever plants, palynology, weeds

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

Cultivated crops, *Hordeum*

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Flora of Canada

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Chemotaxonomy, *Brassica*

J. McNEILL, B.Sc., Ph.D.

Weeds, Polygonaceae, Caryophyllaceae

G. A. MULLIGAN, B.Sc.

Weeds, Cruciferae

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

Weeds, genecology

Honorary Research Associates

C. FRANKTON, B.Sc., Ph.D.	Weeds, Polygonaceae
D. F. HARDWICK, B.A., M.Sc., Ph.D.	Noctuidae (cutworm moths)
G. P. HOLLAND, B.A., M.A., D.Sc., F.R.S.C.	Siphonaptera (fleas)
R. MACRAE, B.A., M.Sc., Ph.D.	Basidiocarpic wood rots, polypores
W. C. MCGUFFIN, B.A., M.A., Ph.D.	Geometridae (geometer moths, loopers)
M. K. NOBLES, B.A., M.A., Ph.D., F.R.S.C.	Basidiocarpic wood rots, hymenomycetes
O. PECK, B.Sc., M.Sc., Ph.D.	Chalcidoidea (chalcid wasps)
D. B. O. SAVILE, B.S.A., M.Sc., Ph.D., D.Sc., F.R.S.C.	Plant rusts
G. E. SHEWELL, B.Sc., M.Sc.	Lauxaniidae (lauxaniid flies), Calliphoridae (blow flies)
G. S. WALLEY, B.S.A., M.S.	Ichneumonidae (ichneumon wasps)
A. WILKES, B.S.A., M.Sc., Ph.D.	Insect genetics

Departures

J. A. DOWNES, B.Sc. Retired December 1978	Ceratopogonidae (biting midges, sand flies)
D. F. HARDWICK, B.A., M.Sc., Ph.D. Retired December 1978	Director, Biosystematics Research Institute
C. F. HINKS, B.Sc., Ph.D. Resigned October 1978	Developmental physiology of cutworms
W. C. MCGUFFIN, B.A., M.A., Ph.D. Retired December 1977	Lepidoptera: Geometridae
R. M. ARNOLD, B.A., M.Sc. Died June 1978	Ascocarpic parasites of trees and shrubs

¹Seconded 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 number of years, the Institute has strongly emphasized the production of identification manuals on the flora and fauna of Canada and studies on organisms of economic importance.

Floral and faunal surveys of national parks, in cooperation with the Parks Branch of the Department of Indian and Northern Affairs, continued in St. Lawrence Islands and Kouchibouguac national parks.

Dr. D. F. Hardwick, Director of the Institute, retired at the end of 1978. He served as Director of the Entomology Research Institute and later the Biosystematics Research Institute, from April 1973 to December 1978. During 1977 and 1978, Dr. B. R. Baum, Mr. G. A. Mulligan, Mr. R. H. Mulvey, Dr. D. E. Bright, Dr. R. V. Peterson, Dr. J. W. Arnold, Dr. W. C. McGuffin, Dr. J. S. Barr, and Dr. J. A. Parmelee stepped down as section heads. The number of sections was reduced from ten to six, and five new section heads were appointed.

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.

G. A. Mulligan
Acting Director

IDENTIFICATIONS, COLLECTIONS, AND SURVEYS

National Identification Service

Material received for identification for the 2-yr period (1977-1978) amounted to 1928 shipments totaling some 294 000 specimens. Major users of this service were Environment Canada, Agriculture Canada, and Canadian universities. Some 5500 specimens were received from the general public requesting identification, general information, or control. Provincial departments continued to make considerable use of our service. More than 210 000 specimens were identified and returned to the sender. Several students encountering problems with identification of material were assisted and cooperation in this area continues.

What is believed to be the first case of spotted fever was reported from the Ottawa area in 1978 and the Institute was called upon to assist in the identification of the tick involved.

Weedy, cultivated plants, native plants, and fungal material received for identification amounted to 459 shipments in 1977 and 333 shipments in 1978, containing a total of 26 393 collections. Principal users of the service were Agriculture Canada (4400, 23%), Canadian universities (3414, 18%), other federal departments (3237, 17%), and Environment Canada (3229, 17%). During the 2-yr period 19 018 collections were identified.

Due to favorable weather conditions, 1950 mushroom collections were received from the general public for identification. Numerous requests for assistance on identification of mushrooms and plants were received from the Poison Control Centre at the Children's Hospital. During the peak season, mushroom displays were held to assist the public in collecting and identifying mushrooms. The accompanying table shows the number of specimens identified and their sources.

Collection development

The holdings of the Canadian National Collection of Insects, Arachnids, and Nematodes increased by some 437 000 specimens.

Major contributions were made by 36 officers of the Institute collecting in all the Canadian provinces, Yukon Territory, Alaska, South Carolina, and southwestern United States. Collections of importance were plant bugs, pests of fruit trees in Quebec, New Brunswick, and Nova Scotia; *Euxoa* species from the Prairie Provinces for the rearing program; mites from the Cypress Hills of Alberta and Saskatchewan; and a large collection of rove, click, and aquatic beetles from Alaska and the Yukon Territory. Donations of specimens to the collection totaled some 60 000 specimens and purchases amounted to 38 000. Loans to 320 institutions around the world amounted to 137 000 specimens being forwarded for research study. Material incorporated into the collection totaled some 300 000 specimens, which included a large collection from the Harrow Research Station.

The holdings of the botanical collections at the end of 1978 stood at 660 637 specimens of vascular plants and 220 488 specimens of fungi, with the incorporation of a total of 28 930 specimens: 18 663 vascular plants and 10 267 fungi. Major contributions were made by research scientists and technicians who collected in Newfoundland, New Brunswick, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, Northwest Territories, and Alaska. Increased emphasis was placed on collecting cultivated plants both within and outside Canada. Collecting expeditions for wild species of oats, barley, and wheat were carried out in the Middle East and South America. Also added were 11 765 collections, through gifts and exchange material. Botanical material loaned to 106 institutions around the world during 1977 and 1978 amounted to 14 200 vascular plant collections and 1505 fungal collections.

The holdings of the Mycological Culture Collection stand at 5732 cultures with a total of 424 genera and 1047 species. This collection was worked on extensively in 1978, during which time duplicate cultures and those no longer considered useful to the collection were discarded. A total of 1625 cultures have been successfully freeze-dried for long-term preservation. Also, 350 cultures were sent out in answer to requests.

Institute visitors

The Canadian National Collection of Insects, Arachnids, and Nematodes and the expertise at the Institute attracted some 50

visitors from various parts of the world: Australia, China, Haute Volta, Hawaii, Sweden, Switzerland, United States, and Canada. Notable visitors were Dr. Lars Huggert, University of Omea, Sweden; Dr. Ian Naumann, C.S.I.R.O. Canberra, Australia; Dr. Michael Costa, University of Haifa, Israel; Dr. I. Löbl, Muséum d'Histoire naturelle, Genève, Switzerland. Twenty officers of the Institute visited various institutions in the United States, Trinidad, Great Britain, and Italy.

The botanical collections and expertise at the Institute attracted many visitors including delegations from Vietnam, scientists from various European countries, and from many institutions throughout the United States and Canada as well as student groups from various universities. Notable visitors were Dr. John Cooke from the University of Connecticut who spent 6 mo studying Hyphomycetes; and Dr. A. J. P. Oort, Laboratory for Phytopathology, Wageningen, and Mrs. Jean Clark, Western Forest Products Lab, Vancouver, who studied the identification of cultures of wood-rotting fungi. Among visitors to the Vascular Plant Section were P. M. Taschereau, L. Cwynar, J. K. Morton, D. Woodland, B. McMullan, D. M. Britton, G. Ringuis, R. Maher, W. H. Wagner, L. E. Pavlick, C. Garton, and G. Douglas.

Kouchibouguac National Park survey

In cooperation with National Parks, the Institute continued the floral and faunal survey in Kouchibouguac National Park, New Brunswick. This Park of approximately 150 km² was established in 1969 and is still under development. There are extensive bogs throughout the Park, several kilometres of sand dunes bordering the shore line, Acadian type forests, salt marshes, and numerous rivers and streams. Some 175 000 specimens of arthropods, 2000 mycological collections, and 2000 collections of vascular plants were gathered. Included were numerous new and interesting species and range extensions for many groups. Some 25 scientists and technicians participated during 1977 and 1978. Much of the material collected has been identified and the information data banked. A report will be presented to Parks Canada in March 1979.

Zoological and botanical identifications for 1977 and 1978

	Vascular Plants, Collections*	Fungi		Arthropods and nematodes, Number of specimens	Total
		Collections*	Cultures**		
Canada					
Agriculture Canada	3 707	192	501	37 674	42 074
Environment Canada	3 091	60	78	27 798	31 027
Other federal departments	1 917	1274	46	73 118	76 355
Provincial departments	1 394	114	25	15 219	16 752
Industry	60	1	8	534	603
Universities	3 010	103	301	19 029	22 443
General public	745	1950	19	5 747	8 461
USA					
Government departments	8	89	8	7 291	7 396
Universities	60	11	7	14 123	14 201
General public				2 869	2 869
Other countries	176	37	26	6 742	6 981
Subtotal		3831	1019		
Total	14 168		4850	210 144	229 162

*The term collection refers to all of the plants or fungi of one species that were collected at a certain location at one time and may in fact consist of from one to more than 1000 individuals.

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

Identification aids

Insects and Arachnids of Canada. This faunal series was begun several years ago and is now established as an Institute activity. The activity is designed to treat the insect and arachnid fauna of Canada in a series of books which will permit the nontaxonomic biologist to identify various arthropod entities. Since the last annual report, three contributions were published. These include: *Collecting, Preparing, and Preserving Insects, Mites, and Spiders*; *The Aradidae (Hemiptera) of Canada*; and *The Anthoridae (Heteroptera) of Canada and Alaska*. Four other contributions are in the final stages of editing or production. They include: *The Mosquitoes of Canada*, *The Crab Spiders of Canada*, *The Genera of Canadian Trichoptera*, and *The Miridae (Heteroptera) of the Prairie Provinces*. Work is nearly completed on the *Fleas of Canada, Alaska, and Greenland*; only small portions of the text remain to be done. Manuscripts on *The Spittlebugs (Ceropidae) of Canada*, *The Sac Spiders of Canada*, and *The Rhyacophitidae (Trichoptera) of Canada* have been completed. Numerous other contributions are being prepared by Institute scientists. Several additional contributions have been initiated under negotiated contracts. *The Orthopteroid Insects of Canada* is being produced at McGill University, Montreal, Que.; *The Alticinae (Chrysomelidae: Coleoptera) of Canada* is nearly finished at Carleton University, Ottawa, Ont.; *The Histeridae (Coleoptera) of Canada* is being produced also at Carleton University; and *The Hydropsychidae and Polycentropodidae (Trichoptera) of Canada* is being produced at the University of Alberta, Calgary, Alta.

Fungi Canadenses. Since the last annual report in 1976, 39 contributions were published plus an index for numbers 1-100. Twenty more contributions are in press or are with an editor for processing. To date, 150 contributions to this series have been published. The taxa illustrated and described include one new genus, eight new species, one new subspecies, two new varieties, and thirteen new combinations. The series includes several first-published records of Canadian fungi. Included are all of the commonest Canadian species of *Apiosporina*, *Atopospora*, *Brachysporium*, *Dendryphon*, *Endophragmiella*, *Coleroa*, *Steganosporium*,

Pseudospiropes, and *Puccinia* on *Heliantheae*, *Gymnosporangium* on *Juniperus*, and *Massaria*. Copies of *Fungi Canadensis* are distributed to 51 countries around the world and to numerous Canadian institutions.

A study of the poisonous mushrooms and fleshy fungi occurring in Canada was initiated at the University of Toronto under a negotiated contract.

Vascular plants. Several identification aids have been produced by scientists in the Vascular Plant Section. *An Atlas of Airborne Pollen Grains and Common Fungus Spores of Canada* culminated many years of work. This publication discusses the problem of assessing allergenic airborne plant material in Canada, provides the keys to all common pollen and spores, and presents detailed descriptions and illustrations of these. The work is documented with outstanding scanning electron micrographs and represents an important achievement in Canadian botany.

Common Weeds of Canada. A definitive, bilingual, illustrated compendium of Canada's most common weeds was prepared as a semipopular guide, complementing *Weeds of Canada*, the standard reference work of its kind, which appeared earlier as an Agriculture Canada publication. This contribution provides the amateur and interested layman with a simple and effective means of identifying weeds. A monograph of the genus *Avena* culminated more than a decade of work on this important genus of cereals. This treatise, entitled *Oats: Wild and Cultivated*, provides an up-to-date means of identifying the species and hybrids of wild and cultivated oats. This technical work provides agronomists, breeders, and cereal scientists with a much-needed clarification of a complex genus. A revision of *Ferns of the Ottawa District* was recently published. This treats 41 species, and provides keys, descriptions, and ecological and distributional information. The publication can be used for determination of fern species throughout most of Ontario and Quebec.

Vascular Plants of Continental Northwest Territories. This publication, coauthored with the late A. E. Porsild of the National Museum of Natural Sciences, was completed and will be published in 1979.

Grasses of Ontario. It is scheduled to be published shortly. This manual accounts for

the 238 species of grasses of Ontario, providing keys, descriptions, illustrations, detailed distribution maps, and discussions of the introduction and spread of the introduced species.

Several studies on the biology of Canadian weeds were produced at the University of Western Ontario under contract, and a study of the blueberry genus *Vaccinium* in North America was initiated at Acadia University.

Plant-parasitic Nematodes. An illustrated key to 50 genera of plant-parasitic nematodes of Canada is in press and expected to be available for distribution in 1979. Genera are organized by family and their diagnostic characters represented by 340 labeled scanning, electron, and photo micrographs. Included are sections on techniques of collecting and processing nematodes, general and selected references to literature, an index to genera and 30 Canadian species, and an illustrated glossary of 160 nematological terms.

SECTIONAL RESEARCH

Coleoptera, Lepidoptera, and Trichoptera

Coleoptera. Staphylinidae. A revision of the genus *Tachyporus* was completed and accepted for publication; it treated 38 species, 18 of which were new to science. Two papers were published revising nine genera and 24 species of the subfamily Omaliinae; three smaller papers treating 17 species and describing seven new species of miscellaneous groups were published or accepted for publication. Considerable progress was made toward the completion of a monograph of the subfamily Xantholininae; 17 genera and 87 species were treated to date; three additional papers dealing with the taxonomy, synonymy, and nomenclature of the subfamily were published or accepted for publication. A rough draft of a revision of the genera *Lordithon* and *Carphacis* for North America was completed. *Hydrophilidae.* A monograph of the subfamily Sphaeridiinae for North America was published; it treated 13 genera and 62 species; three genera, one subgenus, 12 species, and one subspecies were described as new. A manuscript treating the subfamily Sphaeridiinae for the handbook series *The Insects and Arachnids of Canada* was completed. *Elateridae.* A manuscript on western species of the genus *Athous* was

completed, as well as three other manuscripts relating to associated genera. *Alleculidae.* Preliminary work started for a handbook of Alleculidae and Lagriidae of Canada. Three papers were published describing new taxa and presenting new synonymy for this handbook. *Scolytidae.* Research on the genus *Pityophthorus* continued; a reassessment of generic concepts within the subtribe Pityophthorina resulted in reducing several related genera to subgenera of *Pityophthorus*; the genus now contains about 235 species in North and Central America; numerous scanning electron microscope photographs, eight habitus drawings, and over 50 distribution maps were prepared; two papers describing new species and reporting new synonymy were published. *Miscellaneous.* A paper on the European leaf beetle *Pyrrhalta viburni*, which was found for the first time in North America in the Ottawa area, was completed; the species is a potential pest of ornamental and native species of *Viburnum*.

Lepidoptera. A manuscript on Pyraloidea for the *Checklist of Lepidoptera of America North of Mexico* was completed; it presents new classification, as well as new synonymies and new combinations. Revision of the genera *Vitessidia*, *Cosmothella*, and *Vitessa* was completed, as well as two papers on European corn borer complex, and one paper on garden webworm complex. Several papers dealing with the taxonomy of Odontinae, Pyraustinae, Nymphalidae, and Scoparinae were published. The work on the handbook of Sphingidae of Canada continued. Work on the reclassification of the coniferophagous genus *Choristoneura* was initiated. Three papers dealing with new introductions *Epiblema cynosbatella* and *Pandemis heparana* in British Columbia, and *Cnephasia stephensiana* in Eastern Canada were completed. Research on Microlepidoptera infesting coniferous trees continued. Work on the larvae of the pyralid moths continued. A paper on the larvae of two species of Macrothecinae was published. One paper on the last-instar larva of the gooseberry fruitworm *Zophodia convolutella*, and another paper on the morphological characters of the larval and pupal stages of the European corn borer were completed. Final draft of the third part of the subfamily Eunominae for the *Guide to the Geometridae of Canada* was almost completed; it treats the tribes Baptini, Caberini, Angeronini, Nacophorini, Campaeini,

and Epirranthini. A checklist of the cutworm genus *Euxoa* was prepared for an upcoming list of the Lepidoptera of North America. A study of the systematics and biogeography of *Euxoa detersa* was largely completed. A preliminary draft of "Part 3, Subfamily Eunoiminae" of *Guide to the Geometridae of Canada* was completed.

Trichoptera. A manuscript on the family Rhyacophilidae for the handbook series was completed; it treated 80 species. Work toward the completion of a world revision of the family Xiphocentronidae continued.

Diptera and Hemiptera

The Diptera manual. Forty-four of the forty-six chapters for Volume 1 (of two volumes) of *Manual of the Nearctic Diptera* were completed by the end of 1978. Of these, all but 15 were edited for scientific content and style. Over 1760 illustrations for these chapters were also completed, over 100 plates were labeled, and a card index of over 3000 scientific names and morphological terms was prepared. A standard terminology, for both larvae and adults, was developed for use throughout the manual.

A comprehensive base-line study of the present status of taxonomic knowledge of all Diptera of Canada (estimated 14 500 species in 101 families) was completed for inclusion in a book entitled *Canada and Its Insect Fauna* being published by the Entomological Society of Canada as part of its pilot project, the Biological Survey of Canada.

Feeding and mating behavior in 15 genera of insectivorous Ceratopogonidae was monographed. The females enter mating swarms and capture their prey, small insects such as midges or mayflies, with their raptorial legs. They then feed on them by piercing the cuticle and dissolving the body fluids with saliva. In several genera, females also capture their mates and feed on them during the mating process. The *Culicoides variipennis* complex was shown to consist of two species; the primary blue-tongue vector of North America must now be called *Culicoides occidentalis* Wirth & Jones.

An illustrated key to the genera of Chironomidae occurring in the Mackenzie and Porcupine river watersheds was prepared to facilitate northern environmental impact studies. The eight Nearctic species including four new species of the black fly genera *Twinnia* and *Gymnopais* were revised. These

genera were shown to be most probably derived from a *Prosimulium*-like ancestor of the family Simuliidae. A synopsis of the rare black fly genus *Parasimulium* was published, which included one new subgenus and two new species. A comprehensive treatment of the black flies of Iceland appeared, and a paper on the larval ecology of some lower Michigan black flies was also published. It included keys and illustrations for the identification of the larvae and pupae of four genera and 19 species, and two new black fly records for Michigan. Two chapters, "Larvae of Aquatic Diptera" and "The Simuliidae", were contributed to the textbook *An Introduction to the Aquatic Insects of North America* by Merritt and Cummins. A common, widespread species of Tabanidae, until now confused under the name *Hybomitra typhus*, was described as new, based on morphological, behavioral, and biochemical differences involving adults, larvae, and pupae.

A revision was published of the North American species of *Syndyas*, a genus of small Empididae comprising six species, four of which are new.

The larva and puparium of a fly, *Canace macateei*, which lives in the unusually harsh environment of intertidal algal mats on the Atlantic coast, were described. Two papers on new chamaemyiid predators of adelgid pests of conifers in Canada were published. Also two papers on the classification of scavenger flies of the family Piophilidae, which includes the well-known "cheese skipper", were published. The largest of these latter papers treated all the piophilids of the world (67 species); the family was redefined to include two other related groups that were previously treated as separate families, i.e. Neottiophilidae (bird nest parasites) and Thyreophoridae (corpse-flies). The ephyrid genus *Parascatella* and the *triseta* group of *Scatella* were revised.

Catalogs were published on the Lonchaeidae (lance flies), Lauxaniidae, Anthomyzidae, Pseudopomyzidae, Scathophagidae, Teratomyzidae, and Diastatidae of the Oriental region.

A report is in press on fly puparia of six species found in pre-Christian human graves in New Brunswick. Three of the species are Holarctic in distribution and their presence in Canada at such an early period shows they were not introduced to this continent through the agency of man in historical times.

Two papers on Anthocoridae described three new species from North America and two European species reported from Canada. Three papers on Miridae described five new species from North America, and one European species reported from Canada. Three papers on Cercopidae described six new species from North America. Four papers on the Cercopidae of the Pacific Islands have been prepared, covering 126 species (67 new). The suprageneric classification of the family Cercopidae has been revised, and the genera formerly included in one of the subfamilies have been reviewed. A review of the Cicadellidae, tribe Idiocerini, in temperate North America has been completed, covering 57 species (11 new) in three genera (formerly only one genus was recognized). The leafhopper-host relationships for the Idiocerini in North America were deduced, and a phylogenetic analysis of the group was presented. The world genera of the leafhopper tribe Macropsini were reviewed, and six new genera and 10 new species were described.

Experimental taxonomy and nematology

Biosystematics of the cutworm genus Euxoa. The genetic characteristics of populations of the dark-sided cutworm, *Euxoa messoria*, from Saskatchewan and southern Ontario were compared by means of gel electrophoresis of allozymes. Analysis of the data indicates that allele frequencies of the enzymes studied are quite similar in the two populations. This homogeneity could be interpreted as supporting the hypothesis that gene flow by dispersal and migration is sufficient to prevent differentiation of populations. However, examination of small samples from other species of *Euxoa* indicates that the allele constitution is very similar in all of them. This is in contrast to the results from a concurrent study of two forms of *Hybomitra typhus* (Diptera: Tabanidae) which showed that the isozyme phenotypes of two of the six enzymes examined were diagnostic. The two forms are now recognized as separate species.

Hemocytes of the last instar larvae of two species in the *comosa* group, *E. annir* and *E. lutulenta*, are distinguishable on the basis of one type of blood cell, the plasmatocyte. This same character can be used to differentiate between larvae of the three species in the *declarata* group previously studied. The

expression of this character seems related primarily to ecophysiological differences between species, particularly the duration of prepupal aestivation, and its validity and usefulness as a taxonomic character is limited.

Mating frequency, an important reproductive parameter in Lepidoptera, was determined for field populations of 13 species of *Euxoa* and for laboratory populations of three of the species. The laboratory populations behaved similarly to the field populations in this respect and it appears that reproductive behavior of *Euxoa* species under laboratory conditions can be considered normal. Mating-choice tests established that the three interfertile sibling species in the *declarata* group are reproductively isolated and confirms that they are valid biological species. Studies to determine the isolating mechanisms showed that there are discrete differences in the mating activity rhythms of each of the species.

Insect morphology. Scanning electron microscopy of the chorionic features of bumblebee eggs revealed differences in surface sculpturing that are species specific. Taxonomic relationships indicated by the chorionic characters are in concordance with those based on adult morphology. The chorionic features of the microtype eggs of 21 species of tachinids (Diptera) were found useful in distinguishing some closely related and morphologically similar species.

A comprehensive survey of abnormal metamorphosis, the involvement of hormone-environment interaction and its significance in arthropod evolution, was completed and published.

Nematology. Eight new species of the insect parasitic mermithids from Canada were described and published with a key to 10 indigenous genera and 24 species. A comparative study of the sexes established that characters of the male are particularly important in identification and taxonomy of mermithid species. Also published were descriptions of two new genera and three new predacious species of Monochidae from Canada with diagnoses and a key for 23 recognized genera, one new plant parasitic species of spiral nematodes (*Helicotylenchus*), and one of pin nematodes (*Paratylenchus*). The male of the stunt nematode (*Tylenchorhynchus maximus*) was described for the first time. New diagnostic characters

were published for *Merlinius laminatus* (Tylenchorhynchidae) and males of the ring nematode, *Northocriconema sphagni*, which clarify relationships and facilitate their identification. A sterile female intersex of a species of *Aphelenchoides* was described, which differs from other known intersexes in having an underdeveloped gonad, gonoduct, and postuterine sac, and which apparently represents a further transition in intersexuality in nematodes.

Completed and in press are descriptions of a new species of *Helicotylenchus* with a key to 50 species, a new species of *Teratorhabditis* with an emended generic diagnosis, and a review of the genus *Dorylaimus* which includes a key to 23 valid species and a new species and genus of a new family, Arctidorylaimidae. A description, in press, of a new species of *Criconemoides* includes five new synonyms, and a new combination and key to nine recognized species.

In preparation is a revision of the Criconematidae which establishes new genera and species. Descriptions are being prepared of a new cyst-forming species (Heteroderidae) and a root-knot species (Meloidogynidae) which have the same host, spike-rush. Studies are underway to determine if these two species have the potential to attack agricultural crops.

Hymenoptera and Arachnida

Hymenoptera. A section was completed on Hymenoptera for the publication *Canada and Its Insect Fauna* in collaboration with the Entomological Society of Canada. A series on the hymenopterous parasites of Canada as a contribution to the insects of Canada is underway and the section on Chalcidoidea is nearing completion.

Symphyta. Work is in progress on the genera of *Symphyta of Canada* for the faunal series of the *Insects of Canada*. A revision of the genus *Dolerus* is underway. A preliminary work on association of adults and larvae of sawflies was undertaken. Various rearing techniques were evaluated. *Braconidae:* In cooperation with the Saskatoon Research Station, European parasites of lygus bugs were identified and released in Saskatchewan. A new species of euphorine braconid that is parasitic on the strawberry sap-beetle was described. The Microgastrinae, a very large group of parasites of Lepidoptera, is being redefined. A new classification is being

completed comprising four new tribes and 50 genera of which 23 are new. The genus *Apanteles* is being divided into 21 genera and two tribes. *Ichneumonidae:* The genera *Nelio-pisthus* and *Oedemopsis* are being reviewed. A revision of the genus *Phytodietus* was completed. These are tryphonine parasites of lepidopterous larvae. A revision of the world species of the genus *Euceros*, excluding those from the Nearctic region which were treated earlier, was completed. These are parasites of sawflies. The Nearctic species of *Ctenopelma*, parasites of pamphiliid sawflies, were revised. *Chalcidoidea:* A new species of *Megastigmus* and a new genus of Eurytomidae were described and a revision of the Nearctic species of *Chrysonotomyia* (*Achrysocharella*), parasites of lepidopterous leaf miners, was completed. Also nearing completion is a revision of the Nearctic species of *Pediobius*. Two new species of *Epiclerus* from the New World were described. *Proctotrupoidea:* Twenty-five New World species of the genus *Leptoteleia* were revised. Six papers on members of the families Scelionidae and Diapriidae were completed and six others on various species of Proctotrupoidea are underway. Several new collecting devices and techniques for microhymenoptera were tested and evaluated, and one paper was written on this subject.

Arachnida. A section on Arachnida was prepared for inclusion in the publication *Canada and Its Insect Fauna* in collaboration with the Entomological Society of Canada. A revision of the Nearctic species of wolf spiders of the genus *Alopecosa* was completed. Nearing completion is a faunal guide to the families, genera, and species of sac spiders (Clubionidae and Anyphaenidae) of Canada and Alaska. Studies of systematics of ainsitsiellid and larval arrenuroid water mites in North America were completed. Comprehensive reviews of eriophyid mites infesting fruit and pine trees in Canada were continued and nearing completion. Field work for a survey of Acari of Kouchibouguac National Park was completed and approximately 15 000 mounted specimens are currently being identified. Two papers on tarsonemid mites were published; one included a description of a new genus for a group unique among tarsonemids in being predators of eggs in other kinds of mites. The other paper includes a key and redescription of five species and defines a species-group for these

economically important mites. An invitational review paper on the evolution of plant feeding habits among the mites was completed.

Mycology: plant disease and biodegrading fungi

Over 100 isolates of *Phlyctochytrium*, a large genus complex abundant in agricultural soils, have been examined by light and electron microscopy. They can be divided morphologically and physiologically into at least three genera, and with *Entophlyctis*, classified as a new order of the *Chytridiomycetes*. Isolates of *Olpidium brassicae* from lettuce and other crops which transmit tobacco necrosis virus (TNV) can be distinguished from isolates from cabbage, which do not transmit TNV, on the basis of a unique ultrastructural component in the zoospore.

The eight species (two new) of *Phyllosticta* causing leaf-spot diseases on the Liliaceae were revised. The liliaceous fungi related to *Dothiorella smilacina* (Peck) Petrak & Sydow were also studied. Twenty-two species names were placed in synonymy with *Macrophoma smilacina* (Peck) Berl. & Vogl., and two varieties were distinguished for the species. A revision of the genus *Trichoderma* and the related genera *Gliocladium* and *Clonostachys* was initiated. Certain species are important for outcompeting or parasitizing soil-borne disease fungi in the plant rhizosphere. Others are highly effective cellulose-decomposing species.

Species of the genus *Didymella* in the National Mycological Herbarium were examined and compared; some species of *Didymella* are parasites of raspberry, cucurbits, grasses, and legumes. One manuscript was published and a second is close to completion. A joint study with Dr. R. G. Ross, Research Station, Kentville, on the morphology of *Venturia inaequalis* (Cke.) Wint., the apple scab fungus, developing under different concentrations of the fungicide benomyl was completed.

The taxonomic monograph of the genus *Leucogyrophana* was completed. It integrates laboratory studies of the living fungi with traditional taxonomic analyses and ecological data. The genus *Ramaricium* was redescribed using biochemical and scanning electron microscope data, a key to the species was

prepared, and several species were transferred from *Coniophora* to *Ramaricium*. A study (with Dr. T. Nilsson, Uppsala) was completed of brown-rot fungi (family Coniophoraceae) that decompose pure cellulose, a feature that does not occur in the similar genus *Paxillus* and may be restricted to Coniophoraceae. A study of tumors on mushrooms led to a reinterpretation of the cause (i.e. other fungi are parasitic on the mushroom) and the description of two new species of *Christiansenia*. The genus *Henningisia* of the family Polyporaceae has been redescribed and contrasted with the similar *Rigidoporus*.

Various genera of hyphomycetes were redefined or revised as a result of the definition of different kinds of proliferation associated with conidium production.

A study of the taxonomy of Canadian fusaria was begun with detailed observations on the growth and morphology of 20 species of *Fusarium* found commonly in Canada. Preliminary work was carried out on the nutritional physiology of spore germination in *Fusarium acuminatum* and a sample of overwintered maize was examined for potentially toxigenic mold contaminants as part of a cooperative project with the Animal Research Institute.

A study of the obligately parasitic powdery mildews occurring in Ontario was published. Twenty-eight species in six genera were recognized. A cooperative study of airborne pollen and fungus spores was published. This atlas-type book emphasizes photomicrographs and scanning electron microscope photographs of pollen grains and selected fungus spores.

The occurrence in Canada of a number of mushroom species previously only known from Europe or the United States is documented in a flora of northern peat bogs. The taxonomy, nomenclature, morphology, and ecology of 150 species in 46 genera are discussed. Proof of parasitism of mosses by mushrooms has been demonstrated for the first time. Additional new Canadian records of mushrooms including a new species of a bolete have been made in the National Parks survey in New Brunswick.

The basidiomycete causing fisheye rot of stored apples has been recognized as a new species in a new genus, on the basis of the distribution of different kinds of hyphal branching as development proceeds, and the

difference in organization of the basidiome on an agar plate and a woody substrate.

Other activities. In 1978, the housing facility for the over 220 000 specimens in the National Mycological Herbarium was improved by the purchase and installation of movable shelving (compactor) that provides shelf space equivalent to 50 standard herbarium cases. The compactor occupies the same floor space as 27 metal cases and the total cost was equivalent to the cost of 12 standard cases.

A review of the present condition and availability of the John Dearness collection of fungi including a listing of over 300 TYPE specimens in that collection was published.

In collaborative studies with a member of the National Museums of Canada, a pioneering approach to the phylogenetic biogeography of Ascomycetes and their fossil record has presented evidence for the postulation that bitunicate fungi made their mark in ascomycete history before unitunicates.

Vascular plants

Biology of Canadian Weeds series. Papers were published on stinging nettle, *Urtica dioica* L.; poison ivy, *Rhus radicans* L.; white cockle, *Silene alba* (Miller) E.H.L. Krause; hay-scented fern, *Dennstaedtia punctilobula*; and lamb's quarters, *Chenopodium album* L.

Weedy Chenopodiaceae. Taxonomic studies of the family Chenopodiaceae were conducted. The taxa of *Suaeda* in Canada were clarified, and a new species, *S. rolandii*, was described. This proved to have the highest chromosome number ever reported in the Chenopodiaceae. *Atriplex* of Canada was examined, and it was found that 23 species occur in this country. A systematic account of the genus was prepared. A study of the 31 species of *Chenopodium* found in Canada revealed that most of them could be identified by their seed characteristics.

Weedy Caryophyllaceae. Pollen dimorphism was discovered for the first time in the Caryophyllales, a large order of plants. This was found in white cockle, *Silene alba* (Miller) Krause. However, in the related species night-flowering catchfly, *S. noctiflora* L., and red cockle, *S. dioica* (L.) Clairv., the pollen was uniform. It was shown that North American weed populations of white cockle are referable to the European *Silene alba* and are not, as has been suggested, the products

of hybridization between that species and *S. dioica*. The present status and distribution in North America of *S. alba*, *S. dioica*, and the hybrids between them was described. Evidence for different generic circumscriptions of *Silene*, *Lychnis*, and *Melandrium* was analyzed and the limited applicability of the capsule dehiscence character demonstrated. New subspecific combinations were proposed.

Miscellaneous weeds. A paper, containing a key and taxonomic discussion, was published on the eight species of prostrate spurges (*Euphorbia*) found in Canada. Papers on a new introduced mustard, *Barbarea stricta* L., and the taxonomic status of Rydberg's poison ivy, *Rhus radicans* var. *rydbergii* (Small ex Rydb.) Rehder, were submitted for publication. Biosystematic studies continued on members of the water-hemlock genus, *Cicuta*, and on the creeping yellow cress, *Rorippa sylvestris* (L.) Bess., and the marsh hedge-nettle, *Stachys palustris* L., complexes. Distinctive somatic karyotypes were discovered for each *Cicuta* species and those chromosomal differences were correlated with some new taxonomic characters. Three chromosome numbers were found in Canadian material of creeping yellow cress, and crossing studies revealed a complex incompatibility-compatibility breeding pattern. It was found that marsh hedge-nettle contains two chromosome races, an introduced weedy hexaploid and a native, nonweedy tetraploid.

Oats. Experimental equipment was assembled to identify automatically cultivars of oats, as a first step in identifying grain cultivars automatically. Testing will begin shortly. The world-wide monograph of the genus *Avena*, including its computerized bibliography, was published.

Barleys. A new improved system for the barley cultivar registry has been elaborated and is now being used for barley cultivars on a world-wide basis. The computer system was made general enough for application to all cultivars of various crops. As part of a monographic revision of the barley genus, a trip to Western Canada, Yukon, and Alaska was conducted in 1977, in order to collect and study material of the *Hordeum jubatum* complex. Analysis of this material using numerical taxonomic methods is almost completed. Also as part of a monographic revision of the barley genus a trip to Iran,

Turkey, and Greece to collect *Hordeum* germplasm for studies and breeding was undertaken. A team of three participated in this collecting trip, representing Biosystematics Research Institute; Ottawa Research Station; and Research Station, Winnipeg.

Wheat. Generic classifications of Triticeae, which includes the important cereals, using new approaches and numerical taxonomic techniques, were completed and published.

Stipeae. A manuscript revising this important tribe of range grasses in Canada was prepared. This work includes keys, descriptions, distribution maps, and illustrations.

Hops. A numerical and nomenclatural analysis of *Humulus* was completed. This represents the first comprehensive systematic analysis of this economically important genus. A hitherto ignored species, *H. yunnanensis* Hu, was discovered. Using a newly invented numerical taxonomic method, *H. lupulus* L. (which provides the hops of commerce) was discovered to comprise five well-demarcated geographical groups, which are recognized as varieties.

Carrots. A numerical analysis of variation in cultivated carrot, *Daucus carota* L., and its wild relatives, was completed and an extensive report prepared on this variation and on the nomenclature of wild and cultivated carrots. It was found that domesticated carrot plants differed by 11 adaptive morphological features from wild carrots. An uninterrupted spectrum of variants connect the two basic kinds of cultigens: the familiar orange-rooted carrot, and the extraordinary purple- and yellow-rooted carrot of Asia. Wild carrots closely related to cultivated carrots were found to comprise two broad groups which differed in morphology, geography, and weediness. A physiological analysis, measuring photosynthesis, respiration, and transpiration of the different kinds of wild and cultivated carrots, demonstrated striking differences in adaptive properties.

Cannabis. Studies of *Cannabis* were completed by preparing a two-volume publication of the systematics of this complex and controversial genus. These volumes document the "species problem" in biology and how various criteria of species apply in biology and in law to *Cannabis*. The books summarize extensive multidisciplinary

studies based on morphology, genetics, chromosome analysis, chemistry, micromorphology, geography, interfertility, statistics, numerical taxonomy, and nomenclature.

Alfalfa. A systematic project on *Medicago*, which includes the world's major fodder crop, alfalfa, was initiated. Work to date has indicated that pollen and floral characters provide important features for clarification of the relationships of the approximately 60 species of this genus.

Oil seed Brassica. A chemotaxonomic study of members of this genus was initiated, stressing the taxonomic value of secondary metabolites, particularly anthocyanin glycosides, other flavonoid derivatives, and glucosinolates and related compounds. Over 200 cultivars of *B. napus* L., *B. campestris* L., and *B. oleracea* L. have been sampled, and initial results suggest biochemical characters will be helpful in clarifying the systematics of this economically important genus, which includes rape and several vegetable crops.

Species-area relationships in the St. Lawrence Islands National Park, Ontario

An account was published analyzing different models of species-area relationships for the 17 islands and one mainland area of the Park. In a comparison with the area of each island the number of species was found to give a close and almost equally good fit to both the semilog and the power function models, as well as to a curvilinear modification of the former. A comparison with similar data from limestone islands in Lake Ontario suggests that the latter may show greater species diversity, but a significant difference was not established. From the power function fit, the St. Lawrence River islands appear floristically as segments of a continental area with isolation playing little or no part in determining species composition.

Genecological studies

Experiments examining the comparative biology of atrazine-resistant and -susceptible biotypes of lambs'-quarters, *Chenopodium album* L., were conducted. Results indicated differential growth and response to atrazine both between and within the different biotypes. A manuscript describing atrazine resistance in late-flowering goosefoot, *Chenopodium strictum* Roth, was prepared. Experiments simulating trampling and examining adaptation to this natural selective force were

conducted on populations of broad-leaved plantain, *Plantago major* L., and annual bluegrass, *Poa annua* L. Results indicated that populations of both species collected from trampled sites were better adapted to withstand trampling stress.

Floristics of Canada. As noted in the section describing identification aids, a treatment of the ferns of the Ottawa district was

updated, with five additional species reported for the area and additional information incorporated into the revised text; and a comprehensive two-volume publication describing the flora of the vascular plants of continental Northwest Territories, with the late A. E. Porsild of the National Museum of Natural Sciences, was completed.

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Analytical Chemistry Services

S. U. KHAN, B.Sc., M.Sc., Ph.D., F.C.I.C., F.R.I.C.	Head
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Electron Microscope Centre

I. L. STEVENSON, B.S.A., M.S.A., Ph.D.	Head
J. BRONSKILL, B.A., Ph.D.	Postal service
G. H. HAGGIS, B.Sc., Ph.D.	Electron microscopy

Departures

W. D. MARSHALL, B.Sc., Ph.D.

Resigned December 6, 1978

J. BRONSKILL, B.A., Ph.D.

Died April 5, 1978

Fungicides; analytical methods

Postal service

VISITING SCIENTISTS

L. CORTEZ, Les. Sc., Dr. ès. Sc.

NATO fellow

K. GHOSH, B.Sc., M.Sc., D.Phil.

National Research Council visiting fellow

H. KERNDORFF, B.Sc., M.Sc.

German academic exchange fellow

A. I. ÖZKAN, B.Sc., Ph.D.

IDRC visiting fellow

J. J. PATEL, B.Sc., M.Sc., Ph.D.

DSIR, New Zealand

Soil organic matter

Soil organic matter

Soil organic matter

Soil mineralogy

Biological nitrogen fixation

INTRODUCTION

The Chemistry and Biology Research Institute is engaged in research in several areas of concern to agriculture. The winterhardiness program has the objective of understanding the nature and causes of damage due to frost and increasing the tolerance and winter survival of crop plants. Investigations in the plant pathology program are aimed at better understanding of the biology and biochemistry of the pathogenic fungi *Fusarium* spp.; epidemiology of spot blotch disease in barley; and host-parasite interactions of viruses and mycoplasmas. A new program on symbiotic nitrogen fixation was initiated in 1977 with a view to increasing the efficiency of biological nitrogen fixation by legume crops. The environmental chemistry program continues to develop methods for determining pesticides, toxic organic and inorganic chemicals in soils, crops, and foods and to study their persistence, translocation, and degradation as well. Research in soil chemistry and biology is directed toward making more efficient use of soil nitrogen and phosphorus, a better understanding of the effects of mineralogy on soil fertility and soil genesis, and the development of methods for slowing the subsidence of organic soils.

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 microscope facilities; and X-ray diffraction.

There were some organizational changes in the Institute. The Agrometeorology Section was transferred to the Land Resource Research Institute and the group of scientists working on soil chemistry and mineralogy was transferred from the Soil Research Institute to C.B.R.I. The Host-Parasite Relationships Section was combined with the Agricultural Microbiology Section to form the Plant Pathology Section and a new section was established on Symbiotic Nitrogen Fixation. Dr. I. L. Stevenson replaced Dr. G. H. Haggis as the Head of the Electron Microscope Centre and Dr. S. U. Khan was appointed Head of the Environmental Chemistry and Analytical Chemistry Services Section.

Dr. J. Singh joined the Winterhardiness Section and Drs. L. Purdie and C. Preston joined the Soil Chemistry Section. Dr. W. D. Marshall left the Institute to take a faculty position in Macdonald College. The Institute is missing the dedicated service of Dr. Joan Bronskill, who died in April 1978.

This report summarizes only the highlights of our achievements in 1977-1978. More detailed information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. G. Saha
Director

PLANT PATHOLOGY

Fusarium

Cell wall structure and properties of spores. The structure and properties of fungal spore cell walls are being examined in order to better understand their role in relation to the specificity of host - plant pathogen interactions. Cell wall of *Fusarium sulphureum* macroconidia contained higher levels of β -1,3-glucan but lower levels of chitin than the chlamydospores. Cell walls of both types

of spores were high in protein content but contained relatively low amounts of lipids.

Dithioerythritol induced the formation of irregular "giant" and "dumbbell"-shaped cells in addition to other cells of various shapes. The chemical reduced macroconidia cell wall proteins by 50% while chitin increased two- to three-fold in treated cells.

Properties of the membrane. An understanding of the membrane properties of fungal pathogens will enable development of specific and more efficient measures of their

control. Several specific effects of surfactants on the macroconidial plasma membranes of *F. sulphureum* (isolate 1) were distinguished. The fungicide, dodecylguanidine acetate, was bound to cell walls, intracellular membranes, and cytoplasmic components. A primary effect of the fungicide at low concentration was the induction of water uptake by the cells. At higher concentrations both the impermeability of the plasma membrane to divalent cations and active transport of L-phenylalanine were lost irreversibly. The fungicide physically disrupted the plasma membrane and caused complete disorganization of cellular membranes and lipid storage droplets. A spin label technique was developed that allowed estimates of the number of cells in a preparation sustaining membrane damage associated with Ni^{+2} permeability and the rate at which such damage was induced.

Ultrathin sections and freeze-fracture replicas of macroconidia, macroconidial chlamydospores, and hyphal protoplasts were compared by electron microscopy. Numerous 25 nm particles were randomly distributed on inner fracture faces of the plasma membrane. Many of the protoplasts showed hexagonal arrays of smaller particles but they were rarely seen in macroconidial cells. Freeze-fractured protoplasts showed either smooth fracture faces around the outside surface of lipid droplets or cross-fractured droplets having a crystalline appearance.

Enzymes related to membrane structure and function. Sterol hydrolyase, which mediates hydrolysis of sterol - fatty acid complexes, was isolated from *F. oxysporum* and its substrate specificity determined. The presence of this enzyme in multiple forms was demonstrated. These have been partially purified and relative rates of hydrolysis for a series of fatty acid esters have been determined. A low molecular weight inhibitor of this enzyme was also isolated from *F. oxysporum*.

The structural fluidity of cell membranes constitutes an integral facet of their functioning and, in case of a soil-borne pathogen subjected to temperature extremes, is significant to their survival. In order to understand this phenomenon in *F. oxysporum* f. sp. *lycopersici*, the synthesis of polyunsaturated fatty acid was examined. Vegetative cultures grown at suboptimal to elevated temperatures showed marked changes in lipid and

fatty acid composition. The fatty acid desaturase, which catalyzes the conversion of 18:0-18:1 fatty acid, showed an unusual preference for NADPH over NADH as electron donor and unusually high optimum pH near 8.5. The activity of the enzyme was highest in microsomes from cells grown at 37°C and lowest in 15°C grown material. Measurement of the microsomal transport components showed that NADPH-linked reductase activities and hemoprotein contents were lowest in cells grown at 37°C.

Control of growth and sporulation. The effects of several environmental and chemical treatments on the survival of spores of *F. sulphureum* were determined. Both conidia and chlamydospores survived several freeze-thaw regimes, freeze-drying and storage for 5 yr at -20°C, and dehydration for up to 3 wk. Macroconidia showed little change in lipid class and fatty acid distribution during dehydration but in chlamydospores a large decrease in triglyceride and an increase in free fatty acids were noted. Macroconidia treated with dithioerythritol (DTT) showed less resistance to dehydration. These spores were killed by 10 µg/mL of the fungicide Europhen. DTT (1 mM) completely protected the macroconidia against the fungicide. Internal water movements, critical to survival and fungicidal activity, were monitored directly using spin probes.

The biological effects of a number of fatty acylamino acids and fatty acids on *F. oxysporum*, pathogenic to wheat, were examined. N⁶-Linoleoyl-L-lysine was the most effective inhibitor of hydroxymethylglutaryl-CoA reductase. Linoleoyl-L-aspartic acid also inhibited the activity of the enzyme and completely inhibited both microconidia germination and mycelial growth but did not kill the fungus. Wheat seeds treated with linoleoyl-L-aspartic acid germinated normally on filter paper in the presence of the pathogen. Seeds treated similarly with other compounds did not germinate.

A recent outbreak of a disease of spinach in Ontario required biochemical examination of the causal agent, *F. oxysporum* f. sp. *spinaciae* race 1. A number of biochemical parameters, including growth, inhibition, oxygen uptake, isoenzyme distribution, and serology, were examined for race 1 and race 2 of this organism. These were done to define additional differences between the two races.

Spot blotch disease

Field trials of 2 yr confirmed that secondary sporulation and spread of spot blotch in barley are the direct result of periods of prolonged leaf wetness at elevated temperatures. The internal infestation of barley seed by the pathogenic fungus *Cochliobolus sativus* was related to high populations of aerial spores at the time of flowering. Early seeding and the use of early maturing varieties ensured that the barley was sufficiently advanced to escape these spore showers. Foliar application of the fungicide maneb prior to heading and again just after flowering markedly reduced symptoms of spot blotch and increased yield.

The toxins involved in spot blotch disease have been separated into two types: those that produce necrosis and others that produce chlorosis without destroying leaf cells. An assay method was developed to measure the amount of extracellular adhesive substance excreted by germinating conidia of *C. sativus* to cement the developing fungus to barley leaves. This substance has been isolated, purified, and partially characterized.

Virus and mycoplasma diseases

Barley yellow dwarf virus. Identification of virus strains in cereal crops and serological diagnosis of the disease were studied. Infected oat and barley plants as well as aphids were collected from various counties of eastern Ontario and western Quebec. Aphid-transmission experiments showed the presence of three vector-specific and one vector-nonspecific strain of the virus, the latter being the most prevalent.

Three virus strains were purified but their yields varied significantly, suggesting that this difference is a characteristic property of the virus strains. Studies on serological relationships between the strains showed that some were closely related to each other while others were only distantly related.

Infection of winter cereals with the virus resulted in decreased plant weight, lowered cold hardness, and reduced survival after total ice encasement. The response was most severe on Coast Black oats and Dover barley, less severe on Fredrick and Kharkov wheats, and absent in Puma rye.

The rice root aphid, *Rhopalosiphum rubiabdominalis*, was found to be a new vector of BYDV and was detected for the first time in Canada in 1978 in some Ontario barley

and wheat fields. The aphid transmitted three strains of the virus and, therefore, may play an important role in late-season spread of the virus in Ontario crops.

Peach-X mycoplasma. The following studies were conducted to understand the epidemiology of this disease. Electron microscopy of choke cherry plants collected near the peach orchards around Harrow showed the presence of mycoplasma in phloem cells. The disease was transmitted through bark grafting from the choke cherry plants to peach seedlings and then from the infected peach to healthy peach seedlings. Electron microscopy disclosed the presence of mycoplasma in these infected peach seedlings. Choke cherry and milkweed plants with disease symptoms were abundant in eastern Ontario. Mycoplasma cells were observed in both hosts but their relationship to peach-X disease remains to be determined.

Forage legume diseases and aster yellows mycoplasma. The physicochemical, serological, and biological properties of certain viruses and mycoplasmas were studied in order to determine their distinguishing features.

Clover phyllody mycoplasma could be stored in an infective state at -64°C for 64 wk and 26 wk in frozen whole leafhoppers *Macrostes fascifrons* and *Aphrodes bicinctus*, respectively. Examination of freeze-fractured tissues of infected plants in a scanning electron microscope revealed the presence of mycoplasma cells in various reproductive stages. The mycoplasma purified from diseased plants was shown to contain about 10 major and 7 minor proteins. Amino sugars, amino acid composition, and various classes of the lipid were also studied.

Electron microscopy of clover leaves and leafhoppers infected with clover yellow edge disease revealed the presence of mycoplasma cells in phloem tissues and in the gut and salivary glands of insects. The infectivity of the causal agent could be preserved in frozen leafhoppers at -64°C for 32 wk.

Ten oat cultivars were found to be susceptible to noncelery-infecting strains of aster yellows from the Ottawa area and from Prince Edward Island. Only five cultivars showed a low level of infection with a celery-infecting strain from Ottawa. Studies on transmission of the celery-infecting strain by two vector leafhoppers showed that the role of a plant species as an acquisition or

inoculation host is dependent to a certain degree on the leafhopper species involved. *Anthysanus argentarius*, a grass-feeding leafhopper species, was shown to transmit the celery-infecting strain of aster yellows. Infectivity assays showed that the causal agent was present in the alimentary canal, hemolymph, fat body, ovaries, and salivary glands but not in the brain of the vectors.

The infectivity of the mycoplasma can be preserved for 3 yr in frozen whole *M. fasciifrons* leafhoppers stored at -64°C . An antiserum against the mycoplasma was prepared using preparations purified from infected plants. Serological analysis of the purified mycoplasma showed two cytoplasmic antigens and one membrane antigen. The mycoplasma contained about 40% lipid, and the main classes were phospholipids, glycolipids, sterols, glycerides, and free fatty acids. The total fatty acids and various types of phospholipid were also determined.

Rumen microbiology

Investigations have been concerned with the ability of rumen bacteria to excrete amino acids during growth and the possibility of using this capability to supplement the supply of essential amino acids to the ruminant. Amino acid analyses of supernatants of 116 individual isolates indicated that most rumen bacteria are capable of producing and excreting amino acids while growing on nonprotein nitrogen. It is significant that the amino acids produced in the greatest abundance by both the fresh rumen isolates and known species *in vitro* are the same as the free amino acids commonly found in rumen fluid in the greatest concentration.

ENVIRONMENTAL CHEMISTRY

Inorganic chemistry

Trace mineral ruminant nutrition. Knowledge of the role of trace minerals in ruminant nutrition has a bearing on optimizing productivity of feedlot operation. In an investigation with sheep, each equipped with a rumen fistula and a reentrant cannula, intraruminally dosed with 0–1800 mg nitrilotriacetic acid (NTA) per day and on diets with excessive concentrations of Mn, Fe, Zn, and Cu, fecal excretion of Zn increased and apparent absorption decreased with increasing dose of the chelating agent NTA. However, the behavior of Mn, Fe, and Cu was

unaffected. Flow of soluble Fe through the duodenum increased with increasing dose of NTA. There was no effect of NTA on concentrations of the four elements in rumen bacteria or on microbial activity.

Silicon in animal blood. The role of silicon deficiency as a possible causative factor in health impairment of sheep is being studied. Analysis of a number of ovine plasma samples has indicated native levels of silicon to be in the vicinity of $1\text{ }\mu\text{g/mL}$. The importance of environmental, collection, and analysis factors in relation to different silicon levels observed has also been investigated.

Organic chemistry

Mycotoxins. In order to assess hazards associated with consumption of ergot alkaloid contaminated feeds for domestic animals, methods were developed for determining the alkaloid content and spectrum of ergot sclerotia from cereal crops. The methods were applied to samples collected from rye, wheat, and triticale.

A new analytical method for part-per-billion levels of the mycotoxin patulin using thin-layer chromatography was developed and applied to apple juice. Patulin was detected in only one of seven samples investigated.

Pheromones and attractants. Fourteen compounds were isolated from the volatile fraction of collected royal jelly and identified. Some of these were also found in fresh royal jelly and worker bee mandibular gland and head extracts.

Pesticides

Pesticides in organic soils. The average losses of carbofuran and 3-keto and 3-hydroxy metabolites on drying the samples in the dark at room temperature for 4 days were 18, 21, and 35%, respectively.

Prometryne was rapidly bound to organic soil in laboratory and field studies and a considerable amount of the applied herbicide could not be released after exhaustive solvent extraction. The unextractable residue consisted of prometryne, hydroxyprometryne, and some unidentified compounds.

Pesticides in mineral soils. In a clay loam soil fonofos was the most persistent with $t_{1/2}$ of approximately 120 days, followed by isazaphos, fensulfuthion, and phorate with $t_{1/2}$ of approximately 22, 20, and 4–5 days,

respectively. Phorate and fensulfothion were readily oxidized to the sulfoxide and sulfone derivative, to give $t_{1/2}$ (total residues) of 60–70 days. Both the sulfoxide and sulfone derivatives were bioactive.

Residues of simazine and the metabolite hydroxysimazine persisted for 40 and 28 mo in soils of two orchards that received the herbicide at 4.5 kg/ha for 7 and 9 yr, respectively. Hydroxysimazine was degraded more slowly than simazine and the residue levels of hydroxysimazine were at least 40 times those of simazine 40 mo and 28 mo after the last application.

Pesticides in plants and food crops. The uptake of *Ruanui* ryegrass and *Huia* clover from pesticides-treated soil indicated that fonofos and isazaphos had little systemic action, whereas fensulfothion and particularly phorate showed high residue levels in the plant tops. The oxon analogues of fensulfothion and its sulfone were prominent metabolites in ryegrass. None of the other insecticides appeared to be metabolized in the same manner.

In a study to examine the difference in varietal response of peach root stock seedling to glyphosate sprayed on the lower branches it was found that seedlings of Harrow Blood, Bailey, and Kalamazoo were more susceptible to injury than those of Siberian C and Rutgers Red Leaf.

Two methods, hypochlorite wash and hot acid blanch, for the removal of ethylenebisdi-thiocarbamate (EBDC) and ethylenethiourea (ETU) residues from field-treated tomatoes were demonstrated to be effective in decreasing the residue levels of each toxicant in finished juice samples.

Pesticides in farm animals and poultry. Permethrin was assessed for blowfly control using sheep. The animals were dip-treated at two levels (0.1 and 0.15%). The half-life of the insecticide was 7 days, although traces (> 10 ppm) were detected after 18 wk.

The soluble fraction ($105\,000 \times g$) from chicken liver homogenates contained a heat-labile, glutathione-dependent enzyme(s) that metabolizes atrazine in vitro incubations. The pathways of formation of different metabolites were determined.

Analytical methodology and chemistry of pesticides. A study of the dealkylation of dimethyl phosphorothioates with various nucleophiles indicated *p*-nitrothiophenol to

be the most efficient in forming the thiono isomer of the demethyl product, which was irreversibly converted to the thiole isomer (isodemethyl product) on standing at room temperature or more rapidly on heating.

The hydrolysis of atrazine in aqueous fulvic acid solution was studied. The effects of pH and concentrations of the herbicide and fulvic acid on the rates of hydrolysis were determined.

The photochemical stability to ultraviolet (UV) radiation of atrazine in aqueous solution in the presence of fulvic acid solution was greater at low than at high pH. The photolysis followed first-order kinetics with respect to herbicide concentrations. The photolysis of atrazine in water yielded the 2-hydroxy analogue only, but in the presence of fulvic acid three *N*-dealkylated products were also formed.

The mechanism of hydrogen peroxide and hypochlorite mediated oxidations of ethylenethiourea (ETU) was reinvestigated. Hydrogen peroxide oxidation of ETU leads (via $ETU-O_2$) to 2-imidazoline hydrosulfate or ethylene urea (EU) or both, with 2-imidazoline sulfonate as a minor product. Base hydrolysis of the former resulted in ethylenediamine via *N*-formyl ethylenediamine. Jaffe's base [1-(2'-imisazolin-2'-yl)-2-imidazolidinethione] may be hydrolyzed to ETU and EU. However, if present as a surface contaminant on field-treated produce, the capacity of this product to degrade to ETU may be eliminated by pretreating the produce with an alkaline oxidative waste.

SOIL CHEMISTRY AND BIOLOGY

Inorganic chemistry

Cadmium in soils. The disposal of cadmium-containing sewage sludges and industrial wastes on soils may increase concentrations of soil cadmium that may enter the food chain through plant uptake and exert toxic effects. For the soils studied, proportions of fixed relative to adsorbed cadmium were small (4–9%). Concentrations of adsorbed and fixed cadmium correlated well with the cation exchange capacity and the organic matter content.

Clay mineralogy of Canadian soils. Mineralogical data of Canadian soils were compiled from the literature published from 1937 to 1977. The data showed that clay minerals

in subsoils were mainly inherited from bed-rocks and that genetic soil types could not be characterized simply by specific assemblages of the clay mineral content. The data also showed that Podzolic soils exhibited the most prominent mineral transformations among all Canadian genetic soil types.

Mineralogical analyses of 100 Canadian soil profiles were carried out in 1977 and 1978 for the soil tours that were organized in connection with the 11th Congress of the International Society of Soil Science in Edmonton in 1978.

Mineralogical analysis of Maritime soils, containing cemented subsoil horizons, were carried out to contribute to the elucidation of the nature of cementing material in these soils.

Hydration reactions and identification of clay minerals. Smectite and vermiculite are common soil clay minerals that can be distinguished from each other using criteria based on hydration characteristics. Because this distinction is often difficult, research was conducted to understand hydration characteristics of these minerals in terms of layer charge and charge location. The results indicated that there was no discontinuity in the parameters by which the two minerals could be distinguished.

When interlayer potassium ions in micas were replaced by hydrated ions, the micas became vermiculitic. In this hydration process, the cationic distribution in interlayer positions appeared to be related to tetrahedral Al-Si substitution and microcrystal distortion of the original mica.

Relationships of clay content, specific surface area, and mineralogy to physical soil behavior. Clay content, clay mineral composition, and specific surface area have a major influence on the shrinking and swelling behavior of soils. Shrink-swell potential, expressed as COLE, was closely related to clay content for soils having similar clay mineral compositions. COLE was more closely related to specific surface area than to clay content for soils having diverse clay mineral compositions. Equations predicting COLE from clay content and specific surface area were formulated for different groups of soils.

Stability and exchange characteristics of interlayered clay. Aluminum hydrous oxides are often present in interlayers of expanding

layer silicates in acid soils. Such interlayer material reduces the cation-exchange capacity of expanding clay. On equilibration with sulfate solutions the aluminum hydroxide in montmorillonite interlayers reacted with sulfate ions, forming a neutral precipitate which vacated the interlayer and so freed blocked exchange sites.

Characterization and quantification of inorganic soil components including poorly crystalline and noncrystalline components. Poorly crystalline and noncrystalline aluminum silicates and aluminum and iron hydrous oxides are of widespread occurrence in soils. Analyses of poorly crystalline and noncrystalline soil components in some British Columbia soils showed evidence for the presence of imogolite, a poorly crystalline fibrous aluminosilicate, previously not positively identified in Canadian soils.

Analyses of iron hydrous oxides in soils showed the presence of lepidocrocite (α -FeOOH) in five poorly drained acid Canadian soils. This mineral has seldom been found in Canadian soils and is difficult to identify unequivocally in soils.

Characterization of iron oxide minerals in soils indicated that Mössbauer spectroscopy was especially useful for the identification of small amounts of these minerals, which are far below X-ray detection limits, as well as for providing information on particle size, on $\text{Fe}^{2+}/\text{Fe}^{3+}$ ratios, and on "amorphous" fractions.

In addition to the aforementioned procedures, a basic X-ray procedure was developed to facilitate quantification of minerals in soils and to improve the quality of soil mineralogical data.

Microbial interactions with iron compounds and other soil minerals in relation to acid sulfate soils and to clogging of agricultural tile drains. The reaction of concern in acid sulfate soils is the microbial formation (by *Thiobacillus ferrooxidans*) of basic ferric sulfate minerals. These minerals, of which $[\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6]$ is most commonly found in soils, are indicative of strongly acid and corrosive soil conditions. Studies have shown that: (a) the K or Na required for the microbial basic ferric sulfate formation in soils can be supplied by micas and feldspars causing specific alterations in these minerals, and (b) the rates of microbial formation of the different forms of basic ferric sulfates

crystallizing at room conditions in the presence and absence of clay follow the order K form > NH₄ form > Na form.

Clogging and sealing of farmers' field drains by iron oxide (ocher) is very extensive in the poorly drained soils of Ontario. It has been found that microbes such as *Sphaerotilus natans* and *Gallionella ferruginea* play a major role in the clogging of field drains.

Interaction of soil organic matter with iron oxides. When fulvic acid was added to Fe(III) hydroxide gels, crystallization of iron oxide minerals depended on the concentration of the fulvic acid and the pH of the system. Crystalline iron oxides were formed most readily at high pH but their formation decreased with increases in the concentration of fulvic acid. However, when Fe - fulvic acid complexes were used as starting materials, no crystallization of Fe(III) oxides was observed. These findings may explain the failure to detect substantial concentrations of crystalline oxides in even relatively iron-rich Canadian soils.

Organic chemistry

"Unknown" nitrogen in soils. About 50% of the total nitrogen in soils has so far not been identified. A procedure was developed for the isolation from soils of fractions rich in "unknown" nitrogen. The most purified of these fractions was readily degraded by soil microorganisms at pH 7.0; the rate of biodegradation was more rapid when the fraction was admixed with sand than with clay. The data suggested that most of the "unknown" nitrogen occurred in the form of nucleic acid bases. The lower the total soil nitrogen content, the greater the proportion of that nitrogen that was present in purines + pyrimidines. The purines and pyrimidines detected in soils appeared to originate mainly from microbial DNA.

Interactions of "protein-like" materials in fulvic acid. Shaking dilute, aqueous fulvic acid solution with montmorillonite removed about 40% of the "protein-like" fulvic acid components along with about the same proportion of the fulvic acid weight. About 65% of the "protein-like" fulvic acid components were reversibly adsorbed in clay interlayers, 20% were reversibly adsorbed on external clay surfaces, but 15% were adsorbed irreversibly. The data indicated that "protein-like" materials occurred uniformly throughout the fulvic acid structure, strongly

associated with major fulvic acid components.

Chemistry of humic and fulvic acids. Characterization of humic and fulvic acids extracted from soils from widely differing origins showed that all humic substances had essentially similar chemical structures and characteristics. Major humic "building blocks" were in all instances complex phenolic and benzenecarboxylic structures. Physicochemical studies showed that humic and fulvic acids behaved like flexible polyelectrolytes, aggregating at low pH, most likely through H-bonding, but dispersing at high pH because of increased dissociation of functional groups and subsequent repulsion of particles.

The surface tension of water was lowered by the addition of humic and fulvic acids. The more humic or fulvic acid was added and the higher the pH, the lower the surface tension. The results suggest that if there is a deficiency of fulvic acid in the soil solution, water repellency will result, but if there is an ample supply of fulvic acid, soil wettability increases.

Humic and fulvic acid extracted from suspended and bottom sediments of small agricultural watersheds in southern Ontario were similar to humic and fulvic acids from adjacent soils in chemical and surface structural features. From the results it appeared that humic substances in bottom sediments of agricultural streams originated from adjacent soils.

Soil pesticide - microbe interactions in organic soils. The tendency of organic soils to retain pesticides may affect the environmental quality of these soils, crop contamination, production costs, choice of subsequent crops, and the development of resistant strains of pests. Research was, therefore, continued on pesticide management in collaboration with the Saint-Jean Research Station.

Disulfoton, prometryne, and permethrin field-applied to carrots and lettuce crops at about recommended rates influenced soil microbial population and activities significantly but the effects were generally temporary.

A similar study on the effect of D.D., Vortex, Telone, Bunema, Temik, Menacur, Vydate, Nematak, and Furadan nematocides applied to fields growing carrots has also been completed. Stimulation of Furadan was

noteworthy and consistent with results of previous work.

Fourteen chemical analogues of soil humic acids were synthesized and characterized. A portion of a Methoxychlor- ^{14}C present during the synthesis of one of these analogues was found to be incorporated, thus indicating one of the mechanisms by which pesticides may be retained by soil humus.

Characterization and classification of organic soils. A novel method was developed for assessing the degree of humification of organic soils. The method involves determination of the free radical content in alkaline extracts of the organic soils, with the free radical content being directly proportional to the degree of humification. The method was used for the characterization of organic soils from across Canada.

A study of 26 samples from five peat bogs showed that relative biodegradability was best indicated, compared to many other properties, by the content of fibers which withstands rubbing.

Acid hydrolyses of peats showed that the neutral monosaccharide composition was a characteristic feature. Ratios of amounts of arabinose to xylose were related to the degree of decomposition. The neutral monosaccharide composition was greatly affected by the particle size of the peat.

Subsidence of organic soils. Efforts to devise and develop an effective, economic, and safe method of mitigating organic soil loss are continuing. Studies showed that both the rate of carbon loss through aerobic soil microbial respiration and the level of an 'indicator' enzyme were correlated with copper in the soils. Further, soil respiration (C loss) under field conditions was noted to decrease by 66% where Cu had been increased by 150 ppm in a 2 ha field. The desirability of recommending application of copper (20–100 kg/ha) for slowing down mass loss and subsidence is being tested in two series of microplots at Sainte-Clothilde, P.Q. At the same time, the behavior of the soil-Cu in the 2 ha field was probed to a depth of up to 100 cm. The residual fertilizer copper appears to stay in the top layer of the organic soil, thus posing no threat to the quality of the drainage waters and also indicating that there is no need for repeated copper applications. Another series of experiments showed that copper toxicity will not occur at the levels of copper applications that

are being envisaged. Further work along these lines is in progress.

The activity of the enzyme acid phosphatase was significantly related to actual rates of biological degradation, suggesting that certain extracellular degradative enzymes play an important role in the decomposition (and subsidence) of organic soils.

SYMBIOTIC NITROGEN FIXATION

A new research program designed to study and subsequently to enhance the nitrogen fixation capacity of the *Rhizobium*-alfalfa symbiotic system was initiated in 1977. It is an integrated approach directed towards improvement of symbiont bacteria and the host plant, and an understanding of the biochemical and physiological parameters involved in this interaction. The following outlines the essential preliminary research carried out in preparation for future investigations to meet the program objectives.

Improvements of *Rhizobium* species

A national culture collection consisting of approximately 30 strains of *Rhizobium meliloti* and *R. japonicum* has been established. Twenty-five strains of *R. meliloti* have been tested for their infectivity and effectivity with six alfalfa cultivars. All were capable of inducing nodule formation. Their ability to fix nitrogen symbiotically, however, differed significantly. Five strains were classified as superior and 19 as average in effectivity. One strain was unable to fix nitrogen and was classified as ineffective. A plastic pouch technique has been adapted to provide increased statistical significance in determining the nitrogen-fixing efficiency of *R. meliloti* strains with less effort but consistent reproducibility.

It was essential to develop methods for strain identification before evaluation of *R. meliloti* strains isolated from natural soil for their nitrogen-fixing ability. Satisfactory progress towards their development has been made. Antisera against four strains of *R. meliloti* were produced and methods were developed for analyzing their surface and internal antigens. This method has been successfully tested to distinguish and differentiate three strains of *R. meliloti*.

Thirteen rhizophages have been isolated from two local alfalfa fields by the enrichment method. They were tested with the *R. meliloti* strains in our collection. The pattern obtained indicated that 8 of 13 can be used to group the rhizobia for identification. Further work to characterize the rhizophages for the purpose of single-strain identification is being carried out.

R. meliloti mutants resistant to four different antibiotics were isolated and tested for their nitrogen-fixing ability. No quantitative differences in either infectivity or effectivity were found. The antibiotic resistance of these mutants was stable during passage through alfalfa nodules as shown by the tests following reisolation from the nodules. Double antibiotic-resistant mutants were made from these and they were also found to be stable after passage through the plants indicative of their usefulness for genetic work.

Thymidine, a specific precursor of DNA synthesis was rapidly degraded by *R. meliloti* cells. This limited its use for prolonged labeling of *R. meliloti* DNA for preparation and isolation of cellular plasmid DNA. A method was developed which reduced the degradation of thymidine and enhanced the incorporation of labeled thymidine into DNA by three- to four-fold. The possible role of plasmid DNA in the process of nitrogen fixation was examined by effecting their elimination from *R. meliloti* cells by chemical treatments and testing the single-colony isolates for their symbiotic effectiveness. Although the cells treated for plasmid elimination showed normal ability for N_2 fixation, the complete absence of any plasmids in the cells could not be fully ascertained due to usually low recoveries.

Improvement of host plants

Cuttings and seed stock of both alfalfa and soybean cultivars have been examined for symbiotic efficiency. An assay system for determining the nitrogen-fixation efficiency of *Rhizobium* - *Medicago sativa* symbiotic association with whole plants has been developed. The system has been successfully used to identify optimal combination of *Medicago* and *Rhizobium* strains. About 20 "best" alfalfa plants have been selected for self- and cross-breeding. Seeds of F_1 plants should be available shortly. Plants have also been selected from high- and low-protein

content and were propagated for supply of seeds.

Biological nitrogen-fixation process

A complex relationship was found to exist between CO_2 concentration, nitrogen supply, and plant growth kinetics of alfalfa. The growth of nodulated plants was slower than unnodulated plants in the presence of limited amount of available nitrogen. Carbon dioxide stimulation of growth depended on nitrogen supply. Nitrate levels in growth medium were found to be critical in the establishment of nodules. High nitrate levels completely inhibited nodulation while some nitrogen was required for effective nodulation.

It has been established that nitrogen fixation in alfalfa is limited by photosynthesis. This was shown by the dependence of nitrogen fixation on light intensity and on the concentration of carbon dioxide in the air in the manner characteristic of photosynthesis. At high (saturating) light intensity, quadrupled (saturating) CO_2 concentration doubled the rate of growth and the size of 1-mo-old plants. The plant growth parameter (coefficient) that relates rate and size was not affected by high light intensity and CO_2 concentration, indicating that some nonphotosynthetic process was limiting plant growth in the enriched environment. The corresponding growth parameter for directly measured nitrogen-fixing activity on the other hand was enhanced further by high light intensity, and it was doubled again by quadrupled CO_2 concentration. We are now developing a rapid testing and selection system for plants for high photosynthetic activity.

In the 1st mo of growth the enhanced CO_2 concentration was necessary to make the symbiotic plants (inoculated with *Rhizobium*) exceed the growth of sterile plants under partial NO_3 deficiency. However, fully NO_3 fertilized plants also benefited from raised light intensity and CO_2 concentration such that symbiotic growth never exceeded 30% of the growth in unlimited CO_3 . This demonstrated the scope for genetic improvement.

Gas chromatographic procedures were developed for determination of hydrogen production, CO_2 production, and acetylene reduction. These methods allow determination of the efficiency of nitrogen fixation in

isolated nodules, bacteroids, and nitrogenase preparations. Bacteria and bacteroids were isolated from both alfalfa and soybean nodules and inoculated into a synthetic medium which had been equilibrated with a gas mixture containing 1% O₂. The bacterial cells which grew on this medium developed nitrogenase activity in the absence of plant cells or extracts. The identity of bacterial strains present in the culture is being determined. The ultimate aim of this work is to study the rhizobial nitrogenase enzyme system in the absence of plant host.

WINTERHARDINESS

Environmental factors associated with overwintering injury to winter cereals

Cultivation of winter cereals in eastern Ontario is generally unsuccessful due to the lack of cultivars capable of withstanding the adverse winter conditions in this area. Investigations are continuing to determine the relationship between specific environmental conditions and overwintering injury to cereals, and into the development and application of better methods of selection of winter cereals more resistant to overwintering damage.

Damaging effects of natural ice sheeting in the Ottawa area could not be assessed during the winter of 1976-1977 because of lack of icing conditions and consequent high survival of winter wheat in the area. However, artificially applied icing in plots generated typical icing injury with greater survival obtained in Kharkov than in Fredrick winter wheat. Decline in oxygen consumption and proliferation of membranes in the form of ultrastructurally visible whorls of membranes, the latter probably of endoplasmic reticulum origin, were distinctive metabolic and cytological features of ice-encased plants. During the winter of 1977-1978, survival of winter cereals was relatively high, but in contrast with previous years, greater damage was observed in control than in artificially iced plots. This unusual observation resulted from protection of the plants from attack by fungal pathogens (snow mold) afforded by the ice cover, which itself did not induce serious injury because the soil was not saturated when frozen. The observations of widespread incidence of snow mold in the spring of 1978 indicates that damage from this source may play an important role in some years of

overwintering losses of cereals in eastern Ontario.

Laboratory studies continue to disclose rapid accumulations of anaerobic metabolites such as ethanol, lactic acid, and CO₂ in ice-encased plants. Application of these metabolites singly at low temperature to plants without icing elicited only slight injury, but when applied to plants in combination at levels observed under ice-encasement conditions, both the injury and the characteristic membrane proliferation associated with ice encasement were observed. Injury by ice encasement or by externally applied anaerobic metabolites is preceded by a marked increase in cell permeability. Lipid analyses and studies with inhibitors of protein synthesis of membrane fractions from iced and non-iced encased plants have shown that the membrane proliferation during ice encasement derives not from new net synthesis of lipids and protein, but rather from reorganization of existing membrane elements within the cell.

Direct flooding at low temperature without ice encasement under controlled environment conditions caused accumulation of toxic anaerobic metabolites and induced many of the injurious, ultrastructural, and metabolic changes observed after icing. Due to its frequent occurrence under some fall and spring conditions, flooding also may be an important factor in winter survival of cereals in Ontario.

Studies have continued into the development of better methods of selection of hardier winter cereals. An important development in this area is the observation that while the cold hardiness of various winter lines of wheat has been found to be correlated to some extent with tolerance for ice encasement, there is sufficient variation to warrant independent selection for resistance to ice encasement in addition to that for cold hardiness as measured by freezing in air at different temperatures.

Development of a protoplast system for cold hardiness studies

Investigations have continued in an effort to develop a free protoplast system suitable for studying cold hardiness and freezing injury of plants. This will provide, through elimination of the cell wall barrier, a better system for examination of the relationship

between cytological and biochemical properties of the plasma membrane and cold hardness. Initial microscopic studies have demonstrated that free protoplasts undergo the same freezing and thawing behavior and stresses as do their normal parent cells. A medium has now been developed which enables protoplasts to be frozen in bulk in a programmed freezer. Using this medium, it was shown that protoplasts prepared from hardy winter rye seedling epicotyls tolerated freezing better than those from unhardy seedlings and also showed greater resistance to dehydration during plasmolysis in strong salt solutions.

The incorporation of fatty acid spin labels into membranes of higher plant cells also has been made possible by the use of protoplasts isolated from hardened and nonhardened winter rye. Analyses by electron spin resonance indicated that during freezing, the removal of water around the membrane had a profound influence on the microviscosity and order of the lipid arrangement in the membrane and this change in order may be a cause of injury. Protoplasts also have been prepared from the living bark of summer and winter trees and these protoplasts have been shown to retain all the respective properties of susceptibility or of extreme resistance to freezing and osmotic dehydration of the cells from which they were prepared. The availability of such protoplasts should now enable the properties of the plasma membranes of even the hardest plant cells to be studied with similar facility.

Desiccation and freezing studies on winter rye seedlings

Studies on the effect of desiccation stress are of considerable interest in our efforts to understand the basic mechanisms of induction of cold resistance in plants and also the relationship of drought to freezing resistance. The induction of cold resistance in the epicotyls and coleoptiles of winter rye seedlings by simple desiccation at room temperatures in the dark has been established. Restriction of growth of seedlings by desiccation induces an increase in osmotic concentration and an accumulation of protein in the epicotyls and coleoptiles with accompanying increase in both their cold resistance (tolerance to -12°C) and plasmolysis resistance. The same degree of cold resistance in the

entire seedling, however, has not yet been achieved under these desiccating conditions.

New methods to examine ultrastructural changes in the membranes and the protoplasm of rye cells during freezing and hyperosmotic stress enable the location of ultrastructural changes at the moment of stress to be made. Results obtained confirmed that one of the mechanisms of freezing injury may be a destruction of the membranes caused by irreversible coagulation of lipid or lipoproteins during freezing.

Chloroplast membrane proteins

A possible role of membrane proteins in the development of cold hardness is being investigated. Since ribulose diphosphate carboxylase is the major leaf protein which changes during hardening, it has been selected for further study. The amino acid composition of purified ribulose diphosphate carboxylase isolated from fraction I protein of chloroplasts from cold-hardened and unhardened rye plants was identical. However, titrations of sulfhydryl groups revealed twice as many exposed groups in the unhardened enzyme and that its further unfolding in the presence of sodium dodecyl sulfate (SDS) was more rapid. Further evidence of important structural changes which occur in chloroplast membrane proteins during cold hardening was obtained from SDS gel electrophoresis studies. Large and small subunits of 55 000 and 14 000 molecular weights were separated from hardy and unhardy chloroplasts while an additional band corresponding to a dimer (mol wt 110 000) of the large subunit appeared only from the unhardened enzyme. Because of these structural changes occurring in the enzyme during hardening, the enzyme becomes more resistant to deformation and inactivation by low temperature and its catalytic efficiency for photosynthesis at low temperature is also enhanced.

ANALYTICAL CHEMISTRY SERVICES

The Institute continued to provide Branch establishments with a comprehensive analytical chemistry service. The overall productivity of this section doubled in 1978.

Amino acid analysis laboratory

About 860 protein hydrolysates and 340 physiological fluid samples were analyzed in 1977. The comparable figures for 1978 were 2410 and 560, respectively.

Instrumentation Centre

This unit cooperated with several Branch establishments in the identification and/or confirmation of organic compounds by producing 1750 mass spectra and 437 NMR and IR spectra in 1977 as compared to 2895 and 466 spectra, respectively, in 1978. The Centre also published a reference guide of about 250 pesticides and their metabolites.

Micro analytical laboratory

The purchase of a Coleman carbon and nitrogen analyzer increased the productivity of this laboratory in 1977, when 1224 samples were analyzed. The productivity was further increased in 1978 with the analyses of 1774 samples.

Technological Services Unit

This unit performed 32 129 analyses for a variety of constituents in 1977 as compared to about 79 000 in 1978. The unit adopted a computerized system for recording and processing of analytical data. In addition, a method was developed for determining molybdenum in biological samples.

ELECTRON MICROSCOPE CENTRE

The Electron Microscope Centre continues to provide facilities and expertise for electron microscopy and associated techniques to various Branch establishments, universities in Ottawa, and other government agencies.

The effectiveness of the Centre was increased in 1977 by the installation of an AMR 1000A scanning microscope with a lanthanum hexaboride gun which provides

greater resolution and reliability. A film thickness monitor was installed in the Edwards 12E6 coating unit to aid in developmental work for the ultra-thin coating of scan specimens. The capability of the Centre was further expanded by the addition of a Kevex X-ray (fluorescence) spectrometer on the Cambridge Stereoscan MKIIA. In 1978 a Polaron freeze-fracture module was installed and a multiple-sample holder designed and fabricated.

Research investigations were concerned with a diversity of subjects of agricultural significance (dairy products; egg shells; fungal, bacterial, plant, and animal cells; insects; host-parasite interactions; clays; minerals; soil organic matter). In addition the Centre also provided resources for some notable developmental work. A freeze-fracture, thaw fix method (FfTF) was developed for plant tissue using a cryoprotectant (DMSO). This method allows soluble proteins to diffuse out prior to fixation revealing cytoskeletal components normally not seen in scanning electron microscopy (SEM) of cells fixed prior to fracturing and thawing. This technique has been used successfully to determine the *in situ* arrangement of cellular bodies in carrot protoplasts and leaf mesophyll cells. More recently this method has been extended and used to demonstrate the helical substructure of the chromatin in the nuclei of chicken erythrocytes at a resolution comparable to transmission electron microscopy (TEM). This ability to view the spatial arrangements of cellular organelles in three-dimension SEM is a marked advancement over serial section reconstruction using TEM. Pioneering studies on the SEM of the texture and microstructure of dairy products (cheese, yogurt, and cottage cheese) have resulted in methodologies for the preservation of these products with the minimum of artifacts. These methods have very practical application in following cheese processing, producer-product comparisons, and monitoring dehydration processes.

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INTRODUCTION

The research and development program of the Food Research Institute became more closely aligned to the Department's newly stated high priority of research in food science and technology during the period of reporting. An interim food program was introduced into the Research Branch program in 1977, and this became a permanent part of Branch and Departmental objectives in 1978. The Institute initiated a reorganization during 1978, which established four program teams concentrating their activities on food quality, food processing, new food ingredients, and food safety and nutrition. As in previous years, a continued increase in interaction with the food industry was seen, with a resulting emphasis in the Institute program upon those research subjects deemed to be of high priority by the private sector. All members of the Institute now serve in one or another working group or committee which bears responsibility for guiding our program toward important and economically attractive goals. This period has also seen a marked increase in the amount of contracted-out R and D, and this Institute has maintained a broad contract research program totaling in amount a sum equal to its in-house R and D activities.

During 1977-1978 some members retired and others left the Institute to continue their activities elsewhere. The Institute welcomed Drs. D. Wood and R. Holley to its staff and to the meat research part of its program.

Enquires regarding any aspect of the Institute program and for reprints of its publications are welcomed, and should be directed to the Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

John Holme
Director

FOOD PROCESSING

Curing of Cheddar cheese

Good Cheddar cheese is a very important Canadian dairy product. A serious marketing deterrent, particularly for export markets, is the high cost of storing for the 2-yr ripening period essential to full flavor development. A cooperative project involving the ministries of agriculture for Ontario, Quebec, and the Federal Government has been undertaken to test the hypothesis that higher storage temperatures might produce aged Cheddar cheese in less time. The experimentation is almost complete and the results are encouraging. Unfortunately, off-flavor appears to develop more frequently at higher storage temperatures, which may cause some concern. Overall, the cooperants are confident that some manufacturers will be able to shorten ripening time by storing their Cheddar in the temperature range 5-10°C for at least part of the ripening period.

Microstructure of dairy products

A special fixation procedure has been developed to facilitate the study of the structure of pudding gels made from mixtures of milk and low methoxyl pectin. Cocoa powder was found to interfere with good gel formation due to the competing action of phytate for the available calcium ions which are an integral part of the pectate gel structure.

Curd granule junctions have been found in various cheeses by scanning electron microscopy and shown to be related to the manufacturing process used. In Cheddar cheese these granule junctions were noted to contain less fat than in the internal areas of the curd granules. These different patterns assist in determining whether the declared process (cheddaring, stretching, etc.) has indeed been employed. Further SEM studies have resulted in a proposed model which explains the development of the microstructure of Cheddar cheese and the importance of fat globules.

Microstructure of the superficial layer of cottage cheese granules was studied by electron microscopy as it relates to porosity,

important for whey expulsion from the granules during cooking. In commercial cottage cheese, casein micelles at the granule surface were compacted to a greater extent than those in the interior of the granules but no impervious membrane (such as was hypothesized by earlier researchers) could be found. In high-quality cottage cheese the pores between the compacted micelles were large enough to allow a free passage of whey outwards and dressing (cream) inwards. It has been concluded that the defects in cottage cheese attributed to the existence of a hypothetical skin are the result of changes in the overall microstructure of the cottage cheese protein matrix.

The rheological properties and microstructure of acid milk gels have been further studied as a function of type of acidulant, temperature of gelation, and pretreatment of milk. Gels made with glucono- δ -lactone were firmer and showed less syneresis than those made with hydrochloric, citric, or oxalic acids. Firmness increased with temperature of gelation. Gels made with fresh skim milk were firmer than those made with NFDM. Microstructure (TEM, freeze fracturing, and SEM) varied predictably with treatment. An unusual core-like structure of casein micelles in gels at pH 5.5 was seen with all acidulants.

Milk-coagulating enzymes

In times when rennet becomes in short supply it is important to identify alternative enzymes which will coagulate milk and produce Cheddar cheese of good quality and in good yield. Protein losses in cheese whey, while unavoidable, must be kept to a minimum since all such coagulating enzymes are proteolytic in nature. Yield loss measurements are extremely difficult to perform in commercial plants; a laboratory method has been devised whereby cheese making is done in small beakers thus affording strict control of sampling and analysis. Using this technique porcine, bovine, and chicken pepsins have been compared to calf rennet in Cheddar cheese making. The first two give lower yields estimated at about 0.1–0.2%, while chicken pepsin and a microbial enzyme preparation gave higher loss values of around 0.5%.

Bacterial genetics

A comprehensive study of the genetics of bacterial starter cultures has led to the conclusion that the lactose-metabolizing genes involved in milk coagulation are located on the plasmid DNA and are thereby unstable.

Starter cultures often fail because of attack by bacteriophages. Strains have been isolated which have shown selective resistance to different phages, one strain showing resistance to at least 29 bacteriophages in addition to some commonly used antibiotics and metal-ion inhibitors. The possibility therefore exists for use of such a culture in Cheddar manufacture.

Indications that bitter flavor development may be under the control of bacterial genes have been found.

Microbiology

The effect of heat on a number of heat-resistant microorganisms has been studied over a wide pH range. At pH 4.6 and above where *C. botulinum* can germinate and grow, full sterilization (as is presently used for neutral foods) is required to ensure safety. Below pH 4.6 where this organism does not germinate and grow, heat treatments need only prevent spoilage. It is suggested that acid foods of this nature are presently being processed at higher temperatures than are necessary for shelf stability.

Proposed regulations under the Food and Drug Act will require cheese to meet coliform standards. Studies have shown that the Violet Red Bile plate count method (VRB) involving incubation at 45°C is quicker and cheaper than present procedures and sufficiently accurate and reliable for control purposes.

Sanitary conditions in most egg-grading stations have been identified as poor; packaged eggs have shown high bacterial loads which further contributes to household sanitation problems. Regulations are under consideration for improved wash water quality standards.

Mechanisms of extrusion cooking

The effects of chlorination on the extrusion characteristics of soft wheat flour have been described. Cl₂ treatment allows easier penetration of water into the starch granules resulting in improved cooking with less starch degradation. These findings have been related to the role of chlorine in cake flour

performance. Component interaction studies have shown that devital gluten competes more for available water than vital gluten in a starch-gluten mixture which results in an extrudate exhibiting increased starch damage and low product viscosity. Addition of wheat flour solubles lessens this degradative effect. Present results indicate that the starch in an intact unbleached flour is less degraded than starch in any composite and highlights the role of water in these systems.

A novel horizontally split extruder barrel has been designed and built which affords the opportunity of observing the state of the screw contents at the completion of an extrusion experiment.

Meat products

The texture of wiener products can be satisfactorily measured by the Universal Food Rheometer and related to sensory assessments. This instrument has also been used to measure various linear deformation properties of wiener batters, including stickiness, for correlation with wiener texture and yield. Contract work conducted by J. M. Schneider Inc. has demonstrated synergistic effects of mixing meat with other proteins when assessed in model system functionality tests.

Work contracted to the University of Waterloo has provided microscopic techniques to assess wiener batter structure. Structural changes due to extender proteins and processing conditions have been identified.

Horseradish

At the request of a producer in Ontario a feasibility study was done to compare conventional dehydration procedures to freeze-drying for obtaining a good-quality product. A good correlation was obtained between chemical analysis for characteristic isothiocyanates and sensory evaluation.

FOOD QUALITY

Amino acid methodology

New chromatographic methods have been developed for determining the amounts of collagen, elastin, and myofibrillar proteins in beef muscles, and for assessing the total meat and connective tissue content in meats and meat products. These new approaches have been effectively employed for evaluating the

protein quality and essential amino acid index of animal protein supplements such as fish, meat, and bone meals, and in a collaborative study with Dr. H. W. Hulan of the Research Station, Kentville, N.S., the nutritive value and quality of squid meal as a dietary protein supplement in broiler diets have been determined. Using the same methodology, attempts have been made, in collaboration with E. Larmond (FRI) and Dr. J. I. Elliot of ARI, to relate the chemical and structural changes in postrigor pork muscle to carcass quality.

A simple new chromatographic method has been developed for determining tryptophan and lysinoalanine in both plant and animal tissues.

Rigor mortis investigations

The long-term research on rigor mortis and its effect on the physicochemical properties of beef muscle proteins have continued. The denaturation studies at Memorial University showed that the thermal unfolding of cardiac G-actin as it occurs during rigor and processing is a reversible two-state transition, and the molecule has a temperature of maximum stability near -5°C . Contract research at the University of Alberta on beef carcass handling has made many significant findings for improving the traditional handling of beef carcasses in centralized boxed beef operations. Canada Packers Ltd., on a contract research program, has developed an immunochemical method for the identification and quantitation of soya proteins in cooked and uncooked meat mixtures.

Cheddar cheese flavor

It has been established that the greatest contribution to the total intensity of Cheddar cheese flavor is made by components that are nonvolatile and water soluble. This water-soluble fraction contains salts and degradation products from proteins, components that have been considered essential to the flavor but of relatively less importance than the aroma components. This new information will provide impetus for renewed and redirected efforts to accelerate the ripening of cheese.

Whey flavor

A study of the flavor of cottage cheese whey has provided evidence on the identity of components responsible for the objectionable flavor that limits the use of acid whey in bland products. Components that create brothy, buttery, bitter, and acid flavors are principally responsible. These include amino acids and peptides, diacetyl, acetic and lactic acids, and their salts. Neutralization of whey and ion-exchange treatment markedly alters its flavor. The major portion of the components causing the objectional flavor is dialyzable.

Meat quality

Sensory evaluation of meat that results from animal studies at Branch research stations is continuing. In a cooperative project with Animal Research Institute the eating quality of meat from once-bred gilts was determined by sensory evaluation. In two experiments unbred control animals slaughtered at market weight yielded more tender meat than animals that had been bred. In the second experiment where the diets of the experimental animals were very restricted in order to prevent excessive gains the meat was quite tough.

In collaboration with the Melfort Research Station beef and lamb from animals fed diets containing different ratios of grain to hay were evaluated. The lower levels of grain had no adverse effect on meat quality.

In collaboration with Kentville Research Station chickens fed 10% and 15% squid meal in the diet were found to have a fishy flavor. Those fed 5% squid meal did not have any off-flavor.

Sensory evaluation of turkeys fed Candle rapeseed meal (RSM) at the Swift Current Research Station showed very few differences related to the level of RSM in the diet. Birds fed higher levels of RSP weighed less at slaughter, received slightly lower carcass grades for finish, and were less juicy. This could possibly be corrected by feeding for a few extra days.

Durum wheat

The international collaborative study of a durum wheat and pasta quality was completed and the report sent to the collaborators. A total of 239 different tests were performed on 20 samples of wheat, semolina, and uncooked and cooked spaghetti by 16

laboratories in North America and Europe. Multiple linear regression analysis showed that certain objective tests of wheat, semolina, and cooked pasta can be used to predict sensory firmness.

Functional properties of plant proteins

Heat-induced viscosity increases of protein suspensions have been demonstrated by selective physical and chemical treatments indicating the possibility of modifying proteins to impart desired functional properties. Contract research at the University of British Columbia has resulted in the development of techniques to increase the solubility of rapeseed protein isolates and to modify the rheological properties both in solutions and gels. A method for measuring the water hydration capacity of proteinaceous materials was developed in the Institute and has been presented to the American Association of Cereal Chemists for consideration as a standard method of analysis.

White beans

An extensive survey of 65 fields of white bean in Ontario showed markedly varied mold contamination. Evaluation of off-odor by sniff test, and by taste panels following canning, showed samples with high mold counts were unacceptable. The phenolic off-flavor of concern in exported beans was identified in collaboration with U.K. Laboratories as 6-chloro-*O*-cresol which has a taste threshold of 0.5 ppb. This compound occurs as an impurity in herbicide chemicals. The contamination was traced to containers used in transatlantic shipments.

Margarine

Canadian margarines (95 brands) were analyzed for fatty acid composition with particular reference to polyunsaturated and *trans*-fatty acids. High levels of *trans*-acids were noted. Fifty percent of samples had less than 10% *cis-cis*-methylene interrupted unsaturated fatty acids.

FOOD SAFETY AND NUTRITION

Cruciferous crops

A large number of cruciferous crops have been studied for their glucosinolate content. Preliminary work was directed towards the assessment of the average daily intake of

glucosinolates, the intervarietal differences, and the effect of processing on cruciferous vegetables. Later studies have involved the analysis of 44 cultivars of rutabaga and turnip, the former being the main contributor of goitritin to the diet.

During the course of the work, some of the methods of analysis were modified and updated and a new method of sample preparation was devised. The application of HPLC to the analysis of glucosinolate hydrolysis products has met with some success.

NEW FOOD INGREDIENTS

Oats

Oat gum. A high-protein oat cultivar, Hinoat, in addition to being a potentially valuable source of starch and protein, contains a polysaccharide gum composed mainly of a mixed-linkage (β -1,3- and β -1,4-) glucan. Variables affecting extraction and properties of the gum have been studied. Thus it has been shown that ungerminated oat flour contains significant β -glucanase activity and this activity can be carried through the alkaline extraction procedure used to extract the gum. Fractions obtained from enzyme-deactivated flour have shown viscosities in excess of 2000 mm²/s at 0.5% (w/v) in water, making this gum a potentially valuable industrial hydrocolloid. It has been shown that direct dyes (used in dyeing of cotton) interact in solution with oat β -glucan to give a dye: β -glucan complex as a precipitate. This reaction can be used to directly isolate oat β -glucan from alkaline extracts of oat flour, and as an analytical detection method for β -glucan based on a red shift in the absorption spectra of the dyes. Studies with various polysaccharides indicate that the dye interaction has specificity for contiguous β -1,4-linked glucopyranosyl units. The interaction has been exploited histochemically to show that most of the β -glucan resides in the endosperm cell walls of the oats and that β -glucan enriched fractions may be obtained from bran fractions of the flour.

Oat starch. Oat starch isolated from the variety Hinoat has the unique property of gelling very quickly when a hot paste is subjected to cooling. This property is unaffected by salt solutions but is markedly affected by urea and to a lesser extent by dilute acetic acid. β -Amylase digestion

studies indicate a more highly branched structure for Hinoat starch in comparison to wheat or corn starch. Gel permeation chromatography has revealed the presence of an intermediate starch fraction which is highly branched. These findings are helping to explain the rather anomalous behavior of Hinoat starch.

A rapid method for the determination of the diastatic activity of cereal flours has been developed using the Ottawa Starch viscometer.

Oat lipids. Lipids of six oat cultivars have been characterized. Increase in total lipid content from 5 to 11% showed a proportional increase in neutral lipid. Ten polar lipid components have been identified and quantitated in Hinoat. Free fatty acid (FFA) development was not related to total lipid content. Steam-treated oats showed a significant degree of inactivation of lipase. The FFA levels were not significantly related to the development of off-flavors in oat cookies.

Oilseeds

Rapeseed protein concentrate. FRI-71 process rapeseed protein concentrate (RPC) has been nutritionally evaluated. Young growing and pregnant rats require Zn supplementation to overcome development of Zn deficiency. With the exception of these Zn factors, believed to be associated with phytic acid content, no abnormalities have been detected in rats fed RPC. These tests indicate that problems with the goitrogenic properties of rapeseed meal have been overcome. An additional problem is found with phenolics, which can effect the appearance, functionality, and nutritive value of rapeseed protein. A major phenolic component, sinapine, has been determined in various rapeseed and mustard seed products and the FRI-71 process shown to remove a considerable proportion of this component.

The true metabolizable energy (TME) of rapeseed meal fractions fed to poultry has been measured. Fractionation produced meals of comparatively high TME values but in most cases the TME recovered was not substantially greater than the TME input.

Carbohydrates of rapeseed. Studies of the carbohydrate of rapeseed were completed. The composition of the low molecular weight carbohydrates is now known and the following polysaccharide components have been isolated and structurally characterized:

xyloglucan (two types, namely hot water soluble with no fucose residues, and alkali soluble with fucose residues), acidic arabinogalactan, arabinan, pectin, acidic xylan, and cellulosic residue. Of these, the major components were pectin, cellulosic residue, and xyloglucan.

Polyphenols. Studies of polyphenols in seed proteins showed that soy, fababean, and rapeseed protein isolates contained soluble and insoluble bound phenolic acids, probably as esters. The insoluble bound acids in soya proteins and rapeseed protein were solubilized by proteolytic enzyme (Pronase) but not by cellulase, indicating that they were associated with the protein, probably as acyl groups on the carbohydrate moiety of the seed glycoprotein. Certain conditions in fractionation procedures (e.g. isoelectric precipitation) appear to encourage phenolic binding, and some of the phenols are covalently bound to the protein or glycoproteins of the seed.

Whey utilization

Efforts to increase the recovery of whey proteins, prepared by acid-heat denaturation were continued. By the use of ultrafiltration (UF), the recovery of whey proteins was increased from 60 to over 90%. The mineral content of the final UF concentrate and starting whey are very similar which allows flexibility in terms of processing. Flux rates are higher if heating is delayed until after UF. Samples of WPC are being prepared by UF to study their functional properties.

In an attempt to understand the physico-chemical basis of the effects of acid-heat denaturation, model studies of the thermal

denaturation and aggregation behavior of β -lactoglobulin were undertaken using techniques such as solubility, electrophoresis, differential scanning calorimetry, and electron microscopy. The nature, rate, and extent of denaturation were shown to be influenced by ionic environment (pH, ionic strength), concentration of protein, and temperature of heating. Higher ionic strength and protein concentration resulted in increased rate and extent of denaturation and destabilization. Thermally induced aggregation reactions were minimal at low pH (2.5) but at higher pH (4.5) were shown to result from disulfide linkages. Rate and kinetics of thermal denaturation of individual proteins of acid cheese whey varied with pH of heating and were more complicated than in model systems.

Amino acid derivatives

Significant advances have been made in studies of the nutritional value of amino acid derivatives. Following development of new synthetic methods, several derivatives of essential amino acids were prepared. Nutritional evaluation in animals and a single cell organism has shown the potential usefulness of the derivatives as vegetable protein fortifiers. Some of the compounds were effective inhibitors of *microconidia* germination and mycelial growth.

Alginates

Studies of the food hydrocolloid alginate have resulted in new methods for isolation of the component uronic acid as their brucine salts. This approach allowed development of a new polarimetric procedure for determination of the mannuronic acid / guluronic acid ratio in alginates.

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D. R. CAMERON, B.Sc., M.Sc., Ph.D. Transferred to Research Station, Swift Current, 30 June 1977	Modeling
L. COSTESCU, B.Sc., Ph.D. Resigned 31 March 1978	Metals and sediments
P. H. CROWN, B.S.A., M.Sc., Ph.D. Resigned 30 June 1977	Alberta soil survey
D. S. GAMBLE, B.Sc., M.Sc., Ph.D. Transferred to CBRI, 1 April 1978	Metal ion - organic interactions
K. C. IVARSON, B.Sc., M.Sc., Ph.D. Transferred to CBRI, 1 April 1978	Microbial processes
B. KLOOSTERMAN, B.S.A., Ph.D. Resigned 14 August 1978	Soil data bank
S. S. KOCAOGLU, B.S. Resigned 12 May 1978	Alberta Soil Survey
H. KODAMA, B.Sc., M.Sc., Ph.D. Transferred to CBRI, 1 April 1978	Clay mineralogy
C. G. KOWALENKO, B.S.A., M.Sc., Ph.D. Transferred to Research Station, Agassiz, 1 April 1978	Nitrogen cycle
E. M. MACDONALD, B.Sc. Resigned 31 March 1978	Pollution and land use
A. J. MACLEAN, B.Sc. (Agr.), M.Sc., Ph.D. Retired 29 December 1978	Metals and fertilizers

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Information systems

INTRODUCTION

In 1977 the Soil Research Institute continued activities in soil survey, research on the properties and behavior of soils, interpretation of the soil inventory, research on methods of evaluation of land for agricultural production, implication and development of the computerized soil data system, and publication of soil maps and of land capability maps. Research was conducted on nutrient and water transport, on nutrient and toxic waste management, and on soil nitrogen.

On 1 April 1978 the institute organization and objectives were changed. The personnel and research programs associated with soil organic matter chemistry, soil nitrogen, and soil clay mineralogy were transferred to the Chemistry and Biology Research Institute. The personnel associated with the agrometeorology program were transferred from the Chemistry and Biology Research Institute to the reorganized institute which was named the Land Resource Research Institute.

The Land Resource Research Institute was established to bring together the main professional disciplines involved in land studies within Agriculture Canada. In view of the growing demands on Canadian land resources, emphasis is on the interpretation of information relevant to the interaction of soils, climate, and hydrology, and to the seasonal dynamics of weather, land use, and food production.

The Land Resource Research Institute programs now are organized along the following lines:

1. Resource inventory and mapping
2. Soil classification
3. Land use and evaluation
4. Agrometeorology and crop identification

This report of activities covers 1977 and 1978. Due to the change of personnel and programs referred to above and the difficulty caused thereby in preserving continuity in the record of research, the reader is referred to the research report of the Chemistry and Biology Research Institute.

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J. S. Clark
Director

RESOURCE INVENTORY AND MAPPING

The soil resource inventory and mapping program involves personnel of the soil survey units throughout Canada and a group at headquarters of the Land Resource Research Institute (LRRI) in Ottawa concerned with soil correlation and cartography. The survey projects are conducted in cooperation with personnel of provincial agencies following working priorities that are established in the provinces through consultation and mutual agreements. Many of the federal soil survey units share offices and other facilities with their provincial counterparts. In the report which follows no distinction is drawn between the contributions of the personnel of the different agencies.

Atlantic region

Newfoundland. Reconnaissance surveys are in progress in the Bonavista, Codroy, Cormack, and Port au Port sheets. The maps for Avalon peninsula were printed and the report is at press. Exploratory surveys are in progress in the Botwood, Sandy Lake, Gander Lake, and Red Indian Lake sheets. Land capability for agriculture maps were printed for St. John's, Bonavista, Belleoram, Botwood, Sandy Lake, Stephenville, and Port aux Basques sheets.

Prince Edward Island. The field work is completed. Compilation of the 350 1:10 000 photobase map sheets is in progress; approximately half are at various stages of cartography in Ottawa. Suitability ratings of soils for various crops have been prepared.

Nova Scotia. The field work was completed in Colchester county, and work was begun in Pictou county. Research was conducted on soil moisture, soil temperature, and water table fluctuations, and soil erodability (K) factor was determined for selected soils.

New Brunswick. The exploratory soil survey of central and northern areas became active; 18% was surveyed. Compilation of soil map and report for the Richibucto-Rogersville was vigorously conducted. A detailed survey was initiated in the Sussex area and detailed investigations were continued in Salisbury Parish, Restigouche planning district, and Gloucester county.

Quebec. The detailed survey conducted by the federal group in the St-Hyacinthe area is proceeding well; about one-third of the area has been surveyed. The report for L'Islet was edited in Ottawa; that for Rivière-du-Loup is ready for editing. Compilation of maps and reports by the provincial group is in progress for Témiscouata, Arthabaska, and Charlevoix.

Ontario. Field surveys were conducted in Haldimand-Norfolk, Ottawa-Carleton regions, and Beverly township of Waterloo county. Provisional maps and legends are compiled each year. Compilation is well advanced in maps and reports in the Cochrane-Kapuskasing, Lakehead, Sault Ste. Marie - Sudbury regions, but less well advanced in the Middlesex, Brant, and Timmins areas. Reports for the Nepean-Gloucester and Peterborough areas are at the printer. Research was conducted on moisture regimes in clayey soils. The PLUARG project on erosional losses, sediment delivery ratios, and physical-mineralogical properties of agricultural soils and sediments was completed.

Manitoba. Detailed surveys were conducted on 11 localities for agricultural evaluation, rural residential, or parks planning. Interim reports and maps of similar projects in five localities were completed. The report and maps for the Boissevain-Melita project was published. Compilation of reports and maps was completed for Berens River, Deer Lake, Oxford House, and Knee Lake areas in the northcentral region. Detailed studies were continued on the effects of SO₂ fallout emanating from Thompson.

Saskatchewan. Field work was completed in the Weyburn-Virden sheet. About one-third of the Melville-Riding Mtn. sheet was mapped. Reports were published for Saskatoon, Prince Albert, and Pasquia Hills - The Pas sheets. Soil salinity studies were continued to evaluate the effect of crop rotations and of deep plowing on soil composition and yield. The report of the biophysical survey of Prince Albert National Park was completed.

Alberta. Field work was completed in Newell county, maps for 82H/NE were edited, maps and report were compiled for Brazeau Dam area, report for Yoho National Park was published, and field work was completed in Banff National Park. Field work was initiated in Warner county. The Research Council staff has completed the Wapiti, Two Hills, and Iosegun reports, and initiated field work in Beaver county. Detailed surveys were conducted in three provincial parks, and in urban areas at Edmonton and Calgary. The reconnaissance survey was continued in the oil sands area at Fort McMurray.

British Columbia. Detailed mapping was continued in the Mill-Woodfibre creeks area, and in the Cariboo-Chilcotin wetlands. Correlation studies were continued on Vancouver Island and in the northcentral Interior. Correlation studies were initiated on the new Quadra project, located in the Coast Mountains to the northwest of Vancouver. Studies were conducted on soil water, soil erosion, wetlands, and on mapping practices.

Yukon and Northwest Territories. The soil surveys undertaken in 1975 and 1976 in the Liard River valley, in selected areas of the Yukon, and in the Hat River valley were completed. Interpretative reports describing the agricultural potential of the Northwest Territories and of the Yukon Territory were completed, and single-factor and interpretive maps were drawn for areas in the Yukon.

Progress was made on the compilation of soil reports in the Cornwallis Island and Fockhart River areas in the Northwest Territories.

Soil temperature studies were conducted in the Inuvik area and eight sets of thermocouples were installed at sites representative of important soil-landscape regions. Initial results indicate that all equipment is functioning as expected.

Ottawa. The correlation staff was increased by one. Work was conducted on correlation of mapping projects in cooperation with unit heads, organic landforms in the St. Lawrence Lowlands, soil classification and mapping in frozen soils in the north, land management systems and crop identification by remote imagery in the Great Plains, and environmental impact assessment studies in connection with a proposed uranium refinery. Considerable progress was made on the development of a soil mapping system.

Nearly all survey staff across the country and the cartography unit were involved to some degree in the preparations for the International Society of Soil Science Congress in Edmonton. These included preparations of soil tours and guidebooks, site selection, soil sampling, soil analyses, and conducting the tours. This 3-yr project had many beneficial effects, and due to the extra effort by the staff the detrimental effects on the survey field and office routine were minimal. Twelve tour guidebooks were published.

Cartography. In 1977 production increased by about 20%. Two extensive projects were completed; the Boissevain-Melita with 98 individual map sheets, and the Agroclimatic Atlas of Canada with 17 map sheets. Five soil and agriculture capability maps of Tanzania were completed for CIDA. Also a total of 570 figures, plus 167 landscape and micromorphology photographs in both official languages, were prepared for use in reports of soil tours conducted for the International Soil Science Congress. In total 19 soil maps, 144 capability maps, and 4 miscellaneous maps were published.

In 1978 production was lower due to ISSS contributions. A soil monolith display was prepared for the ISSS. Another display of soils, land use evaluation, CanSIS remote sensing, and agrometeorology research conducted by Agriculture Canada (total 23 m) was prepared for the science fair "Shaping the Future" at Ottawa University. A workshop on cartographic production problems was held for soil surveyors in Ottawa. Fifteen soil maps and 45 capability maps were completed.

The CanSIS cartographic system has been further developed by the addition of two digitizing tables and a flatbed plotter. The plotter is a vital link in cartographic editing of data that enabled the rapid compilation of

the single-factor and interpretative maps required by planning agencies. All soil maps in cartographic production are digitized; 285 maps have been stored in the system or are in some stage of editing. The remote sensing unit of Agrometeorology has assisted in experiments to overlay digitized soil data with various kinds of photo imagery.

SOIL CLASSIFICATION

Publication of *The Canadian System of Soil Classification* in 1978 made available the current systems of soil and landform classification in Canada. Introduction of a Cryosolic order for soils having permafrost close to the surface was one of the major changes in the soil classification system.

Soil water regime

Research on soil water was focused on development and application of methodology to study the water regime of soils in the field. An air-entry permeameter developed for making rapid measurements of saturated hydraulic conductivity was improved and used in studies of the variability of water properties of soils within mapping units in the Ottawa area. Variability of hydraulic conductivity, water table, and water retention was appreciable at sites within the same unit. Such variability must be known before useful models can be developed of water redistribution in soils on a landscape basis.

Field investigations showed that soil structure is an important contributor to the variability of soil-water properties. Laboratory studies in progress are designed to develop ways of determining the influence of soil structure on hydraulic conductivity and water retention. Measurements in cracked clay soils showed that rain water was penetrating rapidly by way of the cracks without wetting the near-surface soil.

A technique using radio frequency electrical signals was used to measure water content of soil rapidly and nondestructively. In the laboratory studies it was shown that the dielectric constant of the soil depended strongly on water content but not on texture, density, or salt content. Research is under way to design the best probe and installation procedure for application of these techniques for long-term field monitoring of soil water content.

Organic soils

Physical, chemical, botanical, and micro-morphological properties of layers of five typical peat soils from Quebec and Ontario were determined by a wide variety of methods. The importance of botanical composition in determining the properties of peat was evident and a reference collection of peat plant fragments is being developed to aid in the identification of botanical origin of peats. Data for the five soils are being used to develop improved procedures for organic soil characterization and classification.

The effects of lime and copper on the decomposition and subsidence of organic soil are being determined in cooperative (LRRI, CBRI, and St. Jean) greenhouse and field studies. A new system was developed and installed for accurate measurement of long-term subsidence of organic soil.

Mineral soils

Studies of soils from many areas of Canada showed that micromorphology is useful in distinguishing illuvial clay from inherited clay in B horizons. Reliance on texture differences between A and B horizons in identifying horizons of clay accumulation (Bt) results commonly in classification errors.

Ortstein horizons (cemented podzolic B) in sandy soils of Nova Scotia and New Brunswick were strongly developed and continuous in poorly drained sites and intermittent in associated well-drained sites. Chemical and energy dispersive X-ray analysis showed that they were cemented mainly by Al-organic or by (Al, Fe)-organic complexes. The work showed that compact and cemented soil horizons have a continuum of properties encompassing the range of fragipan, ortstein, and duric horizons. Clearly defined limits are essential to avoid ambiguities in soil classification.

Investigations of Cryosolic soils in northern Canada showed by means of radiocarbon dating that most earth hummocks were probably formed between 4500 and 2500 yr ago. Cryogenic earth hummocks were found to have average diameters of 80–160 cm and average heights of 40–60 cm. They developed in materials having sand contents below about 40% and a high ice content.

Mean background levels (parts per million) of minor elements in more than 300 soil samples from many areas of Canada were Mn 544, Zn 77, Cu 22, Pb 20, Co 21, Ni 22,

Cr 45, Sr 207, Se 0.3, Hg 0.05. Four reference soil samples were certified for total contents of 17 elements and preliminary data were reported for 47 other elements through the Canada certified reference materials project.

Summarized physical and chemical analysis data for 28 CSSC reference soil samples show excellent results for several laboratories and an urgent need for effective quality control of soil analysis generally.

Progress was made in the characterization of soil of alpine and subalpine regions and in the development of criteria for differentiating these soils from others.

Engineering interpretations

Work continued on the development of a system for improving the interpretation of soil survey information for engineering applications.

LAND USE AND EVALUATION

The land use and evaluation program is directed to the development of quantitative methods for land evaluation, soil degradation, conservation and protection, agricultural land use typology, and computerized information systems.

Land evaluation

Research on the development of land allocation and crop growth models demonstrated the application of techniques for policy assessment and decision making. Other research was undertaken on phenological crop modeling and improvement of the agroclimatic data base. The data base for the FAO agroecological crop suitability project was completed.

Soil information systems

Documentation programs and procedures for the soil data and soil cartographic files was completed. The input forms for the performance/management file were printed and a users' manual written. Procedures for digitizing and processing soil maps were optimized to the point where the system became fully operational. A fourth digitizing table was added. The RAPID data base management system was evaluated and a program to produce "flat" files was begun. The cartographic and hard data subsystems of CanSIS were transferred and installed in Manitoba. Data collection contracts were

established for seven regional centers. Productivity information for land evaluation and other programs was assembled. The cooperative program with Parks Canada and the soil mapping and interpretations projects for DINA continued for the development and improvement of data handling systems required for the special needs of these projects.

Land resource protection

The final 23 reports of the PLUARG program were completed. These show the role of agricultural pollution to be associated primarily with phosphorus and with stream sediments deposited in the Great Lakes and with upstream and groundwater nitrogen problems. Preliminary assessment was made of the requirements for a national land and environmental degradation program. Reports were prepared on the effects of pipelines on crop yields; the yields of corn and soybeans were depressed by vehicular compaction of the soil and by mixing of topsoil and subsoil.

Agricultural land use systems

The techniques of agricultural land use inventory developed in the Ottawa-Carleton area were further tested in a mapping project in Saskatchewan. In six land use systems 891 000 ha were mapped, and 150 farmers were interviewed. Results indicate the usefulness of the approach in at least two areas in Canada.

AGROMETEOROLOGY AND CROP IDENTIFICATION

A task force was established to study a national farm weather service. An operational crop yield prediction system was established on a real-time weather data base for wheat, oats, and barley. The real-time agroclimatic information system was upgraded to better serve in-house projects. Soil moisture normals (30 yr) were calculated for 80 locations in the Prairie Provinces.

Agroclimatic resource maps were prepared for the Niagara Peninsula. A field workday analysis was completed for 18 locations across Canada.

Crop-environment modeling

A new integrating and recording system was constructed for monitoring plant environments and improvements re micrometeorological instrumentation: (i) air-bearing wind vane and anemometer, (ii) CO₂ analyzer, (iii) leaf chambers.

Development of a forage/yield model using nonlinear regression analysis is complete. Marquardt Algorithm approach was used to solve a series of nonlinear equations.

An implicit finite element model was translated and adapted for computer simulation on the minicomputer.

Adaptation of a modified Marquardt estimation technique was made in order to fit pressure head and hydraulic conductivity functions.

The Akaike information criteria for selection of the optimum Markov chain probability model was introduced and found to be effective.

A package of computer programs was developed using coordinate transformations and a Thiessen polygon procedure for evaluation of areal averages of meteorological variables.

Using the Mann-Whitney U test on climatic variable, monthly winter survival indices were developed relative to alfalfa survival in Canada.

A report was prepared from the results of a national survey on alfalfa winter survival for the 1976-1977 season.

Operational systems

The 1941-1970 climatic normals have been obtained from the AES in the form of a 1290 equal area grid system. This climatic information has been incorporated with the LRRI soils data on a grid square basis.

An operational real-time weather based crop yield prediction for wheat, oats, and barley was prepared on a monthly basis. Updates were made at the ends of April, May, June, and July 1978.

Assistance was given to the Lands Directorate, Fisheries and Environment Canada, in including information and maps on ACRI (agroclimatic resource index) and on the resources for maturing barley and wheat in Canada in the Lands Directorate's study on critical lands.

A national spring workday probability analysis involving 18 selected stations was

completed. A computer program for specifying horsepower needs from climatic estimates was also published.

A revision of the documentation on the versatile soil moisture budget was prepared as a result of the universal interest in this budgeting technique.

Agroclimatic resource maps at a 1:250 000 scale were prepared using SYMAP for several variables for the Niagara Peninsula and for the Wynyard map sheet area of Saskatchewan.

The 1978 soil moisture evaluation program (SMEP) introduced a new base map depicting the crop report districts (Statscan). District values were generated using a Thiessen polygon approach.

A technique to interpret climatic data useful to farm operations was developed by a series of crop maturity calendars based on various levels of risk and time of maturity using three threshold temperatures (5, 10, 13°C).

Agrometeorological research services

Agrometeorological data processing services were integrated with other activities in LRRI and the Branch to meet requirements in three major areas: research and development, user requirements, and operational user systems.

Requests for services have increased in number and complexity. Responsibilities have also increased due to collaboration with the Sibbald group and the recent alignment with LRRI. Data-processing support was also extended to support the Branch crop information system and the use of WMO Synop data.

All five Branch projects using real-time agroclimatic data remained active during 1978. With the inclusion of on-line synoptic traffic, the available station coverage will now number well over 100 points across Canada.

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INTRODUCTION

This report summarizes highlights of research carried out during the period 1977-1978 at the London Research Institute. The laboratory was established in 1951 to meet the problems created by the introduction of synthetic organic pesticides. Although the emphasis has changed over the years, present research programs reflect current concerns regarding the agricultural use of pesticides by concentrating effort in the areas of integrated pest management (IPM) and environmental toxicology.

Research activities include studies on the mode of action of pesticides (toxicants); the search for new target sites for the development of new-generation pesticides; the interaction between plants, pests, and pesticides; the isolation and characterization of biologically active materials such as phytoalexins and their role in disease development and resistance; insect neurotransmitters and insect attractants and repellants; fumigation studies on stored products; environmental studies aimed at providing answers regarding persistence, transport, and breakdown of pesticides in the environment. The transfer of laboratory findings to the field forms an essential part of the programs.

The sudden death of Dr. Brian E. Brown in June 1977 was a shock to us all. Dr. Brown is best remembered for his discovery of proctolin.

Copies of this report, reprints of publications listed at the end of the report, and further information are available on request from the Research Institute, Agriculture Canada, University Sub Post Office, London, Ont. N6A 5B7.

H. V. Morley
Director

INTEGRATED PEST MANAGEMENT

European corn borer

Good progress was made in the development of a predictive model for the emergence of overwintered European corn borers, *Ostrinia nubilalis*. Present predictions based on the average date of emergence were shown to have an average deviation of 6.1 days. The multiple-regression method developed here has an average deviation of 1.25 days, which is a significant improvement in accuracy in timing for pesticide applications. The use of pheromones for monitoring of the European corn borer has continued but the problem of pheromone traps becoming unattractive to corn borers after 1 wk in the field has still not been explained. All obvious explanations such as isomeric ratio of attractants, incorporation of antioxidants, interconversion of *cis-trans* isomers, and trap composition have been eliminated as possible causes. Despite the "ageing" effect, the traps have been shown to be easier and more efficient than light traps to show the beginning of moth flight. Cooperative work with scientists in Quebec have shown that there is

in Quebec a two-generation strain of the corn borer phenomally identical to ones found in New York. Hybrids of the two strains were also found. Support for this work was provided by marked improvements in electroantennogram (EAG) recordings which provided the first record of corn borer receptor response potential accompanied by neurone spike activity. Use of this technique has shown that the electrically excitable system in every sensillum responds almost simultaneously to the pheromone stimulants and are interconnected in parallel and not in series. This finding is important in helping to establish a hypothetical model for pheromone receptor systems.

Fall armyworm

Work was started on the fall armyworm, *Spodoptera frugiperda*, which during the past 2 yr has caused considerable damage to late-maturing sweet corn in southwestern Ontario. Initial work has demonstrated the marked superiority of pheromone traps baited with (*Z*)-9-dodecyl acetate over light traps in terms of number of moths caught. Similar problems with "ageing" were encountered, and field location of the traps appears to be critical.

Tobacco hornworm

The substance isolated from female tobacco hornworm moths, *Manduca sexta*, which elicited a strong EAG response specifically with male antennae has been characterized. The structure proposed for this sex pheromone is (*E,Z*)-10,12-hexadecadienal, and material prepared synthetically was shown to be identical with the natural product as determined by chromatographic and EAG behavior.

Onion maggot

Holland-Keswick Marsh. Highlights of the results from the joint project with the Department of Environmental Biology at the University of Guelph concerning the control of the onion maggot are as follows. Crop loss studies indicated that when no insecticide treatment was applied, onion maggot destroyed 58% of the crop. This represented a loss of \$560/ha. Using recommended insecticide treatments maggot loss was <0.5% or <\$5.60/ha. In laboratory studies maggot strains have been selected which are resistant to parathion and carbofuran. Field studies at the Holland Marsh indicated that resistance has now developed to a level where ethion, carbofuran, and fensulfothion will not provide effective control at application rates currently recommended. Insecticides currently recommended for control and three experimental insecticides are being evaluated in the laboratory, greenhouse, and field for potential for onion maggot control. Resistance and degradation of these insecticides in soil and residues in the crop at harvest were determined. Seed furrow treatments with granular pyrethroid insecticides were not effective against onion maggots at application rates considered economical.

Crop loss estimates in Keswick Marsh in 1978 indicated a loss of one-third of the dry onions in a large untreated plot at an estimated loss of \$233/ha. The sterile insect release program attained a promising reduction (average 69% fertility as compared to 93% in the control of native females), which compared with the poor reduction obtained in 1977. Research results over the past few years have indicated the feasibility of an integrated pest control program in this area for the control of the onion maggot resulting in a reduction of at least 50% in the number of insecticide applications.

Thedford Marsh. Biological studies have demonstrated interesting differences in behavior of the onion maggot in the Thedford Marsh as compared to the organic soil areas studied elsewhere in Ontario. High levels of overwintering pupae (average 35 430/ha) were present in the Thedford Marsh in 1977 as compared to the Keswick Marsh (average 2904/ha).

Laboratory studies demonstrated that they were still susceptible to organophosphorus pesticides unlike the resistant insects encountered in the Holland Marsh. An intensive adulticide spray program using parathion resulted in a reduction of the overwintering population in 1978 to an average of 3727/ha. Another difference making direct application of the results from the Holland-Keswick Marsh area to the Thedford Marsh difficult was the marked preference shown by the adults to different onion varieties at different times in the growing season. Crop loss estimates in the absence of control measures together with the potential dollar value loss were calculated for Dutch sets (2.8% loss, \$18/ha); pickling onions (30.8% loss, \$345/ha), sets from seed (30.6% loss, \$378/ha); and dry onions (22.9% loss, \$160/ha). Residues of ethion and fonofos determined in crops and soil were below 10×10^{-9} g.

Potential insect control agents and sites

Juvenile hormones are effective in certain situations in insect control, primarily by interfering with morphogenetic events, and for this reason have been investigated as potential "third-generation" insecticides. Juvenile hormones I, II, and III have now been shown to function as uncouplers of oxidative phosphorylation probably acting in a "nonclassical" manner.

In the course of studying chitin synthesis as a potential target site this led to the discovery of a unique protein kinase inhibitor involved in the insect molt-intermolt system in the grasshopper. Since these changes are under rigorous hormonal control one aspect of the work has concentrated on a second messenger system involving cyclic nucleotide dependent protein kinases, their activators, inhibitors, and natural substrates. The natural kinase elaborated by the insect after the molt has been purified and found to be a dimer of identical subunits with a holoenzyme molecular weight of 18 000.

Improvements have been made in the synthesis of proctolin analogues which remove problems encountered previously in purification procedures. Significant improvements have also been made in bioassay techniques for monitoring the activity of the neuropeptide proctolin which allow greater quantitative reliability.

Fumigants

Studies on the mechanism of insect resistance to phosphine have shown that resistant insects absorb considerably less fumigant than normal insects and that respiration is not depressed to the same extent as that of the normal insects. Similarly, different stages of a species which have different tolerances to phosphine absorb fumigant in quantities related to their tolerance. Eggs and pupae are much harder to kill than larvae and adult and they absorb considerably less fumigant. Carbon dioxide can synergize the action of a number of fumigants to increase their effectiveness to insects. This synergism is closely related to temperature and declined as the temperature approached 0°C. Carbon dioxide can be used to eliminate living eggs from harvested apples without injuring the apples or otherwise affecting quality. Insects can develop resistance to carbon dioxide if selected over a number of generations. The two fumigants methyl bromide and phosphine can be used in combination to improve toxicity and to exploit complimentary properties of both materials.

To assist in the study of the effectiveness of fumigants, their mode of action, rate of loss, and final residue, suitable analytical methods are essential. A special analytical method has been developed for determining very low levels of phosphine. This has been used to determine the rate of desorption of phosphine from wheat and corn following varying times of exposure and then aeration. The results indicate a fast initial desorption followed by a very slow rate. This general method permits rapid determination of very low amounts of other fumigants in wheat and other foodstuffs.

In studies on desorption of fumigants and residues after fumigation ethylene dibromide was found to desorb more rapidly at low than high temperatures. This surprising result was found to be due to the residue being more tightly bound at higher temperatures and was shown to be reversible. These results

will help to establish optimum conditions for desorption of residues from treated commodities.

Soil insecticides

In the studies concerning the factors affecting the activities of insecticides in soil, organic matter has been included in the model system being developed for insecticide adsorptive behavior. Water-solubility studies have been intensified with the determination of 27 insecticides and their metabolites. Fulvic acid has been shown not to influence insecticide solubility but does selectively affect insecticide adsorption by both clays and soils in aqueous systems.

In the study of pesticide persistence and metabolism the pH-hydrolysis rate profiles for five more insecticides were studied. The influence of solid phase pH on adsorbed insecticide degradation was examined. A cooperative 32-wk laboratory experiment on the chemical and biological persistence of the new pyrethroid insecticides in sand was completed. The field study on the comparative persistence and degradation of phorate, terbufos, and chlorpyrifos in sand and muck soil was completed. Methods of analyses for methomyl and the new pyrethroids were improved.

Major insect cultures including insecticide-susceptible and -resistant strains of root maggots were maintained. Good progress was made toward development of a satisfactory mass rearing technique for carrot rust fly. Success was finally achieved in establishing a tomato hornworm culture, and baseline toxicity data are being obtained for a number of insecticides. The pyrethroid insecticides were found to be approximately 100 times more toxic than insecticides currently recommended for hornworm control. One new pyrethroid, FMC 45498(nrdc 161), was ca. 10× more toxic by contact to several species of insects than earlier pyrethroids. Tests indicated that cabbage maggot strains collected in Ontario and Quebec were not resistant to fensulfothion as feared. In field microplot tests, four pyrethroid insecticides with active ingredient at 70–140 g/ha were effective in controlling white, darksided, and black cutworms attacking vegetables and tobacco. At these rates they did not provide effective control of Colorado potato beetle

attacking direct-seeded tomatoes. Chlorpyrifos (EC or WP) applied at rates recommended for cutworm control was not phytotoxic to peppers and cucumbers.

As part of the study on insecticide plant interaction, pyrethroids, carbofuran, carbaryl, and its metabolite α -naphthol have been tested in bioassays for plant growth. α -Naphthol stimulated plant growth in the presence of indole-3-acetic acid (IAA). The inhibitor activity of α -naphthol in the enzymic oxidation of IAA appears to be related to the synergistic effect of α -naphthol and IAA while both carbofuran and carbaryl affected IAA metabolism in vivo. The effect of carbaryl differed markedly from that of carbofuran especially in the formation of bound IAA.

The field studies on persistence, uptake, and degradation were backed up by pesticide residue determinations for ethion, fonofos, chlorfenvinphos, carbofuran, permethrin, cypermethrin, fenpropionate, fenvalerate, and chlorpyrifos. The specific method developed for carbofuran using a mass spectrometer-gas chromatographic method was refined to the quantitative limit of 2×10^{-11} g with a detection limit of 1×10^{-11} g.

ENVIRONMENTAL TOXICOLOGY

Effect of pesticides on nontarget organisms

Soil animal surveys of several Ontario sites have been expanded and are progressing favorably with identification collaboration with a number of national and international agencies including the Biosystematics Research Institute. A primitive order of insects, Collembola, apparently has sophisticated behavior-affecting chemicals controlling population densities. Examination of pipeline construction sites has indicated a very significant effect on soil fauna on those in southwestern Ontario farmlands. The 2-yr study on litter decomposition rates and the effect insecticides may have on them is providing valuable insight into soil decomposition processes and the importance of soil fauna in these processes. The 4th-yr study of the use of benomyl treatments in airport precincts confirmed the reduction of earthworm populations while the 2nd-yr study confirmed minimal side effects on soil animal populations. Detectable residues of benomyl do not last longer than 4 mo even with repeated

annual treatments. Earthworm respiration rates have been measured precisely under controlled conditions to determine quantitatively whether herbicides affect earthworm respiration. Intensive studies on the biology of the manure worm *Eisenia foetida* have produced a number of remarkable observations about its growth rate and fecundity of value to earthworm farmers.

Soil microflora-pesticide interaction progress is summarized as follows. Using the acetylene reduction technique as a measure of nitrogen fixation it was observed that most physical treatments affected the results in sandy loam. None of the treatments suppressed ethylene (C_2H_4) formation in the sandy clay loam until after 2 days. Autoclaving and oven-drying of the muck resulted in a pronounced increase in C_2H_4 formation. The only significant decrease in number of nonsymbiotic nitrogen fixers in all soils took place in heat-treated soils. In the reinoculated soils, none of the physical treatments inhibited C_2H_4 production in the sandy loam. Significant increase was noticed with autoclaving in both sandy clay loam and muck. Thirty-eight pesticides did not suppress nitrogen fixation in the muck. Phorate, maneb, and thiram decreased nitrogen fixation in the sandy clay loam. Microbial population was similar or greater than that in control after 1 wk incubation. No inhibition of nitrogen fixation was evident with any of the five pyrethroid insecticides at 0.5 and 5 ppm active ingredient. A culture tube technique for screening of the activity of acetylene reduction (nitrogen fixation) by nitrogen-fixing bacteria was devised. Isolate of *Rhizobium japonicum* resistant to thiram was obtained. Two hundred and ten nonsymbiotic nitrogen fixers were isolated from a sandy loam, and a study on their activity in nitrogen fixation and viability has been started. A cooperative study with Delhi and Vineland research stations on effect of nematocides on nitrification in tobacco soils indicated that nitrification was suppressed by the fumigants in the early stage of planting.

Studies carried out on herbicide-microflora interaction using terbacil concentrations up to 500 ppm showed little effect on soil bacteria, actinomycetes, and molds over a period of 140 days. At similar concentrations of terbacil both stages of nitrification were retarded but not inhibited whereas cellulose hydrolysis was stimulated. Similarly, atrazine, simazine, diuron, linuron, and paraquat,

as well as combinations of the latter with each of these herbicides, affected nitrification and proliferation of rhizobia bacteria and azotobacters, but stimulated cellulose hydrolysis. Glyphosate favored soil bacteria and actinomycetes with no effect on the molds. Resistance to paraquat of *Agrobacterium radiobacter* and rhizobia from each of the cross-inoculation groups was increased from 1 $\mu\text{g/mL}$, or less, up to 30 000 $\mu\text{g/mL}$.

Environmental studies

The comprehensive study begun in 1972 on the occurrence of organochlorine (OC) and organophosphorus (OP) insecticides in organic soils used for vegetable production in Ontario was completed. Residues of OC and OP (mainly ethions) insecticides were commonly found, sometimes at relatively high levels, but DDT levels are still the highest. Organophosphorus residues (mainly diazinon) were also detectable in water in the Holland Marsh drainage system at approximately 70% of the levels of OC compounds still being found. Organophosphorus compounds could also be detected qualitatively at very low levels in air samples collected at the Holland Marsh during the growing season.

Laboratory studies on the adsorption/desorption of 10 OC, OP, and carbamate insecticides by sediments and on the persistence of these insecticides in water were completed. Adsorption was shown to be positively correlated with organic matter content of the soil or sediment and inversely correlated with the water solubility of the insecticide. Degradation was dependent on chemical and microbial action. Several OP insecticides were relatively resistant to degradation in natural water. As a part of the integrated control program on onion maggot, farms on the Keswick Marsh were sampled to determine insecticide residue levels in soil. The occurrence and persistence of carbofuran in organic soils was completed and showed no significant accumulation of carbofuran residues.

Mode of action of toxicants

A wide-ranging study was made of a choline transport system. Structure-activity relationships for synthesized choline analogues showed that inhibitory power increased regularly as the *N*-*n*-alkyl substituent

was lengthened, so that the *N*-*n*-decyl derivative was a strong inhibitor.

In the course of studying inhibitors of a critical component of the glucose transport system, iodo- and bromo-dinitrobenzene were shown to undergo the same chemical reaction as the fluoro derivative, causing irreversible inhibition of an essential component. The first two compounds appear to be surprisingly selective in their inhibition. Meantime a hypothesis has been developed for an important physiological mechanism that could be fundamental in the cellular control of transport processes. Disruption of this in target organisms could be the basis of new pesticides comparable to the inhibitors found for choline transport, an essential component of nerve function.

Previous studies here investigating the mode of action of organochlorine insecticides raised the question whether the inhibition of certain membrane functions by this class of insecticides is due to direct effect on the enzyme or indirectly by affecting some membrane parameters. It has now been shown that seven organochlorine insecticides are strong inhibitors of the carrier-mediated K^+ -transport system to the inner mitochondrial membrane. Structure-activity studies demonstrated that dieldrin and three DDT-biodegradable analogues were the most effective inhibitors. Concomittant with inhibition, the countermovement of H^+ ions was also inhibited.

PLANT DISEASES

Mechanism of disease development and resistance

A simple screening procedure was developed for demonstrating resistance of soybeans to races of *Phytophthora megasperma* var. *sojae* (Pms.). Preliminary results on adaptation of this system to determining the presence of tolerance in soybean cultivars to the root rot pathogen were promising (cooperative project with Harrow). Three experimental fungicides, CGA 48988, CGA 38140, and RE 26745, were evaluated as to their specific in vitro toxicities to selected plant pathogens.

Further progress has been made in determining the nature and role of naturally occurring antifungal compounds in disease resistance in the Solanaceae and collaborative work on soybean phytoalexins has been

initiated with personnel at Harrow. In the potato system three additional compounds have now been obtained, making 10 in all, and their biosynthetic relationships established by ^{13}C -incorporation studies. Both capsidiol and rishitin have been shown to be metabolized to their 13-hydroxy derivatives and these in turn to unidentified products by the plant tissues that produce them. Infecting fungi appear to block the process and the possibility which this raises, that phytoalexin accumulation occurs by blockage of a normal metabolic pathway, has potential practical significance. Aliette a fungicide active only within the plant, examined as a possible 'blocker', was not found to act in this way. In other work on antifungal factors, material from *Cymbidium* (in collaboration with University of California) has been tentatively identified as monolinolein, and appears to be selectively fungitoxic to *Phytophthora infestans*. Methods have been developed to incorporate isotopic carbon into avenacin, the antifungal factor from oats; additional phenanthrenes, related to orcinol, have been synthesized as potential IAA oxidase inhibitors and the relation between hordatine and calcium ions has been reexamined. Orcinol was shown to interfere with the reaction between IAA and the ferriporphyrin group of peroxidase and was degradable in the active enzyme system indicating a possible involvement of phytoalexins in the growth processes of fungi and higher plants.

Mode of action of selected fungicides

Many new thiophene carboxamides have been prepared and a number show good antifungal activity towards carboxin-resistant strains of corn smut and to non-Basidiomycete fungi, particularly *Phytophthora* sp. Altering the structure of the parent molecule extended the fungitoxic spectrum to pathogens resistant to carboxin. Two of the new carboxamides with photoaffinity labels were tritiated for binding studies in the purified mammalian succinic dehydrogenase complex which should eventually lead to the identification of the membrane component involved in the interaction of the enzyme complex with carboxamide fungicides. Such knowledge would be of use in the design of new active compounds.

The apparatus designed to measure the permeability of the roots of *Zea mays* to various compounds has provided a wealth of

quantitative data on the general physiological functions of the roots. New simplified procedures have been developed for measurements of the root at the macroscopic and microscopic level. The method determines the overall number, length, surface area, and volume of the various root branches as a function of their diameter. At the microscopic level the surface area and volume of the xylem vessels are determined.

A preliminary evaluation was made of the effectiveness of the candidate fungicide Aliette (May & Baker LS 74-783) against Phycomyces. In vitro, this chemical caused no inhibition of mycelial growth of *Phytophthora infestans* or *Pythium ultimum*, even with 100 ppm in the agar medium. Aliette was highly effective, however, against preemergence damping-off of pea seedlings by *P. ultimum* when applied as a seed dressing or a postplanting drench. Some phytotoxic effects were observed when concentrations greater than 1 g/L were applied.

WEEDS

Herbicides and plant growth regulators

Evidence obtained previously from the work with carbofuran, 2,4-D, picloram, and other growth regulators points to a regulatory role of IAA metabolism in plant growth. In searching for the mode of action further work revealed a selective binding of certain metabolites of IAA to soluble RNA. Among the bound metabolites 98% were basic or neutral products of IAA from two different degradation pathways. Use of the plant tissue culture technique showed that, contrary to published information, inhibition of aromatic acid biosynthesis is not the mode of action of glyphosate nor did it inhibit protein synthesis to a significant degree. Glyphosate increased the activity of phenylalanine ammonia-lyase and the level of phenolic substances in soybean tissues. In a cooperative project with Harrow the growth-regulatory activity of hydroxyatrazine was investigated. This metabolite of atrazine was found to promote growth of wheat coleoptiles but not pea stem or tobacco callus suggesting a specific effect on monocotyledons. Callus cultures of atrazine-resistant and atrazine-susceptible lambsquarters, *Chenopodium album*, were established. In the study of structure-activity relationship for the inhibition of IAA decarboxylation, the phytoalexin orcinol was

more active than any other phenanthrenes and stilbenes tested except the trihydroxyl derivatives. Shifting the hydroxyl group of orchinol from the 7 to 5 or 6 position lowered

the inhibitor activity. Opening the second ring destroyed completely the inhibitor activity.

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R. CORMIER, B.Sc., M.Math. Transferred to Plant Products Division, September 1978	Systems and programming
C. G. E. DOWNING, B.E., M.Sc., D.Sc., F.A.S.A.E., F.E.I.C., F.C.S.A.E., F.A.I.C. Retired April 1977	Director, Engineering Research Service
L. P. LEFKOVITCH, ¹ B.Sc. Transferred to Biosystematics Research Institute, September 1978	Director, Statistical Research Service
C. D. McLEOD, B.A.Sc., M.A.Sc. Transferred to Fredericton, January 1975	Atlantic region mechanization engineer
J. TSANG, B.Sc. Resigned February 1979	Systems and programming

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¹On transfer of work to Rothamsted Experimental Station, Harpenden, U.K., June 1978 - June 1979.

INTRODUCTION

In January 1978, the Engineering Research Service and the Statistical Research Service were amalgamated to form the Engineering and Statistical Research Institute (ESRI). This recognized the contribution of engineers and statisticians to Research Branch programs. The Institute is responsible for providing a broad and comprehensive service to the Research Branch, the Department of Agriculture, and elsewhere on all aspects of engineering and biometrics with collaborative association in all areas of the research program.

The statistical program emphasizes the planning of research, the development of statistical methodology, and the interpretation of results. A new activity is the collection, collation, and rationalization of statistical software in the Branch to promote widespread utilization of this resource.

Engineering work emphasizes structures, environment, mechanization, and systems engineering. Support of research through the development of instrumentation and equipment improved the efficiency and accuracy of research operations and facilitated discovery of new physical phenomena. Considerable engineering information was disseminated.

Contracting out of engineering R and D and its management represent a significant portion of the Institute's program and are making a major contribution in solving agricultural problems. Successes such as the combine straw spreader point out the benefits of this approach. A new program in energy research through contracting out was initiated. This includes work on solar, wind, economics, greenhouses, energy conservation, buildings, and the conversion of crop and animal residues. The contracting programs were consolidated into a program of agricultural engineering research and development (AERD). This permits better management of the interrelationships between mechanization, buildings, and energy.

Overall, the Institute's diverse activities support and collaborate with most of the crop and animal goals of the Research Branch. The contributions are possible because the combined professional and technical resources permit a broad view and an integrated approach.

Peter W. Voisey
Director

MECHANIZATION AND SYSTEMS

Research

Swedish and Israeli precision planters were imported, and several vegetable crops planted. Accurate seed placement and good soil contact increased yields. Results of tests with pregerminated seeds were poorer than expected. A prototype injector-tanker, using a shank designed by Macdonald College, demonstrated a suitable method for injecting liquid manure between corn rows. A prototype, high-clearance, low-ground-pressure tractor was designed and field tested in Newfoundland for mechanization of vegetable production on peat bog soils. Tobacco mechanization work included a rack system for curing stalk-cut tobacco; a single-row harvester for cigar tobacco; and a two-row harvester for burley tobacco, now produced commercially.

A catalog of computer programs of interest to Canadian agricultural engineers was assembled. The forage system simulation program was further modified and is now operational. A simulator for wheat kernel and straw moisture changes during field drying was developed to generate combine-harvesting work-day probability tables using historical crop and weather data.

Contract research and development

Thirty mechanization projects were contracted out each year, with six energy projects in 1977 and 25 in 1978. Results are summarized annually and the contract reports are available from the Institute.

Once a program of projects has been selected from all proposals received each year, contracts are apportioned to Branch establishments for scientific supervision. Results are reported by each establishment as part of their program. Results of projects

supervised by the Institute included development of computer models for a grain harvesting system, of a combine-harvester, and of a comprehensive dairy waste management system; assessment of equipment suitable for seed cleaning plants; measurement of power requirements for plowing; evaluation of corn planters for seed placement; study and assessment of the effects of mechanization on soil compaction, and measurement of yield reductions in corn due to higher soil densities; investigations showing unresolved problems in adapting a ridge-and-furrow tillage system for row crops; development of a composite tractor wheel to automatically reduce wheel slip; and adaptation of a rubber track to a combine-harvester to improve flotation in wet soil conditions. A combine straw spreader was developed to distribute the straw over 10 m to eliminate the need for a separate operation. This attachment is being rapidly adopted by Western grain growers and is being made commercially.

Studies of solar heating of animal buildings showed very doubtful potential for cost-effective brooding of young livestock and heating of dairy washwater, but better potential for supplemental heating of ventilation air supply; vertical-wall solar collectors with built-in heat storage appear the most feasible for preheating ventilation air. Similarly, retractable insulation systems were found to be the optimum approach to energy savings in greenhouse operations. Solar-adapted greenhouses are also being studied.

Two farm-scale anaerobic digesters for producing methane from hog manure were placed in operation. A big bale straw burner provided the energy for grain drying and barn heating on a farm. The potential of gasification of crop residues as energy sources for farm operations is under study.

RESEARCH SERVICE

Equipment for mechanization of field or laboratory experiments

Equipment developed to mechanize field experiments included a planter for processing peas; a bed seeder for forage plots, tree nurseries, and vegetables; a seeder to space preselected seed quantities along a row; and a herbicide applicator for fence rows. A gel seeder was designed for plot research on horticultural crops. A dormant oat direct

reseeding attachment for a combine was completed. A separator was constructed to separate desired seeds from other seeds by their different frictional characteristics. A simple automatic chick feeding system was constructed to dispense dry feed at two predetermined intervals each day. A commercial dry feed pig feeder was modified to dispense accurate feed amounts for research on baby piglet nutrition in artificial rearing from birth. A cigarette diameter control system was installed on an experimental cigarette machine. Development of a soil temperature control module with the associated ambient air control cabinet was completed. An electronic albumen height gauge was developed for improving the accuracy and speed of measuring the albumen height in broken-out eggs for research and quality control. A microcomputer-based temperature integrator was developed to provide a selection of threshold temperatures. A low-cost activity recorder was developed for monitoring insect behavior. A multiple sample holder was constructed for the freeze-fracturing of electron microscope samples, which tripled the number of samples processed daily. A conductivity-controlled, digital height gauge was developed to simplify the measurement of sample volumes by water displacement. Studies were undertaken to develop standards for interfacing data acquisition equipment to departmental computer networks.

Field tests of the remote sensing laboratory were concluded at the University of Manitoba. Results show that field spectroscopy can be used to: (a) identify crops; (b) identify varieties within crops; (c) detect root rot; (d) detect nutrient deficiency; (e) detect disease; and (f) detect crop maturity. An open-path analyzer which measures CO₂ concentration above the crop canopy was developed which has a resolution of 0.1 ppm and a 1% accuracy. A bioluminescence spectrometer to measure as low as 1 photon light energy was developed to determine plant winterhardiness characteristics.

Food processing and quality

The individual quick-blanch system developed by ESRI and the Research Station at Kentville has been licensed by Canadian Patents and Development Ltd. to a commercial firm. A split extruder barrel was developed for a fundamental study of the extrusion of food products. An apparatus for

measuring weight loss, temperature, and the development of structural cohesion in baking cakes was developed. A new eggshell strength apparatus was developed to test 200 eggs per hour by quasistatic compression, puncture, or nondestructive deformation. It was found that eggshell strength decreases linearly with increasing temperature in the range -5 to $+45^{\circ}\text{C}$. Techniques were developed for measuring the crispness and brittleness of the fat and lean portions of bacon. Bacon becomes crisper with cooking time until brittleness occurs. Work on the uncooked strength and cooked firmness and stickiness of spaghetti was completed. Stickiness was related to the surface microstructures and starch/protein ratio. The Ottawa Starch Viscometer was applied to the measurement of amylase activity in flour using only 70 g of slurry. This permitted 35 tests per day instead of the eight previously done by the Amylograph method.

Studies on the FMC pea tenderometer showed that this instrument operates as an extrusion device, which permits a better approach to instrument standardization. Errors in fruit pressure testers were found to be primarily systematic calibration errors; size, shape, and spring rate did not introduce operator effects. However, females applied force at twice the rate of males.

The Universal Food Rheometer was used for additional texture tests through the development of attachments for viscosity, firmness, stickiness, and surface tension measurements. Techniques were developed for assessing tobacco seedling stalk strength and the force to lift seedlings from the seedbed. An improved tobacco filling value instrument was constructed. Methods were developed and evaluated for measuring the doneness of smoked meat, the effect of storage and cooking on cow pea texture, and cherry firmness.

STATISTICAL RESEARCH SECTION

A highlight of 1978 was the acquisition of a DATA 100 terminal for access to commercial computer service centers. A workshop for Branch statisticians was held during 1978 to discuss applications of statistical techniques in agriculture research and new and untried techniques of statistical analysis. Presentations included categorical data, time series,

multivariate statistics, growth curves, bioassay, and experimental design.

Programming and data processing

Service provided is in the development and maintenance of computer programs. Once operational, these programs are incorporated in a library for use via the Department's computer services. The library currently comprises 100 programs for the analysis of data. In 1978, the seven most commonly used of these was each utilized five times per day. Time was devoted to batch processing and maintenance of large volumes of field data. Reports based on these data were generated for such projects as the corn trials, the Fredericton potato field book, the Ontario regional potato trials, and rapeseed pest management. The section implemented or enhanced 23 complex statistical programs, including an interactive program for single-line probit analysis; a program to perform maximum likelihood nonlinear parameter estimation; a program to generate contour plots; and a program for clustering based on set covering and partitioning.

Animal science

A survey of federally inspected slaughterhouses provided additional evidence that Aujeszky's disease is not endemic in Canadian swine. The monitoring of CPK levels in turkeys suggested a promising method of diagnosing green muscle disease. A new method of diagnosis of viral infection in cattle, based on the inhibition of bacterial agglutination, was found to have a highly significant association with serum neutralization, the conventional test.

Time series techniques were used in analyzing behavioral characteristics and the vaginal temperature of sheep under various lighting regimens. For any regimen involving a 24 h cycle, circadian rhythms were evident, whereas under continuous dim light the behavior became essentially random. Nutrition data for sheep showed that a dietary sulfur level of 0.16% in urea-supplemented corn silage, with a N:S ratio of 15:1, was sufficient to meet maintenance and growth requirements with no adverse effects on the blood mineral profile. The effect of nitrilotriacetic acid on the solubility of various trace minerals was found to be that the solubility of iron was increased by chelation with nitrilotriacetic acid. Other trace mineral

studies indicated that manganese-deficient rations lowered the fertility of ewes; low levels of chelated trace minerals satisfactorily maintained blood mineral profiles in the normal physiologic range for beef cattle and lambs; manganese-deficient diets altered choline metabolism in pregnant ewes; and the incidence of nutritional muscular dystrophy could be reduced by including oat silage in beef cattle rations. Radioisotope techniques in the metabolism of vitamin D in sheep showed an osteodystrophic condition. Tissue uptake of vitamin D₃ was greater in sick sheep than in healthy sheep and retention of radioactivity was greater when labeled vitamin D₃ was injected intramuscularly than intraruminally.

Grazing regimens, simulated by clipping pinegrass, indicated that frequent intensive clipping reduced stem counts, yield, and height, while regimens of frequent light clipping, intensive clipping at the end of the season, or no clipping at all increased stem counts, yield, and height. Other experiments on pasture management included a comparison of the economics of pasture versus indoor feeding for beef cattle, and the design of a sampling method to estimate the effects of grazing strategies on the distribution of plant species. Analyses of the effect of ration and slaughter criteria on the performance of two breeds of gilts showed that the best ration and slaughter criteria combination depended on the breed.

Estimates of the genetic parameters (including maternal genetic effects) associated with gestation length and birth weight of Holstein calves were obtained from records on 1522 calves born at Agassiz over a 20-yr period. The genetic correlations between fetal and maternal traits were negative, indicating that a cow whose own genotype gave rise to a longer-than-average gestation length (or greater birth weight) is expected to exert an opposite maternal genetic effect on the fetus she carries. The genetics of poultry blood cholesterol levels in a selection experiment indicated that selection could be used to alter blood cholesterol levels without reducing production. Using poultry data as an example, aberrant values were shown to seriously distort estimates of genetic parameters and to give misleading results in selection experiments.

In a poultry nutrition experiment, true metabolizable energy (TME) values were estimated for various rapeseed samples.

Attempts to predict TME from various physical and chemical characteristics of feeds were not successful. Estimates of TME obtained using adult roosters were found to be less variable than the estimates obtained using chicks. The effects of age and strain of the bird on the relationships between measures of shell strength were that the regression coefficients for those relationships which were linear differed significantly over both age and strain, a result which may explain seemingly contradictory data in the literature. The relationships between shell strength measurements from the same egg were similar to those between measurements from different eggs from the same bird and, rather surprisingly, the correlations were not much higher.

Statistical work on other studies included the availability of amino acids after correcting for endogenous losses, and the development of a bioassay for essential amino acids in cereal grains; pasturing in northern Ontario; the measuring of temperature and humidity in barns; the effects of hormones on the uptake of trace minerals in the accessory genital glands of rams; the effects of pregnancy on the body composition of gilts; the effects of prepubertal dietary protein levels on the subsequent reproductive performance of gilts; and the diagnosis of Aleutian disease in mink, John's disease in cattle, and influenza in swine.

Plant science

Analysis of life tables of alfalfa weevil showed that larval disease was the principal determinant of intrageneration survival, the key factor governing population decline of the weevil. Survey data of alfalfa leaf blotch eggs and miners were investigated for their distribution: the Neyman type A seemed to be most appropriate. Sources of variation such as that among stems within a three-stem "bouquet" for eggs could be ignored, and attention was focused on field variation among stems and among leaves within stems. Sampling methods for surveying alfalfa foliage diseases were studied, varying the size of sampling area, the pattern of sampling paths, and the spread among sampling sites. Increasing sampling size decreased CV% and increased the precision of estimates for random disease distribution. No similar improvement was observed for clustered disease distribution where the precision of

estimates was about the same for all methods tested.

Crop identification from reflectance data showed that differentiation of lettuce based on maturity is possible. Two methods for testing wheat seed hardness were compared, showing that the two methods agree for soft varieties but differ for hard varieties. Different methods of applying fungicides to barley, oat, and barley-oat mixture cultivation were compared. Significant differences were observed among varieties, among fungicides, and their interaction.

Carrots growing in sites of varying pH levels showed that copper uptake varies with pH, but over the normal pH range for growing carrots the uptake is reasonably constant. Container-grown spruce, juniper, and cedar under three environmental conditions during overwinter storage all showed a higher water status and higher sugar and starch contents in single- and double-layer polyhouses than in an outdoor environment. Regression analyses for rapeseed oil data to study the relationship between incidence of myocardial lesions and levels of fatty acids in the diets of male Sprague-Dawley rats showed that 22:1 had little, if any, relationship with incidence whereas 16:0, 18:0, and 18:3 were related to incidence.

Species compositions in pasture with respect to their distributional properties and sampling variance generally follow a negative binomial distribution. However, for alfalfa and alsike clover, a logarithmic distribution is also compatible. There appears to be heterogeneity in composition throughout the pasture. Responses of stem length of various Kentucky bluegrass cultivars to photoperiod and to temperature treatments were studied. A new dissimilarity index based on the sum of squares for genotype \times environment interaction was used and the resulting groups were found to reflect the cultivar characteristics.

Other statistical studies included the combining abilities for tobacco and pea diallel crosses; effect of soil type on onion and forage yields; optimum seeding rate for maximum yield for wheat; effect of fertilizer combination on the growth of onion; and comparison of varieties for Bumper orchard grass and potato.

Bioassay

A four-parameter nonlinear model was used to assess the effect of a synergist in insecticide trials, and analytical expressions for curves of minimum cost were derived. Obtaining interval estimates of optimal dose-mixtures was approached via the four-dimensional relative likelihood surface. In assays of mixtures in which more than one component is active when applied on its own, synergism and antagonism are more difficult to define and measure. Misconceptions current in pesticide research were corrected, and methods provided to examine departure from certain models that are often assumed to represent lack of synergism.

The toxic effects of fumigants on insects infesting stored products indicated that mixtures of fast-acting and slow-acting fumigants were more effective than would be expected from an independent-action model. In a small proportion of assays on the development of resistance, the results suggest the existence of extra-Bernoulli variation.

Several years' results on the development of less-hazardous tobacco were examined, and assessed in relation to those of the large-scale collaborative program in the United States.

The reduction in shoot growth of wild oats by three nonionic, soil-incorporated herbicides (diallate, triallate, and trifluralin) was shown to vary considerably for five different soils. For each herbicide, the estimated concentration required for 50% reduction in growth was closely related to the adsorption in the soil, which in turn appeared to be related to the organic matter content. Differences in the bioactivity of different herbicides in the same type of soil could not, however, be explained by the different adsorption rates. The dose-response curves were approximately logistic, the lower asymptote varying from about 7% to 38% of the control value. A peak in the response at low doses suggested a multisite reaction within the plant, and a two-site model was successfully fitted to the data, but the representation of low doses was inadequate to give good estimates of the height of the peak in all cases. Since interest lies more towards the upper end of the dose range, a practical recommendation is to avoid biasing estimates by forcing a nonpeaked curve to accommodate low-dose data.

In studies on bluetongue virus using plaque neutralization assays, a model relating plaque reduction to the number of occupied sites on the virions was derived, giving a family of sigmoid dose-response curves that flatten off at levels that can be expressed in terms of the biokinetic parameters. Curves of this type were fitted by maximum likelihood to homologous and heterologous reaction data. Justification was advanced for a model requiring fewer assumptions in the analysis of balanced cross-reaction experiments.

Food science

In taste panel experiments, incomplete block designs, rarely used in other fields, are common, because the kitchens—or the tasters—cannot cope with all the treatments at one sitting. When several attributes are measured at once, multivariate analyses including factor analysis seem appropriate, but interpreting them has proved difficult. The technique of “magnitude estimation” was found to have deficiencies in its theoretical basis, and was modified, by including a reference sample in each testing session. Foods tested included beef, veal, lamb, chicken, pork, wieners, spaghetti, cheese, and ham.

Data from an international collaborative experiment on durum wheat quality were collated, summarized, and in part analyzed. The summaries included a 239-variable correlation matrix, printed from the computer directly on to microfiche. The data from another international study, on the absorption spectrophotometric method for detecting arsenic and selenium in foods, were difficult to analyze, because of outliers, heterogeneity of variance, and other problems. The analyses were completed using special statistical techniques; but the fact that such problems arose in the first place argues against the use of the method for routine assays.

Soils

Logistic-type curves were fitted to several series of data relating the effect of soil type to hydraulic flow. The interpretation of the parameters confirmed expected results. Soil samples have been collected from various sites throughout Canada and the amounts of about 20 elements determined. Relationships among the elements were investigated within several geographical regions and for several

soil horizons. In general, it was not possible to find good predictive equations for the minor elements.

For another set of data collected from sites in British Columbia, analysis of variance techniques were used to illustrate the effects on several chemical constituents of the age, horizon, and profile of the soils from which the data were collected.

Taxonomy

A system for maintaining a barley register was enlarged to contain over 2000 cultivars and a feature added to maintain a bibliography pertaining to the register. A method developed earlier for evaluating the structural characteristics of taxonomic trees was refined and tested, and compared with alternative methods. Also described was the applicability of the method to any specifications for preferred configurations.

Several statistical methods were applied to study the classification of different isolates of microsporangia. Although few characteristics were found to be helpful for differentiation purposes, useful suggestions were made with respect to sample size and sampling procedures which can considerably reduce the laboratory work.

Mating behavior and esterase isozymes of *Euxoa* were studied in two experiments. The mating frequency seems to be a species characteristic. Phenotypic distances based on the presence of isozymes were established between populations of three closely related *Euxoa* species. Grouping of populations was determined by a minimum loss strategy and found to be satisfactory.

Insect behavior

An experiment, designed to test whether usually nongregarious springtails will cluster in a particular area when it has been conditioned by previous exposure to springtails, was analyzed statistically from two points of view. It was clear that one of the three species used in the experiment did cluster and that the other two species did not. Closer examination of the experiment showed that it was not well suited to the question being asked; this was explained and more powerful experimental designs were developed. An experiment on the egg distribution of *Tenebrio molitor* L. was analyzed.

STRUCTURES AND ENVIRONMENT

Farm structures

The 1977 *Canadian Farm Building Code* was published, including revised specifications for tower silos. Improved designs were developed for reinforced concrete ring foundations for tower silos bearing on low-strength clay soils.

Construction cost estimates of eight types of long-term storages for semisolid and liquid manures showed that concrete storages with roofs to exclude precipitation cost \$26–33/m³; clay-lined earth storages cost as low as \$6/m³.

Lightweight gambrel roof arches for framing farm storage and livestock buildings were designed to meet snow and wind load requirements across Canada; the arch plans were prepared for clear spans from 6 to 21.6 m, in both traditional and metric dimensions.

Air-to-air heat exchangers were evaluated for improving winter ventilation for poultry and swine; exhaust air heat recovery showed the greatest cost and energy savings where the animal rooms must be quite warm and where high winter ventilation rates are required.

Improved information was prepared for planning farrow-to-finish swine housing, and recommendations were published on why and how to produce cleaner feedlot cattle.

Plans were reviewed for 33 construction proposals for increased food storage under the Agriculture Canada fruit and vegetable storage assistance program, resulting in \$3.4 million in grants.

Building engineering courses were presented to provincial extension engineers at Lethbridge, Alta., and Brandon, Man., and metric design-drafting courses were given to provincial draftsmen at Quebec, Que.; Woodstock and Brighton, Ont.; Regina, Sask.; and Moncton, N.B.

Canada Plan Service (CPS)

The CPS Design Center, cooperating with Information Services of Agriculture Canada and the 10 provincial departments of agriculture, prepared and distributed 71 building plan sets and 55 catalog leaflets. Annual indexes were issued for plans and leaflets available at April 1977 and April 1978. All 10 series of the CPS system were revised, but the main changes were in the dairy, swine,

grain forage and feed, and building engineering series.

The CPS is committed to support and encourage complete and rapid conversion to metric construction in Canada. Plans and leaflets since November 1976 have been produced in both traditional and metric measurements. A *Metric Fact Sheet* was developed to aid designers in preparation of plans to the latest metric standards, and over 25% of CPS plans and leaflets listed are now available in metric.

Environment

Concrete manure storage tanks, built below ground and water table, have leaked groundwater inwards when emptied, but outward leakage has not been serious enough to have any adverse effect on the quality of surrounding groundwater. Repeated high rates of manure application (providing N at 700–1100 kg/ha per year) on coarse-textured soil caused abnormally high (but not increasing) concentrations of nitrate nitrogen; groundwater concentrations averaged 33 mg/L directly beneath the field area.

On fine-textured flat fields previously not manured, manure applications at N rates of 500–700 kg/ha per year have not affected the quality of the groundwater. Tile drainage effluent concentrations of phosphorus and potassium were unaffected by the manure, but nitrate nitrogen concentration increased nonlinearly, exceeding 10 mg/L after accumulative manure application reached a N rate of 2200 kg/ha.

Rate and time of manure application studies on gently sloping medium-textured soil showed that winter-spread manure at all application rates resulted in spring-melt surface runoff concentrations of nitrate plus ammonium nitrogen and phosphate phosphorus that were much higher than those resulting from spring, fall, or spring–fall applications regardless of rate. However, tile drainage effluent quality showed little effect of time of application but showed an increase in both nitrate nitrogen and phosphate phosphorus with increasing rates. Formulae developed from studies of feedlot and manure storage runoff appear to be acceptable across Canada for design of feedlot runoff control structure size.

TECHNICAL AND SCIENTIFIC INFORMATION

The information retrieval system for agricultural engineering information was expanded by the addition of over 3800 references. In addition to its use for locating documents on specific subjects, it has been used for preparing a list of Canadian extension publications having agricultural engineering. Reports from the contracting out of research program have been cataloged and a cumulative cross-referenced list prepared. Problems relating to metric conversion of agriculture, particularly at the farm level, have been studied, and a list of metric units was produced. Documents and other information have been acquired on most areas of

agricultural engineering, with emphasis on new developments related to energy. Numerous regional, national, and international enquiries for information were handled.

TECHNICAL SERVICES

The workshop completed 294 fabrication and machine construction jobs during 1977 and 1978. These ranged from simple parts or devices to sophisticated instruments as well as plot and farm scale agricultural machinery. Curing chambers were developed for experiments with cigar and cigarette tobacco to better simulate and improve commercial processes.

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Research Program Service

Ottawa, Ontario

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Departures

G. W. MERRITT
Retired July 19, 1978
T. H. STOVELL
Retired December 28, 1978
D. B. WADDELL
Retired December 28, 1978

Photography
Photography
Head of Section;
Information liaison

INTRODUCTION

Research Program Service continued to support the Research Branch by providing quality technical services. Among its accomplishments in 1977 and 1978 were the development and implementation of the Inventory of Canadian Agricultural Research, including the publication of the 1976 and 1977 indexes; the close examination of the operations of the Pesticide Information Liaison Section for the purpose of defining its role; and the expansion of text-processing capabilities to include the use of optical character recognition technology by Branch establishments in the preparation of manuscripts in order to reduce production costs and time required to produce a publication.

This report summarizes developments in 1977 and 1978. Additional information may be obtained by writing to: Director, Research Program Service, Research Branch, Ottawa, Ont. K1A 0C6.

S. Plourde
Director

SCIENTIFIC EDITING

Scientific editors prepared for publication scientific and technical manuscripts covering a wide range of agricultural subjects, including animal nutrition, crop production and protection, food processing, engineering, and soil science. Many of the publications were useful to farmers and homeowners; other publications were intended for scientists and research workers in universities, industry, and government. Some of these publications were reports of special studies, whereas others were compilations of extensive research carried out for several years on one subject.

Some of the books issued in 1978 were *The Canadian system of soil classification*, *An atlas of airborne pollen grains and common fungus spores of Canada*, and *Ferns of the Ottawa district*. Other publications included *Turkey broiler production*, *Tobacco diseases*, and *History of soil survey in Canada, 1914-1975*.

GRAPHICS

In 1978, the number of requests for services received from the executive and scientists in the Department was 1551, an increase of 12.5% over the previous year. These services included technical and biological illustrations; publications layout and design; drafting and line artwork; photomicrography; laboratory, field, and studio technical

photography; film processing and print production; color separations for offset reproduction; and lithographic line and halftone production.

INFORMATION PROCESSING

During the past 2 yr, mechanized text processing has been expanded. In 1978, computerized phototypesetting was used for about 5000 pages of Branch and Department publications.

In mid-1975, an inventory of agriculture and food-related research and development was started. This Inventory of Canadian Agricultural Research (ICAR) is used by the Canadian Agricultural Services coordinating Committee (CASCC), Canadian Agricultural Research Council (CARC), and other organizations in Canada concerned with agricultural and food-related research and development. With the assistance of the CARC Inventory Committee, members data on research projects are collected from provincial governments, universities, and industry and transferred by our staff into ICAR, which is computerized, and handled by system 2000 data base management system. New projects are entered in ICAR as they are started. ICAR is updated each year.

INFORMATION LIAISON

An important vehicle for communication among the research establishments across the country is the in-house newspaper *Tableau*.

Nine issues were published in 1978. One issue was concerned only with the Branch reorganization. Itineraries were arranged for visiting French scientists under the Canada-France exchange agreement. Exchange missions were coordinated under the Canada-USSR exchange agreement, and arrangements were made for visiting scientists and other visitors.

PESTICIDE INFORMATION LIAISON

Eighty-four submissions for registration under the Pest Control Products Act administered by Agriculture Canada were reviewed and evaluated in 1978. These consisted of 10 herbicides, 31 fungicides, and 43 insecticides, which were carefully scrutinized for efficacy, toxicity, crop tolerance, and soil and water metabolism and residues. The majority of these applications were subsequently registered.

Ten summary data sheets on new candidate pesticides under development in Canada were prepared and issued. Information and advice on pesticide research and pesticide use were provided to officials and scientists in industry, the Branch, provincial governments, universities, and intradepartmentally to research coordinators and the executive for their consideration in formulating Branch policies, programs, and priorities.

For the first time, the *1978 Pesticide Research Report* was made computer-searchable, with a capability of access for 1975, 1976, and 1978. The 1977 report will soon be placed on the computer.

A biological control importation service is provided to federal agricultural and forestry laboratories. Information and collections of natural enemies are gathered mainly in central Europe as arranged under a contract with the Commonwealth Institute of Biological Control. Projects in 1978 included the cereal leaf beetle for the Research Station, Ottawa; rape insects (flea beetles, bertha armyworm, and red turnip beetle) for the

Research Stations, Winnipeg and Saskatoon; the European skipper for the Research Station, Sainte-Foy; the tarnished plant bug and alfalfa plant bug for the Research Station, Saskatoon; the leaf midge on apple for the Research Station, Fredericton; weed-feeding insects for the Research Station, Regina; the winter moth and larch casebearer for the Forest Research Centre, Victoria; and the European pine shoot moth for the Forest Research Centre, Sault Sainte Marie.

AWARDS

The Administration Section is responsible for administering two granting programs in aid of university research for the Department: the extramural research program and the operating grants program.

The extramural research program is used to solicit specific research activities from university scientists to undertake research on priority activities that the Department does not have personnel to work on. The program is the responsibility of a departmental committee appointed by the Deputy Minister. It is representative of all operating branches and operators with an annual budget of \$327 000. Each year there are approximately 50 applications received.

The operating grants program pays for projects conducted by university researchers and assists in graduate training. The selection committee is composed of three representatives of Agriculture Canada and seven representatives of faculties of agriculture and veterinary science. Each year about 300 applications requesting funding are received. The annual budget is \$889 000.

The Administration Section also administers the visiting fellowship program for the Department. The purpose of the program is to give promising young Canadian and foreign scientists the opportunity of working with distinguished researchers in their respective disciplines before embarking on careers in scientific research. Approximately 200 applications are received each year and the number accepted is the responsibility of each region or branch.

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Research Station

Brandon, Manitoba

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Departures

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INTRODUCTION

This report summarizes the highlights of research activities in 1977–1978. Research continued to emphasize breeding and physiology of beef cattle and swine in animal science; and breeding, physiology, and management, soil fertility and plant nutrition, cultural practice, and weed control in plant science. Research was initiated in swine nutrition and discontinued in poultry genetics and physiology.

Dr. D. L. Grinwich and Dr. R. R. Grandhi were appointed in July and September 1977, respectively, to strengthen the research team in swine physiology and nutrition.

Dr. R. I. Hamilton was appointed for a 2-yr term as expert advisor in the India dryland project at Hyderabad and Mr. R. D. Dryden for a 2-yr term as the Canadian team leader for the Sri Lanka project on rainfed agriculture.

For further information concerning details of activities or related subjects, direct enquiries to: Research Station, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef cattle

Foreign cattle breed evaluation. Since 1970, Agriculture Canada research stations at Brandon, Man., and Lacombe and Lethbridge (Manyberries), Alta., have become engaged in a cooperative research program with specified breeds of European cattle to determine their role and usefulness in the Canadian beef industry. Considering physiological and economic factors important to beef production, initial research evaluated the European breeds as top crossing sires on females of the common British breeds in producing hybrid calves for meat production. Currently, hybrids representing 10 breed combinations (Charolais, Limousin, and Simmental \times Hereford, Angus, and Short-horn; plus a Hereford \times Angus control cross) are being evaluated for beef production when mated with sires of four European breeds (Charolais, Chianina, Limousin, and Simmental) in such a way that no backcrosses occur. Birth data for 3379 three-breed-cross calves clearly indicate that sex of calf has the greatest effect on ease of calving. Little difficulty was experienced with births of female calves, which averaged 3.1 kg (7%) less than males. Among males, calves sired by Charolais bulls had the highest incidence of difficult calving, followed in order by those sired by Chianina, Simmental, and Limousin bulls. Breed-of-sire rankings for 200-day adjusted weight, weight on test, postweaning gain on a 140-day feedlot period, and final

weight indicated Limousin-sired calves grow more slowly (5–10%) than calves from the other three sire breeds, which were about equal. Based on 2092 carcasses preliminary results indicate that those from Limousin sire groups had less bone and more lean meat than carcasses from the other sire groups. Chianina carcasses had the most bone but ranked second to the Limousin carcasses in proportion of high-priced cuts (rib, loin, and round). Carcasses produced by the progeny of Simmental and Charolais bulls were similar in most traits but the Simmental progeny had the smaller area of rib eye, heavier hides (reduced dressing percentage), and a slightly lower content of lean meat in the loin and round.

Control of gastrointestinal parasites. In a 140-day trial, 406 feeders were assigned to four treatment groups to evaluate treatment with a broad spectrum anthelmintic to control gastrointestinal parasites in the feedlot. A light infestation was observed and only 11% of the 54 animals from which fecal samples were taken showed a significant parasitic egg count. Treatment on day 1, day 84, or days 1 and 84 failed to indicate any response to treatment and there was clear indication that routine treatment was of no advantage unless a significant degree of infestation is diagnosed as present.

Observations on reasons for culling barren cows. In an 8-yr period a 530-cow herd was reduced by 107 head by culling animals failing to conceive in two consecutive years

with the culling decision based on a pregnancy diagnosis by rectal palpation. Examination of the reproductive tracts revealed that failure to conceive without apparent reason accounted for 57% of barren cows, adhesions on the ovaries or abnormal fallopian tubes 19.5%, anestrus 7.5%, abnormal ovarian activity (cystic follicles) 4.7%, evidence of recent embryonic death (fetal resorption) 4.7%, and late pregnancy 1.9%. In the first 5 yr of the period 42% of the cows removed as barren had completely normal reproductive tracts (appeared fully capable of conception) and in the last 3 yr this increased to 75%.

Swine

Correlated response to selection for growth rate. Correlated responses in various carcass traits were evaluated in a population of Lacombe pigs during 11 yr of selection for rapid postweaning growth. Positive correlations were found between growth rate and length of carcass, backfat thickness, and ham weight while negative relationships were established between growth rate and percentage lean in the ham face, color, texture, marbling, and area of loin eye.

Sex odor in market hogs. Samples of lean and fat from gilts, barrows, and young and older (171 vs. 195 days of age) boars at market weight (90 kg) were evaluated according to taste and odor by a taste panel. Pork chops from barrows were preferred over those from gilts, older, and young boars for tenderness, juiciness, and flavor. Fat odor scores were lower (more desirable) for barrows and gilts than for either group of boars. The "hot iron" test confirmed this except that older boars had a much stronger odor than young boars. Barrows had the firmest fat while the boar groups had a softer more oily fat (higher iodine number) than either barrows or gilts.

Inside vs. outside housing for sows during gestation. Following the weaning of their first litters two comparable groups of sows were subjected to two types of housing management for three successive gestations. One group was maintained in a climate-controlled piggery throughout gestation and lactation while the other group was housed in outside pens during gestation and returned to the climate-controlled piggery during each lactation. Considering all sows in this test the interval from weaning to rebreeding after

para 1 was longer than the corresponding interval following paras 2 and 3 (8.2 vs. 4.6 vs. 4.7 days). Type of housing during gestation had no significant effect on length of gestation (115.7 days), birth weight (1.3 kg), and weaning weight (8.9 kg), number of piglets per litter (10.1 vs. 10.7), number born alive (9.6 vs. 10.0), or total birth weight per litter (12.8 vs. 13.8). However, litters from sows housed outside had lower mortality (28.6 vs. 21.2), more pigs weaned (7.1 vs. 8.3), and greater total weight at weaning (63.5 vs. 74.2 kg).

Effect of feed consumption levels on embryo number and survival. Comparison of gilts on a low (1.5 kg/day) vs. high (2.5 kg/day) level of feed consumption for a 30–35 day period after breeding revealed a tendency for gilts on a low level of feed to have a larger number of embryos (11.3 vs. 9.5) and a significantly higher percentage of embryo survival (84.7 vs. 70.6) than gilts on the high level of consumption. No clear effects of changing from low to high or from high to low levels, 10 days after breeding (preceding implantation about day 12) were observed.

Embryonic mortality. Preliminary studies of physiological mechanisms associated with embryonic death losses in Lacombe gilts indicate that supplementation of specific reproductive hormones may be effective for increasing the percentage of embryo survival. In a pilot study the administration of estrogen, progesterone, and a combination of the two hormones resulted in survival percentages 96.6, 87.3, and 82.9 after 21–23 days pregnancy compared with 71.4% in an unsupplemented control group.

Biotin supplementation for sows. Biotin supplementation (200 mg/kg) of a barley-wheat-soybean meal ration for gestation and lactation did not affect reproductive performance but appeared to reduce the severity of hoof and leg lesions causing lameness in sows and gilts housed in outside pens.

Feed restriction for market hogs. Comparison of restricted feeding vs. full feeding from about 60 kg live body weight to market weight (90 kg) indicated clearly that there was no economic advantage to feed restriction for finishing hogs. On comparison of five treatment groups (continual full fed, full fed for two 24-h periods a week, full fed for three 24-h periods a week, limited daily feed from 60 kg body weight, and limited daily feed

from 70 kg body weight) the average gains were 0.73, 0.68, 0.65, 0.67, and 0.68 kg/day and average feed requirements per kilogram of gain were 3.2, 3.2, 3.2, 3.3, and 3.3. Feed restriction had a slightly greater effect on the rate of gain in barrows than in gilts and feed conversion was less efficient for the two groups on limited daily feed allocations (floor fed). Backfat thickness and body weight were highly correlated and there was a reduction in fat deposition with restricted feeding. Although restricted feeding resulted in lower average daily feed consumption than under full feeding more total feed was required to reach market weight.

PLANT SCIENCE

Forage crops

Alfalfa production and management. Alfalfa responded in yield and quality (protein content) to applications of P, K, and S. Fertilizer P is a requirement for all Prairie soils. Applications of K and S increased longevity of stand, N utilization by the plant, and N fixation in the soil in addition to producing yield increases. For maximum yield of quality alfalfa a N/S ratio of 12:1 and a N/K ratio of 1:1 should be maintained. Supplementation of micronutrients Cu and Mo either as soil amendments or as foliar sprays increased protein content and N fixation. At low levels of fertility, alfalfa is subject to severe winter killing (up to 38%) but the use of recommended varieties and recommended levels of fertility can reduce damage to less than 10%. Flamande type alfalfas showed better regrowth characteristics than standard varieties but continued to show requirement for improved winter hardiness.

Grass-legume mixtures for hay and pasture. Grasses in mixed stands (1:1) with alfalfa, sainfoin, or birdsfoot trefoil yield 40% more when the grass and the legume were seeded together in the same rows or seeded separately in rows at right angles than when the grass and legume were seeded in alternate rows. By the 4th yr after establishment, all legume species suffered some degree of winter killing (Leo birdsfoot trefoil 98%, Melrose sainfoin 74%, Vernal alfalfa 15%, and Rambler alfalfa 11%). The grasses showed no winter injury.

Oilseed crops

Response of soybeans and fababeans to P, K, and S. Both crops responded to applications of P, K, and S but differed in the manner of utilization for plant development. Yields of beans at maturity were similar (2.9 vs. 3.2 t/ha) but at the 'full-pod' stage of development fababeans produced 10–15% more whole-plant material. Analyses for N, P, K, and S in whole-plant samples at the full-pod stage were 4.80, 0.29, 3.50, and 0.35% for fababeans compared with 4.68, 0.28, 3.42, and 0.32% for soybeans. Similar analyses of the mature beans indicated that soybeans contained 6.60, 0.86, 2.58, and 0.36% N, P, K, and S compared with 5.23, 0.82, 1.37, and 0.21% for fababeans. Thus it was indicated that fababeans fixed and used more N than soybeans but the latter showed greater accumulation of the nutrient elements in the beans.

Soybean production. Investigation of the potential for soybean production on the eastern Prairies and improvement of the crop to increase its adaptation was initiated in 1974 and has made significant progress. In cooperation with Brandon scientists, soybean breeders at the Ottawa Research Station have developed several promising lines of soybeans with good yield potential and early maturity to permit adaptation to low heat unit areas (2100 CHU) of the Prairies. One line, BD 21117, represents a breakthrough for maturity and has been recommended for licensing. In 1978 tests, the new line matured 2 wk earlier than the earliest standard variety, Portage, and yielded 2.5 t/ha compared with 2.7 t/ha for Portage. In the same test McCall, a recently licensed USDA variety of the 00 type, yielded 3.0 t/ha.

Weed control in soybeans. Soil-incorporated trifluralin at 1.1 kg/ha followed by a postemergence application of bentazon or RH 6201 (0.4 kg/ha) is the most effective herbicide combination for the control of grassy and broadleaf weeds. The 1978 data indicate that the bentazon application could be reduced to 0.2 kg/ha without reducing the herbicidal effect.

Fertilizer placement for flax. When fertilizer P was placed directly below the seed (2.5 cm) the flax yield response ranged up to 2.0 t/ha. This differs from the response of rapeseed to fertilizer placement where the

response was equally satisfactory when fertilizer P was placed 2.5 cm below and 2.5 cm to the side of the seed (side banding).

Weed control in flax and rapeseed. The action of diclofop-methyl (Hoe 23408) at 0.84–1.12 kg/ha and BAS 9021 at 0.56–0.70 kg/ha for controlling wild oats and green foxtail was enhanced when either Renex or Atplus was used as a wetting agent. The increased activity of the herbicide did not adversely affect the crop. Diclofop-methyl, BAS 9021 and 9056, and Hoe 29152 controlled volunteer crops (corn and other cereals) in rapeseed. Yields of rapeseed were increased and wild oats were controlled with a preplant application of trifluralin and NH_4SO_4 as a granular mixture. Similarly broad spectrum control was achieved and yield was increased when BAS 9052, broadleaf herbicides, and solution N were applied as a tank mix prior to seeding.

Cereal crops

Barley breeding and genetics. In 1978 a new cultivar superior in yield (7.0%) and agronomic characteristics to Klondike in central and eastern Manitoba and comparable in other areas was approved for license. Two new multiple recessive marker stocks (chromosomes one and seven) have been developed with contrasting alleles on one outstanding multiple dominant marker line.

In the malting barley phase of the program two lines with excellent yield potential are in the final stages of evaluation and several advanced lines are in preliminary tests. The haploid breeding technique is being used as a procedure for making wide crosses such as two-row \times six-row lines and a large number of these lines are being evaluated.

Date of seeding for cereal crops. Over a 15-yr period date-of-seeding studies with wheat and barley have shown that yield, test weight, and seed size decreased while the incidence of leaf diseases increased as the date of seeding advanced from early May to mid-June. Conquest barley, which was added to the test in 1968, has been an exception and has performed as well when seeded in early June as when seeded in early May.

Weed control in wheat and barley. In evaluating herbicides alone and in combinations, several chemicals have been identified as effective against specific weeds or weed types. Some are compatible with the crop

being grown while others are injurious and of limited use.

Diclofop-methyl at 0.6–0.7 kg/ha applied with Renex 36 as a wetting agent have excellent control of wild oats and green foxtail in wheat and barley. At high rates of application barley (two-row and six-row) was less tolerant than wheat.

Difenzoquat at 0.6–0.8 kg/ha gave good control of wild oats in wheat and barley but except for Sinton all wheat cultivars (Glenlea, Neepawa, Selkirk) were susceptible to the herbicide. Mixing difenzoquat with bromoxynil, bromoxynil/MCPA ester, MCPA ester, or 2,4-D ester gave effective control of broadleaf weeds without loss of effectiveness against wild oats, but Sinton continued to be the only tolerant wheat cultivar. Postemergence application of a three-herbicide mixture (barban, flampop-methyl, and difenzoquat) following soil-incorporated triallate or trifluralin did not alter the lack of tolerance of wheat cultivars but did improve wild oat control.

Dinitroaniline herbicides in mixtures with triallate controlled green foxtail and some broadleaf weeds in wheat.

A mixture of triallate and solution N (28-0-0) with N at 66 kg/ha applied as a soil-incorporated treatment gave effective wild oat and green foxtail control, increased yields by 2.3 t/ha, and increased protein content (16%) of wheat.

Corn production and management. Screening trials have identified several lines with adequate maturity for the 2250 CHU region of the eastern Prairies. A number of these lines surpass the established target yield of 7.2 t/ha while maintaining a test weight above 70 kg/hL. The linear relationship between date of seeding and grain yield and test weight has been established for corn seeding dates from early to late May.

Nutrient requirements for corn. Tissue tests in corn have enabled the identification of nutrient deficiencies and excesses. According to USDA standards Zn may be marginally deficient while Mg levels appear to be excessive.

Weed control in corn. Soil incorporation of atrazine, cyanazene, and alachlor resulted in increased efficiency of grassy weed control over preemergence applications. Corn tolerated rates of EPTC as high as 13 kg/ha without a protectant. Partial control of

Canada thistle top growth was obtained with a mixture of dicamba, 2,4-D, and bentazon.

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Research Station

Morden, Manitoba

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Transferred to Lethbridge, June 1978

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Breeding of vegetables and
sunflowers

INTRODUCTION

The program of the Research Station at Morden is directed toward improving cultivars and management practices in several special seed crops, herbaceous and woody ornamentals, vegetable crops, and new crops.

Research has resulted in new releases of two shade trees, two roses, and two hardy chrysanthemums, and in licensing of one cultivar each of flax and field peas, two cultivars of sunflower, and three hybrids of field corn.

We welcome Dr. D. E. Vanstone, a physiologist, who joined our staff to conduct research on nursery management and propagation of woody ornamentals. Dr. E. D. P. Whelan, vegetable breeding, was transferred to the wheat cytology program at Lethbridge. In August 1978, Dr. D. G. Dorrell was seconded to the Planning and Evaluation Directorate in Ottawa for a period of 1 yr. Dr. E. D. Putt retired in December 1978 after 12 yr here as Director.

This report summarizes some of the more important research results from the Station in 1977 and 1978. Further information can be obtained by personal communication with the scientists at the Research Station, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0.

B. B. Chubey
Acting Director

FIELD CROPS

Buckwheat

Breeding. CM136 is to be considered for release. It matures 1 day earlier and outyields Mancan by 10% in 3 yr of co-op testing with seed size 29.7 g/1000 seeds compared to 31.1 g for Mancan. Emphasis is now on development of semidwarf, large-seeded lines resistant to lodging to allow growing buckwheat on more fertile soils by reducing problems of severe lodging and in harvesting. Development of large-seeded lines maturing earlier than varieties presently licensed is also emphasized. Preliminary studies indicate early \times semidwarfs/large-seeded have higher yield potential than semidwarfs \times large-seeded lines.

Management. Yields did not increase when six growth regulators and three antitranspirants were applied during flowering and seed development stages; however, daminozide did increase weight per seed. A technique was implemented to measure shattering resistance in new lines. Preharvest losses from shattering in present varieties has been as high as 35% depending on cultivar and winds.

Disease. In 1977, downy mildew on buckwheat was identified, ranging from light to severe leaf infection with some systemic infection. Preliminary tests indicate that some

lines in the breeding program may be resistant to this disease.

Field corn

Breeding. Morden hybrids Pride 1108, Asgrow RX17, and Pride R090, all excellent in grain yield and maturity, were licensed for sale in Canada. Seed Trade used Morden inbreds to develop and license hybrids Pioneer 3995, Pioneer 3996, Trojan 737, Hyland 3208, PAG501, and Dekalb 23. All of these hybrids were recommended for Manitoba and some were recommended for Alberta. Morden inbreds were also used in hybrids now grown in Ontario and USA. New hybrids with improved yield, earlier maturity, and better stalk quality were identified, one exceeding checks by 0.5 t in yield with 5% less moisture at harvest. Dent inbreds \times French line F₂ produced fast-drying, high-yielding hybrids, incorporating excellent cold tolerance and stalk rot resistance from normally slow-drying European lines. Flint, dent, and semident kernel types from Canada, USA, and Europe were used to develop 1000 inbreds with maturity from 6 days later to 10 days earlier in flowering than CM7; combining ability is still to be determined.

Management. Simulated spring frost studies carried out on plants 15–30 cm tall

produced yields 70 and 39% of check averaged over 2 yr. Simulated hail damage at silking produced 88% loss of grain yield with all leaves removed, and 17% loss with 50% of leaf tissue removed. Treatment advanced maturity and in some cases reduced moisture by 8% at harvest. Plantings in summerfallow on sandy soil showed reduced plant height and grain yield with delayed flowering. Purple coloration at seedling stage remained in inbreds while hybrids usually recovered green color later in the season.

Field peas

Breeding. Tara, a high-yielding yellow-seeded cultivar resistant to powdery mildew, was licensed in 1978. The Station is considering licensing MP790, a yellow-seeded selection from Century \times Costa Rica outyielding checks by 20% over 3 yr of testing in Ontario and Quebec. Green-seeded cultivar Triumph purified of pea seed borne Mosaic Virus and other genotypes is planned to be released in 1979. Selections were made to transfer leafless characters in Canadian cultivars. Some leafless *af af/St St* genotypes have yielded up to 2642 kg/ha.

Quality. In cooperation with Catelli Ltd., studies were conducted to determine factors affecting field pea cooking quality. Peas harvested immediately after maturity were best for cooking. Chemical analysis showed soft-cooking peas had higher P, K, Ca, Mg, Fe, and Zn content but lower N than hard-cooking peas. In electron microscopic studies no significant differences in seedcoat structure between soft- and hard-cooking cultivars were revealed.

Diseases. Field plot studies showed PSbMV reduced seed yield in Trapper and Century by 11 and 36%, respectively, mostly due to reduction in seed size. Seed transmission of the virus was about 0.5–5.8%. In detecting PSbMV the quality of the immunodiffusion serology reaction in Bacto agar was enhanced over Special Noble agar. Other modifications of the test reduced demand on antiserum and increased sample size from the population being tested. Over 2000 breeding lines were screened for PSbMV, with approximately 7% showing virus infection. Fungicide treatment of severely cracked and normal seed of two cultivars improved field emergence to 99% from 58 and 79%, respectively. In a field assessment, several advanced breeding lines

showed good resistance to mycosphaerella blight and two lines besides Tara were found to be highly resistant to powdery mildew.

Management. In field studies of effect of lower light intensity on quality, yield, and seed weight, shading for 3 wk before maturity increased protein content but decreased seed yield, seed weight, and viscosity of cooked peas. Shading before and after maturity in 3-wk periods resulted in reduction of green color loss in pea seeds. Ethalfluralin, a new herbicide, used on Century at 0.69, 0.87, and 1.1 kg/ha showed no injury symptoms or significant differences in yield or seed weight.

OILSEED CROPS

Flax

Breeding. Culbert, a US-developed cultivar with oil quality/protein content superiority, was licensed in 1978. It is similar to Linott as it is well adapted to late seeding, but 2–4 days later in maturing. FP692 and 698, two experimental lines, continued to outyield Linott and Dufferin in coop tests.

Diseases. Cultivars with seedling susceptibility to races of *Melampsora lini* showed varying levels of "postseedling" resistance when plants 5–6 wk old were exposed to infection by four virulent races. In the field and greenhouse rust infection was severe in Summit, moderate in Nored, light in Redwood 65 and Noralta, and very light in Norland. Plants of Redwood 65 inoculated with virulent race 371 at 6 wk and repeated at prebloom stage, were less severely rusted and yielded more seed than flax inoculated only at prebloom stage. The protective action of preinoculation appeared to be systemic, as expressed in newly formed tissue at remote sites. Yield was depressed most with single prebloom stage inoculations.

Management. A study of effects of temperature and growth regulators on growth of flax under controlled environment showed that, under continuous light, raising the temperature from 20°C to 30°C hastened maturity by 7–19 days but greatly reduced number of seeds produced and weight per seed. Foliar applications of daminozide reduced plant height and increased weight per seed at both 20°C and 30°C. At 30°C, daminozide treatments increased number of capsules per plant and seeds per capsule,

resulting in a large increase in seeds per plant.

Weed control. Results of a field test carried out over several years to screen flax cultivars for relative susceptibility to herbicide injury showed such tests to be of doubtful value. It was found impossible to obtain reliable, reproducible susceptibility indexes for any cultivar.

Quality. Flaxseed mucilage concentration is strongly affected by both genotype and environment. Certain widely diverse growing locations in the southern prairies produced lower than expected levels of mucilage, with Raja averaging less than 6% and Linott more than 8%. Severe seed weathering in 1977 seriously reduced bushel weight and grade, lowering mucilage content of the seed and water-holding capacity of the meal; however, oil and protein content were not significantly reduced.

Sunflowers

Breeding. Saturn and Corona, open-pollinated varieties, were licensed during the last 2 yr. Four experimental hybrids look promising after 2 yr of testing, with earlier maturity than current US hybrids and 7–15% higher oil content than open-pollinated varieties; licensing is being considered for at least one. The Station will propose licensing US hybrids 894 and 8944; these showed 15% higher yield over open-pollinated varieties in Manitoba tests, but were rather later maturing with considerable variability in disease resistance. New sources of cytoplasmic male sterility were found in *Helianthus petiolaris*, but restored only by the French line, thus indicating at least two restorer genes are involved. Field performance studies of two sources of Krasnodarets showed significant differences in achene characteristics and oil content, but there were no significant differences in plant and seed characteristics with advancing generations.

Diseases. A soil-borne disease of unknown etiology, which causes premature ripening, is found to be increasingly widespread in the oldest sunflower production area in Manitoba. Biological control of sclerotinia wilt by the hyperparasite *Coniothyrium minitans* resulted in increase in yields in naturally infested fields in 1977 and artificially infested fields in 1978 by 24 and 37%, respectively. The hyperparasite appears to survive over

winter and was found in 32% of fields surveyed. Sunflower seedlings were screened for tolerance to the wilt phase of the disease syndrome using culture filtrates of *S. sclerotiorum*. Reactions varied from moderately resistant to highly susceptible among nine inbred lines, six F₁ hybrids, and one open-pollinated cultivar tested.

Quality. Sclerotinia wilt, occurring any time from flowering to near maturity, significantly reduced seed weight and yield. Seed quality, measured by test weight and by oil and protein content, was significantly reduced if plants wilted within 6 wk of flowering. Oil quality was not affected. Seeds of several cultivars and hybrids in five classes were screened and analyzed for several physical and chemical characteristics. Those 3.2–4.0 mm in diameter gave the best overall combination of oil, test weight, dehulling efficiency, and packing.

Weed control. Flamprop methyl gave excellent control of wild oats and was selective at a rate that may be economically feasible. Ethalfluralin looks promising as an alternative to trifluralin for general weed control. To date, none of the herbicides screened gives selective postemergence of wild mustard; oxadiazon, although effective on Brown soils, appears ineffective on Black soils.

VEGETABLE CROPS

Sweet corn

The Station is considering release of three sweet corn hybrids: Morden 71112, an early fresh-market type with maturity similar to Early Vee; and Morden 71154 and 71276, processing types maturing 2–10 days earlier, respectively, than the standard commercial control NK51036. This program was terminated in 1978.

Potatoes

Breeding and evaluation. In 1977, the first use of rapid increase procedures by single node cuttings was made to obtain final evaluation of promising new cultivars, which were then given grower and industry exposure in 1978. The Station developed an approved model for industry participation in the program whereby input is provided for increase, monitoring grower fields, and industry evaluation. Ten cultivars were identified from prairie regional and northcentral

trials. They were increased in 1979 industry evaluation for potential release and licensing as improvements over standards grown for tablestock, chipping, or French frying. The present most promising cultivars are M69S06-69 (chipping), ND8891-3 (chipping/French frying), and A68678-1 (midseason French fryer).

Quality. In a 3-yr storage study with chipping potatoes from Quebec, Ontario, Manitoba, and Alberta, it was determined that "crop-to-crop" storage is possible. Physiological tuber maturity at harvest is the most critical factor influencing tuber suitability for long-term storage. Sucrose content of tubers at harvest is being investigated as an estimate of physiological maturity.

ORNAMENTALS

Breeding. The Station introduced two shade trees in 1977: Jacan, a Japanese elm resistant to Dutch elm disease, selected to replace disease-susceptible American elm on the prairies; and Delta hackberry, a hardy native seed strain. Two introductions of Parkland rises, Morden Ruby and Morden Amorette (miniature), were distributed in 1977. To be introduced in 1979 are Tower poplar, a disease-resistant columnar aspen hybrid originating from *P. alba* L. \times *P. tremula* L.; Erecta, which is seedless and relatively free from suckering, with potential use as a tall hedge, shelterbelt, or accent plant; and Spring Gold forsythia (jointly with Ottawa) with flower bud hardiness. Two cushion type chrysanthemums will also be introduced in 1979. The one is Morden Gaiety, free-blooming in early fall and winter hardy, selected from an unnamed seedling derived from Sunny Glow \times Minnesota Autumn F₂ crossed Eva Marshall. It has double flowers over 5 cm in diameter ranging in color from persimmon to Spanish orange. The other is Morden Garnet, developed from a cross between two unnamed seedlings. It blooms in early fall with double cardinal red flowers 6 cm in width. A new coral bell, *Heuchera* Northern Fire, will be introduced in 1979. It is from Brandon Pink through open-pollinated selections. This hardy long-lived perennial has numerous bell-shaped flowers on many panicles up to 60 cm in height in early summer, ranging from currant red tips to Delft rose at the base.

Promising selections have been identified in poplar, willow, honeysuckle, and rose breeding programs. Tetraploid rose seedlings were derived from apparent fusion of a nonreduced egg cell with normal pollen from the male, and combine two valuable species for breeding hardy roses, being highly cross compatible with both hardy and tender high-quality tetraploids. These will be released to breeders as germ plasm.

Arboretum and evaluation. Woody plant evaluation continued in the Morden arboretum, in eight regional zonation tests, and three shade tree sites. This was publicized in two series of articles and a bulletin on alternative trees to American elm. New arboretum plantings were established for the *Viburnum* and *Cornus* collection; over 400 accessions have been received as seeds, cuttings, or plants.

Propagation. Tower columnar poplar was successfully propagated from small root cuttings. Studies with aspen poplar hybrids indicate that significantly improved rootability is possible through intersectional breeding. Commercially acceptable germination of American basswood seed was obtained when collected and sown as soon as the pericarp had become grayish brown.

Fruit breeding. The Station evaluated 51 apple selections in the prairie fruit breeding cooperative second test based on quality, hardiness in three orchards (Morden, Melfort, Brooks), and disease resistance. Three selections originating in colder prairie regions (Scott, Lacombe, Brooks) are to be named and distributed to nurserymen in 1979. The introduction of the Ure pear, originally selected in 1953, marks an advance in prairie pears and budwood. Requests suggest that the cultivar will be widely grown; trees are medium tall, sturdy, and hardy and fruit is medium in size with good texture and flavor.

NEW CROPS

Jerusalem artichoke

Evaluation. There was no increase in existing variability with new accessions. The coop test yield averaged 36.4 t/ha with the highest yield being 67.3 t/ha.

Management. Maleic hydrazide (foliar spray, first to 50% flowering) prolonged in situ spring tuber storage (though complete

sprouting inhibition required critical concentration). Thiobendazole most effectively controlled *Sclerotinia sclerotiorum* infection. Ethaphon (foliarly applied at 90% flowering) effected greater tuber separation as did modifications to the potato harvester.

Quality. Total reducing sugar content in tubers increased to 21.2%, decreasing to 15.4% during winter and subsequently to 11.4% in the following 4 wk. Fructose content decreased to 77.7% in the first period and subsequently to a constant 70% level. Forage quality was best prior to flowering. High N fertilization improved and sustained high protein (19.7%), and low fiber (30.7%), and lignin (6.4%) contents.

Chicory

Management. Planting, growing (except weed control), and harvesting practices of chicory were assessed as adequate for initiating commercial production. No yield advantage was found from varying combinations of N, P, and K. Average DM yields for 2 yr at Morden and Ottawa were 8.5 and 11.1 t/ha, respectively.

Quality. Low N and high P and K fertilizer regimes achieved high reducing sugar contents.

Pulse crops

Evaluation. The Station evaluated accessions and selections of mungbean, white and yellow lupin, red lentil, field beans, chickpeas, and *Lathyrus* spp. The best 4-yr yield averages (kilograms per hectare) in coop tests were: small-seeded yellow lentil (NC7-6), 1958; *Lathyrus sativus* (NC8-3), 2498; and *L. cicera* (NC9-1), 2518. High-yielding *Lathyrus* lines in seed color groups gave uniform flower colors.

Management. Several *Rhizobium* strains specific for *Lathyrus* produced differential yield responses.

Alternative grain crops

Evaluation. The Station evaluated additional proso/foxtail millets and sorghum, selecting for desirable agronomic characteristics. Variability included proso millet maturity (82–102 days) and yield (to 2500 kg/ha); foxtail millet maturity (91 days—not mature) and seed yield (3300 kg/ha) with forage yield up to 5.2 t/ha (dry matter basis). Early-maturing white seed sorghum was selected from CIMMYT cold tolerance test. Coop test 2-yr yield averages suggest agronomic suitability to parts of the southern prairies, yields (kilograms per hectare) being: Proso (NC22-3), 1736; foxtail (NC21-10), 1169; and sorghum (NC20-63), 3684. Some potential was observed on *Plantago* spp. and niger.

Essential oil and spice crops

Evaluation. Good potential/accession variability was found in coriander, caraway, fennel, dill, *Papaver* spp., and fenugreek; lack of accessions of others prevented adequate assessment.

Management and quality. In coriander, early shallow planting with good seed-soil contact gave rapid uniform emergence and increased yield. Fennel planted May 2 produced 2044 kg/ha of commercially acceptable seed (1.2% volatile oil content); delayed seeding gave lower yields. Commercially acceptable yields of sweet basil dry leaf (stem-free) increased to 2843 kg/ha with delayed planting (0.4% volatile oil content). Gramoxone and Sinbar sprayed at early plant emergence gave weed and rust control in Monarda, with oil yield 0.71% (90% geraniol) of fresh crop weight.

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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 latest variety produced from these programs, the durum wheat variety Coulter, was licensed in 1977. It is early-maturing, strong-strawed, resistant to rust and smuts, and yields 7% more than Wascana in the Black soil zone of Western Canada.

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. Cooperative research on the control of pests by radiation is also conducted with the Institute of Physics, University of Mexico.

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.

Five scientists were added to the staff to support research on durum wheat quality, molecular biology of cereal rusts, preharvest cereal seed dormancy, mycotoxins in stored grain and oilseeds, and systems biology.

Cooperation in cereal research was initiated with the National Center for Wheat Research, Passo Fundo, Brazil, under sponsorship of the Canadian International Development Agency.

Further information on the research summarized in this report can be obtained from: Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9.

W. C. McDonald
Director

BREEDING, GENETICS, AND CYTOGENETICS

Common wheat

The most advanced line in the breeding program, B.W. 20, received support for licensing. It combines good yield with earlier maturity, along with good resistance to lodging and rust. From the Neepawa back-cross program to incorporate sprouting resistance, one line has received 2 yr of testing at the Cooperative Test stage. B.W. 37 appears to have satisfactory agronomic and quality characteristics, and approaches R.L. 4137 in sprouting resistance.

A study of grinding time for wheat samples indicated that this was a useful screening test for classifying wheat according to hardness, and for estimating the potential milling and baking quality of wheat. Genetic studies showed that the difference in kernel hardness between Neepawa and Pitic 62 was controlled by two major genes, while the difference between Neepawa and Glenlea was controlled by one major gene. Evaluation of the "inbred-backcross" method, used in the

above studies, showed that the method is useful for the study of genetics of quantitative traits only if those traits show a discontinuous distribution. A genetic study of the differences in gliadin electrophoregrams of Neepawa and Pitic 62 wheats indicated that nine protein bands were controlled by single genes while the remaining 10 were controlled by two or more genes.

Further investigations were carried out on adult-plant leaf rust resistance. The variable adult-plant resistance of P.I. 250413 was shown to be controlled by a single gene, independent of *Lr12*, *Lr13*, and *Lr22*. This gene also differed from the gene for adult-plant resistance present in Glenlea. From an intercross of four lines with "minor" genes for field resistance, one each from Maria Escobar, Trintecino, EAP 26127, and Exchange, plants were selected with a high level of field resistance. These minor genes apparently interact to provide excellent resistance.

The inheritance of seedling resistance to leaf rust was studied in the cultivars Rafaela and EAP 26127. Rafaela has genes *Lr14b* and *Lr17*, while EAP 26127 has *Lr17*. *Lr17* is located on chromosome 2A, independent

of *Lr11*. It was confirmed that El Gaucho has gene *Lr11* (previously designated *LrEG*), and that Glenlea has *Lr1* in addition to the gene for adult-plant resistance. A study of the complex resistance of the cultivar Terenzio using Thatcher backcross lines identified the following: gene *Lr3*; a gene *Lrt* giving a 1⁺ reaction; and two genes which interact to give a variable X type reaction. *Lrt* has been located on chromosome 4B. The variable X type of resistance is also found in Lageadinho, P.I. 32199, P.I. 197249, two Turkish lines, and one Ethiopian line.

In the search for sources of rust resistance among the relatives of wheat, eight accessions of *Aegilops squarrosa* L. with leaf rust resistance were identified. Three of these were shown to be genetically similar; the other five differed from these and from each other. A gene for stem rust resistance, *SrSQ*, transferred to Marquis from *A. squarrosa*, is located on chromosome 1DL, more than 50 crossover units from the centromere. Stem rust resistance transferred to common wheat from the synthetic *Aegilops speltoides* Tausch \times *Triticum monococcum* L. is controlled by two dominant, duplicate genes.

Durum wheat

The cultivar Coulter was licensed in 1977, and in 1978 occupied 15% of the area in Manitoba planted with durum wheat. It is short and strong-strawed, with good disease resistance and quality. Its major advantage is in the Black soil zone where it has outyielded other cultivars by 5–7%.

The genetic basis of resistance to two cultures of stem rust in five durum wheat lines was investigated. Despite the fairly complex, diverse origin of the resistant material, it would appear that relatively few different genes are involved. A single dominant gene in the line *Triticum dicoccum* v. Vernal/Gil (CB-090) conditioned a high level of resistance to several races.

Backcross lines were available for testing from the program to transfer postharvest dormancy to durum wheat from the common wheat line R.L. 4137. Under simulated sprouting conditions, a number of lines possessed levels of dormancy equal to R.L. 4137. However, all resistant lines were red-seeded, tending to confirm a close linkage or pleiotropy of the genes for red seed color and this source of dormancy. Use of sources of

intermediate levels of dormancy in “non-red wheats” is being explored.

Oats

Significant progress was made in developing a rust-resistant cultivar. O.T. 210, from the cross Random \times R.L. 3013, performed well in the Western Cooperative Oat Test, particularly in Manitoba. It has good resistance to prevalent races of stem and crown rust, and smut. It is strong-strawed and has a white seed similar to Random and Hudson.

A number of promising lines in preliminary trials with good resistance to rust and smut also possess good tolerance to barley yellow dwarf virus (BYDV). An intensive testing program for tolerance to BYDV also identified many lines in earlier stages with good tolerance.

New sources of rust resistance were isolated and studied. Several apparently new and distinct crown rust resistance genes were isolated in five collections of *Avena sterilis* L. from North Africa. Two lines each have a single, different gene for resistance to a large number of races; the two genes unfortunately appear to be allelic. The extremely effective stem rust resistance of C.I. 9139 appears to be due to the combined effect of gene *Pg12* and one or two modifier genes.

Barley

Advanced material from the two-rowed barley breeding program combines the fast-acting cytolytic and proteolytic enzyme systems of six-rowed barley with good agronomic type and resistance to stem rust and net blotch. Lines with a 25% increase in lysine content were entered into preliminary yield trials. Development of two-rowed barley genetic stocks of good agronomic type with resistance to stem rust, net blotch, loose smut, cereal leaf beetle, and barley stripe mosaic virus was completed.

The most promising six-rowed barley line exceeded Bonanza by 13% in yield in the 1978 Eastern Prairie Barley Test. It is shorter and stronger-strawed than Bonanza, and has promising malting quality.

The genetics and nature of resistance to corn leaf aphid was determined in cultivar EB-921 and its derived hybrid D.L.-117 from Taiwan. Resistance was found to be dominant and conditioned by antibiosis, which decreased with the aging of the plants.

Automated assays were developed for saccharifying activity in unmalted barley, and for polyphenols in wort and beer. It was also shown that an automated assay of amino nitrogen in alcohol extracts of barley was useful for selection for low hordein content. A simple test, based on viscosity of alkaline extracts of barley, was developed to identify lines with a high content of viscous, non-starch polysaccharides, which impede malting.

Lysine content was found to be highly correlated with beta-amylase activity in the selection H.L. 143. This relationship provides a useful alternative in selecting for high lysine.

CEREAL RUSTS

Rust surveys

Stem rust of wheat. The 1976 and 1977 physiologic race surveys showed that the Canadian wheat stem rust population was as variable as it had been in 1974 and 1975. In 1976, 23 races, including five new ones, were found. Race C33 continued to predominate, as it had since 1970, but there were sharp increases in the prevalence of two related races. Race C53, which comprised only 0.3% of the 1975 isolates, increased to 16.3% in 1976, and race C49, which comprised 4.8% of the 1975 isolates, increased to 10.6%. In 1977, 27 races were identified. Race C53 became predominant, displacing C33 which had been the main race since 1970. Race C25 (third in prevalence) is the most dangerous race identified, being moderately virulent on seedlings of Manitou, Neepawa, Napayo, and Sinton. However, it did not attack these varieties in farm fields nor did it attack adult plants of these varieties vigorously in a greenhouse test.

For many years the wheat stem rust race survey has been performed mainly with rust collected on foxtail barley, because rust cannot be found on our highly resistant wheat varieties. It is potentially important that in 1978 nearly all the rust collected on foxtail barley was rye stem rust. The amount of wheat stem rust on foxtail barley had been variable for several years and to offset a possible decline, plots of susceptible Klein Titan wheat were planted at Morden, Portage, Brandon, Indian Head, and Regina. The 1978 race survey was performed mainly with 50 or more collections from each of

these locations. This is a potentially dangerous situation because these collections do not replace the extensive sampling from foxtail barley of earlier years. A sound method of sampling is vital to the detection of new races and for studying rust evolution.

Leaf rust of wheat. In 1976, lines with genes *Lr11*, *Lr19*, and *Lr21* were resistant to all isolates tested and only a few isolates were virulent on *Lr9*, *Lr16*, and *Lr17*. Twenty-two virulence combinations were obtained in 1976 but all combinations had been isolated in previous years. The virulence patterns of isolates from different areas of Canada clearly showed three leaf rust populations in Canada: (1) British Columbia and southern Alberta; (2) Manitoba, Saskatchewan, and northern Alberta; and (3) east of Manitoba. In 1977, lines with resistance genes *Lr11*, *Lr16*, *Lr19*, and *Lr21* were resistant to all isolates in 1977 and only one isolate was virulent on *Lr9*. Thirty-one virulence combinations on 13 genes for resistance were identified in 1977. A culture virulent on Tobari was isolated for the first time in Canada.

Stem rust of oats. A severe epidemic, the worst in two decades, caused serious crop losses in Manitoba and eastern Saskatchewan in 1977. An estimated 530 000 ha of the 800 000 ha in the rust area were affected, sustaining losses from 5% to near total loss. A survey of 218 cultures indicated eight virulence combinations, but there were no new combinations that would constitute a threat to material in the breeding program.

Crown rust of oats. In 1977 and 1978, there were no major changes in virulence patterns detected from rust surveys. Combinations of genes Pc38-39 and Pc55-56 remained highly effective against all races.

Life-cycle phases of *Puccinia coronata* Cda. were examined in the electron microscope. The intracellular complexes of the uredial thallus in oats and pycnial thallus in *Rhamnus cathartica* L. were compared. The intracellular complex of pycnial infections was determined to be haustorium-like, but at a more primitive level of structural organization than uredial haustoria. Spermatium genesis in pycnia of *P. coronata* was examined, and details of the wall relationships between the spermatophores and developing

spermatia were elucidated. Spermatium ontogeny was found to be basically annellidic, but with some phialidic analogies.

Search for new sources of rust resistance

Over 7000 entries from the World Wheat Collection were screened with leaf rust and many of these entries were found to be resistant. A series of backcross lines is being developed containing a number of genes for leaf rust resistance that were found in this collection.

Several thousand oat lines produced by intercrossing parents with so-called "minor gene resistance" were tested for resistance to oat stem rust. Numerous lines with excellent resistance and reasonable economic traits are now available for early inclusion in the breeding program. In 1978, a collecting expedition to Turkey and Iran was completed in cooperation with the Research Station, Ottawa, and the Biosystematics Research Institute. A total of about 3200 accessions of wheat, *Aegilops* spp., barley, and oats were obtained.

Molecular biology of rust resistance

Wheat stem rust. A histological study with the fluorescence microscope showed that various incompatible interactions involving resistance genes *Sr5*, *Sr6*, *Sr8*, and *Sr22* differ significantly, depending on the major genes involved, the genetic background of the host material, the type of host tissue in contact with the fungus, and the stage of fungal development when avirulence is first expressed. The findings support the concept that each incompatible interaction may be unique with respect to the histological events. Further support for this concept was obtained in an ultrastructural study in which incompatible interactions involving resistance genes *Sr5* and *Sr6* were compared. As a preliminary to the study of incompatibility, a detailed fine-structural study of the compatible (*Sr6/P6*) interaction was conducted. This study showed a complex and highly specialized structural relationship between the host and fungal protoplasts. It also showed that the effect of temperature on the interaction involving the *Sr6* gene is complex and may include a direct effect on the fungus as well as an effect on the expression of the *Sr6* gene.

OTHER CEREAL DISEASES

Smuts

In Manitoba and Saskatchewan smut was found in 57 and 78% of the barley fields surveyed in 1977 and 1978, respectively. No change in biotypes was detected. Analysis of survey collections from 1972–1977 showed that the increase in smut on six-rowed barley may be attributed to Bonanza, the predominant variety, being more susceptible than Conquest. All the virulence genes required to test breeders' material were placed in a synthetic albino strain of *Ustilago nuda* (Jens.) Rostr., which simplified the procedure for testing the resistance of barley. Two independent virulence genes were identified in *U. nuda*, one being effective against Conquest and the other against Campana, Titan, Warrior, and Valkie.

Very few spores were produced on plants of foxtail barley, slender wheatgrass, or Virginia wild rye that were infected with *U. tritici* (Pers.) Rostr. and overwintered in the field. But there was excellent sporulation on plants of Canadian wild rye under the same conditions, which indicates it to be the only one with possible significance in the epidemiology of loose smut of wheat. In a study of the relationship between cereal smuts, *Hordeum compressum* Griseb. (a species native to South America) was recognized as a new host for all these important smuts of small grains: *U. nuda*, *U. hordei* (Pers.) Lagerh., *U. nigra* Tapke, *U. tritici*, *U. avenae* (Pers.) Rostr., *U. kolleri* Wille, and *U. bullata* Berk. *H. procerum* Nevski and *H. stenostachys* Godron, also native to South America, were recognized as new hosts for *U. tritici* and *U. nuda*. *H. compressum* and *Agropyron tsukushiense* (Honda) Ohwi var. *transiens* (Hack.) Ohwi were identified as new hosts for *U. turcomanica* Tranzsch. and a smut believed to be *U. ugamica* Golov.

Foliage diseases

The reaction of 38 barley cultivars grown in Canada to barley stripe disease, *Pyrenophora graminea* (Ito & Kurib.), ranged from 0 to 73% susceptibility in greenhouse tests. The cultivars Betzes, Fairfield, and Klages showed good resistance. The incidence of this seed-borne disease appears to be increasing after many years of relative obscurity.

A field experiment was completed to test the effects of single and dual inoculation of

Fergus barley with *Pyrenophora teres* (Died.) Drechsli., the incitant of net blotch, and barley stripe mosaic virus. In 1977, total yields were reduced by 17% with either pathogen and 27% when both pathogens were used. These organisms appear to be antagonistic rather than synergistic in their action and their effect on barley yield. The effects of pathogen inoculation on total necrosis/chlorosis of the flag and second leaf were also monitored. At the milky to soft-dough stage of growth the second leaf was 80% necrotic in the dual-inoculated plots and 40% necrotic in the control plots. Most of the necrosis was attributed to net blotch infection. The flag leaf was approximately 75% necrotic in all plots. Leaf spot infection (primarily net blotch) was reduced as much as possible in the control plots by applying several foliar sprays of Dithane M-45 fungicide. The experiment was repeated in 1978 with similar results.

Viruses

In 1977, barley stripe mosaic virus (BSMV) was detected in 4 of 53 (7.5%) fields of two-rowed barley and in none of 13 fields of six-rowed barley surveyed in southwestern Saskatchewan. Disease incidence varied from a trace to 13%. A survey of fields in southern Manitoba in 1978 showed that BSMV was present in 36.9 and 4.0%, respectively, of the fields of two- and six-rowed barley. The disease occurred almost as commonly in southwestern Manitoba as it did in southeastern Manitoba, a situation not previously recognized.

Intraspecific and interspecific contact transmissibility of BSMV was examined under field conditions using seed-infected wild oats and two cultivars of barley as virus sources and healthy plants of the same species as test material. The virus was transmitted by contact from wild oats to both Herta and Conquest barley, but in reciprocal tests, the virus was transmitted only from Conquest barley to wild oats. Transmission in these tests was relatively infrequent compared to contact transmission of the virus from infected to healthy Herta or Conquest barley. In each of five mechanical inoculation tests conducted in the greenhouse, isolate C4 of BSMV from barley was transmitted to only a small proportion of inoculated wild oat plants but was subsequently transmitted from infected wild oats to most or all wild oat

plants inoculated. Evidence suggests that this pattern of transmission was attributable to strain selection during the initial passage of C4 through wild oats.

The epidemiology and crop losses on wheat, barley, and oats during a severe epidemic of barley yellow dwarf (BYD) in southern Manitoba in 1978 were studied in detail. On wheat alone, the virus was estimated to have caused a mean loss of 24% of the potential yield in late-seeded fields.

Seed losses were significantly greater on Herta barley or Rodney oats in a growth cabinet when individual plants were inoculated simultaneously with two isolates of barley yellow dwarf virus (BYDV) (nonspecific and *R. maidis* specific) than losses on plants inoculated with only one or the other isolate. Also, when plants were inoculated first with one isolate and then, after 4 or 10 days, with the other, both viruses subsequently could be recovered from the plants. These results suggest that the two virus isolates are not closely related. Field plot trials, in which inoculations were made at later growth stages than in the growth cabinets, confirmed synergistic effect on Rodney. A similar effect was found on Hudson oats.

In electron microscope studies, cytopathological changes found in oat cells infected with *Rhopalosiphum maidis* specific isolates of BYDV were basically similar to changes found in cells infected with *R. padi* specific isolates in earlier studies. Certain minor features could be used to distinguish between changes induced by the *R. maidis* specific and the *R. padi* specific isolates. In further electron microscope studies, cytopathological changes in oat cells infected with *Schizaphis graminum* specific or *S. graminum* nonspecific isolates were basically similar to those found earlier with *M. avenae* specific and aphid nonspecific isolates. The presence of proliferated, membranous, tubular bodies in cells infected with *S. graminum* specific isolates could serve to distinguish these isolates from the *M. avenae* specific and aphid nonspecific isolates. These cumulative studies suggest that BYDV may be divided into two sections on the basis of cytopathological alterations.

STORED PRODUCTS PROTECTION

Biology

A survey of primary elevator points in Manitoba to determine the incidence of insect infestation of grain shipped in railway boxcars to terminal elevators showed that 46% of 129 loaded cars sampled from May to December, 1978, had one or more stages of the rusty grain beetle, an increase of nearly 50% over the levels found in 1977. Infestations increased in the autumn of both 1977 and 1978 but peaked in November 1978, compared with September and October in 1977. Improved methods of identifying infested cars resulted in 60% of the cars being resampled at the terminal elevator.

Laboratory studies of the survival of all stages of the rusty grain beetle at temperatures of 22°C to -4°C, programmed to simulate gradually decreasing and increasing temperatures in farm-stored grain in Manitoba during autumn, winter, and spring, showed that mature adults and larvae survived for 24 wk. Eggs, young larvae, and pupae died after 18 wk under these conditions.

Fat acidity value (FAV) of stored grain, an important indicator of grain storage quality, is related to grain moisture content and fungal infection. Laboratory studies suggest that FAV is influenced also by the presence of fungivorous mites. The FAV of wheat samples, of 16% moisture content, stored at 20°C and 75% RH increased from 9 to 23 after 26 wk but the FAV of similar samples infested with 100 individuals each of three species of common stored grain mites increased at a lower rate, as follows: warty grain mite, 19.5; *Acarus farris* (Oudemans), 12.1; and *Lepidoglyphus destructor* (Schränk), 16.8.

Control

A commercial aeration fan (1.7 m³/h) connected to a perforated duct at the bottom of a 50 t metal granary on a farm was used to cool 45 t of Tower rapeseed from 14°C to -17°C over an 11-wk period from September to December, 1978. The temperature of a similar unaerated bin of rapeseed cooled from 24°C to 15°C during the same period and was found to be infested with rusty grain beetles, fungus beetles, and mites. In addition to lowering grain temperature below the

threshold of biological activity, aeration reduced grain moisture content by 1.2–2%.

The effects of physical disturbance of infested grain on mortality and reproduction of insects were studied by dropping grain 14.1 m or by rotating and tumbling grain. Adults of the granary weevil and the rice weevil suffered 96% mortality when infested grain in sacks was dropped; only 5% mortality resulted when the weevils were dropped in free-falling wheat, and 13% mortality when infested grain in sacks was rotated and tumbled. The physical disturbance of grain had no adverse effects on the emergence of F₁ adult weevils.

Cooperative experiments with the University of Mexico demonstrated the effectiveness of accelerated electron machines for controlling insects in infested grain. Studies of the susceptibility of three strains of the red flour beetle to accelerated electrons showed differences in response at 7 and 15 krad but no differences at 25 krad, the recommended dose. Red flour beetle eggs were controlled at 3 krad; larval development was suppressed at 15 krad; and adults were controlled at 25 krad, 4 wk after irradiation. A cost analysis of accelerated electron irradiation using a Dynamitron accelerator showed a favorable cost-benefit advantage at high annual throughputs when compared with chemical controls.

Persistence and effectiveness of malathion, bromophos, iodofenphos, and pyrimiphos-methyl applied as aqueous formulations to dry or tough wheat were compared against susceptible and resistant strains of the red flour beetle. Pyrimiphos-methyl at 4 and 6 ppm was most effective during 24 wk against both strains. Malathion at 8 and 12 ppm was ineffective against the resistant strain. Chemical assay of treated grain samples revealed that pyrimiphos-methyl was the most stable compound in both tough and dry wheat, followed by bromophos, malathion, and iodofenphos.

Translocation of malathion, bromophos, and iodofenphos into stored corn, wheat, or barley from treated wood or concrete surfaces was determined by bioassay and chemical assay at different times after treatment. Larger amounts of each insecticide were taken up by all grains in contact with wood than with concrete surfaces. More insecticide was taken up by wheat and barley than by corn. Persistence of insecticides on structural

surfaces and their translocation into stored grain decreased with age of deposit.

FIELD CROP INSECTS

Grasshopper surveys

The forecast of grasshopper infestation in Manitoba for 1979 showed an increase of approximately 20% in area with an expected population density three times that of 1978. This is the first increase in area and density since 1974 when the last grasshopper outbreak reached its peak. The largest area infested lies between Gladstone, Carberry, and McGregor, with small areas of infestation near each of Treesbank, Holland, Rathwell, and Elm Creek. In these areas the infestations range from light to moderate. A small area of severe infestation is present east of the Red River between Green Ridge and Tolstoi and is bordered on the south and west by a light infestation. In the south central part of the province the migratory grasshopper is dominant and the clearwinged grasshopper is the main species east of the Red River.

Rapeseed insects

A comparison of the effectiveness of insecticides currently recommended for the control of flea beetles in rape showed that carbofuran as an in-furrow granular treatment protected plants from flea beetle damage, and seed yields were significantly greater than those of untreated rape. Lindane, widely used as a seed treatment, had no significant effect on yield unless followed by a postemergence foliar spray. Similarly, a postemergence spray alone had relatively little effect on seed yield of rape.

Oftanol (Chemagro), a seed dressing, provided excellent control of flea beetles in field trials and effectively reduced the overall numbers of beetles throughout the season; seedling protection, plant stand, and general plant development were outstanding. The material is used as a seed dressing for control of insects on mustard in Europe and may prove to be a suitable alternative to lindane.

In other trials, granular formulations of Counter (Cyanamid of Canada), Dacamox (Diamond Shamrock Corp.), and aldicarb, and an emulsifiable formulation of methidathion, gave excellent results and were as effective as or superior to corresponding

compounds that are currently registered for use on rapeseed.

Sugar beet insects

In field trials, aldicarb and Counter effectively controlled the sugar beet root maggot and produced a high yield response in sugar beets. Results of several recent trials showed that sugar beets treated with these materials outyielded untreated beets by approximately 60% (11.5 t/ha) and those treated with carbofuran, the most commonly used insecticide, by approximately 23% (4 t/ha). Both insecticides were granted temporary registration in 1978 for use on sugar beets in Canada.

Strawberry insects

Measures for the control of the strawberry cutworm, *Amphipoea interoceanica* Smith, were developed using a treatment with the insecticide chlorpyrifos and a cultural practice. These measures significantly reduced damage by the cutworm, which feeds on the strawberry crown thus preventing fruit formation and destroying plants. The insecticide treatment was effective when applied before fruit set, and under moderate infestations prevented losses estimated at \$1000/ha. The cultural control involved a delay of 1 mo in the customary practice of discing-down the planting at the end of the fourth season. The delayed cultivation destroyed the eggs of the insect.

INTEGRATED CONTROL OF INSECT PESTS

Flea beetles

In Manitoba, populations of flea beetles in 1977 and 1978 increased in areas north of the Riding Mountain National Park. In the more southerly rape-growing areas populations decreased slightly in 1977 but rose again in 1978 to levels as high as in previous years. However, weather conditions were favorable for germination and early growth of rape in both years so the damage caused by flea beetles was not as severe as in years with unfavorable weather. A method for determining the abundance of flea beetle eggs and larvae in the soil was developed. This will be useful to determine the effects of treatment with different insecticides on the

production of the next generation of flea beetles.

Phyllotreta cruciferae (Goeze) and *P. striolata* (Fabricius) are the two predominant flea beetle species on rape in Manitoba. *P. cruciferae* is generally the most abundant, but in some areas around Winnipeg, *P. striolata* became increasingly abundant relative to *P. cruciferae* in 1977 and 1978. A survey of flea beetle populations in Manitoba revealed that one insect parasite, *Microctonus vittatae* Muesebeck, that parasitized adults of both flea beetle species was present but rare in all localities. In 1978, a European braconid parasite *Microctonus bicolor* Wesm. was released for the first time in Manitoba in an attempt to reduce the abundance of flea beetle pests of rape. Laboratory studies clarified various aspects of the biology and seasonal life history of this parasite and confirmed that it kills and develops on both *P. cruciferae* and *P. striolata*. A second European parasite, *Microctonus* sp. "Z", that also had been a candidate for release in Canada, was found to be indistinguishable from and possibly synonymous with the native parasite *M. vittatae*. Studies to clarify details of the biology of *M. vittatae* and to evaluate it as a control agent were continued. Color variability, a complication in identifying both field-collected and propagated adults, was shown to be related to the temperature at which the parasite pupae developed. Rearing procedures to prevent diapause in the first-instar larvae of the parasite were improved. The hypotheses that flea beetles parasitized by *M. vittatae* finish hibernating earlier than unparasitized beetles, and that female flea beetles are parasitized more often than males, were confirmed.

Winter rape sown in the spring maintained a lush growth of leaves in August and September and attracted flea beetles from maturing spring rape. Large numbers of flea beetles were concentrated in a small area, which facilitated spraying with insecticides. This trap-crop method shows promise as a means to reduce flea beetle numbers.

Bertha armyworm

In Manitoba, no larvae of the bertha armyworm were found during field sampling in 1977. In 1978, bertha armyworm males were collected at 7 of 10 locations at which sex attractant traps were placed in western Manitoba. A total of 56 males were taken in

20 traps. The paired traps at Bowsman and Durban caught 17 and 15 males, respectively. Larval sampling in fields adjacent to the trap locations yielded five larvae, the first found in Manitoba since 1975. Four of the five larvae collected were parasitized by the ichneumon *Banchus flavescens* Cresson, showing that this parasite is effective even at very low host densities. *Athrycia cinerea* (Coquillett), an important tachinid parasite of bertha armyworm, was reared from larvae of the armyworm *Pseudaletia unipunctata* (Haworth), which suggests that this is an alternate host during periods when the bertha armyworm is scarce. *Ichneumon canadensis* Cresson also attacks the pupae of bertha armyworm in Manitoba, and a single chrysopid predator was observed to kill about 50 young bertha armyworm larvae during development. Observed densities of chrysopids in some Manitoba fields have been high enough to reduce bertha armyworm numbers significantly.

A linear relation between yield loss and larval density was established at 0.325 g per larva, or 3.25 kg of seed per hectare for each larva in 1 m² of crop. This loss was stable for infestations established at different plant stages and on different rape varieties but was greater for a crop under drought stress. Exposure of prepupae and pupae to 25°C, a temperature that may occur in the soil in August, was found to cause sterility in the adults without adversely affecting survival.

Four distinct stages of diapause development in pupae of bertha armyworm can be recognized by means of a newly described "beta-ecdysone sensitivity index". The index provides a useful conceptual and experimental framework for dealing with diapause development. Cold-induced pupal mortality of bertha armyworm might vary from zero to 100% depending on climatic conditions (e.g. temperature, snow cover, type of tillage) and therefore is an essential component of a survival model for the species.

Encouraging progress was made in a new area dealing with insect central nervous system function. Specifically, dopamine- and octopamine-sensitive adenylate cyclases were identified in the brains of diapausing pupae, diapause-terminated pupae, and developing

pharate adults of armyworms. The octopamine-sensitive adenylate cyclase was thoroughly characterized in terms of its biochemical properties. Physiologically, the amine-sensitive adenylate cyclases may be especially important in integrating sensory input from the eyes and in diapause induction-termination. The product of octopamine-stimulated adenylate cyclase, cyclic AMP, was shown to be important in brain processes that become established during the development of the adult brain (likely as a mediator of central synaptic transmission). Cyclic AMP is also critical in the process of differentiation itself, i.e. during the transformation from pupal to adult brain.

Red turnip beetle

Adverse weather conditions during the fall, winter, and early spring of 1976-1977 caused high mortality of red turnip beetle eggs, and beetle populations were very low in 1977 and 1978. No insect parasites have yet been found in field-collected larvae. The following cruciferous weeds serve as alternate host plants for red turnip beetle adults in June and during August, September, and October: wild mustard, flaxweed, wormseed mustard, and

dog mustard. These four species of weeds are relatively common in the rape-growing area of Manitoba. X-ray energy-dispersive spectroscopic analysis of the relative concentration of elements, and discriminant function analysis, can be used to discriminate between beetles emerging from individual fields and to identify the source of beetles after dispersal. Studies on the biology of the beetle showed that mating began almost immediately after the adults emerged from aestivation. The females initiated vitellogenesis during the 3rd day, contained mature oocytes by the 6th day, and after emergence began egg-laying in about 7 days. Eggs laid during August and September apparently complete embryological development before the onset of cold weather and have high hatching rates under normal field conditions. Eggs laid in October have little chance of surviving the winter because temperatures are too cold for embryological development. In the spring the critical temperature for egg hatch is about 5°C. The hatching rate of red turnip beetle eggs buried in the fall at depths of 1.3-10.3 cm under loosely packed clay loam soil (as might occur during normal tilling practices) was very low. The data suggest that fall cultivation significantly reduces the survival of red turnip beetle eggs.

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INTRODUCTION

Production, harvesting, and utilization of forage crops for pasture, silage, and hay is the major research program at Melfort, but the cereal, oilseed, and special crops evaluation, production, and utilization program is also given considerable attention. A strong livestock program involving beef cows, feeder steers and heifers, ewes and lambs, and feeder pigs is maintained to evaluate crops and harvesting systems. A beef cow-calf management project in cooperation with the Saskatchewan Department of Agriculture, started in 1974, is proceeding according to plan. Long-term agronomic studies at off-station sites complement the work at Melfort. In 1977 Dormie, a variety of Kentucky bluegrass developed at Melfort and Saskatoon research stations, was licensed.

Our *Research Highlights* publication and any further information can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Response of brome-grass-alfalfa pasture to N and P fertilizer

Studies in which N at 45, 90, and 135 kg/ha and P at 20 kg/ha were applied to a brome-grass (*Bromus inermis* L.) and alfalfa (*Medicago media* Pers.) pasture show that N uptake ranged from 90 to 210 kg/ha and P uptake ranged from 6.3 to 18.9 kg/ha with herbage yield significantly related to levels of N and P applied and available soil P ($R^2 = 60.4\%$). Concentrations of N in brome-grass ranged from 2.1 to 3.5% and in alfalfa from 2.8 to 4.0% while concentrations of P in brome-grass ranged from 0.17 to 0.31% and in alfalfa from 0.16 to 0.30%. The most economical return occurred with N at 90 kg/ha and P at 20 kg/ha, which increased yield by 74% (total yield 6129 kg/ha).

Plant species composition on a community pasture

In 1974, the proportions of forages as estimated by point quadrat in a pasture near Pathlow were 5% alfalfa and alsike clover, 11% brome-grass, 65% creeping red fescue, and 19% forbs, mostly dandelion. Estimates in 1975 and 1976 showed decreases in legumes and fescues, and increases in brome-grass and forbs. Plant cover was uniform but sparse. Bare ground, cattle dung, mosses, and trees together made up 72% of the pasture area, suggesting that it was in poor condition.

The relative proportions of plants as estimated by cutting at 7.5 cm were: 15% alfalfa and alsike clover, 58% brome-grass, 21% creeping red fescue, and 6% forbs in 1974. In 1975, fescue had increased, legumes had decreased, and brome-grass and forbs remained the same.

In the fall of 1975, fertilizer was applied and in 1976, a rotational grazing pattern was imposed. Preliminary observations in 1978 suggest that alfalfa has increased markedly in some areas since 1975.

Effects of repeated applications of herbicides to established alfalfa

Applications of simazine (2-chloro-4,6-bis(ethylamino)-*S*-triazine) at 1.7 kg/ha each spring for 4 yr to an established stand of alfalfa did not affect seed yields, and reduced dandelion populations. Simazine residues in the soil the spring following the last application averaged 1.88 ppm in the top 20 cm of soil, as measured by an oat bioassay. Four applications of Dichlobenil (2,6-dichlorobenzonitrile) at 2.2 kg/ha increased alfalfa seed production by 26%. Dandelions were eliminated, sow thistle was reduced to insignificance, and no residues were detected in the soil 1 yr after the last application. Terbacil (3-*tert*-butyl-*s*-chloro-6-methyluracil) at 1.1 kg/ha eliminated both dandelion and sow thistle, and resulted in a 34% increase in alfalfa seed yield. Soil residues 1 yr after the last application averaged 0.42 ppm in the top 10 cm of soil and 0.04 ppm in the 10-20 cm

layer of soil. Applications of 2,4-D ((2,4-dichlorophenoxy)acetic acid) at 1.1 kg/ha damaged alfalfa severely and reduced seed yields by 32%. Weeds were not controlled adequately. Applications of asulam (methyl sulfanilyl-carbamate) at 4.5 kg/ha increased alfalfa seed yields by 31% and also resulted in increased weed populations.

Forage harvesting systems

Modifications to the Melfort hay-drying tower (electric winch to raise roof, cutting blade at end of auger to loosen hard packed edges, installation of a spinning disc distributor, electrically powered blower) and discovery that more effective drying occurred if the central bung was hung 40 cm below the hay surface, have improved the operating efficiency. A Schwarting haytower, erected in 1976 to evaluate its performance under western Canadian conditions, has worked well for light-textured crops such as brome or brome-alfalfa but problems arose when drying alfalfa. Since cost of the unit necessitates its ability to handle high-quality forages, modifications (coarser chopping, lower moisture content, and more effective drying) are being evaluated to improve effectiveness for drying alfalfa.

A German-made silo press unit was used in 1978 to put up experimental lots of silage of different moisture contents. Protecting the 2.5 m diameter plastic bag with a layer of straw bales did not prevent freezing of a 32% D.M. silage occurring following several weeks at -20 to -30°C.

Harvesting straw and chaff with six different hay-packaging machines revealed that units equipped with flail-type pickups produced feed with a higher crude protein content (4.83%) than those using finger pickups (3.96%).

Evaluation of forage-harvesting systems

Bromegrass-alfalfa was harvested as silage (S), chopped artificially dried hay (C), long hay mechanically stacked with a compression (ST-C) and noncompression (ST-NC) type wagon, and as baled hay using a giant round (RB) and regular (B) baler. Forage from each system was fed ad lib. to two groups of eight steer calves.

Field losses during harvest were inversely related to moisture content of forage when harvested from windrow and varied by as much as 13% between treatments. Variation

in field loss was partially offset by storage loss since percentage recovery from storage averaged ca. 87% for S and C, 90% for ST-C and ST-NC, and 94.5% for RB and B. Surface freezing and spoilage of S resulted in further significant storage losses for this treatment.

Average daily gains were highest for treatments S and C (0.72 and 0.68 kg/head, respectively). Liveweight gains for the remaining treatments were not significantly different, ranging from 0.57 to 0.60 kg/head. Silage and chopped hay also produced the highest gain per hectare (402 and 399 kg, respectively), followed by B (369 kg), ST-C (342 kg), RB (328 kg), and ST-NC (314 kg).

Finishing steers with little or no grain

Steers fed (1) 90% barley, (2) 20% barley, (3) 99% ground brome-alfalfa hay, or (4) from 0 to 58% barley over the feeding period gained at the rate of 1.42, 1.23, 1.09, and 1.31 kg/day, respectively, and all graded A₁ or A₂ except two which graded A₃ (overfinished). Eating quality of the meat (courtesy F.R.S., Ottawa) from the lower grain diets (2, 3, and 4) was equal or superior to meat from control steers (1) with respect to flavor, juiciness, and tenderness.

In another test Rumensin (monensin) reduced rate of gain of steers on both high-grain and all-forage finishing rations and improved feed conversion only when added to the grain ration. Forage-fed steers gained faster (0.08 kg/day) than grain-fed steers. Administering a second implant of progesterone estradiol (Synovex S) at 6 wk caused a highly significant increase in rate of gain and significantly increased cutability as compared to steers receiving only one implant at the start of the test.

Nutritive value and yield of forage oats

Fraser, Foothill, and IH 1863-4 were assessed as either hay or silage over a 3-yr period. Digestible organic matter (DOM) content of IH 1863-4 was lower than Fraser, with Foothill not significantly lower than Fraser. Neutral and acid detergent fiber was higher for IH 1863-4 than Fraser. While yield of dry matter was highest for IH 1863-4 followed by Foothill and Fraser in that order, crude protein content and digestibility of crude protein were in the reverse order.

Nutritive value and yield of silages

Whole crop fababean, field pea, oat, and corn silages were compared over a 2-yr period. Mean yield of dry matter (tonnes per hectare) was 9.5 for fababeans, 8.1 for field peas, 8.5 for oats, and 9.4 for corn. Mean daily dry matter intakes and rate of liveweight gain (grams) for lambs was 1169 and 195 for fababean silage, 1004 and 148 for field peas, 690 and 42 for oats, and 727 and 57 for corn. The values for energy digestibility, nitrogen digestibility, and crude protein content indicated that fababean and pea silages were superior to oat and corn silages. The results indicate that excellent quality silage can be made from whole crop fababeans and field peas. However, because of higher yield, fababeans have a greater potential as a silage crop than field peas.

PRODUCTION AND UTILIZATION OF CEREAL AND SPECIAL CROPS

Crop evaluation

Altex rapeseed is earlier maturing but has not outyielded the currently grown cultivars, averaging 100 kg/ha less than Regent and Tower and 300 kg/ha less than Midas, in seven tests.

Culbert flax has not performed as well as Noralta or Dufferin in late-seeded tests at Melfort in 1977 and 1978.

B.W. 20 wheat has equaled Neepawa in yield, has superior rust resistance, and unlike Sinton does not shatter. Coulter produced yields equal to the later-maturing cultivars Wakooma and Wascana from 1976 to 1978.

From 1976 to 1978, Klages barley outyielded Betzes and Fairfield by 15% and 7%, respectively. Klondike, a six-rowed feed barley, has given highest barley yields in northeastern Saskatchewan.

Fraser oats, two "forage" type oats, and Wakooma durum wheat produced from 5 to 24% more forage when seeded in June than when seeded in May (1975-1977).

Whole plant DM from fababean cultivars Diana and Herz Freya averaged over 8000 kg/ha, and DM crude protein from these cultivars averaged 19.5%, in 1976 and 1977.

DM yield from Jerusalem artichoke was 5520 kg/ha under good management conditions. A number of economical phenoxy-type herbicides have been identified for control of volunteer plants of Jerusalem artichoke in

subsequent crops, and some herbicides have been found to control weeds in the crop.

Tara field peas yielded 4% less than Trapper at Melfort from 1976 to 1978. From 1973 to 1977, Mancan and Tokyo buckwheat have yielded 1910 and 2010 kg/ha, respectively.

Yields of winter wheat, seeded directly into standing stubble, have ranged from 2040 to 3310 kg/ha from 1976 to 1978 when adequately fertilized.

Crop sequence. The yield of wheat on stubble (16-yr average) has been 89% and 71% of that on summerfallow at Melfort and Somme, respectively. At Melfort rape and flax produced 35% more grain (8 yr average) when seeded on wheat stubble than when seeded on rape or flax stubble. At Melfort 2-yr (fallow, wheat), 3-yr (fallow, wheat, wheat), and 6-yr (fallow, wheat, wheat, hay, grass-legume), wheat rotations gave returns of \$201.17, \$270.03, and \$270.09/ha, respectively, in 1978; and \$143.48, \$181.34, and \$197.81/ha, respectively, over the past 20 yr. The NO₃ content of the soil in the fall was 50% higher on fallow and stubble land in the 6-yr rotation than in the other rotations over the past 10 yr.

Crop residue. Under continuous wheat for 20 yr there was a greater loss of soil carbon and nitrogen in the "fall-plowed" and "spring-burn" treatments than in treatments where the trash was retained on the soil surface. The yields in 1978 (and 20-yr average) were 1822 (1923), 2034 (2061), 2251 (1939), and 2406 (1964) kg/ha for the fall-plowed, spring-burned, fall-disced, and no fall or spring tillage treatments, respectively.

Reducing tillage. Chemical summerfallow or treatments that had one to three tillage operations supplemented with chemicals for weed control have produced 10% more yield than normally tilled fallow.

Seeding. Direct seeding with a zero-till double-disc press drill produced a yield of wheat on stubble equal to a seedbed preparation and hoe press drill seeding treatment in 1978.

Herbicides. Five herbicides have been identified, tested, and registered for controlling wild oats in rapeseed, increasing the yield potential by up to 50%. Green foxtail

and some broadleaf weeds are also controlled with these herbicides. The tandem disc and power rototiller were compared and gave equally good herbicide incorporation when they were adjusted and operated properly at Melfort in 1977 and 1978.

Response of wheat to phosphorus. Fertilizer and moisture use trials on six soil types over 4 yr in northeastern Saskatchewan have shown that wheat (*Triticum aestivum*) yields ranged from 1297 kg/ha (control) on a soil having a NaHCO_3 -soluble concentration of P at 8.4 $\mu\text{g/g}$ to 4973 kg/ha where N at 11 kg/ha and P at 22 kg/ha were applied on a soil with P testing 17.9 $\mu\text{g/g}$. Wheat yield responses were negatively correlated with NaHCO_3 -soluble P and exchangeable ammonium N, and positively correlated with nitrate N in soil at planting. Wheat yield response was negatively correlated with soil moisture deficit from heading to maturity and positively correlated from jointing to heading (mean $R^2 = 77.6\%$). Yield response with P at the highest rate of 29 kg/ha was not affected by moisture. Control yields had a significant quadratic relationship to NaHCO_3 -soluble P ($R^2 = 64.3\%$).

Evaluation of barley cultivars. Two-row (Fairfield, Fergus, and Klages) and six-row (Bonanza, Klondike, and Peguis) cultivars yielded, respectively, 7436, 6164, 6333, 5416, 6410, and 5140 kg/ha in 1977. In 1978, yields were lower (4543, 5394, 3380, 4343, 4625, and 4802 kg/ha, respectively) but range and average for protein content were higher (13.1–14.3%, 13.8% vs. 11.3–13.1%, 12.0% of DM). Diets based on each cultivar, with identical supplementation, were fed to pigs from 28 to 91 kg. The 1977 cultivars had little effect upon growth rate (average 791 g/day) or carcass measurements; however two-row barleys were more efficiently used (3.73 vs. 3.88 kg feed per kilogram gain).

Alternative sources of protein for pigs. Four diets containing 17% protein were fed consisting of either 10.5% field peas (plus 8% soybean meal (SBM) or 10% Candle rapeseed meal (RSM)) or 5% SBM (plus 10% Candle or Tower RSM). Over the period, 17–30 kg, pig performance favored the RSM-free diet and Tower (*Brassica napus* L.) over Candle (*B. campestris* L.) low-glucosinolate RSM. Complete replacement of SBM by Candle RSM, in diets fed to 91 kg had no significant effect on performance although dressing percentage was higher with the RSM-free diet.

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INTRODUCTION

This report outlines the work done in 1977-1978 at the Experimental Farm at Indian Head and the Research Station at Regina.

The Indian Head establishment is operated as a substation. The program evaluates new cultivars of cereal, forage, oilseed, and pulse crops for adaptability to conditions in southeastern Saskatchewan. Management research designed to increase efficiency of production of those crops as well as long-term rotation experiments is also conducted.

The Regina station is the center for weed control research in Canada. Four programs, biological control, weed physiology, weed ecology, and herbicide behavior in the environment, are underway. Good progress has been made in surveying the weeds not only in Saskatchewan but also in British Columbia, Alberta, Prince Edward Island, and Newfoundland. In 1978, L. Hume joined the staff to conduct research on crop losses caused by weeds.

The facilities at Regina and Indian Head are also used to increase and distribute breeder seed and seed of new cultivars of cereal, forage, oilseed, and pulse crops developed by the Branch.

Only a portion of the results are reported here. More can be obtained from the scientists at the following address: Research Station, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. R. Hay
Director

BIOLOGICAL CONTROL

Combined populations of *Urophora affinis* and *U. quadrifasciata* plateaued at 1.2-1.8 galls per head on diffuse knapweed and 3.4-5.0 galls per head on spotted knapweed. On diffuse knapweed, the dry weight of the attacked plants was reduced by 74%, average seed weight by 18%, and seed production by 95%. However, 1500 viable seeds per square metre were still produced and these maintained the weed population. Thus, additional agents will be required to effect control. *Sphenoptera jugoslavica* released on diffuse knapweed is increasing as is *Metzneria paucipunctella* on spotted knapweed.

In a Saskatchewan pasture *Rhinocyllus conicus* has increased the grazing capacity and reduced the density of nodding thistle from 16 to 1 flowering plant per square metre. However, dense stands still persist on bare ground where there is no competition from grass. The weevil is now well distributed in Saskatchewan and additional releases were made in Quebec. The stem weevil, *Ceutorhynchidius horridus*, is also well established on nodding thistle in Saskatchewan. Releases of this species were made in Quebec and Ontario from larvae collected in Saskatchewan.

Chamaesphelia tenthrediniformis and *Acrothosiphon neerlandicum* collected on *Euphorbia esula* in Europe failed to survive on Saskatchewan leafy spurge.

Longitarsus jacobaeae from an established colony in British Columbia was released in Prince Edward Island to supplement damage done to tansy ragwort by the cinnabar moth.

Coleophora parthenica released in Saskatchewan on Russian thistle did not survive although a few *C. klimeschiella* have completed one generation.

The stem-mining weevil *Ceutorhynchus litura* increased satisfactorily on Canada thistle in British Columbia, Saskatchewan, and Ontario. From a release site in Saskatchewan, 600 weevils were collected and released in Alberta and British Columbia.

The gall fly *Urophora cardui* continued to survive in Alberta, Saskatchewan, and Quebec and increased satisfactorily in New Brunswick. In Western Canada, cattle graze the tops of young thistles in overgrazed pastures and thus destroy eggs and larvae. Overwintering success of the larvae is good; however, many larvae die in spring and early summer while pupating.

The laboratory colony of the leaf-feeding *Lema cyanella* was freed from the disease

caused by *Nosema* sp. Release of this promising biocontrol agent is being delayed until the possible hazard to some native thistles is determined.

From a study of the stem-mining *Cleonus piger* and leaf-feeding *Cassida rubiginosa*, both naturalized in Eastern North America, it was concluded that neither should be transferred to Western Canada for control of Canada thistle.

After screening the seed head gall fly *Tephritis dilacerata*, it was concluded that this promising biocontrol agent should be released on perennial sow-thistle.

Verbascum spp. must be present for the survival of the mullein moth, *Cucullia verbas-ci*, although the caterpillars can be forced to feed to a limited degree on a number of other economically unimportant plants.

The Argentine ragweed thrips, *Liothrips* sp., were extremely damaging to ragweed but unfortunately they also attacked sunflower and cosmos. Since the risk of releasing this species was too great the colony was destroyed.

The host range of an absinth stem and root moth *Euzophera cinerosella* included several beneficial species of *Artemisia*. This range was too broad to permit release.

WEED PHYSIOLOGY

Quackgrass

Water availability is a major factor in the mechanism controlling the growth of buds on quackgrass rhizomes. Increasing the humidity around the rhizome stimulated the growth of inhibited buds and significantly increased their accumulation of ¹⁴C-labeled assimilates from the parent shoot. Experiments with isolated rhizomes showed that bud growth was completely inhibited by reducing the ambient humidity from 100 to 98%. A reduction of only 0.5% caused a significant inhibition of growth. Light-induced inhibition of bud growth was prevented by supplying water through the cut end of the rhizome.

A study of factors affecting water distribution in the intact plant showed that removal of the parent shoot increased the water content of the rhizome apex within 12 h. Removal of the apex reduced the water content of the rhizome if the rhizome remained attached to the parent shoot. These results suggest that competition for water

between the shoot and rhizome may be one of the factors controlling the growth of the rhizome buds.

Stinkweed

A study of flowering in natural populations of stinkweed revealed the occurrence of several genetically distinct strains. When grown under controlled conditions from unvernallized seed, the progeny of five selected plants showed significant differences in rate of flowering, leaf number, lateral branching, and seed germination. Vernalization of the germinating seed eliminated the differences in rate of flowering and leaf number but the strains still differed significantly in germination. Such genetic variation in germination and flowering behavior contributes to the adaptability of the species and thus to its persistence as a troublesome weed.

Propanil

Yellowing occurred on the leaf tips of wheat and barley treated with propanil or a mixture of propanil + MCPA ester, but the plants recovered in 8–10 days and yields were not affected.

Control of green foxtail in the two- to four-leaf stage was excellent (96%) with propanil at 1 kg/ha alone or in combination with MCPA ester at 0.3 kg/ha. Propanil at 1 kg/ha alone and propanil at 1 kg/ha plus MCPA ester at 0.3 kg/ha controlled redroot pigweed, wild buckwheat, and stinkweed. Flixweed and wild mustard were controlled by propanil plus MCPA.

Cow cockle was not controlled by propanil alone or in combination with MCPA ester. Removal of wild mustard resulted in an increase in the size of the cow cockle plants.

Difenzoquat

Wheat leaves were chlorotic 4–5 days after treatment with difenzoquat at 0.70 and 0.84 kg/ha. Treated plants did not elongate as rapidly as the checks and heading time was delayed 2–17 days. In time, the treated plants of most varieties grew to the same height as the checks. Manitou, Napayo, and Sinton cultivars showed the typical symptoms while Neepawa did not. Glenlea and Macoun were only slightly affected.

Wild oats

A method of removing hulls and determining viability of oats was developed. The hulls of wild or cultivated oats were removed (degraded) by immersing the seeds in 6% NaOCl (sodium hypochlorite) for 24 h. The outline of the embryos became clearly defined during this treatment. The percentage of seeds showing this clear demarcation was closely correlated with the percentage viability as determined by germination and tetrazolium tests.

NaOCl increased germination of wild buckwheat while GA (gibberellic acid) and light did not. NaOCl increased germination of cow cockle and increased its response to GA and to light. GA, NaOCl, and dehulling interacted to affect the germination of wild oats. It was concluded that dormancy in wild buckwheat is simply due to impermeability of the seed coat while with cow cockle and wild oats several factors are involved.

A bioassay for diclofop-methyl was developed using shoot and root lengths of 7-day-old Sioux oat seedlings germinated in solutions of the herbicide over a range of 0.0001–10 ppm at 18°C in the dark. An accurate estimate of the amount of diclofop-methyl can be made between 0.001 and 10 ppm.

WEED ECOLOGY

Weed surveys and crop losses

In a large-scale weed survey of 1500 randomly selected fields seeded to cereal and oilseed crops in Saskatchewan in 1977, 130 species were recorded. Green foxtail, wild buckwheat, and wild oats were the most abundant species. Background information on the fields was obtained from questionnaires distributed to the persons who farmed the fields.

Seventy percent of the surveyed hectareage was treated with a herbicide for the control of broad-leaved weeds and 26% for wild oats.

In 1978, the project was expanded to include surveys of the Peace River area of British Columbia, Essex and Kent counties in Ontario, Avalon Peninsula in Newfoundland, and all of Manitoba and Prince Edward Island. Thus 2500 fields across Canada were surveyed in 1978.

Using the 1977 Saskatchewan survey results and Dew's index of competition, the

loss due to competition from wild oats in cereal and oilseed crops was estimated to be \$92 million.

Population biology of weeds

Using a simple flow diagram model of a leafy spurge population, five key subsystems (seed bank, seedling, crown, crown shoot, lateral root) were recognized. The reaction of each subsystem to the application of picloram was documented. Picloram applied at 2 kg/ha eliminated four of the subsystems for 3–5 yr in Saskatchewan populations. The species survives the herbicide treatment only as seed. The seedlings emerging 3–5 yr after treatment tolerated the remaining picloram residues. By the end of the first growing season buds were formed on the crowns (vertical underground portions of the stem). These buds overwintered and produced crown shoots the following spring. Lateral roots were also produced during the first growing season. In this way the species successfully reestablished itself following treatment with picloram.

Rangeland ecology

Aspen poplar was controlled following the application of tebuthiuron at 1–2 kg/ha. However, the yield of native grass and brome grass was reduced for the 2 yr following the application of the herbicide. When fertilizer was applied at the same time as the herbicide pellets, the yield of brome grass was not reduced during the following two growing seasons. On both the fertilized and nonfertilized areas shoots of brome grass were killed near the pellets of tebuthiuron. However, the brome grass shoots that were growing between the pellets responded to the fertilizer to maintain the yield of forage on treated areas.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Air monitoring

A new high-volume air sampling technique was developed using polyurethane foam plugs. The detection limit for 2,4-D was 1 ng/m³ of air. During the 1978 spraying season, 2,4-D was detected in about 40% of the samples, with levels ranging from 1 to 40 ng/m³.

During 1978, air was sampled daily from May 4 to freeze-up in November and analyzed for triallate. The detection limit was 0.5 ng/m³. Nearly all samples collected up to freeze-up contained triallate, with highest levels (up to 100 ng/m³) being found during the spraying season. The presence of triallate was confirmed by multidetector (ECD, N, and Cl modes) analysis.

Vapor loss studies

The vapor pressure of triallate was determined using the procedure suggested by Environmental Protection Agency of the USA. The relationship between the log₁₀ vapor pressure and 1/T was linear and expressed by the equation $\log_{10} P = 11.045 - (4401/T)$. The heat of vaporization was calculated to be 8.4 kJ/mol. The vapor pressure value at 25°C was 2.067×10^{-4} mm Hg. The rate of volatilization of triallate from nonadsorbing surfaces was also determined, the value being 5.6 μg/cm² per hour at 25°C and air-flow rates of 1 L/min.

The initial vapor loss of triallate from wet soil at 10 ppm was 1.7 μg/cm² per day at 25°C and an air-flow rate of 1 L/min. The rate decreased to 0.13 μg/cm per day after 9 days. The amount of triallate moving in the mass flow to the soil surface was equivalent to 0.1 μg/mL, which is well below its water solubility (4 μg/mL) and was ascribed to the high adsorptive nature of this chemical.

Droplet drift studies

The droplet drift from agricultural aircraft was 10 times more than that from ground sprayers. This was affected by the type of aircraft, the wind speed at the time of spraying, and the volume of application. In a series of field trials, considerably less drift occurred with the Piper Pawnee (by a factor of about 2 at winds of 10 km/h) than with the Cessna Agwagon. For both aircraft the amount of droplet drift almost doubled with the doubling of the wind speed from 5 to 10 km/h. When the volume of application was increased from ca. 4.5 to 22.5 L/ha, the initial drift was reduced by 44% for the Piper Pawnee but had no effect with the Agwagon. However, at a downwind distance of 30 m, the volume effect was discernible for both aircraft.

Herbicide residues in soils

In a 3-yr field study several herbicides were applied in early May of each year and the residues remaining in the 0-5 and 5-10 cm soil depths were measured at 5, 12, and 17 mo.

Asulam, dicamba, bromoxynil, bromoxynil + MCPA, propanil, 2,4-D, and 2,4,5-T were not carried over from one growing season to the next, when applications were made in May. Herbicides applied during the summer or fall were sometimes carried over, especially if the soil was dry. Slight carry-over (5-15% of the original application) was noted with alachlor, atrazine, benazolin, benzoylprop-ethyl, diclofop-methyl, dichlobenil, dinitramine, EPTC, flammprop-methyl, triallate, and trifluralin. Moderate carry-over (15-30%) was observed with linuron, niclofen, picloram, profluralin, and simazine. Persistence data with picloram was difficult to assess since the herbicide was leached readily.

The rates of degradation of triallate and trifluralin were the same when the chemicals were applied alone or together.

Herbicide degradation in soil

The breakdown of 2,4-D, was not affected by the presence of MCPA, difenzoquat, dicamba, 2,4,5-T, or TCA. Similarly, the breakdown of bromoxynil was not affected when MCPA, MCPA + asulam, and MCPA + difenzoquat were present in the soil. These studies were carried out in the lab at herbicide rates normally encountered under field applications.

Herbicide degradation and residues in plants

Analytical methods were developed for the determination of TCA, 2,4-D, bromoxynil, benzoylprop ethyl, dinoseb, and triallate at levels of 50 ppb (10⁻⁹) or less, in green and dry tissues for a number of crops. Residues of dinoseb in green tissues of lentils, treated postemergence at 1.68 kg/ha, decreased from 28.6 ppm at time of application to 1.66, 0.58, and 0.07 ppm at 1, 3, and 7 wk thereafter. At harvest time the residue levels were 0.022 ppm in the straw, and <0.005 ppm in the grain.

There were no differences in either the rates of degradation or residue levels of 2,4-D and bromoxynil when applied singly or as a tank-mix to wheat.

Residue data for dinoseb in lentils and fababeans, terbacil in blueberries, and triallate in lentils have been used to support registration of these treatments under the minor use program of Agriculture Canada.

Residue data from herbicide mixture studies facilitated registration of tank-mixes of bromoxynil + 2,4-D on wheat and benzoylprop-ethyl + barban on wheat. With the tank-mix of TCA + 2,4-D on wheat, TCA residues in the mature grain were too high to permit registration.

CROP MANAGEMENT

Cereals

In cropping sequence tests conducted over 20 successive years at Indian Head, the average yield per cultivated hectare was the same for continuous cropping, fallow-wheat, and fallow-wheat-wheat when no fertilizer was used. With fertilizer the yields were 1650, 1250, and 1450 kg per cultivated hectare, respectively. The yield of wheat on fallow, when a grass-legume mixture was included in the rotation, was similar to that of fertilized wheat in the fallow-wheat or fallow-wheat-wheat sequence.

Barnyard manure was applied to a fallow-wheat-wheat rotation on Indian Head clay soil at 0, 13, 20, and 27 t/ha every 3rd yr since 1946. This produced average yields of 3040, 3400, 3660, and 3670 kg/ha on fallow

and 1010, 1230, 1320, and 1540 kg/ha on stubble for the 5-yr period 1974-1978. The level of available phosphorus in the 0-15, 15-30, and 30-60 cm depths of soil increased from 11 to 29, 8 to 27, and 6 to 18 ppm, respectively, as the rate of manure increased.

When two sources of nitrogen for wheat on stubble were compared, ammonium nitrate produced an average increase of 830 kg/ha compared to 590 kg/ha for urea.

Bromegrass and alfalfa

In a 3-yr test, ammonium nitrate phosphate and manure increased the dry matter yield of bromegrass, alfalfa, and a brome-grass + alfalfa mixture by 17 to 60%. Ammonium nitrate phosphate was 10-15% more effective than barnyard manure for equivalent amounts of N and P. The content of N and P in the forage was increased by both sources of the nutrients.

Sunflowers

A population of 70 000 plants per hectare produced the highest yield of Corona and Saturn oilseed sunflowers. As the population increased from 40 000 to 85 000 plants per hectare, the days to maturity, head size, and seed weight decreased while height increased. With Sundak, a nonoilseed cultivar, the yield was higher at 74 000 than at 37 000 plants per hectare. However, the percentage of seeds passing over a 7.9 mm round hole screen decreased from 44 to 25%.

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Saskatoon, Saskatchewan

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W. L. CROWLE, B.S.A., M.Sc.	Cereals and crop management
R. K. DOWNEY, O.C., B.S.A., M.Sc., Ph.D., F.A.I.C.	Oilseed breeding: rapeseed
R. E. HOWARTH, B.S.A., M.Sc., Ph.D.	Legume bloat: biochemistry
A. J. KLASSEN, B.S.A., M.Sc., Ph.D.	Oilseed breeding: rapeseed
R. P. KNOWLES, B.S.A., M.Sc., Ph.D., F.A.I.C.	Grass breeding
G. L. LEES, B.Sc., Ph.D.	Legume bloat: plant physiology
D. I. MCGREGOR, B.Sc., M.Sc., Ph.D.	Physiology of <i>Brassica</i> spp.
L. G. SONMOR, B.S.A., M.Sc.	Irrigation
G. R. STRINGAM, B.S., M.S., Ph.D.	Cytogenetics of <i>Brassica</i> spp.
H. UKRAINETZ, B.S.A.	Soil fertility
D. L. WOODS, B. Pharm., M. Phil., Ph.D.	Oilseed breeding: mustard

Entomology

R. H. BURRAGE, B.S.A., Ph.D., F.E.S.C.	Head of Section; Wireworms
L. BURGESS, B.Sc., M.Sc., Ph.D.	Associate Head; Oilseed crop insects
A. P. ARTHUR, B.Sc., M.S., Ph.D.	Oilseed crop insects
C. H. CRAIG, B.A.	Forage crop insects
G. R. F. DAVIS, B.Sc., M.Sc., Ph.D.	Insect nutrition
J. F. DOANE, B.S.A., M.S., Ph.D.	Ecology of wireworms
A. B. EWEN, B.A., M.A., Ph.D., F.R.E.S.	Physiology of grasshoppers
R. J. FORD, B.S.A., M.Sc., Ph.D.	Pesticide application: engineering
F. J. H. FREDEEN, B.S.A., M.Sc.	Black flies
L. B. HAYLES, D.V.M. & S., Ph.D., M.R.C.V.S.	Mosquitoes and arboviruses
Y. W. LEE, B.S., M.S.	Pesticide chemistry
K. S. MCKINLAY, B.Sc.	Pesticide application: toxicology
M. K. MUKERJI, M.Sc., Ph.D.	Demography of grasshoppers
O. O. OLFERT, B.Sc., B.S.A., M.Sc.	Crop loss assessment
N. D. WESTCOTT, B.Sc., Ph.D.	Pesticide chemistry

Plant Pathology

R. D. TINLINE, B.A., M.Sc., Ph.D.	Head of Section; Cereal root diseases
L. J. DUCZEK, B.S.A., M.Sc., Ph.D.	Cereal root diseases
J. DUECK, B.S.A., M.Sc., Ph.D.	Oilseed crop diseases
H. HARDING, B.Sc., Ph.D.	Legume and cereal diseases
G. A. PETRIE, B.A., M.A., Ph.D.	Oilseed crop diseases
J. D. SMITH, ¹ B.Sc., M.Sc.	Forage diseases
P. R. VERMA, B.Sc., M.Sc., Ph.D.	Soil microbiology

Departures

R. E. BELLAMY, B.S., M.S., M.A., Ph.D. Died February 7, 1977	Mosquitoes
J. R. BROWNRIDGE, B.Sc., M.Sc., M.L.S. Transferred to Ottawa, September 1977	Assistant Librarian
S. H. F. CHINN, B.Sc., M.Sc., Ph.D. Retired December 28, 1978	Soil microbiology
S. H. GAGE, B.Sc., M.Sc., Ph.D. Resigned November 23, 1977	Insect management
C. H. KEYS, B.S.A. Retired December 30, 1977	Head of Section; Weeds and crop management
J. J. R. McLINTOCK, B.Sc., Ph.D. Retired August 18, 1977	Mosquitoes and arboviruses
L. G. PUTNAM, B.S.A., M.Sc. Retired February 14, 1977	Rapeseed insects
W. W. A. STEWART, B.Sc. Retired August 16, 1978	Mosquito ecology and control

VISITING SCIENTISTS

- | | |
|---|-------------------|
| J. R. KING, B.Sc., Ph.D.
Research Council Canada visiting fellow, 1978-79 | Plant physiology |
| O. N. MORRIS, B.Sc., M.A., Ph.D.
Transfer of work from Environment Canada,
1977-78 | Insect pathology |
| S. K. RAINA, B.Sc., M.Sc., Ph.D.
Rotary Foundation fellow, 1977; Research Council
Canada visiting fellow, 1978-79 | Insect physiology |

Graduate students

- | | |
|--------------------------------|------------------|
| K. J. DEGENHARDT, B.Sc., M.Sc. | Plant pathology |
| D. DOSTALER, B.Sc., M.Sc. | Plant pathology |
| B. HAEBERLE, B.S.A., M.Sc. | Plant physiology |
| D. S. HUTCHESON, B.A., B.S.A. | Plant breeding |
| C. S. SAHA, M.Ag., M.S. | Plant breeding |
| J. R. STONE, B.Sc. (Agr.) | Plant breeding |
| B. E. TOCHOR, B.S.A. | Plant breeding |
| C. L. VERA, Ing. Agron. | Plant breeding |

¹On transfer of work to the University of Newcastle Upon Tyne, England, September 30, 1977, to October 6, 1978.

INTRODUCTION

The Research Station at Saskatoon and the Scott Experimental Farm are responsible for research in genetics, pathology, and entomology in the protection and improvement of rapeseed, mustard, sunflowers, wheat, barley, alfalfa, sweetclover, and numerous grasses. Cultural practices and integrated control of insects and diseases constitute an important part of this responsibility. The recent addition of a new growth chamber complex, complete with 30 walk- and reach-in growth units, will greatly facilitate the achievements of the Station's research goals.

Saskatoon is the main rapeseed and mustard breeding station in Canada. In 1977, this program produced, for licensing, the *Brassica campestris* cultivar Candle, and the *B. juncea* oriental mustard cultivar Domo. Seed of Candle, the world's first *B. campestris* low glucosinolate, low erucic cultivar, has been increased and utilized at maximum rates by Canadian processors, while Domo has been well received by the Japanese market. Good progress was made in identifying and incorporating greater disease resistance in both rapeseed species. This is particularly true for the control of the new virulent strain of blackleg, but the development of white rust resistant cultivars of *B. campestris* and *B. juncea* will also have an impact on potential yields.

Significant advances were made in the forage program with the identification of cytoplasmic male sterility in progenies of brome grass from interspecific crosses, and the licensing of the snow mold resistant Kentucky bluegrass cultivar Dormie. Investigations into the cause of legume bloat have overthrown numerous theories and established the close relationship between the risk of bloat and the ease by which cell walls are broken down, and the leaf proteins released into the rumen. These findings place the breeding of a bloat-safe alfalfa on a firm foundation.

We regret the loss in expertise due to the retirements of C. H. Keys, L. G. Putnam, W. W. A. Stewart, and Drs. S. H. F. Chinn and J. J. R. McLintock, and the untimely death of Dr. R. E. Bellamy, following long and valued service. Mailing address: Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask. S7N 0X2.

J. E. R. Greenshields
Director

CROPS

Oilseeds

Rapeseed breeding. The licensing in 1977 of the low erucic acid, low glucosinolate, partially yellow-seeded *Brassica campestris* L., cultivar Candle, was a milestone in the steady progress towards the breeding of more valuable and versatile products from rapeseed. This cultivar is the first within this species to produce the superior quality, low glucosinolate meal. Candle is 2-3% higher in oil content than Torch, approximately 0.5% higher in protein content, and about 3.0% lower in crude fiber. These quality characteristics have made Candle attractive to processors, and its acceptance by producers is indicated by the fact that the area seeded to Candle increased from 20 085 ha in 1977 to approximately 321 360 ha in 1978.

The breeding program has produced numerous strains now in advanced trials which have quality characteristics similar to Candle but which have exhibited significantly higher seed yield.

Genetic resistance to white rust, *Albugo candida* (Pers. ex Lévl.) Ktze., identified in *B. campestris* introductions from Central and South America, has been successfully incorporated into low erucic, low glucosinolate genotypes, and several resistant, double low strains showed superior seed yield to Candle in preliminary yield trials.

Although efforts to identify pure yellow-seeded *Brassica napus* L. strains have to date been unsuccessful, it has been shown that yellow brown genotypes possess the same desirable quality characteristics of higher oil content, higher protein content, and lower crude fiber which had been found earlier to be associated with yellow seed color in *B.*

campestris. High erucic acid, low glucosinolate strains have been developed in both *B. napus* and *B. campestris* and will be evaluated in field trials in 1979.

Release of free thiocyanate ion by glucosinolates in rapeseed. Evidence was obtained that both high and low glucosinolate rapeseed cultivars of *B. napus* and *B. campestris* contain previously undetected glucosinolates which, upon hydrolysis, give rise to free thiocyanate ion. The presence and amounts of such glucosinolates were obtained by comparison of the amount of glucose, sulfate, isothiocyanates, and free thiocyanate ion released by incubation of oil-free meals with yellow mustard myrosinase isolate. Low glucosinolate cultivars released amounts (8.6–11.4 $\mu\text{mol/g}$) similar to that released by normal glucosinolate cultivars (10.1–13.1 $\mu\text{mol/g}$). Mustard cultivars of *B. juncea* (L.) Coss released somewhat less (5.4–6.9 $\mu\text{mol/g}$).

Methods currently used to estimate the glucosinolate content of rapeseed measure only those which give rise to isothiocyanates stable in aqueous solution. In order not to grossly underestimate the glucosinolate content of low glucosinolate rapeseed, these methods should be complemented by analysis for free thiocyanate ion.

Hail injury to rapeseed. Adjusting for hail injury to rapeseed in the early stages of development has always been difficult because of the ability of the crop to recover. Now experiments to simulate hail injury are helping to develop criteria which could improve hail adjusting. Hail injury to the seedling and vegetative stages of development results in thinning of the stand and defoliation. By artificially thinning stands it has been observed that distance between plants in the row is related to the log of seed yield. Plants remaining after thinning compensate by increasing the number of branches and pods, thus reducing seed yield losses. Similarly, defoliation in the early vegetative stage of plant development has been observed to reduce seed yield, but the reduction has been less than expected. Although somewhat variable in different years, seed yield reduction from defoliation has been about 25% of the extent of leaf area loss. Yield reduction from defoliation for *B. napus* is somewhat greater than that for *B. campestris*.

Studies on the pattern and sequence of flowering in both rapeseed species have shown that about 50% of the flowers and buds abort. Most of the abortion occurs towards the end of the flowering period. It appears that the rapeseed plant is able to quickly recover and partially compensate for hail injury at flowering through the retention of these late flowers and buds.

Isolation distances for seed rape production. Field trials have determined the effectiveness of isolation distance in preventing cross-contamination in *B. campestris*. Tests utilized the 1973 C.S.G.A. regulations for isolation distance in pedigreed seed production, and a recessive genetic market sown in the test plots was used to determine the relative pollen contamination entering from adjacent fields. Average contamination levels from six tests over 2 yr were 8.5, 5.8, and 3.7% at isolation distances of 46, 137, and 366 m. The 46 and 137 m distances were judged to be inadequate and even the 366 m distance showed greater contamination levels than desirable. The data suggest that the current 50 and 100 m Canadian isolation requirements for Certified seed production of *B. campestris* should be reexamined.

Mustard breeding. A new cultivar of oriental mustard, *B. juncea* cultivar Domo, was licensed in 1977. This cultivar has a yield advantage over the best previously existing ones of the order of 10%, while also being superior in allyl isothiocyanate level. The incidence of yellow-colored seeds in the brown mustard, *B. juncea* cultivar Blaze, has been reduced from about 5% to below 0.5%, clearing the way for its widespread use. A study on the genetic control of seed color in this species has demonstrated two duplicate dominant genes for brown seed color.

White rust, *A. candida*, has become an important problem on brown mustard. Fortunately, good sources of resistance have been identified in both brown and oriental mustards, and these will be incorporated as rapidly as possible into new lines of brown mustard.

In yellow mustard, *Brassica hirta* Moench, the high erucic acid cultivar Sabre has been grown for industrial oil purposes but has not been accepted as a condiment. A higher-yielding replacement for this is being evaluated.

Sunflower breeding and management. Corona sunflower, an early flowering, dwarf oilseed cultivar, was licensed in 1977. In 3 yr of testing on the open prairies, Corona exceeded Krasnodarets in yield by 9.5%. Corona is adapted to solid-seeding with small grain drills at populations of 76 200 plants/ha.

Since 1976, there has been an increasing trend towards the contract production of late-maturing sunflower hybrids. In 1978, in farm demonstrations in southeastern Saskatchewan, hybrids exceeded early, open-pollinated cultivars in yield by 15%, but flowered 7–10 days later than Corona. Early hybrids were evaluated on research plots in 1978, with several exhibiting high seed yields and oil content.

Grasses

Meadow brome grass for irrigated pastures. Meadow brome grass, *Bromus riparius* Rehm, which is a less strongly creeping relative of smooth brome grass, has shown significant merit as an irrigated pasture grass at Saskatoon. Under dryland conditions, however, it is lower yielding than smooth brome grass for hay and pasture.

For the period 1976–1978 meadow brome grass, under irrigation, yielded 8.54 t/ha in pasture clippings compared with 7.60 for Carlton smooth brome grass, 7.69 for Kay orchardgrass, and 6.90 for Troy bluegrass. Dryland pasture yields were 3.16 t/ha for meadow brome grass vs. 3.61 for Carlton smooth brome grass. Meadow brome grass appeared greener and more productive in the September–October period than smooth brome grass.

The Regar cultivar of meadow brome grass from the United States was compared with several introductions from Europe and Asia. The S-7414 strain from the USSR is being considered for release in Canada because of its favorable seed yields.

Cytoplasmic male sterility in brome grass. Cytoplasmic male-sterile plants have appeared when meadow brome grass was cross-pollinated with smooth brome grass and the F_1 plants were allowed to open-pollinate. In addition, backcross progenies show a wide range in development, plant vigor, and female fertility. Further backcrossing using self-fertile parents and high-yielding diallels is being done to improve vigor and fertility. A simplified hybrid system is planned in

which male-sterile strains would be offered to the farmer. Such strains would remain green without ripening off and so provide pasture for a longer period.

Native versus introduced grasses. Three native wheatgrasses, which are common components of native prairie, were compared with six presently cultivated grasses originally introduced from Europe and Asia. For the period 1975–1978, hay yields of native western wheatgrass, *Agropyron smithii* Rydb., northern wheatgrass, *A. dasystachyum* (Hook.) Scribn., and slender wheatgrass, *A. trachycaulum* (Link) Molte., were 2.72, 2.80, and 3.43 t/ha compared with 5.02 for Carlton brome grass. When cut two or three times per season to simulate pasturing, yields were 2.49, 2.02, 2.04, and 3.61 t/ha. As well as being lower yielding than the introduced grasses, the native grasses had lower *in vitro* digestibilities. This appeared to result from their more rapid rate of leaf senescence compared with introduced grasses.

Legumes

Bloat research and alfalfa breeding. The primary objective of the alfalfa breeding program is the development of a bloat-safe alfalfa cultivar. A major advance toward this goal has been achieved by development of the cell rupture theory of pasture bloat. This theory emphasizes rupture of the leaf cell walls as a key event in the occurrence of bloat. The leaf proteins, which cause bloat, are intracellular constituents, but they cannot be effective until they have been released from the leaf cell into the rumen fluid where they act as foaming agents. Thus a new approach to breeding a bloat-safe alfalfa is suggested; i.e. the selection of plants which have greater resistance to leaf cell rupture. The effect of this approach would be to slow down the initial rate of digestion so that release of the proteinaceous foaming agents would be more closely matched to their removal from the rumen fluid by microbial digestion, and their accumulation in the rumen fluid would be avoided.

The experimental basis for the cell rupture theory comes from comparisons of three bloat-causing legumes, namely alfalfa, red clover, and white clover; and three bloat-safe legumes, namely birdsfoot trefoil, cicer milkvetch, and sainfoin. Cell wall rupture results from mechanical damage during

mastication and from microbial digestion of cell walls. The bloat-safe species are more resistant to mechanical damage and have slower rates of microbial digestion compared with the bloat-causing forage legumes.

Within a small population of alfalfa genotypes there was a relatively close relationship between ease of mechanical damage and initial rate of microbial digestion ($r = +0.81$), and there was a significant difference among genotypes in initial rate of digestion by rumen microorganisms. Thus a two-stage selection procedure has been proposed, with the first stage based on mechanical properties of the fresh leaves and the second stage based upon initial rate of microbial digestion. A number of different mechanical and microbial digestion assays have been evaluated.

Cereal varieties for forage

Straw components of up to 17 wheat, oat, and barley cultivars, grown at four locations in 1975–1976, were compared for feed quality attributes before and after ammoniation. Based on a combined statistical analysis, significant differences ($P < 0.05$) occurred between crops and among cultivars within crops for crude protein (CP), *in vitro* digestible organic matter (DOM), and crude fiber (CF) in the untreated straw residues. Average CP and DOM levels were lowest for wheat (3.57 and 36.65%). Barley had the highest average CP (4.88%), and oats the highest average DOM (39.84%). Wheat straw had substantially higher average CF than either oats or barley. Straw from Pitic 62 wheat, Random oats, and Fergus barley showed superior quality attributes for their respective crops. Neepawa wheat straw appeared to have the poorest quality overall. The straws were treated with 5% anhydrous ammonia and left in a sealed container at 20°C and 15% moisture for 6 days. Following ammoniation, all wheat cultivars had higher CP levels than the oat and barley cultivars; average improvements in CP for wheat, oats, and barley were 8.08, 4.67, and 5.32%; average DOM levels were similar for wheat, oats, and barley; average improvements in DOM were 8.59, 6.13, and 6.57%. Neepawa had significantly higher CP following ammoniation than the oat or barley cultivars, and showed the highest improvement in DOM (10.07%). Based on DOM values of the wheat, oat, and barley straws, the cultivars

Pitic 62, Random, and Fergus would still be preferred after ammoniation. There was little to choose between several cultivars within crops for CP content.

Agronomy and weed control

Effect of liming on wheat and barley production. Lime incorporated on the acid (pH 5.2) Scott loam in 1963 at 4480 and 6720 kg/ha raised yields of wheat grown in 1978 by 235 and 971 kg/ha, and barley by 125 and 684 kg/ha. At the lower rate of lime, response was almost equal to that obtained from an application of P at 45 kg/ha, and at the higher rate of lime the increase was higher than from phosphate applied alone. Over the 15 yr, the average yield increases for seven wheat crops from a single application of lime at two experimental rates were 268 and 561 kg/ha and for eight crops of barley the average increases were 465 and 771 kg/ha. Phosphate fertilizer applied alone increased yields of wheat and barley 427 and 452 kg/ha.

Lime applied once in 1969 at rates up to 8960 kg/ha increased yields of barley in 1978 by 1466 and 2075 kg/ha for the 4480 and 8960 kg/ha lime rates. Corresponding yield increases for Torch rapeseed were 457 and 458 kg/ha. The 5-yr average increases for barley were 752 and 1308 kg/ha, and 3-yr average increases for rape were 468 and 525 kg/ha. The 1978 and 5-yr average yield increases from phosphate with P applied at 45 kg/ha were 1510 and 935 kg/ha. Phosphate fertilizer with P at 22 kg/ha gave a 503 kg/ha increase in rapeseed yield in 1978, and a 3-yr average increase of 403 kg/ha. Effects of lime and phosphate on straw yields were similar to those for grain. Maximum yields of straw and grain were obtained when lime and phosphate were applied.

The response to liming was related to an increase in available phosphate in the soil and a decrease in soluble aluminum and manganese. High levels of soluble manganese were found in unlimed soils and likely had a toxic effect on wheat and barley. Under average moisture conditions of westcentral Saskatchewan a single application of lime at 4000–5000 kg/ha on acid soils should improve crop production for a period of at least 10 yr.

Crop rotation studies of fallow:wheat (1:1) and (1:2), continuous wheat, and the use of row crops to trap snow were conducted at

Loverna (1964-73) and Scott (1964-78). At Scott, in the Dark Brown soil zone, the continuous wheat rotation averaged 1345 kg per cultivated hectare annually, compared to 1068 and 1010 kg per cultivated hectare for the 1:2 and 1:1 fallow:wheat rotations. The use of sunflower strips and ridging to trap snow did not increase yields. At Loverna in the Brown soil zone, annual yields per cultivated hectare were virtually the same regardless of rotation length.

Crop sequence investigations on a Grey-wooded soil at Loon Lake indicate that repeated cropping to rapeseed encourages severe disease infestation and the rapid spread of perennial weeds, particularly Canada thistle. Yields of wheat and barley on fallow were 9 and 16% greater than when grown on alfalfa sod, and 49 and 42% greater than when grown on brome grass sod.

The tolerance of wheat to repeated applications of picloram over an 8-yr period was acceptable at application rates ranging between 0.020 and 0.035 kg/ha. No significant reductions in height, yield, or maturity occurred. Efficacy of picloram in combination with 2,4-D on wild buckwheat was greater than the widely used bromoxynil + MCPA mixture. Registration of the picloram-2,4-D combination provides control of wild buckwheat and several other broadleaf weeds at approximately one-half the cost of the most commonly used alternative herbicide.

PLANT DISEASES

Diseases of oilseeds

Blackleg on rapeseed. A severe localized outbreak of a highly virulent strain of blackleg, *Leptosphaeria maculans* (Desm.) (Ces. & De Not.), occurred on rape in northeastern Saskatchewan in July 1977. In a few fields over 50% of the plants were infected. The estimated yield loss was 20% in one field in which basal stem cankers were common. This field had also grown an infected rape crop the previous year. In 1978, the disease developed later in the season and its effects were not as serious. However, in August, over 40% of the fields surveyed in the blackleg area of eastcentral and northeastern Saskatchewan had slight infection. In this area, the number of infected fields has at least doubled each year since 1975, the year the presence of the new strain in Saskatchewan was confirmed. The virulent strain has not as

yet been detected in Alberta and Manitoba rape fields. Comparative studies have indicated that this strain is very similar to the virulent eastern U.S.A. strain, which causes cabbage blackleg, and to virulent Australian rape strains. In both countries, blackleg has caused serious difficulties in the rape and cabbage seed industries.

Tests revealed the presence of the virulent strain of blackleg in 2% of 800 Canadian samples of rapeseed from both species in the crop years 1976 and 1977. With few exceptions, all infected samples, which included samples of pedigreed seed, originated in northeastern Saskatchewan; none originated in Alberta or Manitoba. Since seed could be an important means of dispersal of blackleg to uninfected fields and new geographic regions, a fungicidal seed treatment was recommended for the control of seed-borne blackleg. The treatment material contains either benomyl or carbathiin combined with thiram or captan to provide additional seedling disease control. Formulations containing lindane for flea beetle control in combination with the fungicides were found effective for blackleg control.

In 1977, epidemiological studies indicated that ascospore discharge from rape residues of the previous year's crop occurred much earlier in the season in the virulent strain than in the more common weakly virulent strain which had been found on the Canadian Prairies since 1957. This early spore discharge accounted in part for the severity of the disease in 1977. In 1978, however, ascospore development in the virulent strain occurred later in the season due to periods of hot, dry weather in the early spring; consequently blackleg was less severe. Heavy infections have developed only in cases where rape was sown in or adjacent to a rape field which had the virulent strain the previous year. By the second year following an infected crop the original sources of ascospores had largely disappeared. Crop rotation was therefore seen as an important means of blackleg control. Burial of infected rape residues showed promise as a means of rapidly lowering inoculum levels. Fungi highly antagonistic to *L. maculans* were shown to occur naturally in soil and to rapidly invade infected rape straw. The races of *L. maculans* commonly encountered on cruciferous weeds do not attack rape beyond the seedling stage. The only important wild host of the virulent rape strain is wild

mustard, *Brassica kaber* (DC.) Wheeler var. *pinnatifida* (Stokes) (Wheeler).

Canadian cultivars of *B. juncea* (brown and oriental mustard) and *B. hirta* (yellow mustard) have much better resistance to the virulent strain than those of *B. napus* and *B. campestris*. Introductions from around the world, including Australian and French cultivars and breeding lines of *B. napus* and *B. campestris* resistant to blackleg in those countries, have been and will continue to be tested for resistance to Canadian blackleg isolates at Saskatoon. Considerable progress was made in the identification of sources of resistance in both rapeseed species. One *B. campestris* introduction had excellent resistance to blackleg and race 7 of white rust. An extensive breeding program has been instituted to combine resistance with desirable agronomic characteristics.

Another relatively new problem which has required immediate attention is race 2 of white rust on *B. juncea*. Selection of sources of resistance has been highly successful. Development of cultivars of *B. campestris* resistant to race 7 of white rust has advanced appreciably with field testing of yellow-seeded, zero erucic acid, low glucosinolate, highly resistant selections. This material was also resistant to races 1 and 2 of white rust.

Sclerotinia stem rot of rapeseed. Apothecia, the sporulating stage, began to appear in mid-June and were continuously produced throughout the growing season. The critical period of infection appeared to be the mid-to late-flowering stage of the crop. A single application of benomyl, glycofen, vinclozoline, or DPX 4424 (E. I. DuPont) at early flowering gave excellent control of the disease.

Resistance of rapeseed, mustard, and sunflowers to Sclerotinia. Field nurseries for the selection of sunflower and rapeseed lines were maintained. No complete resistance to the disease has been found; however, differences among cultivars are apparent. In the *Brassica* spp. tested, the rape cultivar Bronowski and a line of yellow mustard showed less disease than other cultivars. In sunflowers, the inbred HA₆₁ was less susceptible than other cultivars. A selection from within HA₆₁ was more resistant than the parent cultivar.

Diseases of forage

Snow mold. A revision of the taxonomy of *Typhula ishikariensis* Imai was completed in a cooperative study between Saskatoon Research Station and the Norwegian Plant Protection Institute. This aggregate species is an important snow mold pathogen of grasses and winter cereals in the alpine/arctic regions of the Northern Hemisphere. This involved genetic, physiological, and morphological studies with isolates from North America, Europe, and Asia. *T. ishikariensis* var. *canadensis* Smith & Årsvoll was described from cereals and grasses from Western and Central Canada. An undescribed fungus with resting structures which can be confused with those of some *Typhula* spp. was found in Western and Central Canada and in Norway. This fungus, like the snow molds, grows at temperatures below freezing but does not cause disease. It is also antagonistic to most of the common snow molds and may compete with them on plants under a snow cover.

The *Poa pratensis* L. cultivar Dormie was licensed in 1977 and released for multiplication in 1978. This cultivar is field-resistant to snow mold caused by the low-temperature basidiomycete (LTB). It is believed the cultivar derives its resistance to snow mold by assuming a near-dormant condition well before a snow cover develops. This cultivar is well suited to turf use in the Prairies, green-ing up quickly in the spring and making use of the short growing season available. Because Dormie is also resistant to powdery mildew, *Erysiphe graminis* DC, and highly resistant to another snow mold, *Fusarium nivale* (Fr.) Ces., a common disease in other parts of the world, this new cultivar may find a market also in northern regions outside the Prairies.

Fairy ring fungus. Mutual antagonism between isolates of the common fairy ring fungus, *Marasmius oreades* (Bolt ex Fr.) Fr., which has been demonstrated in culture in the laboratory, may be an important factor in the bilateral extinction of impinging fairy rings. This mutual antagonism and antagonism between many soil fungi and *M. oreades*, which has also been shown to occur in laboratory studies, may be the cause of elimination of the latter fungus when ring and nonring soil is mixed. A promising biological control method for fairy rings

caused by *M. oryzae* has been developed and appears to be based on these effects.

Diseases of cereals

Common root rot. Loss from common root rot in red spring wheat was estimated at 5.3% in 1977 and 2.9% in 1978. These values are below the 10-yr average (1969-1978), but they still represent a large amount of unrealized grain.

Screening and developmental work to improve resistance to the disease was continued. A number of promising barley lines have been identified following preliminary testing of some 1500 strains obtained from the U.S.D.A. World Collection and Canadian plant breeders. In wheat, progeny in the second to fourth generation from crosses between some of the most resistant cultivars were scored in the field for disease reaction. Further evaluations of the more resistant progeny will be carried out to determine the best parental sources of resistance.

Studies at Melfort over a 3-yr period indicate that the severity of common root rot in barley does not change appreciably when the crop is preceded by either a susceptible crop such as wheat or barley, or a nonhost crop such as flax or rapeseed, on fallow. Apparently populations of spores of the pathogens do not decline rapidly in the field during a 2-yr absence of a host crop. A determination of numbers of conidia of *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur, the major cause of common root rot in the Prairies, in different soil profiles showed a relationship between where the spores are located and the depth of cultivation.

Postseeding but preemergent tillage practice for herbicide incorporation caused an increase in disease in Cypress wheat near Regina, whether or not a herbicide was actually applied. It thus appears that disease is enhanced by postseeding soil disturbance.

Seed treatment with imazalil in field trials across the Prairies significantly reduced the severity and incidence of common root rot in four cultivars of wheat, two of barley, and one of oats. A slight yield increase occurred at one treatment dosage in Neepawa and Cypress wheat. Some morphological changes in wheat plants were associated with the seed treatments. Plants from treated seed had deeper crowns, larger diameter but shorter subcrown internodes, and a higher frequency

of coleoptile-node tillers than those from untreated seed. For example, about 60% of Neepawa plants from treated seed at Swift Current possessed coleoptile-node tillers and about 60% of them were productive, whereas the control plants rarely produced this structure, and when present it either aborted or failed to produce ears. Six additional fungicides applied as seed dressings showed promise for the control of the disease in wheat in field trials at Saskatoon and Scott. In a subsequent greenhouse test, Bay KWG 0519 and EL 228 gave the best degree of control. A few seed treatment chemicals also gave some measure of control of root rot in Galt barley in the field.

Over 1000 isolates of *C. sativus* from Western Canada are being studied to determine the extent of variability in the species. The objective is to detect any potentially destructive physiologic races. One aspect of variability is toxin production, and a numerical index for this has been developed. It is based on the degree of inhibition of germination in two wheat cultivars, Little Club and Neepawa. Although there is a continuous distribution over the range 0-100, where 100 represents complete inhibition, the distribution is highly skewed; most isolates have an index of 80 or greater. A more readily detected aspect of variability is colony morphology. Two media containing casein hydrolysate preparations have proved useful in this regard, and work is underway to correlate colony morphology with toxin production and pathogenicity. The root rot reactions of barley cultivars in the field differed from those obtained in the laboratory using seedling inoculations and exposure to culture filtrates.

Prematurity blight was induced in durum wheat by *C. sativus*, and particularly by *Fusarium culmorum* (W. G. Sm.) Sacc. in growth chambers. Conditions conducive to blight were high levels of inoculum and moisture stress of the plants at the flag leaf stage. The method should be useful in screening cultivars for resistance.

ENTOMOLOGY

Oilseed insects

Flea beetles. Flea beetles were a serious threat to rape crops in Saskatchewan in 1977 and 1978. Growers forewarned of the situation each year made effective use of seed and

in-furrow insecticide treatments and foliar sprays. Good control was generally obtained, although a few failures of seed and in-furrow treatments to give adequate protection were reported. The abundance and importance of the striped flea beetle have increased. In some localities, particularly in 1977, this pest was as abundant or more abundant than the crucifer flea beetle, *Phyllotreta cruciferae* (Goeze), historically the most serious flea beetle pest of parkland rape crops.

A large population of the striped flea beetle was discovered in the boreal forest to the north of the rape-growing parklands, and the known distribution of this species was extended northwards to Wollaston Lake in Saskatchewan. It was also trapped near Great Slave Lake in the Northwest Territories. A search of the host plants of this beetle in the forest revealed that it is attracted to various species of mosses, but the extent to which forest mosses serve as a food supply is not yet evident. Cruciferous plants do not appear to be abundant enough in the forest to constitute an adequate food supply for the large population of beetles present. Southwards from the parklands, the known distribution of the striped flea beetle was extended to Swift Current.

The presence in Saskatchewan of another crucifer-feeding flea beetle, tentatively identified as *Phyllotreta oregonensis* Crotch, was established.

An improved method of dispensing allyl isothiocyanate bait from flea beetle traps has more than tripled bait life and removed the hazards of spillage and freezing associated with earlier methods.

Bertha armyworm. Surveillance with pheromone and light traps and larval surveys indicate that populations of the bertha armyworm remained at a very low level in Saskatchewan in 1977 and 1978. The pheromone traps, developed jointly by the Lethbridge Research Station and the Prairie Regional Laboratory of the National Research Council in cooperation with the Saskatoon Research Station, have proved to be a valuable addition to the surveillance trap network.

Sunflower moth. It has been found that infestation of the sunflower crop by the sunflower moth is dependent upon moths being present when sunflowers are in bloom. No accurate method of monitoring moth arrival from the south, or moth abundance,

has been available. However, efficient methods of predicting and monitoring the time, area, and abundance of moth arrivals have now been developed in cooperation with the Prairie Regional Laboratory of National Research Council and D. J. Bauer of the Atmospheric Environmental Service, Fisheries and Environment Canada, Saskatoon. Traps baited with a pheromone attractive to male sunflower moths will be made available for distribution to representative sunflower growers in Saskatchewan. These traps will enable growers to determine if moths are present when their crop is in bloom. If not, no control measures will be required, but if large numbers of moths are present the employment of an appropriate insecticide is indicated.

Grasshoppers

Embryonic development. Investigation of the effects of soil moisture on embryonic development of grasshoppers has shown that a minimum amount of moisture is necessary for eggs to complete development and hatch. The threshold was 13.5% moisture for a silty clay loam; development beyond initial rotation of the embryo would not take place at any level below this. The rate of development after termination of low-moisture stress decreased as the duration of the stress increased. An exponential decay curve was derived for the rate of egg mortality as a function of the level of soil moisture to which eggs were exposed.

Crop damage assessment. It has been found that grasshopper population densities of 20/m² can cause acute damage to wheat in the tillering phase of crop development. Defoliation by grasshoppers significantly decreases yield by increasing plant mortality and decreasing the number of seeds per head and the weight of individual kernels. This effect becomes progressively more severe the later the stage of plant development when the damage occurs. A cost benefit evaluation of control measures used by growers in one outbreak area in Saskatchewan in 1976 indicated that revenue resulting from chemical control measures was greater than the cost of control at the level of application employed. Grasshopper population densities of 3-4/m² did not affect plant growth and yield significantly.

Aerial remote sensing. The techniques of aerial infrared photography and photointerpretation facilitated the detection of grasshopper damage, measurement of the amount of damage, estimation of crop yield, and identification of the kind of crop. A damage key was developed that successfully assisted photointerpreters in differentiating grasshopper damage from other crop anomalies. Aerial survey of grasshopper damage had significant cost and time advantages over ground survey. Furthermore, this method offered a quantitative approach for the investigation of the effects of other stress factors, such as salinity and erosion, on field crops.

Economics of crop loss and crop protection. Evaluation of the economic impact of grasshoppers on wheat production in Saskatchewan revealed that losses caused by grasshoppers were dynamic but small relative to the fluctuations of crop price and yield loss due to vagaries of weather. The average probability of an economic loss from grasshoppers, derived during a 32-yr period (1943–1974) in Saskatchewan was 0.48 for wheat, 0.72 for oats, and 0.32 for barley, with the highest chance of loss occurring in the southwestern region of the province.

Wireworms

Response to carbon dioxide. Wireworms were found to follow concentration gradients of CO₂ that ascend by as little as 0.002%/cm in soil. This orientation response was used to determine the location of the CO₂-receptive sensilla of larvae of *Agriotes lineatus obscurus* (L.) and the sugarbeet wireworm, *Limoniinus californicus* Mann. Selective bilateral amputation of the antennae, maxillary palps, and labial palps indicated that the maxillary palps are the most important for CO₂ perception, followed by the labial palps. The antennae do not appear to be involved in this response. Scanning electron microscopy showed a cluster of sensilla at the tip of both the maxillary and labial palps. More than twice as many sensilla occur on the tip of the maxillary palp as on the labial palp, which may account for the greater importance of the maxillary palps in response to CO₂.

Screening insecticides for soil treatments. A laboratory technique using *Drosophila* flies for predicting the effectiveness of insecticides for use as soil treatments for controlling wireworms shows promise. The use of field

trials alone for screening insecticides as soil treatments can be very costly and time-consuming, and severely restricts the number of insecticides that can be tested. The laboratory method with *Drosophila* is relatively fast and permits the initial screening of a great many more compounds. It should now be possible to limit field trials to only those insecticides which appear to have the best potential.

The laboratory procedure involves determining dosage-mortality curves for each insecticide, using cotton wool alone and soil and cotton wool together as barriers in test tubes between the insecticide and the flies. The mortality of the flies resulting from the use of the two different barriers reflects the basic toxicity of the toxicant and its volatility and ability to move through the soil. Six insecticides, namely aldrin, fonofos, chlorpyrifos, ofunack, azinphos-methyl, and trichlorfon, were tested in this way and also in field trials as soil treatments for protecting potatoes from wireworm attack. Rankings of the effectiveness of the insecticides were the same in both the laboratory and field studies.

Forage crop insects

Integrated control. As a prelude to the introduction of parasites of European origin as biological agents for the control of plant bug pests of alfalfa seed crops in Western Canada, the incidence of parasitism indigenous in the local plant bug population was investigated. The lygus population, composed primarily of *Lygus borealis* Kelton, *L. desertinus* Knight, and the tarnished plant bug, is parasitized by a single species of euphorine, *Peristenus pallipes* Curtis. Parasitism is general throughout all seed-producing areas of Alberta and Saskatchewan, at an average level of 28, 27, and 12% in the south, central, and northern areas. The *Adelphocoris* population, almost solely the alfalfa plant bug, is parasitized by an unknown euphorine at the very low level of less than 2% in all areas where this insect occurs.

In 1978, 350 adults of *Peristenus digoneutis* Loan were received at Saskatoon from the Swiss laboratory of the Commonwealth Institute of Biological Control via the Agriculture Canada Importation Service. Of these, 200 were released into an alfalfa seed field near Moose Jaw, Saskatchewan (50°N lat. 105°W long.), and the remainder into alfalfa seed plots at the Saskatoon Research Station

Farm (52°N lat., 107°W long.). It is too early to gauge the survival or success of this introduced parasite.

Black flies

New problem species. Since 1975, *Simulium luggeri* N & M has replaced *S. arcticum* Mall. as the major pest species of black fly in Saskatchewan. This happened after both branches of the Saskatchewan River became relatively shallow during summertime due to storage of water for wintertime use in new hydroelectric facilities built upstream. Clear, shallow water allows heavy growth of water weeds where none existed before. Weed beds serve as attachment sites for larvae.

S. luggeri differs in several ways from *S. arcticum*. It regularly develops three or more large generations per summer instead of one. Although its bites are relatively nontoxic, it attacks cattle viciously around their heads causing them to stampe. Grazing and breeding activities are affected, fences are broken, and cattle are trampled. Farm business is interrupted when the livestock require extra attention. *S. luggeri* also attacks humans and has caused complete cessation of outdoor activities. In 1977 and 1978, single outbreaks blanketed 20 000 – 30 000 km² for several days at a time, and smaller areas for the entire summers.

Placing a larvicide in both branches of the Saskatchewan River should provide the most efficient control. In the past 2 yr, however, 15-min treatments with 0.3 ppm of methoxy-chlor spaced 4–6 wk apart have provided only temporary periods of relief. Efficacy and environmental impact studies are in progress.

Sampling methods. Attempts to collect quantitative samples of insect larvae from the Saskatchewan River and other large rivers have always presented major problems. Recently, several kinds of artificial substrates and methods for anchoring them on the river bed and surface were devised. Polyethylene-covered plates anchored near the river bottom for 3 wk accumulated mean populations of 426 simuliid larvae and pupae, but only 47 non-simuliids per 100 cm². Populations of non-simuliids occurred in highest densities on complex, rough surfaces, especially those covered with debris. Following a 3-wk exposure, mean populations on 100 cm² aluminum-mesh plates included 606 chironomids, 147 stoneflies, 13 mayflies, and 98 caddis larvae, but only 4.5 simuliids. Large numbers

of these same insects also colonized similar substrates on the river surface. Baskets of gravel on the river bed provided samples yielding larger numbers of species and higher diversity indices than did mesh-covered floats on the river surface. Samples of sand collected directly from the river bed yielded the fewest species and the lowest diversity indices. Substrates other than those in contact with the river bed were colonized entirely by species prone to drift.

Artificial substrates are now used regularly in the Saskatchewan River to measure populations of simuliid larvae to determine need for larviciding, to measure efficacy and environmental impact of larvicidal treatments, and to study growth and behavior of simuliid species.

Insect nutrition

Protein evaluation. Larvae of the yellow mealworm are being used to evaluate protein of cereal seeds and oilseeds produced in improvement programs. Gains in fresh weight, final dry weights, and protein contents of larvae are influenced by the percentage of protein in these seeds and by the concentrations and availabilities of the amino acids which make up the proteins. Larval fresh-weight gains are reflective of the available lysine contents of proteins. They are also influenced favorably by high concentrations of the basic amino acids, namely arginine, histidine, and lysine, and by low concentrations of leucine. The importance of this evaluation technique lies in the fact that minute amounts of material are required for testing. Diets containing 3% of dietary protein are adequate for biological evaluation of protein quality and 0.5 g of diet per larva are sufficient for the 4-wk test period.

Toxic fungal metabolites. Larger quantities of toxic fungal metabolites are produced by isolates of field- and storage-fungi under conditions of constant darkness and an incubation temperature of 24°C than under other experimental conditions. The principal toxic factor produced by these fungi grown in the laboratory appears to be T-2 toxin. Tests with yellow mealworm larvae suggest that certain metabolites are more toxic than others and that toxicity is also inversely related to the nutritional status of the larvae.

Pesticide chemistry

Residues of fenvalerate. Analysis of wheat foliage to which fenvalerate, a synthetic pyrethroid insecticide, had been applied at the tillering stage indicates that concentrations of fenvalerate residues decrease by half every 4-5 days. No fenvalerate residues were detected in wheat grain or straw at the time of harvest.

Persistence of dimethoate on wheat. Chemical analysis and bioassay of treated-wheat foliage indicate that under some crop and environmental conditions only 20% of the dimethoate that was on foliage immediately after application remained 12 h later, and that subsequent rate of loss was lower.

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INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low and variable precipitation, high winds and evaporation, and wide extremes in temperatures. Throughout the region, cereal grains are grown on various soils ranging from sand to clay in texture, and cattle are raised on natural and cultivated grasslands. Small areas are irrigated. The research program is focused on improving the efficiency, economy, and stability of this production.

Precipitation during both 1977 and 1978 was below average for the region; however, timely rainfall at critical stages of crop development led to above-average yields of both cereals and forage crops in southwestern Saskatchewan. The winter of 1976–1977 was extremely dry and necessitated a delay in the utilization of early spring pasture until the potentially serious drought situation was alleviated by above-average rainfall in May of 1977.

During the past 2 yr Dr. T. Lawrence licensed Swift Russian wild ryegrass and Dr. D. H. Heinrichs licensed Rangelander alfalfa.

Cutting alfalfa in the establishment year has resulted in a total increase in hay of 2900 kg/ha during the first 2 yr than when the first cut was delayed until establishment year + 1. There has been no difference in winterkilling or other harmful effects.

These and other research accomplishments are described briefly in this report. Detailed information may 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.

W. L. Pelton
Director

CEREAL CROPS

Wheat harvesting

An Agriculture Canada research contract with the University of Saskatchewan, Department of Agricultural Engineering, resulted in two straw-chopper modifications that increased width of spread. One method, which consists of changing the number and shape of the deflector vanes on conventional straw choppers, increased spreading width to 10–14 m from 3–5 m. The second method involved mounting two separate choppers on the combine, one on each side, which delivered the straw at right angles to the combine direction of travel. Spreading width for this chopper was up to 18 m.

Corn

In a 5-yr study to evaluate the corn heat unit concept (CHU) for selecting corn cultivars for Saskatchewan, it was found that the mathematical method for describing temperature relative to growth of the corn plant was useful. The Saskatchewan and Prairie Corn Heat Unit maps, which were produced by this project, illustrate that areas such as Estevan and Outlook (2500 and 2400 CHU) accumulate more heat units than does Swift

Current (2300 CHU). Later-maturing cultivars that produced ripened grain at Estevan or Outlook failed to ripen grain at Swift Current, i.e. the formula described actual field occurrences. The importance of factors that alter microclimate, e.g. soil type (coarser-textured soils warm quickest in spring), soil moisture content (moist soils remain cooler), exposure to south or north slopes, and wind protection must also be considered in interpreting the CHU map for a given area. The results show that the CHU concept is a valuable tool for the corn grower to use in selecting new cultivars for his area.

Salt concentrations in a dryland seep

Water-table wells were installed to a depth of 300 cm in a dryland salinity area to monitor seasonal changes in salt and water levels in discharge (downslope) and recharge (upslope) positions. Water levels were highest in May–June, approaching to within 60 cm of the soil surface in the discharge areas while remaining near 240 cm in the recharge areas. Throughout the summer and fall the water-table levels decreased to 270 cm in the discharge (seep) areas and decreased to over 300 cm in the recharge areas.

Electrical conductivities measured on collected water well samples were lowest in the spring ranging from 1 mS/cm in the upslope (recharge) positions to 3 mS/cm in the seep areas.¹ Throughout the summer the levels increased to 2 mS/cm in the recharge areas and to 7 mS/cm in the discharge areas.

In addition to concentration differences in the groundwater between the recharge and discharge areas there were differences in ion ratios. Sodium was the dominant ion in the seep areas with concentrations of 1000 mg/L while Ca was the dominant ion in upslope positions with concentrations near 100 mg/L. The Na:Ca:Mg:Cl ratio in the seep area was 1.0:0.3:0.5:0.15, whereas that in the recharge area was 0.4:1.0:0.3:0.1. The approximate increase in ion concentrations in the seep waters over those in the recharge waters for Na, Ca, Mg, and Cl were 25×, 3×, 12×, and 15×, respectively.

Rye

R.T. 121, a Cougar/Petkus/Dakold line, averaged 5% higher yield and a 10% heavier kernel weight, and was 5 cm shorter than Frontier but was 1 day later in maturity. It was deemed not to possess enough of the desired traits to warrant licensing. Such material is not necessarily lost since it will be incorporated into the continuing breeding program. Currently there are eight lines of diverse parentage from the Swift Current program in the cooperative tests.

Introductions of ryes from China, Belgium, Sweden, Russia, United States, and Poland have been evaluated for Canadian conditions.

Snow mold organisms are a limiting factor in the growing of winter cereals, particularly in areas of high snowfall. Material was provided for D. Smith, Agriculture Canada, Saskatoon, who screened it for snow mold reaction. Resistant material, together with introductions from Europe, has been found to be winterhardy and reasonably satisfactory agronomically.

The development of self-fertile winter ryes from the interspecific cross *Secale cereale* / *S. vavilovii* at the diploid level has yielded some winterhardy, self-fertile lines. The tetraploids of this material failed to survive

the winter of 1977–1978. Self-fertile lines should be useful in the study of quality characteristics.

A winterhardy tetraploid form of Frontier averaged 2300 kg/ha, 25% less than diploid Frontier grown under roughly comparable conditions. The 1000-kernel weight of the tetraploid is 25% greater than that of the diploid.

Efforts to develop earlier-maturing spring ryes have not been successful. Early maturity seems strongly linked to smaller kernels and lower yielding ability.

Selections for both large wide and small narrow flag leaves in Petkus spring rye failed to show any significant difference in yielding ability, although both outyielded Prolific spring rye.

Wheat variety response to fertilizer

Tests to compare the response of wheat varieties to fertilizer were conducted for 4 yr at Indian Head and Swift Current. A total of 47 varieties were tested, some for only 1 yr, but others for all 4 yr. There was little variety × fertilizer interaction as measured by yield. The amount of nitrogen and phosphorus in the grain gave significant interaction between fertilizer and varieties showing that the varieties had different abilities for retaining these nutrients in the seed. Significant interactions also occurred for weight per hectolitre and kernel weight. This indicates that while the varieties respond similarly to fertilizer as measured by yield they do not necessarily respond similarly with respect to the quality factors.

Effect of dietary nutrient density on turkeys

Studies reported from this laboratory have demonstrated that toms from the heavy-tonnage commercial strains respond to higher nutrient density levels. This has been accomplished by providing more nutrients within a lower feed intake, which allowed the birds to grow at a faster growth rate at each physiological age.

A market age experiment was conducted to determine the influence of feed intake within four strains on the nutrient density level required by males at weekly intervals throughout a 229-day growing period. Three nutrient density levels were fed and the growth performance data obtained at weekly intervals throughout a 229-day growing

¹S is the abbreviation for siemens, the SI unit of measurement for conductance, and is equivalent to 1 mho.

period. The nutrient to kilojoule ratios in this series of diets remained constant for weekly intervals at 2.78, 3.08, and 13.9 kJ/g (on M.E. basis).

Four Large White strains of males studied utilized the dietary nutrients with approximately the same efficiency at each of the three nutrient density levels. These data were analyzed using Parks' (1970) equations. There was a significant difference in the mature biomass, mature feed intake level, and the chronological age to reach mature feed intake level for all four strains. The higher feed intake strains gained at a faster rate during the first 84 days of age. The two growth rate plateaus at 84 and 133 or 84 and 140 days were constant for all three nutrient density levels. The medium feed intake strains tended to have the second growth plateau at 133 days instead of 140 days for the higher feed intake strains, which would indicate faster maturing strains.

The meat yield data indicated that breast meat expressed as a percentage of the total carcass increases with chronological age and nutrient density level. However, there was a strain \times nutrient density level interaction. The percentage of total thigh, drumstick, wing, and bone decreased with chronological age. The percentage of skin significantly increased with chronological age and nutrient density level. The percentage of breast and thigh meat fat increased with chronological age and nutrient density level. The breast meat nitrogen remained relatively constant regardless of chronological age or nutrient density level, while the thigh meat nitrogen tended to increase with nutrient density level. There was a highly significant increase in the gravy fat from the drip loss of the medium feed intake strains as compared with the higher feed intake strains. Nutrient density level had little or no effect on the amount of fat in the drip loss. Further research work is presently being initiated to determine the economic worth of 20 kg toms vs. 15 kg toms in regard to the higher nutrient density levels.

Rapeseed meal in turkey diets

Rapeseed meal (RSM) of the low glucosinolate cultivars Tower and Candle was found superior to the high glucosinolate cultivar Midas and gave performance comparable to soybean meal at up to 300 g/kg in turkey starter diets. In a further trial 225 g/kg of Candle RSM gave performance

equal to a control diet to 9 wk with turkey broilers but reduced gains between 9 and 14 wk. Reduction in nutrient density of RSM diets did not affect weight gains but increased feed intake and reduced efficiency of feed conversion.

Slaughter losses and carcass composition of turkeys

The average loss in weight in slaughtering 18-wk-old medium-strain turkeys, of both sexes, was: blood 2.8%, feathers 4.9%, inedible offal 10.0%, and neck and giblets 5.1%. Chilled eviscerated weight was 79.2% of liveweight and 84.9% when packed in plastic bag with giblets. The yields of individual skeletal components were similar to those reported for turkeys of heavy strains. Meat from female carcasses contained more fat and less moisture than from males.

Preslaughter starvation of turkeys

Turkeys are commonly deprived of feed or both feed and water prior to slaughter to reduce carcass contamination from the gut contents. The effect of deprivation on liveweight and carcass yield was studied. Deprivation of both feed and water more than doubled the liveweight shrinkage caused by removal of feed alone, and deprivation for 24 h doubled the liveweight shrinkage compared with 12 h. Reduction in eviscerated carcass yield was small (0.4%) when only feed was removed for 12 h but was increased by removal of both feed and water or by increasing the time to 24 h. Carcass weight gain during chilling in ice and water was not influenced by preslaughter treatment.

FORAGE CROPS

Soil salinity under effluent irrigation

With the EC (electrical conductivity) value of 2.5 mS/cm the Swift Current sewage effluent is classified as a salty water. Soil salinity could become a problem if the effluent water is to be used for irrigation. To prevent salt buildup in the crop root zone, irrigation must provide water for growth of crops and at the same time allow enough water to pass through the soil to leach out the excess salt.

Maintaining a favorable salt balance in the soil requires proper irrigation management.

If the leaching fraction (LF, defined as the fraction of the irrigation water that drains below the root zone) is too low, the salt will accumulate and concentrate in the soil to a degree that will adversely affect the crop yield. On the other hand, if the leaching fraction is too high, it not only wastes valuable water but also causes excessive leaching of plant nutrients and adds to the drainage problems as well.

In this effluent irrigation study, irrigation is managed so as to maximize crop production rather than to maximize waste water disposal. Thus, the water application rates were controlled by using a low leaching fraction while trying not to jeopardize crop growth. Over 4 yr (1974–1976), the average LF was about 0.1, a value lower than the leaching requirement of 0.25 as specified in the guidelines. Alfalfa yields are 6500–11 300 kg/ha with effluent irrigation as compared to 5900–9400 kg/ha with creekwater irrigation.

During the first 3 yr of the study, soil salinity in the upper layer of the soil (0–100 cm) increased gradually from the average electrical conductivity of soil saturation extract (ECe) of 0.7–2.2 mS/cm. In the bottom layer of the soil (100–200 cm), the average ECe decreased from 6 mS/cm to 4 mS/cm. In 1977, soil salinity approached a steady-state profile with ECe values in the upper layer of the soil close to the expected steady-state soil salinity calculated on the basis of $LF = 0.1$. At the bottom layer of the soil, the measured ECe values are lower than the estimated values. This can be partly attributed to spring leaching from the snowmelt water and partly to the overestimation of crop water consumptive use.

The results of this study show that alfalfa can grow well under irrigation with Swift Current sewage effluent. As far as the salinity problem is concerned, a leaching fraction of 0.1 can be used without fear of significant yield reduction.

Cutting alfalfa in the establishment year

Cutting alfalfa in the establishment or seeding year is not usually recommended. In a test carried out in recent years hay yields of 2800–5200 kg/ha were realized when alfalfa was cut in the establishment year. In the establishment year + 1 yields were reduced by 300–800 kg/ha by 1st-yr cutting. By the following year yields were equal in both treatments.

In terms of yield advantage for the first 2 yr an average increase of 2900 kg/ha was realized by cutting in the establishment year. To the producer, getting a yield the 1st yr might be more important than some possible higher yield in the next year.

Beef production on pastures

Six-year-old stands of Russian wild ryegrass and alfalfa were grazed with yearling steers from April 25 to August. Seasonal gains obtained amounted to 1.07 kg/day for 104 days. The liveweight production gain per hectare was 140 kg.

A three-year-old stand of Russian wild ryegrass growing in rows spaced 60 cm apart was spring fertilized for the second successive year in 1978. The fertilizer treatments were: check, N fertilizer to bring level to 50 kg/ha, N fertilizer to bring level to 100 kg/ha, and a residual treatment where a “one-time” 300 kg/ha application had been made in 1977. Yearling steer liveweight gains per hectare for the above treatments were 120, 134, 162, and 155 kg, respectively.

A 12 ha field of Altai wild ryegrass supported 66 heifer calves through February and March of 1977 (an open winter), and 115 steer calves for November and part of December in the same year. In 1978 the field carried 65 cows through the month of November with little weight loss.

Ruminant nutrition

Potential increases in nutritive value achieved through treatment of cereal straw with NH_3 , NaOH, and/or pelleting were examined with cattle and sheep. Chemical treatments increased digestibility and intake substantially and allowed incorporation of higher levels of straw into the diet of the pregnant cow or ewe. Pelleting of chemically treated straw further increased voluntary intake of the straw. Increasing straw levels in the ration reduced voluntary intake of digestible energy, however, and suggested practical limits to which incorporation of cereal straws could be used. The economic advantages of straw processing were questionable.

Alfalfa pellets in combination with wheat straw could be used satisfactorily for overwintering pregnant cows or ewes, providing that the pellets were economically priced. Lambs were finished on alfalfa pellets plus barley more economically than on either alfalfa pellets or high grain rations.

Intake by wethers of Russian wild ryegrass or Altai wild ryegrass was considerably higher at mature grass stages than was intake of crested wheatgrass, in spite of only minor differences in chemical composition among the grass species. Reported differences in performance of animals late in the grazing season may reflect differences in intake that cannot be estimated by laboratory analyses at present.

Selecting grasses by germination rate

Selection for fast and slow germination in Altai wild ryegrass (*Elymus angustus* Trin.) through three cycles of selection resulted in significant differences in the speed of germination index between the two populations. The fast-germinating population established significantly better in a field test than the slow-germinating population. Significant differences, although not large, were also found between the populations for spring vigor, seed yield, and dry matter yield. However, observations from a greenhouse test indicate that these differences were attributable to differences in stand establishment in the field test rather than directly attributable to selection for speed of germination. It is suggested that selection for fast germination would be useful in breeding better-establishing strains of Altai wild ryegrass. This would have little effect on either spring vigor or yield of seed and forage.

Thirty grass populations were evaluated for dry matter yield, N content, P content, organic matter digestibility, and winterhardiness. Of these populations, *Agropyron cristatum*, *A. desertorum*, *A. elongatum*, *A. intermedium*, *A. trachycaulum*, *Bromus inermis*, and *Elymus junceus* are used extensively for forage crops and *E. angustus* is being commercialized at present. Of the remaining populations, *A. smithii*, *E. cinereus*, *Oryzopsis hymenoides*, *E. akmolinensis*, *E. curvatus*, *Roegneria sibiricus*, and *Stipa viridula* × *O. hymenoides* do not appear to have any potential as forage crops, whereas *A. sibiricum*, *E. virginicus*, *E. sibiricus*, *A. caespitosum* × *A. caninum*, *A. caespitosum* × *A. trachycaulum*, and *A. cristatum* × *A. desertorum* (4n) show some potential and should be investigated further.

Swift is a new cultivar of Russian wild ryegrass developed at the Agriculture Canada Research Station, Swift Current, Sask. There are no visual characters that

distinguish Swift from other cultivars of Russian wild ryegrass. Swift's main attributes are excellent establishment vigor and ability to emerge from deep seedings. It was developed in a recurrent selection program using depth of seeding as a screening technique.

Rangelander—a new alfalfa

Rangelander is a new variety of alfalfa released in 1978. It was developed from a breeding program designed to produce a persistent, strongly creeping-rooted legume for pastures in Western Canada. Breeding nurseries were overseeded with crested wheatgrass and left for eight or more years before final selections were made. Persistence and good seed set were emphasized in the selection program. With 80% of the plants being creeping-rooted, Rangelander is the most strongly creeping-rooted alfalfa cultivar developed in Canada. Yield trials indicate that it has about the same yield potential as Roamer and Drylander. It is well adapted for use as a pasture and hay crop on dryland throughout the open plains region of Western Canada. It is also an excellent source of breeding material for the creeping-rooted character.

Effects of a single large application of fertilizer on three grasses over 10 yr

Fertilizer, with N in amounts up to 1120 kg/ha or with P up to 900 kg/ha, or both, was applied in a single application to old stands of Russian wild ryegrass (RWR), crested wheatgrass (CWG), and to the native grass association (NG). In two subsequent years the test was repeated on adjacent sites. Effects upon the yields and nutrient contents of the grasses were monitored over the subsequent 10 haying years. Nitrogen increased the yields and N content of the three grasses proportional to the original rate of application. The 10-yr yields of CWG, RWR, and NG were 308, 377, and 458% of the check. Total yields of these grasses at that rate were 19.4, 14.9, and 12.2 t/ha (D.M. basis), respectively. The persistence of the residual effects depended upon the original rate and still continues where the original application contained N in excess of 500 kg/ha. The highest N rate initially increased the N content of the three grasses. Application of P alone did not affect the N content of grasses but when applied with N, it further increased the uptake of N for CWG and NG.

Increases in the N content persisted for up to 7 yr depending on the original rate. Applications of P alone increased the P contents of the grasses in proportion to the original rate. Nitrogen alone reduced the P content but when N and P were applied together the P content of CWG and NG was raised, but lowered in RWR. Soil sampling showed little movement of P through the soil whereas the $\text{NO}_3\text{-N}$ residues were found in the 30- to 90-cm layer. Very little moved below this depth.

SOILS AND ENVIRONMENT

Effects of stubble burning on soil properties and grain yields

Long- and short-term effects of burning cereal straw were assessed on chernozemic soils at Melfort, Indian Head, and Swift Current. Heat from burning barely penetrated the soil below 1 cm, with maximum temperatures reaching 338° to 422°C on the straw mulch. Between 32 and 76% of straw weight and 27 to 73% of N were lost in the burn, but no P was lost. Bacteria and fungi decreased immediately upon burning but only in the top 2.5 cm of soil, with fall burn being more detrimental than spring burn. Repeated burnings permanently diminished bacterial numbers by > 50%, but fungi appeared to recover. Soil respiration also confirmed this permanent reduction in soil biological activity. Burning immediately increased exchangeable $\text{NH}_4\text{-N}$ and bicarbonate P but there was no nutrient buildup in the profile over the years. Long-term burning reduced total soil N and C and mineralizable N in topsoil but did not affect humic and fulvic acids. Effects on soil surface tension and bulk density were not conclusive but burning increased the susceptibility to water erosion and reduced the permeability of the Melfort soil.

At Melfort and Indian Head, 20 yr of burning did not markedly change the yield of wheat grown continuously or in wheat-fallow rotations. The yield results notwithstanding, there are definite danger signals with regard to future soil management of continuously burnt land on the prairies.

Effect of fertilizer N and soil moisture on growth and moisture use by Manitou spring wheat

A field experiment using seven rates of N application on stubble land in lysimeters was

conducted to study the effect of fertilizer N on moisture use and the accumulation of dry matter under both irrigated and dryland conditions.

In the irrigated lysimeters, leaf areas, plant dry matter, and N content increased with fertilizer N. In the dry lysimeters, low rainfall between the shot blade and anthesis stages produced moisture stress; consequently, dry matter production and leaf area were depressed and plants lost significant amounts of N at rates of 61.5 kg/ha. Rain in the latter part of the growing season permitted the stressed plants to recover and by maturity plant dry matter and N content increased with N. Approximately twice as much plant dry matter was produced in the wet treatment as in the dry for all levels of N. Total evapotranspiration (ET) increased with applied N in the wet treatment, and was much higher than in the dry treatment. It was not affected by applied N in the dry lysimeters. Root weight increased exponentially up to the shot blade stage. Between anthesis and maturity, it decreased in the top 75 cm in the dry soil profile and in the top 30 cm in the irrigated soil profile, while in the deeper segments it remained constant. Root weight increased curvilinearly with increasing N under irrigation. On dryland, N at rates of 41 kg/ha depressed root growth at the shot blade stage and at anthesis. Average root yields under wet conditions were 220, 1920, and 1425 kg/ha at three-leaf, anthesis, and maturity, respectively; under dry conditions they were 220, 1535, and 875 kg/ha. The root weight constituted 76% of the total plant weight at the three-leaf stage and 15.6% at maturity. The average root N content at maturity made up 9.4–11.5% of the mean plant N. Root density decreased curvilinearly with depth. At the three-leaf stage about 62 and 23% of the root system was located in the top 15 cm and in the 15- to 30-cm segments of the profile, respectively; at maturity these proportions were 46 and 15%. Nitrogen did not influence root distribution but irrigation increased root growth in the top 15 cm of the profile by about 5%. Rate of moisture use was directly proportional to the rate of root growth.

Wheat-weather relationships

The effects of early moisture stress (tillering, abbrev. Tg, to last leaf visible, abbrev. LLV), late moisture stress (LLV to anthesis,

abbrev. AN), and three rates of fertilization (N at 44, 88, and 132 kg/ha) on the development and moisture use characteristics of spring wheat (*Triticum aestivum* 'Manitou') were determined under simulated irrigation in the growth chamber at day/night temperatures of 27/12°C (T27/12) and 22/12°C (T22/12). Plant height was unaffected by N and by early stress, but was reduced by late stress. Number of tillers increased until LLV then decreased sharply and remained constant to maturity. More tillers were initiated at T27/12 than at T22/12, but by maturity there was little difference. Leaf blade photosynthetic area reached its maximum at LLV while the nonleaf blade photosynthetic area reached its maximum at AN and constituted 75% of the total photosynthetic area at the milk dough stage. Heads comprised no more than 9% of the photosynthetic area at any time. Total plant dry weight accumulated sigmoidally, but at T27/12 and low N rates, plants lost total dry weight after the milk dough stage. Dry matter of the vegetative plant part increased until the milk dough stage, then stems in particular, and roots to a lesser extent, lost weight. Head weight increased linearly at about 17.5 mg/head a day. Dry matter accumulation was directly proportional to N applied, inversely related to temperature, temporarily retarded by early stress, and markedly reduced by late stress. Although stems were the dominant vegetative dry matter sink, leaves were the dominant N sink. A combination of high temperature, high N, and moisture stress resulted in a temporary loss of N from the plants between the LLV and the milk dough stage. As maturation proceeded, N assimilates appeared to move from leaves and roots into stems and thence into heads. The average rate of N accumulation in the heads was 0.22 and 0.27 mg/head a day at T22/12 and T27/12, respectively. Some N was lost by denitrification. The amount and rate of evapotranspiration were directly proportional to N applied and in general inversely related to moisture stress. The rate of moisture use was generally more rapid at T27/12, but the amount used was no different from that at T22/12. Plants stressed early recovered and used water at the same rate as unstressed plants, but plants stressed late did not recover.

Seedling emergence of wheat

Daily emergence counts were made on Canthatch wheat grown in five different soil types and at four soil temperatures and three water potentials, and planted at five different depths. Regardless of soil type, soil water potential, or planting depth, 50% emergence generally occurred within a week at 19.4 and 26.7°C and within 2 wk at 12.2°C, but it took up to 6 wk at 5.0°C.

The heat sum required to obtain 50% seedling emergence did not increase significantly with decreasing soil water potentials, but the minimum temperature for emergence dropped from 1.3 to 0.2°C as the water potential was decreased from -0.33 to -10 bar. This suggested that the seedlings compensated for the increased water stress by lowering their minimum temperature requirements.

Increasing the planting depth not only increased the heat requirement for emergence, but it also increased the variability of emergence, especially at low temperatures.

Seepage control in excavated earthen reservoirs

The use of sodium carbonate for seepage control in farm reservoirs was tested in the laboratory and field, and was found to produce rapid and acceptable control. The gleization method of seepage control was found to be promising. The texture of the overburden, covering the straw, did not affect the gleization process. Wheat, barley, and oat straw as well as manure are materials that can be used to promote gleization. The use of partially decayed manure reduced the seepage rate more rapidly than straw but eventually both were equally effective.

The laboratory study demonstrated that Na_2CO_3 and bentonite provided the most rapid reduction in hydraulic conductivity followed by manure and straw, respectively. Combining the gleization method with Na_2CO_3 or bentonite resulted in an immediate seal upon treatment; furthermore, neither Na_2CO_3 nor bentonite impeded the microbiological gleization process.

Limited field observations indicated that both the Na_2CO_3 and the gleization methods can be used for seepage control with success. Pockets of sand or sand lenses are special problems that must be dealt with carefully.

ANALYTICAL AND MACHINERY DESIGN

A microplot seeder

A microplot seeder was developed as an attachment for the Swift Current self-propelled plot seeder. The attachment is designed to sow rows 0.5 m long spaced at 23 cm and running at right angles to the direction of travel. The center two double disc furrow openers of the plot seeder are removed and the microplot attachment fits in their place. Border rows can be sown at either end of the 0.5 m rows and parallel to the direction of travel using the outer furrow openers on the seeder in the conventional manner.

The attachment consists of a "spade"-type opener supported by a linkage that allows it to move in a vertical plane, a seed distribution system, and a control system. Hydraulic cylinders controlled by solenoid valves automatically move the opener up and down and open and close the opener blades. In the down position, the blades separate, opening a furrow 0.5 m long by 1.5 cm wide. Seeds are dropped into the opened furrow. In the up position, the blades close and the opener advances to the next row. The movements of the opener are completely automatic (controlled by the control system) and are synchronized to ground speed resulting in a uniform row spacing. The control system also releases seeds from a holding funnel into the seed distribution system at the appropriate point in the opener cycle. The operator's tasks are to drive the seeder at a slow speed (3–5 m/s) and to dump packaged seeds into the holding tunnel on the seed distribution system.

This attachment has been used to seed small plots for each of the past three springs. There is no evidence of seed carry-over from row to row. This plot type is useful for seeding disease nurseries, for yield trials where seed or space available is limited, or for seeding head rows in the initial stages of varietal purification.

An automatic sample weight recording system

A weighing system was designed for automatically punching large numbers of sample weights on computer cards. The system consists of a digital electronic scale with parallel BCD outputs, an interface, and an IBM 29 cardpunch. Computer cards are

prepunched with the same identification code as on the sample labels and are arranged in the same order as the samples to be weighed. Samples are placed one at a time on the scale and when the transients settle out, a "punch" button on the interface is pressed. The interface automatically reads this parallel digital output on the scale, converts it to a serial form, and sequentially supplies numeric signals to the cardpunch simulating entering the sample weight on the keyboard. When all of the digits have been entered, the cardpunch program automatically releases the punched card, registers the next one, and advances it to the proper column. In this position, the identification code is visible and the operator can check it against the next sample to make sure the proper sequence is maintained.

This system was used to record the weights of 20 000 wheat samples in August and September 1978. One person can weight 600 samples per hour without error. Speeds of up to 900 samples per hour can be achieved if the electronic scale settles out quickly.

Irrigation ditch maintenance

Persistent chemicals such as simazine and monuron have proved to be effective for approximately 3 yr per application in providing a weed-free irrigation ditch. These chemicals, however, will cause crop damage if they move from the ditch into the field.

In order to establish the amount of chemical required to kill alfalfa, an established stand was irrigated with water containing concentrations of 0, 10, 100, and 1000 ppb of simazine or monuron applied four times a year for 5 yr. Analysis of hay yield data after 5 yr (1974–1978) of irrigation showed that the yield from plots irrigated with simazine at 1000 ppb was lower than the rest; yields from plots irrigated with monuron at 1000 ppb and simazine at 100 ppb were lower than from the check plot and those irrigated with monuron and simazine at 10 ppb. Simazine at 1000 ppb decreased the yield of alfalfa in the 1st yr of irrigation, whereas monuron at the same concentration did not decrease the yield until after 4 yr of irrigation, when simazine at 100 ppb also decreased the yield.

Seeding irrigation ditches to low-growing grasses is the recommended procedure and several miles of ditches have been successfully seeded with the irrigation ditch grass

seeder on P.F.R.A. irrigation projects at Maple Creek and the Saskatchewan Department of Agriculture irrigation project at Miry Creek.

BOTANY

During 1977 and 1978 studies on plant communities in the Prairie Provinces were continued. A classification of grassland communities in accordance with the Zürich-Montpellier system, but in which the North American Prairies are placed in a class-group with the Eurasian steppes, has been completed. The proposal for this classification on

an intercontinental scale was submitted to the International Society for Vegetation Science, and was accepted. The same procedure of using class groups will be used in classification of other vegetation types.

The publication *Wild Plants of the Canadian Prairies* was revised and greatly expanded by inclusion of species occurring in the Boreal forest zone as well as species of the Rocky Mountains. Renamed *Budd's Flora of the Canadian Prairie Provinces*, revision and final editing have been completed. A total of 2194 species and varieties, belonging to 590 genera in 118 families, are included in the revised edition.

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Wheat and rapeseed

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 for 1977 and 1978.

The efficiency of honey production was increased by refining procedures for comb building and for overwintering and managing queens. Breeding programs with rapeseed and barley were enhanced with improved selection criteria and additional progress was made in developing improved cultivars of oats, alfalfa, meadow foxtail, and reed canarygrass. Management programs were developed for controlling dandelions, narrow-leaved hawk's-beard, and wild oats in both forage and rapeseed. The advantages of legumes and manure in soil improvement received further clarification.

Detailed information can be obtained from the publications listed at the end of this report. 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, R.R. 1, Prince George, B.C. V2N 2H8.

L. P. S. Spangelo
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APICULTURE

Environment

Effect of colony size and ambient temperature on comb building and sugar consumption by honeybees. After the main flow, 12 Italian and 12 Caucasian colonies of honeybees were fed and used to build combs from wax foundation. During a 4-day period the most important factor in determining the number of combs built was the weight of the bees in the colony; the relation was linear. Mean-maximum and mean-minimum temperatures also had an effect.

During an 8-day period, colonies weighing 6–7 kg built most combs. Fewest were built at 20°C mean-maximum temperature with any size of colony. Less sugar was consumed as the mean-maximum and mean-minimum temperatures increased. With small colonies, the sugar consumption increased with increasing mean-maximum temperatures, but with larger colonies it decreased. Sugar consumption per comb built depended on colony size, and on temperatures, in a rather complex way. The lowest sugar consumption per comb built was with colonies weighing 4–8 kg, depending on the mean-maximum temperature.

Behavior

Maintenance of caged queens in queenless colonies. Mated honeybee queens were wintered in queenless colonies in various individual cages for three successive winters. In 1972–1973 each wintering colony, in a separate small compartment of a special comb, received 16 queens. The compartments were covered with 3-mm mesh screen (screen-comb cage = SCC, 160 queens) or queen excluder (excluder-comb cage = ECC, 212 queens). Significantly more queens survived the 1st mo after introduction in SCC than in ECC. At the end of November the colonies were grouped for wintering under field conditions, queens in SCC and ECC; in unheated flight-room with 12 h illumination, queens in ECC; with 8 h light, queens in SCC and ECC. The number of queens surviving was not significantly different. The number of queens surviving showed a significant negative correlation with duration of confinement for SCC queens; for ECC queens, after a rapid decrease, the number of survivors remained about the same, regardless of wintering conditions.

Queen losses, supersedures, and net weight gains were not significantly different in small colonies headed by queens from ECC and SCC, and in colonies wintered outdoors.

In 1973–1974 wintering in ECC, 123 of 128 queens survived 1 mo, but only 14 survived 6 mo of wintering. In 1974–1975 wintering in ECC, all queens were accepted but some queens escaped and were detrimental to the caged ones. Only two queens survived the 8 mo of confinement.

Multiple-queen introduction. Fifteen colonies (five groups of three) were prepared for multiple-queen introduction. Each colony queen was caged and kept in her colony for 9 days, then 16 queens were introduced into each colony, some after confinement in screen mailing cages for 1, 2, 3, or 4 wk. In 12 colonies the mean weight of queens when introduced in excluder-comb cages was higher for queens that were accepted (after 24 h) than for queens that were rejected. Queens introduced without previous caging were more likely to be rejected than queens previously caged for 1–4 wk.

Queens were removed from eight colonies and, after 9 days of queenlessness, each colony was given 16 queens in excluder-comb cages. Half the queens had been stored (in mailing cages, each with 10 workers) for 3 days in an incubator, and half had been removed directly from nuclei. One day after the multiple-queen introduction, only four queens were rejected, two from each group. The weight of rejected queens was lower than the mean weight of accepted queens.

Some colonies were kept queenless prior to multiple-queen introduction; as the duration of queenlessness increased (from 1 up to 20 days), workers became less aggressive towards queens introduced in excluder cages. Laying queens 4 mo old were accepted after 5 days of queenlessness, and virgins 1 and 7 days old after 20 days. The numbers of workers attracted by 40 queens of different ages in a queenless and in a queenright colony were positively correlated.

Compared with queens in screen cages, queens in excluder cages attracted more workers in a queenless colony, but released more worker aggression in a queenright colony (which was related to queen weight, age, and condition).

Worker reaction to queens infected with nosema disease was also studied.

Queen introduction in push-in cages and mailing cages. A laying honeybee queen was introduced into each of 18 queenless colonies; nine queens were in a push-in cage that covered a small area of comb, and nine in a

Benton mailing cage; 3-mm mesh screen was used for all cages. After 3 days, when the queens were released, the mean weight loss was 29 mg and 51 mg, respectively, for the two groups. The queens laid eggs in the cells covered by the push-in cages, but no eggs were found in the mailing cages. After 10 further days all queens released from push-in cages were accepted and laying, whereas four queens from mailing cages had disappeared.

CEREAL AND OILSEED CROPS

Barley

Samples of 10–20 plants were required to give consistent yield estimates among 12 cultivars when space planted on a 0.6 m grid. When these 12 cultivars were planted 5 cm apart in simulated segregating rows 15 cm apart, desirable single plants could be successfully selected for seeds per head, 1000 kernel weight, and days to ripe and height, but not for yield per plant, seeds per plant, or heads per plant.

A leaf-spotting gene in Atlas barley caused little reduction in photosynthetic area before heading at Beaverlodge. However, the reduction was enough to decrease head, plant, and seed size and with the heavy leaf-spotting after heading contributed to a 22% yield reduction. Compared with Davis, Calif., the longer photoperiod and higher temperature at Beaverlodge prior to heading depressed yield potential and increased the adverse effect of the leaf-spotting gene.

Oats

In 1976 a record oat yield of 7772 kg/ha was recorded on the Lacombe line OT729. Other yields were 7673 for OT726, 7535 for Maris Tabard, 7028 for Leanda, and 7088 for Random. In 1977 the yield:maturity index of OT726 was over 10% above a line passing through the same indices for Cavell, Random, and Grizzly.

Rapeseed

Seed yield, height, days to mature, and oil content were measured on 16–25 lines of turnip rape (*Brassica campestris* L.) grown at both Beaverlodge and Saskatoon in the years 1970 through 1975. Dividing the total variation observed in each year into sources relating to genetic differences, genotype-location interaction, and plot-to-plot error

revealed that the last component accounted for most of the variation, particularly for yield, height, and maturity. The phenotypic correlation of line mean performance between locations was significantly less than the heritability in only 5 of 20 cases at Beaverlodge and less than the heritability in none of the cases at Saskatoon. This suggests that selection at one location could be expected to give improvement at the other in most instances. Of the four traits, only height and maturity were correlated.

Fall rye

The after-ripening requirement of three fall rye (*Secale cereale* L.) cultivars, harvested at three seed moisture contents (50, 42, and 32%), was assessed by monitoring the changes in seedling emergence from sowings made over a period of 60 days. All cultivars exhibited a short after-ripening requirement which was not affected by the range of seed moisture contents studied. Seed treatment with captan (*N*-((trichloromethyl)thiol)-4-cyclohexens-1,2-dicarboximide) significantly increased percentage seedling emergence. The captan treatment had the greatest effect on seeds harvested at the lowest moisture content.

ENVIRONMENT

Weed control

Effects of 2,4-D, dicamba, and 2,4,5-T on creeping red fescue seed production. The effects of 2,4-D or 2,4,5-T at 0.56 and 1.12 kg/ha and of dicamba at 0.14–0.56 kg/ha on the seed production of creeping red fescue, *Festuca rubra* var. *genuina* L., were evaluated. Mid-September applications of 2,4-D as low as 0.56 kg/ha to fescue in the year of seeding severely reduced yields the following year. Applications of 2,4,5-T at 1.12 kg/ha at the same time reduced yields in 1 of 2 yr. Yields of 1-yr-old fescue were reduced by spring applications of 2,4-D at 1.12 kg/ha made at or before the 50% heading stage and 2,4,5-T at 0.56 or 1.12 kg/ha made prior to stem elongation or at the shot-blade stage. Similar application of 2,4,5-T at the 50% heading stage did not reduce yields. Severe yield reductions occurred when 2,4-D at 0.70 kg/ha was applied at the heading to the 90% flowering stages, but not when applied at the hard dough stage. Dicamba had no effect on yields the year following seeding, regardless

of whether applied in mid-September or in the spring prior to the 50% heading stage. Dicamba and 2,4,5-T had no major effect on seed quality, but applications as low as 0.56 kg/ha in mid-September increased dockage the following year. Applications of 2,4-D at 0.70 kg/ha at the flowering stage during the year following seeding increased dockage and severely reduced both seed weight and germination.

Effects of planting date on the growth and development of narrow-leaved hawk's-beard. Narrow-leaved hawk's-beard, *Crepis tectorum* L., planted prior to June 6 bolted and produced mature seeds as a summer annual. Plantings on June 16 bolted but not all reached maturity during the same growing season. Narrow-leaved hawk's-beard planted in early July developed in one of three ways: (1) bolted and produced mature seeds as a summer annual, (2) bolted but produced no mature seeds in the year of planting, or (3) developed as a winter annual. Plantings made after July 15 developed as winter annuals. Survival of winter annuals the following spring ranged from 12–46% for July plantings to 80–90% for August–September plantings. No plants survived from the mid-October plantings. In growth chamber studies at 20°C, bolting occurred in all plants at an 18-h photoperiod but not in plants at a 14-h photoperiod. The percentage of plants bolting under photoperiods between 14- and 18-h was intermediate. When grown under the same photoperiod, reducing the temperature to 18°C during the light period and 5°C during the dark period did not affect the percentage of plants bolting. These results suggest that photoperiod plays a major role in determining the pattern of development of narrow-leaved hawk's-beard.

SOILS

Soil microbiology

Growth and $N_2(C_2H_2)$ -fixation by red clover and alsike clover. Red clover and alsike clover were grown on two soil types over a 4-yr period. Nitrogen fixation, measured by the C_2H_2 reduction assay, was studied in relation to time, air and soil temperature, soil moisture, and precipitation. The 4-yr mean $N_2(C_2H_2)$ -fixation rates (in kilograms of N) of red clover were 31.3 and 36.8 kg/ha.yr for

seed and forage production plots, respectively. The rates for alsike clover were 58.9 and 64.0 kg/ha.yr, respectively. The differences between $N_2(C_2H_2)$ -fixation by seed and forage crops were small and there were seldom any significant differences in the nitrogenase activity at any given assay time between seed and forage crops. $N_2(C_2H_2)$ -fixation rates were considerably greater on the Orthic Gray Luvisol (64.6 kg/ha.yr) than on the Black Solod (30.9 kg/ha.yr). In general, nitrogenase activity of the clovers commenced in early May, increased rapidly until mid-June, then declined sharply to mid-July and remained low for the remainder of the season. This general pattern was interrupted by periods of above- and below-average moisture conditions, and by above-average soil temperatures. Between 50 and 60% of the maximum amount of $N_2(C_2H_2)$ fixed during the growing season was fixed by the 10% bloom stage. Beyond the 10% bloom stage, the amount of $N_2(C_2H_2)$ fixed increased by about 5% per week until 90% of maximum was reached, and then increased by about 2% per week.

Effect of the nitrogen content of crop residues on nitrogen fixation in soil. The effect of the nitrogen content of barley (*Hordeum vulgare*) and rape (*Brassica campestris*) straw on the nitrogenase activity in waterlogged straw-amended soil was investigated in laboratory incubation experiments. Nitrogenase activity was measured with the C_2H_2 reduction assay periodically throughout the incubation of soil-straw mixtures for 34 days at 25°C and 87 days at 16°C. Suppressed nitrogenase activity in soil amended with rape straw in preliminary experiments was attributed to the high N content of the straw. Removal of the water-soluble fraction of both barley and rape straw generally increased $N_2(C_2H_2)$ -fixation and the increase was highly significant when correlated ($r + 0.80$) with the water-soluble N content of the straw. Incorporation of NH_4^+ and NO_3^- in amounts equivalent to those present in the

original straw delayed the onset of nitrogenase activity but did not significantly affect the amount of $N_2(C_2H_2)$ -fixation in soil amended with the water-insoluble fraction of straw. However, when the water-soluble fraction was added to the water-insoluble fraction $N_2(C_2H_2)$ -fixation was suppressed. This suppression of nitrogenase activity was observed only with the addition of straw materials from fertility plots receiving N at greater than 134 kg/ha. Such fertilizer-N rates exceed that usually required by barley and rape crops; hence the suppression of nitrogenase activity by crop residues containing large quantities of N does not appear to be of practical significance.

Soil fertility

Nutrients and moisture for barley on Gray Luvisols. High rates of chemical fertilizer and barnyard manure were applied separately and together to barley grown on three Gray Luvisolic soils for six successive years. The first crop was grown on fallowed land but the other crops were grown on stubble of the previous crop. In the 15 crop-years on stubble land (5 yr of cropping on three soils), there was only one in which the fertilized crop produced a poor yield. Precipitation and soil moisture were measured and they showed that in the other 14 crop years, rainfall or rainfall in combination with soil moisture reserves supplied sufficient moisture to produce medium to high yields, i.e. yields were equal to or greater than the long-term average yields for the region. However, yields of barley on untreated soil on stubble were low in all years. On the basis of these experiments then, plant nutrient deficiency was the most limiting factor to yield on stubble land.

The productivity of Gray Luvisols is often thought to be affected by their low organic matter content. Yet raising the organic matter level of these soils to greater than 5% from 3.3% with barnyard manure had little or no effect on yields of barley when the crop was amply supplied with chemical fertilizer.

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Meats

INTRODUCTION

The Station suffered a severe loss with the death of H. A. Friesen in January of 1977. In the years to come the weeds research program he developed will continue to provide excellent service to Canadian farmers.

In 1977 and 1978 the meats program has been substantially strengthened; the pig-breeding research program continued to identify substantial gains which can be made from selection. The Athabasca oat variety was licensed, and valuable information on the causes of winterkill in wheat and rye was developed. Summary reports on these activities are contained herein.

For further information on all these research activities please address your inquiry to: Research Station, Agriculture Canada, Lacombe, Alta. T0C 1S0.

F. K. Kristjansson
Director

ANIMAL SCIENCE

Swine

Work on genetic improvement of pigs continued. Ten generations of selection for an index combining maximum growth rate with minimum back fat resulted in direct selection responses of 1.51 standard deviation units (SDU) for reduced back fat and 0.94 SDU for increased growth rate. Indirect genetic responses were a reduction of 1.07 SDU in feed per gain ratio and an increase of 1.21 SDU in carcass index. Based on 1976 values the improvement in index was worth \$3.04 per pig and the decreased feed requirement was worth \$3.13 per pig. Additional economic benefits were obtained from the 10% reduction in fixed and nonfeed variable costs resulting from the improvement in growth rate.

Meats research

Studies of postmortem changes in bovine muscle showed that muscle fibers of two muscles, the longissimus dorsi (LD) and the semitendinosus (ST), undergo progressive fragmentation as aging time increased. For the ST, this progressive change was accompanied by a lengthening of the sarcomeres. Shear force values for both muscles tended to decline with aging. Of the several histological traits measured, fiber length was the most highly and consistently related to shear force values. However, the histological traits of the two muscles were generally unrelated and fiber length, the best histological indicator of tenderness (shear force), explained less than

25% of the variation observed in shear force values.

PLANT BREEDING AND PATHOLOGY

Oat breeding

An oat cultivar developed at Lacombe was named Athabasca and licensed in 1975 for sale in Canada. Athabasca originated from the cross OA123-3 × Pendek made in 1966. OA123-3 is from a cross between *Avena strigosu* and *A. sativa* made in Ottawa. In central and northern Alberta, Athabasca is equal to Random in yield and matures about 7 days earlier than Random. Athabasca has good resistance to lodging. It lacks disease resistance but this characteristic is not important in the area where it is intended for production. Because of its early maturity and good yielding ability, Athabasca should be a valuable short-season cultivar for central and northern Alberta, having advantages in maturity, yield, and kernel type over Cavell.

Cereal diseases

Root rot of barley. Long-term rotation studies at Lacombe have shown that the severity of barley root rot is markedly influenced by the cropping sequence. Root rot is most severe when barley follows barley or summerfallow. It is less severe when barley follows oats or rapeseed and almost absent (up to 2 yr) following bromegrass.

Other studies showed that N, P, and K fertilizers had no effect on yield loss or root rot incidence in barley sown on fallow,

whereas fertilizer markedly reduced disease incidence and yield loss in barley sown on stubble. Root rot incidence was unaffected by increasing the spacing of two barley cultivars although there was a small decrease in yield loss. Deeply sown barley had more root rot than shallow-sown barley whereas yield losses were similar at the two depths.

Winter survival of wheat and rye. It was demonstrated in 1976–1977 and again in 1977–1978 that the killing of fall-sown plots of winter wheat and fall rye at Lacombe was due to low-temperature pathogens. Where the fungicide, mercury chloride, was applied in the fall nearly all the plants survived. The fungus *Sclerotinia borealis* Bubak & Vleugel was consistently isolated from the crown of dead plants.

Forage crops

Alfalfa cutting management. The critical harvest period for the second cut of alfalfa was found to be from about mid-August to early September at Lacombe. Yields and stands in the next year showed a marked increase when the date of second cut had been delayed until September 10 or September 17.

Cutting during the critical period in only 1 yr did not have as serious an effect on yield and stand as when it was repeated in successive years. The effect also was less serious when the first cut had been taken on June 26 instead of July 10.

Forage diseases. Blackpatch, a disease of forage legumes caused by *Rhizoctonia leguminicola* Gough & Elliot, was previously unknown in Canada. Naturally infected red clover, sainfoin, and cicer milk vetch have been found in the field at Lacombe, and five other legume species have been shown to be susceptible in inoculation tests. Sainfoin and cicer milk vetch are new host records. Forage infected with blackpatch is toxic to animals, causing "slobbers disease" but it has not yet been reported from this area.

Downy mildew (*Peronospora trifoliorum* de Bary) of alfalfa was prevalent in 1977, and cultivars were evaluated for resistance to the disease. Cultivars adapted to Eastern Canada and the falcata types were more resistant than western cultivars. Plants within cultivars show differences in resistance indicating resistance could be improved by selection. Cultivars and lines containing high saponin levels showed significantly greater

resistance suggesting that saponin content is one of the factors involved in the resistance of alfalfa to downy mildew.

CROP MANAGEMENT AND SOILS

Weed research

Effect of herbicides on transpiration of wild oats. Transpiration of wild oat plants was reduced after foliar treatment with barban, asulam, diclofop methyl, difenzoquat, or benzoylprop ethyl. Transpiration decreased with increasing herbicide rates. Difenzoquat and diclofop methyl at 1.12 kg/ha reduced transpiration by more than 50% within 2 days after spraying. Barban, asulam, and benzoylprop ethyl did not reduce transpiration to this level until about 12 days after spraying. When wild oats and barley or wheat were grown together, removal of the weed with these herbicides resulted in significantly heavier barley and wheat plants with more tillers per plant than in the untreated control. The earlier removal of wild oat competition with diclofop methyl and difenzoquat treatments resulted in the production of more dry weight and culms per plant of barley and wheat than with the slower-acting barban and benzoylprop ethyl.

Growth studies on wild oats. After an initial lag period, dry matter accumulation by wild oats took place rapidly until 8 wk after emergence. Plant height and the number of leaves per plant increased at a nearly linear rate until 6 wk after emergence. Tillering occurred mainly during the period 2–4 weeks after emergence. Low light intensity and short photoperiod severely restricted growth and delayed heading and maturity. Plants grew best at day–night temperatures of 20–12°C, though initial growth was faster at higher temperatures. Greatest dry matter accumulation was attained when soil pH was 7.5 or 8.5, and when soil moisture was maintained above 75% of field capacity. Hull color of the seed had no effect on rate of growth. Plants produced from large seeds accumulated more dry matter than plants from small seeds.

Spray retention, foliar penetration, and translocation of asulam in wild oats and flax. Wild oat plants retained four times as much spray solution of a commercial formulation of asulam as did flax. Foliar penetration of asulam into flax was more rapid than into

wild oats, but added surfactant and high relative humidity enhanced penetration into wild oats. After foliar application, translocation of ^{14}C -asulam in flax was very limited, but radioactivity was found in all parts of wild oat plants. Spray retention, foliar penetration, and translocation all play an important role in the selectivity of asulam between wild oats and flax.

Comparison of weed survey data: 1948 and 1977. Data from the 1977 weed survey in cultivated fields of Alberta and Saskatchewan were compared to data from a 1948 survey of the same area. Weedy species which increased in frequency of occurrence during the 30-yr period include tartary buckwheat, wild buckwheat, cow cockle, green foxtail, narrowleaved hawk's-beard, hemp nettle, wild oats, redroot pigweed, and smartweed. Night-flowering catchfly, chickweed, flaxweed, and stinkweed showed no apparent change in occurrence, while bluebur, lamb's quarters, wild mustard, shepherd's-purse, and Russian thistle have decreased. Kochia, reported as rare in 1948, is now common throughout the southern part of the region.

OLONETZIC SOIL SUBSTATION, VEGREVILLE

Factors contributing to crop response on a deep-plowed Solonetz soil

Deep plowing was evaluated in the field and simulated in a greenhouse study in an attempt to isolate soil factors responsible for yield effects on a Duagh Solonetz soil. Generally, fertilization provided a more significant yield response than deep plowing in the field or horizon mixing in the greenhouse. In the field, however, deep plowing in combination with fertilization produced an additional 542 kg/ha of alfalfa-bromegrass forage over fertilization alone ($P \leq 0.01$). Also, in fertilized greenhouse treatments, retaining the A horizon on the surface while mixing subhorizons proved significantly beneficial over mixing all three horizons ($P \leq 0.01$). The main factor responsible for yield effects appeared to be the Ca enrichment of surface and B horizons. An increase in the Ca:Na ratio improved water intake rates and reduced waterlogging of the soil, thereby providing a more suitable medium

for root development and a more efficient use of indigenous and applied N.

Amelioration of a Brown Solodized Solonetz soil by a surface application of gypsum plus ammonium nitrate

Combined applications of ammonium nitrate (499 kg/ha) and gypsum (4.48 t/ha) were made annually for 4 yr to a bromegrass sod growing on a Brown Solodized Solonetz soil with an exchangeable sodium percentage (ESP) of 17 and 33 in the Ap and Bnt horizons, respectively. These combined applications reduced exchangeable Na, increased water infiltration and the depth of Ca penetration, and increased the yield of bromegrass over that from ammonium nitrate alone. Analysis of columnar peds from the Bnt horizon showed that the penetration of Ca into the peds had occurred at the expense of Na. These studies indicate a synergistic effect, whereby the solubility and penetration of gypsum are enhanced by ammonium nitrate.

Chemical and physical properties of the parent material of a Solonetz soil after incubation with plant material

Parent material of the Black Solonetz Duagh silt loam was incubated after mixing with bromegrass in amounts equivalent to 20 yr production on unfertilized Duagh silt loam, fertilized Duagh silt loam, and unfertilized Eluviated Black Chernozemic Malmo silt loam. The impact of these amendments on soil properties was measured by laboratory analyses and by growing barley seedlings. The bromegrass from the unfertilized Duagh soil had minimal effect on the chemical and physical properties of the parent material. Bromegrass from unfertilized Malmo and fertilized Duagh soils generally had similar effects and imparted similar organic matter (OM) characteristics to the Duagh parent material. They lowered the breaking strength of the soil, enhanced the yields of the barley seedlings, and increased the uptake of N, Na, Ca, and K by the barley seedlings. The incorporation of bromegrass from the unfertilized Malmo and the fertilized Duagh soils caused an 8- to 14-fold increase in the infiltration rate and mobilized the alkaline earth cations. With leaching in the presence of certain forms of OM, the solubilized cations displaced Na from the exchange complex and lowered the ESP to

the level found in Chernozemic soils. Thus, the composition and amount of the plant material added to the soil may influence the

development of a Solonetzic or Chernozemic soil profile from the same parent material.

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INTRODUCTION

The scientists of the Research Station at Lethbridge represent a wide range of disciplines and functions. They are integrated into multidisciplinary, mission-oriented program groups that have regional and national responsibility for a broad and comprehensive research program in basic and applied science related to agriculture.

Events of 1977-1978 were highlighted by the completion and occupation of a new office-laboratory complex. In addition to providing extensive new facilities for all aspects of the research programs, this building houses regulatory personnel of Agriculture Canada and extension and other resource personnel of Alberta Agriculture, thus permitting close cooperation between the government services to agriculture in southern Alberta. Features of the building include a large phytotron comprised of about 100 growth chambers and growth rooms with a wide range of environmental controls, greenhouses, a vivarium for small-animal research, a comprehensive regional agricultural library, and well-equipped research laboratories. Changes and additions to the professional staff also influenced the scope of the research. Programs were intensified on new crop development, dinitrogen fixation, pesticide residues, insect and disease control, and animal and plant physiology.

In the continuing plant-breeding program, a new variety of winter wheat, Norstar, was released. Because of its increased winterhardiness and good milling quality, it could be used to expand the winter wheat growing area of Western Canada. Resistance to the mite vector of wheat streak mosaic virus was transferred from *Agropyron elongatum* to wheat, and winter wheat varieties resistant to wheat streak and wheat spot mosaics may now be developed.

Species-specific insect sex attractants developed at Lethbridge for eight major pest species are now being used elsewhere for studying pest populations and their distribution.

In crop production studies, zero tillage appears to be a promising practice for recropping cereals, but its successful application requires careful attention to all details of soil and crop management. With conventional cultural methods, economic comparisons of several dryland crop rotations and many combinations of crops showed that average net income is highest with the crop-fallow rotations in the Brown soil zone but with the crop-crop-fallow rotation in the Dark Brown zone.

A significant accomplishment in animal nutrition was identification of the role of bacteria adherent to the rumen wall in the utilization of urea and in the digestion of the cells that are continuously being shed by the rumen epithelium.

A 5-yr interdisciplinary program was completed on the Athabasca River to develop and evaluate effective and environmentally acceptable chemical methods of controlling outbreaks of *Simulium arcticum* Malloch, a black fly causing severe losses in livestock production in all four western provinces. The program has been effective in reducing outbreaks in the adjacent livestock-producing areas by up to 70%.

This report summarizes some of the main research results of work done in 1977 and 1978. 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 PARASITOLOGY

Eradication of cattle grubs

Studies on the sterile-male principle for control of warble flies were extended to a pilot-scale test on a large commercial ranch of about 225 km² stocking more than 5000 beef cattle. After three annual treatments

with systemic pesticides, the initial infestations of both species of cattle grubs were reduced from about 60 to 2 per calf; sterile flies of *Hypoderma lineatum* (de Vill.) were then released on the ranch in synchronization with fly emergence from puparia in outdoor plots. Releases of sterile males, alternated with releases of sterile females at 3- to 4-day

intervals, were made generally in areas where grubs that dropped from overwintering cattle pupated and particularly near previously identified sites of mating aggregations. After the first summer, in which a total of 400 sterile flies were released, no grubs of *H. lineatum* were found during the grub season in 50 untreated cattle brought to the laboratory from the ranch or in 300 cattle treated with a systemic pesticide and monitored on the ranch. With increased releases of sterile *H. lineatum* to 1000 and 1200 flies in the subsequent 2 yr, no grubs were found in untreated cattle and only two grubs have been recovered from over 700 and 1300 treated cattle monitored on the ranch. Neighboring herds around the ranch, which are also treated annually under the Alberta warble control program, have continued, however, to produce low numbers of grubs of *H. lineatum*. These results indicate definite progress toward eradication of *H. lineatum* with the combination of sterile-male releases and pesticidal treatments.

In contrast, grubs of *H. bovis* L. have persisted at low levels in the ranch herd and in neighboring herds despite the chemical control program. Improvements in rearing *H. bovis*, and in increasing the recovery of eggs to produce sterile flies, enabled releases of both species to be made on the ranch in 1978 for later evaluation.

Athabasca black fly control program

The interagency research program has been completed and a consolidated report is being prepared on the 5-yr study which included 3 yr with treatment and 2 yr as pre- and post-treatment baseline monitoring periods to evaluate environmental impact. Methoxychlor dispersed in the Athabasca River at a concentration of 0.3 ppm effectively reduced mass emergence of *Simulium arcticum* Malloch for a distance of up to 160 km downstream. The efficacy of the pesticide was enhanced by its adsorption to the silt load of the river, a phenomenon that is directly related to rate of discharge of the insecticide and to river hydraulics. Effects of treatments on the environment, including nontarget invertebrates, fish, water, bedload, and river deposits in the delta, have been minimal and temporary. Analyses generally indicate that registration of methoxychlor for control of black fly larvae is justified for limited and

environmentally monitored use in large, turbulent rivers.

Single treatments in 1974 and 1975 reduced the overall seasonal densities of black flies infesting cattle in Athabasca County and Improvement District No. 18 by 45 and 58% below the densities in the baseline years with no control. In 1976, a treatment at an upstream site and one at a downstream site, to increase the reach of control operations, reduced infestations on farms by 70%. After the suspension of treatments in 1977 and 1978, the infestation in 1977 increased to the pretreatment baseline level and severe outbreaks occurred in 1978. In 1978, in addition to widespread losses in productivity of cattle on pasture, nine confirmed and 12 suspected deaths of animals from black fly attacks occurred in Athabasca County. Also in 1978, *S. arcticum* attacked humans for the first time on record and caused severe reactions requiring medical attention.

Economics of pest infestations

Progress on solving the long-standing problem of evaluating impacts of pest infestations on livestock has been achieved with the development of a population model for horn flies on cattle. The host-parasite interaction in herds of cattle grazing on irrigated pastures has been simulated by analog computer techniques to quantify the growth rate of the host in short-interval time series in response to variations in seasonal levels of the infestation and its distribution within the herd. Results showed that the effect of the flies in preventing animals from achieving maximum potential growth has been greatly underestimated. A loss of 17–22% of growth potential resulted from low to moderate infestations of the pest. Heavy infestations, which occur in about 1 of every 4 yr, caused more than 45% loss of growth. Reduction in growth for given levels of infestation were proportional to the rates of gain determined by the grazing environment. This indicated low or uneconomic returns from pest control on poorly managed pastures.

Host resistance

The previous conclusion that acquired resistance in sheep to ked infestations was mediated systemically by antibodies has had to be revised in view of results from recent experiments in which keds were confined with cloth cages glued to the skin. It was

shown that acquired resistance is mediated locally within the area of feeding by the insect, that it can be induced sequentially at different sites on the same animal, and that it is lost within weeks of nonexposure to the insects.

Recycling of animal wastes

The efficiency of dung-breeding pests of livestock in the bioreduction of animal wastes has been evaluated for practical application. Seeding rate, yield of dry weight of puparia as a source of usable proteins, and friability of the bioreduced waste residues were compared with a commercial larval rearing mixture as a standard for production of housefly puparia. Optimal production of puparia was measured at 24.8 kg/t for commercial mixture, 37.8 for poultry manure, 17.2 for cattle manure, and 6.6 for sheep manure. Poultry manure was reduced to a fine humuslike material. Cattle manure became moderately friable, but retained a bottom layer of compacted material. Sheep manure was reduced only partially at 10 000 eggs for each 3 kg of medium, the highest seeding rate used in the evaluation.

Pesticide chemistry

Pharmacological chemistry of pesticides for livestock protection has emphasized purification and characterization of insecticidal compounds, elucidation of metabolic pathways of known pesticides in animals, and synthesis of new potential pesticides and repellents for animal applications.

Two isomeric forms of permethrin have been separated on a relatively large scale. Synthetic chemical methods have been developed to introduce into synthetic pyrethroids the dichlorovinyl group, which has a systemically parasitocidal function in animals. This methodology has been applied in preparing novel compounds that resemble the pyrethroids in chemical structure.

An efficient biochemical procedure was developed for oxidative metabolism of water-insoluble pesticides. The procedure employed liver enzymes that were isolated from homogenized tissue by centrifugation at high speed. It has been extended to the preparation of microsomal enzymes from first-instar larvae of *H. lineatum* and *H. bovis*.

The metabolism of citronyl was elucidated to determine the toxicological significance of tissue residues that result from its use as a

new insect repellent. Metabolites isolated from liver enzyme preparations were identified by mass spectrometry and gas chromatography as citronyl alcohol and citronyl epoxide, two oxidized forms of citronyl.

Chemical pest control

Cattle lice. A pour-on application of famphur at 40 mg/kg of body weight reduced heavy infestations of the short-nosed cattle louse by 78% for 80 days. Longer, more effective, protection was obtained by spraying cattle with 0.1% permethrin at 28 kg/cm² or with a pour-on application of permethrin at 0.022 mL/kg. Both applications of permethrin were 99% effective for at least 6 mo.

Horn flies. Sprays with 3.6 L of 0.05% permethrin per animal at 28 kg/cm² were more than 90% effective in controlling horn flies. Two treatments with a 4-wk interval controlled a seasonal infestation. A mixture of equal parts of citronyl and corn oil applied as a spray at 5 kg/cm² and 0.25 L/animal to the backs of cattle reduced infestations by 98, 91, and 70% on post-treatment days 1, 2, and 3, respectively. Citronyl had low mammalian toxicity but the oily mixture increased accumulation of dirt that resulted in dermatitis and exfoliation of treated skin.

Cattle grubs. Intramuscular injections of famphur at 15 and 20 mg/kg were 100% effective for systemic control of both species of cattle grubs. Steers treated with the lower dose outgained those with the higher dose and those with no treatment during a subsequent 7-mo period, at rates of 0.67, 0.62, and 0.60 kg/head per day, respectively. A pour-on application of permethrin at 22 mg/kg was 83% effective in controlling the hypodermal grubs, but ineffective for grubs in the gullet stage. Despite low systemic efficacy of the chemical, 88% of the gullet-stage grubs reached the back after treatment before dying.

ANIMAL SCIENCE

Beef cattle

Renal function in cattle on prairie hay with high levels of added salt. Renal clearances were measured in cattle on native hay diets, with or without a high level (7%) of added sodium chloride (salt). A change from low to high levels of salt caused large increases in urine output, glomerular filtration rate

(GFR), and filtration fraction, but not in renal plasma flow. The increase in GFR increased the filtered loads of sodium, potassium, and total solute (osmoles). As a consequence, the clearance and rate of urinary excretion of sodium and total solute were significantly increased; the clearance of potassium was also increased, but not significantly. Although both filtration and excretion of silicic acid were higher on the high- than on the low-salt diets, the differences were not significant. Consequently, effects on the concentration of silicic acid in urine due to salt-induced changes in the renal handling of silicic acid were less important than the changes in concentration caused by the increase in volume of urine. This result confirms earlier findings that salt-induced diuresis is the most important result of high intakes of salt by cattle on a diet that predisposes to the formation of siliceous urinary calculi.

Feed utilization by F_1 crossbred beef heifers calving as 2-yr-olds. The digestible energy intakes of Simmental \times Angus, Charolais \times Angus, Hereford \times Angus, and Jersey \times Angus from weaning to first calving were lower than the requirements suggested by the National Research Council in the United States or the Agricultural Research Council in Great Britain for heifers of similar weights and growth rates. This difference reflects the lower energy requirement for activity when heifers are fed in individual pens and possibly a higher efficiency of metabolizing a diet with higher energy concentration. Digestible energy intake per unit of metabolic weight was less ($P < 0.05$) for Hereford \times Angus heifers than for the other three types of heifers during the 129-day pregestation period, but did not differ among the four breed types of heifers during the 282-day gestation period.

Factors influencing plasma lactate dehydrogenase levels in beef cattle. Plasma lactate dehydrogenase level, which is an indicator of body cell health, varied with season more in cattle on range than in confined cattle fed on a more uniform type of diet throughout the year. Seasonal changes in levels of plasma lactate dehydrogenase were closely related to changes in the quality and quantity of forage available on the range. In the confined animals, plasma lactate dehydrogenase levels increased at the normal age of first ovulation and decreased after parturition.

Particle size of feedlot diets. Feed particle sizes from 476 to 1526 μ m did not influence rate of gain, feed-to-gain ratio, rumen fluid pH and viscosity, or alkaline phosphatase content of rumen fluid from yearling steers. A diet with a particle size of 344 μ m has previously been shown to cause bloat. Therefore, the critical mean particle size to cause bloat appears to be between 344 and 476 μ m. Increases in feed particle size from 476 to 1526 μ m were related to a gradual decrease in rumenitis, clumping of rumen papillae, and a reduction in numbers of rumen protozoa.

Feeding programs for feedlot cattle. With an all-concentrate diet, the total digestible energy required for finishing weaned steer calves to a market weight of about 475 kg was similar for those that were full-fed throughout, or were restricted in feed during the first 6 mo or the final 6 mo, or were restricted to a moderate rate throughout the feeding period. Feed restriction did not affect the carcass grade and all feed-restricted steers produced leaner carcasses than those that were full-fed throughout.

Testing linear program (LP) model for feedlot cattle. Five groups of steers were fed computer-formulated diets with a wide range of digestible energy (DE) concentrations. In four of the groups, rates of gain, feed efficiencies, and carcass grades were similar and in good agreement with the predictions made by the LP model. The fifth group, which received the lowest DE concentration diet, gained more slowly and required more DE in the final phase (ca. 150 days) of the experiment than the other four groups. It was concluded that a minimum DE concentration of 13.7 MJ/kg of diet was required to permit maximum efficiency of DE utilization when the steers were fed to appetite.

Milk production of cattalo cows. Analysis of data from an earlier study showed that cattalo cows produced an average of 938 kg of milk in a 185-day nursing period. The cattalo cows ranged from 10 to 20% bison and, within this range, each increase of 1% bison in the cow resulted in a reduction of 10 kg in 185-day milk yield. The decrease in milk yield, however, had little influence on gain of cattalo calves from birth to weaning. This suggested that cattalo calves compensated for the deficiency in milk yield by an increase in foraging.

The average daily milk yield of 5.1 kg during the lactation period of these cattalo cows appears to be similar to that of Herefords raised under similar environmental conditions at Manyberries, Alta., and in herds elsewhere. These results were not unexpected as the cattalo were predominately of Hereford extraction.

Selection for weight gain: effect on milk from beef cows. Other traits were affected when replacement cattle are selected on the basis of 168-day postweaning gain on high and low levels of nutrition. Since 1964, calves have been selected for gain on a high plane (HP) diet consisting of 60% barley, 10% oats, 10% beet pulp, and 20% chopped alfalfa or a low plane (LP) diet consisting of chopped alfalfa. In the Angus breed, cows tested and selected as calves in the LP line produced greater weights of milk, fat, solids-not-fat, and protein in a 120-day period than cows tested and selected as calves in the HP line. The increases ranged from 5% more milk to 12.5% more protein. The trend was the same in the Hereford lines, although the differences were not quite as large. The LP cows may outproduce HP cows because the LP cows are more efficient in feed utilization or because the HP diet promotes fat deposits in the udder, thereby interfering with milk-producing cells.

Return to estrus after parturition of beef cows. The interval from parturition to first estrus of 132 mature crossbred cows suckling calves and housed in drylots was compared to that of 165 crossbred cows suckling calves and grazed on the open range consisting of shortgrass prairie. The cows in the drylot gained an average of 0.56 kg/day, whereas those on the open range gained 0.81 kg/day.

More cows were detected in estrus on the range than in the drylot (89 vs. 73%, $P < 0.01$), but the mean interval for cycling cows was similar for the cows on range and in drylot (62 vs. 64 days). Under both management systems, the dates on which the cows calved had similar significant effects on the interval from calving to first estrus, i.e. cows calving late in the season had shorter intervals than cows calving early in the season. Regression analysis showed that the interval decreased by 0.6 day for each day of advance of the calving date in the period April 1 to May 31. The simple correlation between date of calving and interval was -0.54 ($P < 0.01$).

Poultry

Limestone waste from sucrose refining as a source of calcium for broiler chicks. About 37 500 t of limestone are used annually in obtaining sucrose from sugar beets in Western Canada. Because little use has been found for the limestone waste and relatively large areas of land are required for its disposal, it was compared to feed-grade limestone as a source of calcium for broiler chicks. The limestone waste contained 31.8% calcium and the feed grade limestone, 37.9%. Eight diets, in addition to the unsupplemented basal one, were prepared by adding 0.2, 0.4, 0.6, and 0.8% dietary calcium from the original limestone or the limestone waste to the basal diet. The chicks fed the unsupplemented diet weighed less than those fed the other eight diets. Body weight of the chicks did not differ among calcium sources within level of calcium supplementation. Among levels of supplementation, however, body weights increased with increasing levels up to 0.6%. The body weights of the chicks did not differ on diets supplemented with 0.6% and 0.8% calcium. It was concluded that the two sources of calcium were of equal nutritional value.

High-protein wheat in poultry diets. The protein content of wheat can be increased by nitrogen fertilizers and irrigation management. Experiments were conducted with broiler chicks, turkey poults, and laying hens to determine the use of this high-protein wheat (21%) as compared to regular wheat (14.5%). The variety Neepawa was used in the studies. With all three classes of poultry, lysine was the first limiting amino acid in high-protein wheat diets. When broiler chicks were fed 22%-protein diets, lysine supplementation up to 0.24% of a diet containing 21%-protein wheat improved the body weight and feed conversions of the chicks. Lysine supplementation of a 22%-protein diet containing 14.5%-protein wheat did not significantly affect growth or feed conversion.

Turkey poults fed the high-protein wheat in a 28%-protein diet responded to levels of lysine supplementation up to 0.2% of the diet, whereas no weight response was obtained with low-protein wheat.

Diets of 16.0% protein containing high-protein wheats without added lysine gave lower rates of production and egg size than did conventional wheat in White Leghorns. Lysine supplementation up to 0.2% of the

diet increased egg production and egg weight compared to that obtained with conventional wheat.

It was concluded that the protein in high-protein wheat could be substituted for soybean protein in poultry diets provided the diets were supplemented with lysine.

Sheep

Crossbreeding in sheep. A long-term crossbreeding experiment was conducted using the Columbia, North Country Cheviot, Romnelet, and Suffolk breeds. The single crosses as a group surpassed the purebreds in weaning weights by 5%, in feedlot gains by 7%, and in final market weights by 6%. Three-breed-cross lambs as a group surpassed the purebreds in weaning weight by 15%, in feedlot gain by 7%, and in final market weight by 11%. No improvement in growth traits was evident in four-breed-cross lambs as compared to three-breed-cross lambs. Percentage survival was higher for crossbred than for purebred lambs, by 8 percentage points for two-breed-cross, 12 percentage points for three-breed-cross, and 14 percentage points for four-breed-cross lambs. In matings of purebred ewes to rams of another breed, total weight of lamb weaned per ewe per year was 17% higher than in purebred matings. When two-breed-cross ewes were mated to a ram of a third breed, total weight of lamb weaned was increased by 33% over purebreds. No significant additional gain in this trait was demonstrated with three- and four-breed-cross ewes producing four- and five-breed-cross lambs. During the first 7 yr of their life, mortalities of crossbred ewes were not different from the average mortality of the purebreds.

Half-Dorset Horn ewes, yearlings in 1976, yearlings and 2-yr-olds in 1977, and 2- and 3-yr-olds in 1978, gave 177, 152, and 177 lambs at birth for 100 ewes exposed to rams. Corresponding values for half-Finnish Landrace ewes were 231, 238, and 256 lambs.

CROP ENTOMOLOGY

Forage crop insects

Alfalfa seed crops. A cooperative pest management program was initiated in 1978 by the Research Station, Alberta Agriculture, County of Newell, and alfalfa seed growers. Intensive sampling showed that the major seed alfalfa pests were the alfalfa weevil,

Lygus spp., *Adelphocoris* spp., and to a lesser extent the alfalfa seed chalcid. Studies in 1978 indicated that overwintering adults of the alfalfa weevil were active by April 11, egg laying started in early May with 11.5 eggs per site, first-instar larvae hatched intermittently from the last week of May, and summer adults emerged by late August. A new egg parasite, possibly *Patasson luna* (Girault), was recorded but parasitism of weevil larvae by *Bathyplectus curculionis* (Thompson) averaged less than 10%.

Field trials for control of pests in seed alfalfa have shown that dimethoate, methidathion, and trichlorfon at 0.56 kg/ha effectively controlled alfalfa weevil larvae and *Lygus* spp., but not *Adelphocoris* spp. All insecticides seriously reduced predators such as *Nabis alternatus* (Parshley), lacewings, *Reduviidae* spp., and lady bird beetle larvae.

Alfalfa forage. Laboratory and greenhouse tests on alfalfa indicated that nine insecticides were as effective as dimethoate for control of the pea aphid, but none would prevent reinfestation after 1 wk. Pirimicarb was the least toxic insecticide of those tested to the lacewing *Chrysopa occulata* (Say), an important predator of aphids. Field tests confirmed that pirimicarb effectively controlled aphids and reduced syrphid larvae predators, but had a limited effect on other predators present or on the control of the alfalfa weevil and *Sitona scissifrons* (Say). Pirimicarb appeared to be the most promising insecticide for use in the integrated control of the pea aphid.

The western damsel bug, an important predator of the pea aphid and adelphocorids in alfalfa, can be seriously affected by cutting alfalfa forage. Eggs that are laid in alfalfa stems will not hatch after the forage has dried. This predator was parasitized by *Leucostonia simplex* (Fall.) and *Wesmalia pendula* (Foerster).

Pollinators. The environmental and shelter design factors of heat build-up, light intensity, wind turbulence, and orientation patterns influenced the foraging activity of the alfalfa leafcutter bee, the biological factors of bee production, and dropping of leaf pieces used to construct cells. To date, double-decked shelters or shelters with a back extending from the ground to 120 cm above the top and shelters that are 120 cm deep and painted black with white vertical stripes have been consistently better than shelters with

lower profiles and no orientation patterns in producing bees and reducing drift of the bees within fields. Wooden hives were more attractive (20 325 vs. 13 456 cells) and produced a higher percentage of viable cocoons (81 vs. 68%) than did polystyrene hives.

Bumble bee colonies, if occupied by the cuckoo bee (*Psithyrus* spp.), frequently cease production of workers, but sometimes produce sexuals.

Cutworms

Sex attractants. Species-specific sex attractants for eight major crop pests, pale western, redbacked, army, darksided, variegated, and clover cutworms, beet webworm, and *Leucania commoides* (Gn.), have been discovered by laboratory bioassay and extensive field screening of over 2000 combinations of potential attractant chemicals. Most of the attractants consist of at least two chemicals, and results have shown that certain chemicals involved in the specific attractant mixture for one species act as sex attractant inhibitors for closely related species. Bait dispensers and attractant traps designed and developed here are being used elsewhere in Canada to monitor male adult population densities and distribution.

In developing sex attractant trapping systems as forecasting methods, some restrictions in trap placement were found for clover and army cutworms. Catches were significantly higher in open areas than in areas adjacent to buildings or windbreaks. Unobstructed traps at ground level or 1 m in height caught more moths than those at 2 m, and the crop species did not influence the numbers caught. The 1 m trap height was also more effective for other cutworm species.

Effective trap spacing and movement of moths were studied in areas of 0.2, 0.9, 2.0, and 144 ha covered with a grid of 49 traps. In the three smaller areas, over 75% of the moths were caught in perimeter traps with the highest numbers in the upwind traps. In the 144 ha area, less than 60% of the moths were caught at the perimeter and the differences between traps were not significant. As the moths probably did not emerge uniformly, considerable movement of moths was indicated. Trap interference did not occur at 200 m spacings. In 1978, the densities of five

species of cutworm were measured in southern Alberta with duplicate traps at 81 locations (10–20 km apart). Although no outbreaks occurred, army cutworm populations were highest south and east of Lethbridge, whereas redbacked cutworms were most abundant west and southwest of Lethbridge. Populations of *Leucania commoides* and pale western and clover cutworms were less well defined.

Chemical controls. Laboratory, greenhouse, and microplot tests have been completed on over 100 candidate insecticides for control of larvae of the army cutworm. In comparative oral toxicity tests, the synthetic pyrethroids were more toxic than any of the organophosphorus insecticides tested. The pyrethroids cypermethrin, fenvalerate, fenpropanate, and permethrin were as effective as endrin and, in simulated field tests and microplot studies, these insecticides at 0.14 kg/ha gave as effective control as endrin at 0.28 kg/ha and were significantly better than chlorpyrifos at 0.56 kg/ha.

Grasshoppers

Population studies. The grasshopper population in southern Alberta continues to decline. The population decreased in 1978 by 54% from the census values reported for 1977, and is now at the lowest level since 1970. Lightly infested areas declined from 29 080 km² in 1977 to 12 611 km² in 1978, whereas moderately infested areas, usually surrounded by light pockets, increased slightly from 1235 km² to 2165 km². Most of southern Alberta was classed as normal. No heavy infestations were found.

Chemical control. Comparative toxicity studies have been completed with 34 insecticides on the three main economic species of grasshoppers. Of 14 insecticides that were more acutely toxic than dimethoate to these species, five pyrethroids and five carbamates showed promise because of their low environmental impact. The pyrethroids cypermethrin, fenvalerate, fenpropanate, and FMC 26021 were more toxic orally than dimethoate, and were two to five times more toxic as contact poisons than as oral poisons. Of the carbamates tested, bendiocarb appeared in laboratory and in simulated field tests to be a possible replacement for carbofuran because of its low mammalian toxicity. However, the wettable powder formulation now available for this insecticide

was readily washed off by rain, thus decreasing its field efficacy.

Of the carbofuran applied by aircraft to 60 cm high wheat, 50% was deposited in the upper quarter of the crop. Other studies have shown that aircraft application had less effect on nontarget species in both headlands and crop than did ground application. These studies point to the ineffective crop penetration achieved by aerial application under certain circumstances. By grasshopper bioassay, it has been shown that alkaline water used in preparing insecticide spray solutions can affect the stability of the solution. Buffering and spray-tank storage also had varied effects. Carbofuran or dimethoate, applied within 3 days of an application of the herbicide propanil to barley, can significantly influence barley development; thus, timing of such applications is critical.

Sugar beet and potato insects

Sugar beets. Daily minimum and maximum air temperatures, relative humidity, and wind velocity affect the catches of male beet webworm moths in sex attractant traps. Two to three times more moths are caught within beet stands than at the perimeters. An improved two-component sex attractant was developed for *Euxoa tristicula* (Morr.) and effective concentrations and ratios were established by field testing.

The electroantennogram (EAG) technique is being used successfully to study the sensory responses of excised antennae of beet webworm males to various attractant or inhibitory chemicals as well as to the natural sex pheromone.

Infestation levels of the beet webworm and other pests of sugar beets have been low since 1974.

Potatoes. Four insecticides, terbufos, diazinon, CGA 12223 (Ciba-Geigy), and Bay 92114 (Baychem), gave significant protection to potato tubers from attack by the prairie grain wireworm and are possible replacements for chlordane. When the insecticide was applied in furrow at planting or as a side-dressing 1 mo postplanting, tubers from terbufos, CGA 12223, and diazinon plots had negligible residues at harvest.

Residues

A program designed to provide residue data for registration of chlorpyrifos, dimethoate, leptophos, and methomyl applied to

alfalfa, wheat, flax, rape, fababean foliage, and sugar beets has been completed.

Field degradation studies of residues of cypermethrin and fenvalerate applied at 0.14 kg/ha to wheat 27, 20, and 13 days before harvest indicated residues in kernels of 0.05, 0.07, and 1.0 ppm for cypermethrin and 0.05, 0.12, and 0.29 ppm, respectively, for fenvalerate.

Residue methodology has been developed for determining fenvalerate residues in soil. Residues from soil were extracted by acetone, acetone/hexane, and hexane solvent systems with a secondary cleanup using an adsorption chromatography microcolumn containing acid alumina II and eluted with 10% ether/hexane. Cleaned-up extracts were analyzed by electron capture GC using 6% DV-210 column. The minimum detection limit was 25 pg and the method sensitivity was 0.005 ppm. This method will be suitable for detecting cypermethrin as well as fenvalerate residues in soil and water.

ECONOMICS

Beef cattle

Warble fly control. Warble fly control can increase the demand for beef and hides, increase the supply of beef, and decrease the marketing margin for beef products. Cattle producers gain the most from warble control, but consumers and meat packers also share the gains. Cheap and effective systemic insecticides make the economic threshold of warble control very low and thus encourage farmers to treat their cattle. The costs of eradicating rather than controlling the pest, however, make eradication economically impractical.

Feedlot nutrition. A computer model developed at Lethbridge that is concerned with nutritional aspects of beef cattle feeding was used as the basis for a computerized beef finishing program that will be offered to feedlot operators through CANFARM. The model selects feeding programs and formulates diets that maximize net returns to the feeding enterprise.

Poultry

Turkey nutrition. A linear programming model of turkey broiler production was developed in cooperation with poultry scientists at Swift Current. The model selects

market weights and formulates diets for male and female turkeys for specified input and product prices. An application of the model to an experiment designed to determine turkey broiler response to Candle rapeseed meal (RSM) showed that, under most historical price situations, RSM was competitive with other protein sources in diets of growing turkeys.

Cereal and oilseed production

Crop rotations. A dryland crop simulation model developed at Lethbridge was used to determine optimal cropping programs for the Brown and Dark Brown soil zones. Net incomes, resource requirements, and income variability were calculated for typical farms in the two soil zones at various levels of product and input prices. The study used 1978 input prices and grain prices representative of the previous five crop years. The agronomic data were obtained from rotation experiments, fertilizer trials, and tillage experiments.

Average net income over a 5-yr period for the Brown soil zone was highest with the crop-fallow rotation and lowest with continuous cropping. In the Dark Brown soil zone, average net income was highest with the crop-crop-fallow rotation but differences among rotations were much smaller than in the Brown soil zone. In both zones, the cropping combinations that included winter wheat generally provided the highest net income.

Income variability arising from variation in amount and seasonal distribution of rainfall was highest with continuous cropping and lowest with the crop-fallow rotation. Within rotations, income variability was similar in the Brown and Dark Brown soil zones.

Zero tillage. A dryland crops simulation model developed at Lethbridge was used to examine the economic feasibility of substituting herbicides for mechanical tillage operations on fallow in wheat-fallow rotations in southern Alberta. Estimates were made of the maximum expenditures (break-even prices) that could be incurred for chemicals before their use became uneconomic compared with conventional tillage practices. At \$110/t for wheat and \$5/h for labor, break-even prices were estimated at about \$43/ha in a wheat-fallow rotation. In a wheat-wheat-fallow rotation, the break-even prices were estimated to be about \$40/ha. If

efficacious herbicides can be purchased and applied for less than these break-even prices, zero tillage is a profitable substitute for conventional tillage practices.

PLANT PATHOLOGY

Diseases of vegetable and special field crops

Persistence of ring rot bacteria in soil. The effect of soil microorganisms, moisture content, and temperature on the persistence, in soil, of the ring rot bacterium, *Corynebacterium sepedonicum*, was determined by bioassay. Although the bacterium remained viable for 284 days in a sterilized soil at field capacity (FC) and 5°C, it did not survive for more than 6 days in two nonsterile soils at FC and 20°C. Persistence in nonsterile soils increased as moisture content and temperature decreased. For example, in soil at the wilting point, no ring rot bacteria were recovered after 88 days with a mean soil temperature of 15°C but they survived for 362 days at mean soil temperatures of 0 or -10°C. In contrast, when the soil was at FC, no viable cells were recovered after 278 days when mean soil temperature was -10°C.

Rapeseed as an alternate host of the sugar beet cyst nematode. Tests under controlled conditions demonstrated that the varieties of rapeseed recommended for southern Alberta are excellent hosts of the sugar beet cyst nematode. After three consecutive croppings to Midas, Tower, and Torch rapeseed, viable cysts increased from initial levels of 30 per kilogram of soil to 517, 537, and 601, respectively, comparable to the 517 cysts present after three consecutive crops of sugar beets. Despite its susceptibility, rapeseed, in contrast to sugar beets, exhibited no obvious decrease in vigor, even in the presence of over 1000 cysts per kilogram of soil. While rapeseed has previously been recognized to be a host of the sugar beet cyst nematode, these results obtained using local varieties have been useful in advising sugar beet growers and the contracting company of the hazard involved in including rapeseed in rotation with sugar beets.

Control of pea root rot with crop sequences. Yields of processing peas in southern Alberta are reduced about 17% by root rot. Each year, the soils in several irrigated farms in the area become so infested with the root rot

fungus (*Fusarium solani* f. sp. *pisi*) that pea production must be abandoned. Experiments in the greenhouse and in field plots demonstrate that 1 yr under fallow or rapeseed will reduce the severity of root rot in the next pea crop. Disease severity is further reduced by a 2nd yr of either treatment. The reduction in root rot is accompanied by an increase in yield when peas are grown on fallow, but not when they are grown after rape. The yield-depressing effect of rape is not associated with soil levels of nitrogen, phosphorus, or potassium and is not evident in a second consecutive pea crop, which benefits from continuing disease suppression. Other crop sequences are now being studied to identify those that will reduce root rot of peas without depressing their yields.

Cereal diseases

Ergot in rye. Disease-loss surveys were conducted in Alberta from 1972 to 1976 to determine the incidence and severity of ergot in rye fields. Ergot was found in 58% of the 169 fields examined, ranging from 40% in 1973 to 88% in 1975. Mean severity varied from 0.05 ergoty spikes per square metre in 1974 to 0.21 in 1972. Within individual fields, infection levels reached 2.88 ergoty spikes per square metre. The disease was more frequent and more severe in the east-central part of the province than in the drier southern region.

Two equations were developed to estimate the yield and grade losses resulting from ergot in rye: Yield loss (percent) = $0.318x$, and Ergot in grain (percent by weight) = $0.1x$, where x = percent ergot-affected spikes in the standing crop. These equations, together with the survey data, were used to estimate the loss from the disease in Alberta for 1972–1976. This amounted to a total yield loss of 0.031% and an additional loss of 0.11% in 1972 arising from the lower grade received for rye contaminated by ergot.

Stem smut of fall rye. Stem smut of fall rye caused by the seed- and soil-borne fungus *Urocystis occulta* was rare before 1971, but occurred in 34% of fields surveyed in southern Alberta in 1978. The current prevalence of the disease can be attributed to the high susceptibility of the widely grown variety Cougar, the ability of the pathogen to survive for at least 1 yr in the dry soils of southern Alberta, and the fact that seed is not commonly treated with a protective fungicide.

The relatively resistant variety Kodiak is gaining in popularity and offers the best immediate prospect of control. The registered systemic fungicide, carbathiin, has shown decreasing effectiveness in plot tests over the last 3 yr, suggesting that the fungus can develop tolerance to this compound. Possible replacement products have been identified.

Cold hardening of wheat

Patterns of cold hardiness. Winter wheat plants grown for up to 15 wk under controlled conditions at constant 3°C or 5.5/3.5°C (day/night) showed a characteristic pattern of changes in cold resistance. Immediately after the seeds were moistened, resistance began to decrease to a minimum, reached after 2–3 wk, and then rose to reach a plateau that lasted approximately from the 7th until the 11th wk after the seeds were moistened. Cold resistance then gradually declined.

The changes in cold hardiness during growth at 3°C were similar to and synchronous with those in plants grown at 5.5/3.5°C. However, rate of development of the plants, as measured by the number of leaves produced, was slower at 3°C than at 5.5/3.5°C. This observation indicates that duration of exposure to hardening temperatures is more important than stage of development in determining the cold resistance of the plants at a given time. Plants grown at 20°C for 3 wk before hardening show a pattern of cold resistance during hardening that supports this conclusion.

Winter wheat seeded out of doors in the fall but periodically transferred to a growth cabinet at 3°C throughout the winter showed sequential changes in cold hardiness that followed the same pattern as that described above for plants grown continuously in a growth cabinet. This result suggests that one reason for the decrease in cold hardiness of field-grown winter wheat in late winter is that, by then, the plant has been exposed to low temperature for longer than the period during which maximum cold hardiness is maintained.

Changes in the invertase of wheat leaves during cold hardening. Many biochemical changes occur in winter wheat as it undergoes cold hardening. One of these is a drop in the energy of activation of the enzyme invertase, which consequently is able to

function more effectively at low temperatures. This drop in energy of activation has been traced to an increase in the proportion of invertase I relative to invertase II, the former isozyme having a 5–10% lower energy of activation than the latter. The data also suggest that invertase I replaces invertase II during the cold hardening process. A study involving 12 varieties of common wheat that differed widely in cold hardiness showed that their rank order for cold resistance was correlated highly with their rank order for ratio of invertase I to invertase II under a given set of hardening conditions. However, when four of the varieties were grown under three different sets of hardening conditions, the ratio of invertase I to II was not related to the relative effectiveness of the hardening treatments.

PLANT SCIENCE

Cereals

Barley breeding. The new phytotron at Lethbridge has been used successfully to speed up the barley breeding program in early generations. From crosses made in the fall of 1976, F_1 's were sown in early January of 1977. Propagation was by single seed descent and F_5 progenies were sown in the field in the spring of 1978, a year earlier than previously possible. The absence of selection in early generations resulted in a number of definitely inferior lines. However, much better sampling of genetic variability should increase the probability of retaining the most superior genotypes from a population.

Seed produced in propagation rooms at Lethbridge was much superior to that usually produced in California in the winter. Germination was quicker and more uniform, making assessment of individual lines easier and more reliable.

Barley grown under Grolux very-high-output wide-spectrum (VHO WS) lamps without incandescent supplement matured about 10 days earlier than under very-high-output cool white (VHO CW) lamps with incandescent supplement. A constant 20°C growing period gave slightly earlier maturity than diurnal variation of 20/15°C (day/night). Seed set and yield were very satisfactory in all instances.

Inheritance of root directionalism. Winter wheat roots orient in a north–south direction

in response to magnetic influence. As a result of this finding, farmers are recommended to plant winter wheat rows in an east–west direction so that the roots can better utilize between-row soil moisture in dry years.

A study was initiated to ascertain the inheritance of magnetotropism and to determine if this characteristic could be transferred from winter to spring wheat, which does not exhibit a magnetotropic response. The biomagnetic responses of reciprocal F_1 and B_1 populations from spring–winter wheat crosses were the same as that of the maternal parent. Current evaluation of F_2 and B_2 populations will determine if maternal influence is involved or if inheritance is cytoplasmic. The transfer of this biomagnetic response from winter to spring wheat should be relatively simple.

New winter wheat. A license was granted for Norstar, a new hard red winter wheat, in 1977. Norstar is a tall, bearded variety developed at Lethbridge from a cross between Winalta and Alabaskaja. It is superior to Sundance and Winalta in winterhardiness and yielding ability, and is similar to Winalta in milling and baking quality. Norstar is resistant to shattering and more resistant to lodging than Sundance. As it is not resistant to bunt (stinking smut), seed treatment is recommended.

About 30 t of Select seed, produced under contract in 1977, was distributed to growers in Alberta and Saskatchewan. There were no reports of winterkill for the 1978 crop, and excellent moisture conditions resulted in yields of about 4 t/ha. The demand for seed was so high that a restriction was placed on the sale of seed outside Canada for the 1978 fall seeding period.

The area of winter wheat has more than doubled in Western Canada in recent years. The release of the winterhardy variety Norstar will reduce still further the possibility of winter damage, and may result in an even greater production of winter wheat in the Prairie Provinces.

Winter wheat. In three controlled environment experiments, applied N fertilizer decreased cold hardiness of winter wheat, while P applied alone had no effect. When applied together, P counteracted the effect of N and produced plants as hardy as those that had received no fertilizer. The soil was rich in K; consequently, application of additional amounts had no effect on cold hardiness. The

correlation coefficient between dry weight of crowns and cold hardness (LT_{50}) was not significant but that between water content and LT_{50} was highly significant. Aspartic acid increased markedly in the crown with the application of N alone, but only marginally when P also was applied. The content of most other amino acids decreased slightly whereas a few remained unchanged with the application of N. Applied P had little or no effect on amino acid content.

Seasonal dry-weight distribution of corn hybrids. Over the past few years, it has been found that the clear sunny days and cool nights that occur in southern Alberta promote the growth of tillers of corn plants. This characteristic was promoted for a few years in the form of several commercial hybrids that tillered profusely and for which very high fodder yields were claimed. To obtain accurate information, the dry weights of component parts of the main stalk and tillers of multitillered and single-stalked hybrids were measured for 2 yr. Since tiller production is inversely related to population density, the test was conducted at 35 000, 70 000, and 115 000 plants per hectare. At the end of the season, the multitillered hybrid had higher total yields at 35 000 plants per hectare than the single-stalked hybrids because of its large tillers but the single-stalked hybrids had a higher grain content than the multitillered hybrid. The number of tillers increased until late July and then decreased because of the effects of population stresses. The reduction in tiller number was more pronounced at the highest population density. It was therefore obvious that, rather than tillers starting to grow and fill in the canopy because of low population densities, tillers began to grow and develop very early in the season and died because of population stresses only when the canopy filled in. Decreases in tiller and main stalk dry weights were probably due to translocation of carbohydrates to the main stalk and kernels, respectively. The yields of the multitillered and single-stalked hybrids were similar at the intermediate and high population densities, indicating that superior single-stalked hybrids were capable of producing as much total dry matter as the multitillered types. As a result of this study, multitillered hybrids are no longer recommended to farmers in southern Alberta.

Breeding early corn. Inbred lines have been produced by self pollination of plants of European origin. The inbreds were subjected to selection for early silking and stalk strength during their production. Test crosses with a weak-stalked single cross identified two lines with good combining ability for stalk strength. Yield tests showed several single crosses with satisfactory but not outstanding yields. Most of the hybrids were short with medium to small ears. Higher plant populations may be required to obtain consistent grain yields greater than 6.3 t/ha. The production rights for one of the experimental single-cross hybrids has been granted to a hybrid seed company.

Forage crops

Legume mixtures. A 5-yr field clipping trial to assess the potential of mixtures of non-bloat-inducing forage legume species for pasture production showed that the combination of sainfoin with birdsfoot trefoil was the most promising under irrigation. The mixture outyielded either component species grown alone by a significant margin in two of the five test-years, and its total production was only 5% below that of alfalfa grown alone. A good balance of the two species was maintained in the mixture, with sainfoin contributing 68% of the total dry matter production during the first 2 yr, and 43% during the succeeding 3 yr. Cicer milkvetch was dominated in mixture with sainfoin, and in mixture with birdsfoot trefoil; yields of both of these mixtures were about 20% lower than that of alfalfa alone.

None of the legume mixtures appeared promising for dryland pasture production. Mixtures of sainfoin with either birdsfoot trefoil or cicer milkvetch contained about 90% sainfoin, tended to yield slightly less than sainfoin grown alone, and yielded 10% less than alfalfa grown alone. The birdsfoot trefoil – cicer milkvetch combination had a good balance of the component species but yielded 45% less than alfalfa alone.

Seedling competition of some legumes. Seedlings of a rapid-developing legume, sainfoin, and two slow-developing legumes, birdsfoot trefoil and cicer milkvetch, were grown in monoculture and in mixed cultures in the greenhouse and evaluated at 7 wk for leaf area; leaf, root, and total weights; and specific leaf weight. Leaf, root, and total weights of sainfoin seedlings were similar to

those of cicer milkvetch when grown in monoculture. Sainfoin was more aggressive than birdsfoot trefoil or cicer milkvetch in mixed culture. Cicer milkvetch was more aggressive than birdsfoot trefoil. Under partial competition, where the plant was surrounded by three of the same species alternating with three plants of the competing species, leaf area and leaf weight of cicer milkvetch were suppressed by sainfoin as was leaf area of birdsfoot trefoil.

The relationship of leaf weight to root weight in monocultures differed between sainfoin, cicer milkvetch, and birdsfoot trefoil. Birdsfoot trefoil in monoculture produced more, while cicer milkvetch produced less, leaf material per unit of root material than sainfoin. In mixed culture, sainfoin produced more leaf weight per unit of root material when grown with cicer milkvetch than when grown with birdsfoot trefoil. Of the three legumes, birdsfoot trefoil and cicer milkvetch were most compatible during seedling growth in the greenhouse.

Protein quality of sainfoin. Sainfoin, grown for forage in Europe and Asia Minor for centuries, has been introduced to North America recently. Interest in sainfoin in the western regions of Canada and the USA originated because it is adapted to calcareous soils and does not induce bloat in ruminants. Nutritional comparisons indicate that sainfoin is generally higher than alfalfa in N-free extract, total digestible nutrients, and phosphorus, but lower in crude protein, ash, calcium, and crude fiber content.

Sainfoin contained higher amounts of lysine, histidine, proline, cystine, glycine, alanine, valine, leucine, tyrosine, phenylalanine, and tryptophan than alfalfa, whereas alfalfa contained more aspartic acid, methionine, and isoleucine than sainfoin. More than 25% of all amino acids in sainfoin consisted of aspartic and glutamic acids. The share of these amino acids in alfalfa was 29%.

The protein score, an estimate of protein quality for nonruminants, was 68 for sainfoin and 71 for alfalfa, compared with 100 for ideal protein. The limiting amino acid in both sainfoin and alfalfa was methionine.

This research indicates that sainfoin is similar to alfalfa in amino acid content and protein quality, and that the two crops should be of equal value as sources of protein for livestock feeding.

Horticulture

Potato breeding. A major effort in 1978 was directed toward the establishment of a new potato breeding project at Lethbridge. The project will be operated cooperatively with the national potato breeding program in Fredericton and provincial and university agriculture departments in the three Prairie Provinces. Early-generation selection for the program will be carried out at the Substation at Vauxhall. Cooperating provincial departments will assume responsibility for the operation of test sites for adaptation and replicated trials. Pathology, entomology, and food science support is to be provided by scientists at the Alberta Horticultural Research Centre, Brooks, Alta. Close contact with potato breeding programs in the north-western United States will be maintained by participation in breeder trials organized by the North Central and North Western groups. Arrangements for evaluation of advanced and some early-generation selections from these programs in 1979 has been initiated.

Leaf movement affected by low temperatures. Normal movement of the leaves of beans in response to light ceased after 72 h and they remained in the vertical position normal for the dark period. Though the light level was increased, normal leaf movement of the affected cultivars did not resume until the temperature was raised. It was concluded that this interference in the movement of bean leaves was due to the 10°C temperature, and could cause a reduction in early growth. Tolerance to this temperature effect was observed in several lines. Analysis of data from parental F₁ and F₂ populations of two sensitive and one tolerant cultivar indicated that this trait is controlled by two major genes. Tolerance appears to be due to two pairs of recessive genes. The intolerant reaction is due to either one, or both, of the dominant alleles, one of which is epistatic to the second and similar in response. It may be possible to use this tolerant photonastic response to low temperature to enhance early growth in the bean.

Weeds

*Phosphorus uptake from sediment by *Myriophyllum spicatum*.* The rooted submergent aquatic macrophyte Eurasian water milfoil took up about 70% of the phosphorus in new shoots from the hydrosol, when grown in

water containing P at 0.015 and 0.5 $\mu\text{g/mL}$. When the P content of the water was 2.0 $\mu\text{g/mL}$, the uptake of hydrosol P decreased and the uptake of water P increased. Stems of milfoil cut off 2 cm above the crown transferred only 4–20 μg of hydrosol P per plant into the water in the first 18 h after decapitation, and thereafter no further P was released. The interpretation of these results is that if Eurasian water milfoil is harvested from an aquatic environment, the effect will be to decrease hydrosol P and slightly increase water P. Additional studies are under way comparing native species with Eurasian water milfoil and the effect of plant age and height, water temperature, and light on P uptake.

Methods of applying herbicides. Certain herbicides show a much higher level of efficacy when preplant-incorporated in the surface soil than when unincorporated. Examples include metalachlor, cyanazine, and pyrazone, which normally are not incorporated.

Fall application of the soil-applied sugar beet herbicides ethofumesate and pyrazon provided better weed control than spring applications in 1977, equal control in 1978, but a greater degree of crop safety in the latter year. Neither EPTC nor cycloate had sufficient soil persistence from a fall application to give satisfactory weed control in either of the 2 yr.

Metribuzin, as a soil-applied incorporated treatment at the low rate of 0.25 kg/ha, provided excellent total broad-spectrum weed control on Lethbridge soils. This rate is less than one-third of the label rate and allows the reduction in cost by two-thirds for weed control in potatoes on at least some soils in this area.

Atrazine, applied in the fall at 0.8–1.0 kg/ha, is proving to be an effective, inexpensive herbicide for broad-spectrum weed control in sorghum, a new dryland crop for southern Alberta.

Remote sensing

Remote sensing of rangeland. During 1976–1978, a study was undertaken to evaluate remote sensing for assessing productivity and condition of foothill rangeland. The study site chosen was the Range Research Substation at Stavely, Alta., where a long-term grazing study with cows and calves has resulted in fields in excellent, good, fair, and

poor condition. Remote sensing data used in the study included false color infrared (FCIR) photography and thermal infrared imagery obtained twice during the seasons of 1976 and 1977, as well as LANDSAT data from August 1977. Ground data included clipped plots in each grazing field, percentage basal area, and measurements of soil moisture and soil temperature. Visual interpretation of the FCIR photography and thermal imagery indicated that detailed mapping of range vegetation could be carried out and that the amount of detail depended on the scale of the photography. Mapping was best done near the end of the grazing season, in September rather than in July. Thermal imagery was found to be of little value as it was obtained during the daytime and there was differential solar heating, complicated by topographic effects. Productivity in the lower biomass levels appeared to be easily discriminated, but little difference was apparent at higher levels. Generally, it appeared to be very difficult to distinguish between yield levels above about 1000 kg/ha. A final phase of the study involved an interpretation of LANDSAT data for estimation of rangeland condition and productivity. At the original scale of 1:1 000 000, the study area was too small to be interpreted. The study area could be located and resolved on the Image 100 computer analysis system and areas of excellent, good, fair, and poor productivity identified. Generally, these areas conformed to similar known condition classes.

SOIL SCIENCE

Soil-crop relations

Effect of nitrogen fertilizer treatments on amino acids in wheat. The amino acid composition was determined on Neepawa wheat grain grown in a four-by-three factorial experiment (granular fertilizer at N rates of 0, 100, 200, and 300 kg/ha applied to the soil and urea at N rates of 0, 50, and 100 kg/ha sprayed on the foliage). Amino acid responses, when they occurred, were to the first increment of nitrogen in most cases. In general, glutamic acid, proline, phenylalanine, cystine, methionine, and tyrosine increased and lysine, histidine, arginine, aspartic acid, threonine, glycine, valine, and leucine decreased with either or both forms

of nitrogen application. Cystine was increased and glycine was decreased by granular nitrogen applied to the soil but they were not affected by urea nitrogen applied to the foliage. Conversely, the percentages of methionine and tyrosine were increased, and valine decreased, by urea nitrogen but they were not affected by granular nitrogen. There were significant interactions between the two nitrogen treatments for 12 of the 17 amino acids. Each amino acid was significantly correlated (+ or -) with one or more of the other amino acids.

Magnetic seed treatment of winter wheat. Grain yields of hard red winter wheat were increased significantly by magnetic treatment of the seed in 5 of the past 6 yr at Lethbridge and in each of the past 2 yr at Cluny. The average yield of wheat grown from magnetically treated seed at Lethbridge was 2774 kg/ha, or 7.1% greater than that grown from nontreated seed. Yields were not increased by treatment in 1975, when the test plots became infested with wheat streak mosaic disease, which obscured any response that might have occurred. At Cluny, where winter survival of winter wheat may be critical, yields were increased 9.2 and 21.0% in 1977 and 1978, respectively. The greatest increases in yield occurred, at both locations, in years when soil moisture was adequate throughout the growing season and particularly at head-filling time. Treatment generally resulted in grain that contained slightly less moisture at or near maturity and could, therefore, be harvested earlier. Response to treatment was usually independent of the kind or make of equipment used to treat the seed.

Irrigated soils

Irrigation management of alfalfa for seed. In a 6-yr series of plot experiments, alfalfa seed yield averaged 445 kg/ha where the plots were irrigated once or twice, depending on rainfall, in the first half of the growing season but not in the last half. Where the plots were not irrigated, average yield was 363 kg/ha, and, where the plots were irrigated once or twice in the last half as well as the first half of the growing season, average yield was 334 kg/ha. Lysimeter experiments during 2 yr showed that severe soil moisture stress for more than 8 days before ripening reduced seed yields by 45%. Thus the crop reacts unfavorably to excessive moisture but does require some during seed development.

This requirement is normally supplied in the field by deeply stored soil water and occasional rain during July and August.

Irrigating Solonchic soils. Plowing a Brown Solodized Solonchic soil to 60 cm in 1974 increased soil moisture storage in the 30-90 cm depth but did not increase the yields of irrigated cereal crops. Total yields (dry matter and grain) of barley crops in 1975 and 1976 and wheat in 1977 and 1978 that were irrigated and fertilized to fully meet crop requirements were 33.4 and 13.2 t/ha on deep-plowed plots and 34.8 and 13.9 t/ha on conventionally tilled plots. In 1975 and 1976, grain yields were greater where irrigation was applied at 5 mm/h at 13- to 15-day intervals than at 10 mm/h at 22-day intervals. In 1977 and 1978, yields were unaffected by rate and frequency of irrigation. Totaled over the 4 yr, yields of dry plant material were 34.1, 34.2, and 33.9 t/ha where, in the 4 yr, 21 irrigations supplied 994 mm of water, 20 irrigations supplied 1020 mm of water, and 14 irrigations supplied 911 mm of water, respectively.

Control of canal seepage. It is estimated that over 10% of the irrigated land in Alberta has become waterlogged and salinized because of canal seepage. A soil-asphalt lining developed in the laboratory has satisfactorily controlled seepage in the field since 1975. The lining was prepared by spreading bentonite, herbicide, and an enzymatic wetting agent across the surface of a newly constructed ditch and incorporating these materials into the top 8 cm of soil along with an anionic asphalt emulsion. After partial drying, the lining was packed with a V-shaped roller built to fit the ditch. The lining effectively controlled seepage and withstood winter weathering with only hair-line cracking that sealed off after the first irrigation water entered the ditch. The lining is soft and subject to damage from livestock but, because of its flexibility, it withstands frost heaving without damage. Materials cost was 60% less than for concrete, and installation was considerably easier.

Irrigation return flow. Studies of irrigation return flow in the 57400 ha Bow River Irrigation District showed that water passing directly from canals to drains accounted for 87% of the total return flow volume over a 3-yr period. Good-quality canal water (EC = 0.42 siemens/cm) diluted poorer-quality

subsurface drainage water ($EC = 0.84\text{--}3.80$ siemens/cm) so that the salt concentration of the total flow was only slightly more than that of canal water ($EC = 0.57$ siemens/cm). The salt balance index (salt outflow/inflow) was less than 1.0 in every year in two blocks of the district and in 1 of 3 yr in a well-drained third block. Annual outflow of $NO_3\text{--}N$ was 0.7 kg/ha from sprinkler-irrigated land and 0.5 kg/ha from flood-irrigated land. Corresponding total-P outflows were 0.3 and 0.2 kg/ha annually. Under present conditions, quality of return flow from irrigated land does not pose a serious threat to watercourses but the large volume of water spilled from canals to drains reduces the overall irrigation efficiency and this may not be acceptable in the future.

Dryland soils

Moisture and N fertilizer interactions. Regression models were developed describing barley yield in the Dark Brown soil zone as a function of available water stored in soil in the spring (W_s), June–July precipitation, and the N fertilizer level ($R = 0.944$). The protein content of the barley was less dependent on these variables ($R = 0.723$). For each 1 cm increase in W_s , yield increased by 160–230 kg/ha at the W_s level of 5 cm and by 0–80 kg/ha at the W_s level of 20 cm, depending on the rate of N fertilizer. On the basis of 1978 prices, the optimum level of N fertilizer increased by 4 kg/ha with each 1 cm increase in W_s . By comparing the relative costs and expected income from recropping and summerfallowing, we determined that, with average June–July precipitation, a yield to justify recropping was obtained with W_s at 7.5 cm. For recropping to have a higher net return than summerfallowing for 6 of 10 yr, a W_s level of more than 10 cm would be required.

Seed drill development. Experiments were undertaken to determine the functions of a seed drill that affect germination and early growth. Initial results indicated that the degree of soil–seed contact is not a critical factor for seed placement. Moisture imbibition by germinating seeds varied with time, amount of moisture in the soil, and, slightly, with clay content but was unaffected by soil density. Further, imbibition by seeds half embedded in soil at the bottom of holes sealed with rubber stoppers was nearly equal to that obtained when seeds were completely

embedded. In another study, seeds in air at 100% relative humidity imbibed water at about one-third the rate they did in soil at 30 kPa tension. These results indicate that germinating seeds may obtain a significant portion of their moisture from the vapor phase and that soil drying rate may be a critical characteristic for seed placement.

Zero tillage for winter wheat. In 1976, three different winter wheat rotations were established on a clay loam soil to compare zero tillage with conventional tillage systems. In the chemical fallow rotations, atrazine (at 0.7 kg/ha) was applied after harvest for residual weed control until July of the fallow season. Paraquat or glyphosate (at 0.56 kg/ha) was applied as required to control weeds for the remainder of the season and just before seeding in all rotations. In 1977, yields of Norstar winter wheat were higher ($P < 0.05$) on no-till chemical fallow fields than on fields that received conventional seedbed preparation (3174 vs. 3032 kg/ha). In 1978, winter wheat yields from the 2-yr rotation were again higher ($P < 0.05$) on no-till chemical fallows treated with atrazine in the fall of 1976 than those from conventionally cultivated fallows (4326 vs. 3861 kg/ha). In the 3-yr rotation (winter wheat – barley – fallow), winter wheat yields from the no-till chemical fallow fields were also higher ($P < 0.05$) than those from conventionally cultivated fields (4090 vs. 3605 kg/ha). In 1978, recropped winter wheat yielded more ($P < 0.05$) on no-till (continuous winter wheat rotation) than on cultivated stubble fields (3356 vs. 3099 kg/ha). Increased yields on no-till fields in all rotations were attributed to better seedbed moisture, shallower seeding (2–3 cm deep), and less in-crop weed growth than on cultivated fields.

Grassland soils

Soil properties of native range. Analyses of soils under 40- to 49-yr-old stands of crested wheatgrass and adjacent native range showed that bulk density and chelating-resin-extractable C were higher on crested wheatgrass sites whereas total organic C and water-stable aggregates were higher on native range. Amount of polysaccharides did not correlate positively with water-stable aggregates. Total potential energy input into the soil system, through breakdown of the root mass, was 13.9 MJ/m² for native range and 7.8 MJ/m² for crested wheatgrass. Gas

chromatographic patterns of the organic solvent-soluble constituents present in alkaline hydrolysates were qualitatively but not quantitatively similar.

Effects of grazing on soil organic matter. Many of the characteristics of OM (such as N, organic C, and extractable C of the total soil and C, N, and carboxyl and hydroxyl acidity of the extracted humic substances) in a Brown Chernozemic soil containing about 1% organic C were significantly affected by different grazing intensities. There were also differences between samples obtained in spring, summer, fall, and winter, and there was a significant interaction of seasonal and grazing effects. Neither of these factors significantly affected most of the OM characteristics of a Black Chernozemic soil that contained about 10% organic C. It is concluded that the OM in a Brown Chernozemic soil is much more fragile and sensitive to grazing pressures and seasonal effects than in a Black Chernozemic soil.

Decline in grass yields with advancing age of stand. In one study with a group of three

grasses and in an earlier study with a group of seven grasses, the yields of grasses declined during the first 5 yr after establishment. In the study with the seven grasses, the decline in yield with age of stand may have been related to the decline in available moisture (advancing drought). However, in the study with the three grasses, which ended in 1978, the seasonal rainfall was greater in 1978 (132 mm) than in the 1st yr after seeding (110 mm in 1974). Nonetheless, the yields of the three grasses were much lower in 1978 than in 1974. For example, yield of brome grass without fertilizer in 1974 was 3587 kg/ha and in 1978 was 1766 kg/ha; with N fertilizer, the comparable values were 7860 and 4838 kg/ha. Other data show that this result also occurred with irrigated grasses. Therefore, the phenomenon in exotic grasses of yields declining with age of stand cannot be overcome with N fertilizer or with adequate moisture supply. The exotic grasses, especially in the Dark Brown and Black soil zones, apparently require some form of renovation 5–6 yr after establishment.

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Research Station

Agassiz, British Columbia

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¹Seconded to Sarawak Soil Survey Project, Malaysia, from May 1977 to May 1979.

INTRODUCTION

The Research Station at Agassiz has a varied research program that has emphasized the solution of problems facing the agricultural industry today. In the past 2 yr there has been increased interest in the solution of longer range problems with more emphasis being given to the basic aspects of research. The dairy cattle and poultry barns, the dairy nutrition laboratory, and the main office have been upgraded to facilitate the research program.

Highlights of the research program include determination of the appropriate portion of the milk to analyze for progesterone in order to reliably identify estrus and pregnancy in dairy cattle; ensiled alfalfa cubes with corn silage produced more milk than when the two feeds were mixed just prior to feeding; the conventional deep cages for layers were found to be equal or superior to the new shallow cages; restricting feed to laying hens to 90% after peak production reduced egg production by only 1-3%; documentation of the occurrence of phytotoxicity when some insecticides and herbicides with water solubility of over 20 ppm were applied together; transplanted onions outyielded direct seeded onions by 48%; new winter wheats with some resistance to stripe rust outyielded Nugaines, the recommended variety, by 41%.

We wish to acknowledge the long and dedicated service of Dr. D. K. Taylor, who retired in 1978.

This report briefly refers to some of the completed research. More detailed results are available from the scientists and by obtaining the publications listed at the end of this report. Requests for information on other projects, for reprints, or correspondence should be directed to: Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore
Director

ANIMAL SCIENCE

Milk progesterone for early diagnosis of pregnancy in cows. Samples of foremilk, composite milk, and strippings were analyzed for progesterone to compare the effectiveness of the different samples to diagnose pregnancy. All three samples would identify cows in estrus but only strippings reliably diagnosed pregnancy. Both composite and foremilk samples identified some pregnant animals as being in estrus.

Factors influencing gestation length and birth weight. Gestation lengths and birth weights of 1522 live single births were studied to determine the contributions of season and both fetal and maternal genotypes. Calves born in spring and summer had shorter gestations and weighed less than those born in fall and winter. Heritabilities of gestation length and birth weight as progeny traits were 0.73 and 0.51 and as maternal traits were 0.19 and 0.26. The genetic correlations between progeny and maternal traits were negative.

Alfalfa cubes in dairy cattle rations. It was observed that when cows were fed alfalfa cubes ensiled with corn silage they consumed more forage, 2.26% vs. 2.16% of body weight, gained more body weight 27.3 vs. 23.0 kg/35 days; produced more fat-corrected milk, 25.4 vs. 24.0 kg/day, and produced milk of a higher fat test, 3.13 vs. 2.70%, compared to cows fed the same proportion of cubes mixed with silage just prior to feeding. Ensiled cubes gave an overall improvement of 5% in conversion of dietary energy.

Carcass proportions of Holstein-Friesian steers and bulls. One-half of each of 36 purebred Holstein-Friesian steers and bulls each were implanted with hormones (200 mg progesterone plus 20 mg estradiol-17 β -benzoate) at 340 kg liveweight. Carcass sides were compared after rearing on an all-concentrate ration and slaughtering at 476 kg body weight. With steers, hormone treatment increased hind, rump, and rear shank, and decreased rib and belly sections. With bulls, implanting decreased rear shank and hind and increased belly sections. In addition,

implanting increased the lean percentage in steers but not in bulls.

Performance of Charolais × Holstein (F₁) crossbreds. Growth and carcass characteristics of 12 purebred Holstein-Friesian steers were compared with Charolais × Holstein F₁ crossbreds (12 steers and 6 heifers). Crossbred males gained faster than purebred males and crossbred females. After slaughter (500 kg) crossbreds had heavier hides and hindquarters and lighter stomachs and livers than purebreds. Females had greater offal fat and crossbred males the least. Crossbreds had shorter body length, wider shoulders and rumps, and greater round circumference.

Layer cage size and orientation. Two to four birds per cage yielded the highest net returns regardless of profit level. Optimal space per bird was 387–514 cm². Comparing conventional and reverse cages, reverse cages resulted in increased feed consumption and body weight but caused no increase in egg production and also reduced profitability. Birds in reverse cages were more docile and better feathered.

Storage life of egg albumens. With eggs from eight commercial strains, it was shown that oiling eggs as layed can save 8¢ per dozen. To predict albumen quality losses in stores a grading station must sample 15–30 eggs.

Broiler breeder performance in cages. The introduction of roosts, curtailment of population size to four birds, and allowance of 0.186 m² cage floor space per bird improved egg production and hatching qualities and reduced foot sores for birds in cages. Fertility, with artificial insemination and natural matings in cages, was still lower than in conventional floor pens. Progeny performance was unaffected by housing system of the parent stock.

Muka, a potential feedstuff. Muka, ground forest foliage (needles or leaves), is becoming available. Up to 30% of muka in chick diets did not affect livability but retarded growth to a greater extent than cellulose. Sheep did not utilize the material well in growth trials.

Restricted feeding of layers beneficial. Feed restriction of hens to 90% of intake resulted in 1–3% less eggs. No differences occur in other economic traits. The application of restriction after peak production was most

economical. Dietary energy is not a factor but protein intake must be maintained.

Clubbed down (CD) in broilers. This condition occurs infrequently but several farms have experienced 10–12% CD chicks. It was not alleviated by dietary riboflavin or Mo supplementation. Moving breeders to a new farm or introducing new roosters did not alter the incidence of CD.

Sucrose and broiler production. Feeding sucrose (10%) for first 12 h in the broiler house did not stimulate growth, but when an infection of a reo-virus occurred feeding sucrose significantly reduced mortality.

CROP SCIENCE

Response of cole crops to combinations of herbicides and insecticides. In a study undertaken in cooperation with the Vancouver Research Station, the efficacy of three insecticides and 24 herbicides and their combinations were investigated when applied to field-seeded broccoli, cabbage, and cauliflower. Of these, broccoli was the most susceptible to injury. Of 212 herbicide-insecticide combinations, 26 caused phytotoxic symptoms in broccoli, 20 in cabbage, and eight in cauliflower. Ten herbicides and three insecticides were involved in phytotoxic reactions. Interactions generally occurred between pesticides having a water solubility of greater than 20 ppm.

Transplanting vs. direct seeding of onions. Transplanted onions outyielded those that were direct-seeded by 19 t/ha, i.e. 58.9 vs. 39.9 t/ha, due to less disease and larger bulb size. The transplants also matured 5 wk earlier.

Corn nematicides. Seven granular nematicides were compared to autumn D-D fumigation and an untreated control. Fumigation significantly reduced nematode population and increased yield of sweet corn ears by 38% fresh weight and forage corn by 42% on a dry matter basis. Nematicur 15G had a phytotoxic effect and reduced plant population, plant vigor, and yield. Nematode root injury was more pronounced in sweet corn than in forage corn.

Onion white rot survey. All onion farms in the Lower Fraser Valley were surveyed for

incidence of *Sclerotium cepivorum*. The disease was confirmed on 10 of 41 green onion farms and five of 13 dry bulb farms.

Club root survey of Brassica farms. One hundred farms in the Lower Fraser Valley and Vancouver Island were surveyed for presence of *Plasmodiophora brassicae*. The disease was found in all areas sampled. Disease severity varied with 16 farms having a light degree of infection, 34 moderate, and 23 heavy. Only 27 farms showed no infection.

Napropamide for weed control in newly planted raspberry root cuttings. Napropamide at 4.48, 6.72, and 8.96 kg/ha was tested as a postplanting treatment for newly planted root cuttings of the raspberry cultivar Willemette. The root cuttings were planted in early April and the herbicide treatments were applied the next day to weed-free soil. There was sufficient rain following application so irrigation was unnecessary. Napropamide at 4.48 kg/ha gave good broad-leaved weed and grass control. The higher rates resulted in very slight or no improvement in weed control. No injury was apparent on the newly emerged raspberry plants.

Forms and rates of nitrogen for Pennncross bentgrass mowed at 63 mm. Among various nitrogen sources applied at equal rates of nitrogen to Pennncross turfgrass, 21-0-0 had the highest appearance ratings, superior to 34-0-0, 38-0-0, and 46-0-0 over a 7-yr period. Substituting 6-3-0 (organic) for the four summer applications of 21-0-0 further improved the appearance ratings. Late-fall applications of nitrogen increased winter and spring greenness without increasing disease. The incidence of fusarium patch disease (*Fusarium nivale* L.) increased with high rates of nitrogen, high lime (soil pH 7.0), and the use of 46-0-0 as a nitrogen source.

Turfgrass mixtures for lawns. In simple mixtures for lawns, Highlight Chewings

fescue dominated Kentucky bluegrass cultivars Nugget, Merion, and Sodco after a 3-yr period at two locations. Highlight had greater density (tillers per unit area) than Durlawn and Boreal creeping red fescues and as a result was more competitive. The Kentucky bluegrass cultivars had a relatively higher tiller weight and density at Kamloops.

Cereal evaluation. Under conditions where stripe rust (*Puccinia striiformis* West.) is a production problem, semiresistant winter wheats from Oregon have been high yielding. Hyslop, which appears more winter hardy than Stephens, outyielded Nugaines by 41% and spring-seeded Glenlea by 46% over a 4-yr period. In comparison to recommended varieties of other spring cereals, Hyslop winter wheat exceeded Galt barley by 46% and Fraser oats by 49%. On well-drained sites in the Lower Fraser Valley winter wheat has the greatest potential for livestock feed production.

Residual effects on long-term lime and P, K, and Mg applications. Yield and nutrient uptake in oats was affected 4 yr after relatively large amendments were made in a field experiment. Unexpectedly, yield of oats (both straw and grain) was reduced by increasing rates of lime. Chemical analyses of plant material showed that uptake of both Mn and Zn were reduced as lime rate increased, which is consistent with literature reports. However, both Mn and Zn concentrations were below critical concentrations for oats in the lime treatments, showing that lime induced Mn and possibly Zn deficiencies.

Only P and K influenced oat yield. These fertilizers increased oat straw production but did not influence grain production. The soil contained adequate levels of Mg; hence Mg fertilization did not influence yield. Residual effects of Mg fertilization were evident in Mg uptake. Potassium fertilization increased P and Zn uptake, but decreased Ca and Mg uptake. Phosphorus fertilization increased Ca uptake.

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Research Station

Kamloops, British Columbia

PROFESSIONAL STAFF

A. McLEAN, B.S.A., M.Sc., Ph.D.	Acting Director; Range ecology
K. BROERSMA, ¹ B.S.A. (Agr.), M.Sc.	Forage management
W. MAJAK, B.Sc., M.Sc., Ph.D.	Plant biochemistry
D. A. QUINTON, ² B.S., Ph.D.	Range science
D. G. STOUT, ³ B.S.A., M.Sc., Ph.D.	Plant physiology
A. L. VAN RYSWYK, B.S.A., M.S.A., Ph.D.	Soil science

Departures

D. E. WALDERN, ⁴ B.S.A., M.Sc., Ph.D.	Director; Beef cattle nutrition
W. K. DAWLEY, ⁵ B.S.A.	Director

¹Appointed January 1978.

²Appointed September 1976.

³Appointed August 1977.

⁴Transferred to Western Region Office, June 1978.

⁵Appointed June 1978; deceased August 17, 1978.

INTRODUCTION

The research efforts of the Research Station at Kamloops are directed towards solutions of problems in range and beef cattle management and forage crop production. Construction of a range drill that can successfully and economically seed depleted ranges will result in greatly increased forage production on many of our rangelands. After 6 yr of study on the interaction between deer and cattle it has been concluded that the degree of competition between the two ungulates was less than expected. In most cases, it should be possible to adjust cattle grazing patterns to accommodate deer. Eight years of study of competition between tree reproduction and seeded grasses on clearcut-logged areas and effects of grazing on these areas demonstrated that both quantity and quality of forage could be greatly increased. Also, under proper grazing management, damage to lodgepole pine and spruce was slight. Research at Kamloops has established that saponins are not a factor in pasture bloat from alfalfa. Rather it appears to coincide with high concentrations of particulate matter in the rumen. We have concluded that the concentration of toxin in timber milkvetch is affected by rainfall patterns, amount of light penetrating the forest canopy, type of range habitat, and growth stages of the plant.

It was with deep regret that we marked the untimely death, on August 17, 1978, of our Director, W. K. Dawley. Although he had been with us less than 2 mo, he had already had a positive impact on our research program and proved to be a popular personality.

Further information can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, 3015 Ord Road, Kamloops, B.C. V2B 8A9.

A. McLean
Acting Director

BEEF CATTLE MANAGEMENT

Level of feeding pregnant range beef cows

During three winters, pregnant cows were fed good-quality alfalfa-grass hay at either 100, 75, or 60% of the levels recommended for this class of stock by the National Research Council (NRC). The objective was to determine if the amount of hay fed wintered pregnant cows could be reduced and by how much, without affecting cow vigor, calving ease, cow health, calf mortality, calf birth weight, calf vigor, conception rates of cows, and fall weaning weights of cows and calves.

Cows were turned on spring grassland range in mid-April and were moved to forest range from June until late October when calves were weaned. The same cows were fed at the same wintering levels during three consecutive years. Performance of cows wintered at 75% of the roughage dry matter recommended by the NRC was equal to that of cows wintered at 100%. Cows wintered at 60% gave birth to slightly lighter calves which weighed less at weaning than calves from cows fed at 100% of NRC's recommendations. A 60% feeding level would be

acceptable in a year of short forage supply; however, as the low level is continued in subsequent winters, conception rates are lowered, calving interval extended, and late light-weaning calves are produced.

Processed wood waste as roughage for beef cattle

Feeding and digestion trials were conducted with yearling cattle fed steam-cooked and acid-treated softwood waste (AWW). The softwood waste was a mixture of hemlock, fir, balsam, and spruce sawdust, mixed with corn silage at 0%, 22%, 39%, and 54% of the total dry matter intake. Daily gains were: 0.8, 0.64, 0.23, and 0.1 kg for the groups fed 0, 22, 39, and 54% acid wood waste, respectively. Feed required per unit of gain increased as the amount of wood added to the diet increased. Digestibility of the AWW dry matter in all mixed rations was low, averaging only 31%, accounting for the reduction in gain and poor feed conversion as the level of AWW feed was increased. The data indicate that much of the energy in the AWW was not readily available to cattle, and use of the product is not practical under present processing methods.

Steam-processed aspen poplar wood (PPW) has been used as a roughage source for feeder cattle but not as a major roughage source for wintering pregnant cows. Preliminary digestion trials were conducted to determine the nutritive value of PPW when fed to pregnant long-yearling heifers at 20, 40, 60, 80, and 85% of the total feed intake as a replacement for native meadow hay. A mixture of soybean meal and urea was used to balance protein requirements. Dry matter intakes of the animals used in the digestion trials were below normal at 1.4–1.6 kg/100 body weight. Dry matter digestibility of the meadow hay averaged 54% while that of the processed poplar range was between 30 and 41%. In vitro digestibility data indicate that the true value approaches 56%.

PLANT BIOCHEMISTRY

Toxic cyanogens in Saskatoon serviceberry and arrowgrass

A survey was conducted to determine the fluctuations in the concentration of prunasin, the cyanogenic glycoside in Saskatoon serviceberry. Shrub samples were collected over a 12-mo period from various locations and different parts of the shrub. We confirmed that prunasin is the cyanogen in chokecherry and that triglochinin is the cyanogen in arrowgrass.

Causes of alfalfa bloat

Trials have established that there is no significant difference in the bloat potential between high and low saponin alfalfa cultivars. Previous workers have implicated saponins on the basis of their toxic and foaming properties. We have shown, however, that the incidence of bloat coincides with high concentrations of chloroplast particles in the rumen. Suspended particulate matter in the rumen fluid may serve as a matrix for trapping gas bubbles and the entrapment of gas is the primary cause of foamy bloat. Our results suggest that the rapid rate of alfalfa fragmentation in the rumen generates the high particle concentration to trap the gas in legume pasture bloat.

Alkaloids in Reed canarygrass

It now appears that soil moisture stress is a major factor controlling alkaloid levels in Reed canarygrass (RCG). When RCG was

grown on Organic meadows where moisture stress was virtually absent, exceptionally low concentrations of gramine, hordenine, and 5-methoxy-*N*-methyl tryptamine were observed during 1976–1978. When RCG was grown on upland alluvial soils, a dramatic increase in alkaloid concentration was observed. If the moisture stress on alluvial soils was enhanced by minimizing irrigation and increasing fertilizer application rates, exceptionally high alkaloid levels were induced, approaching 1% of the forage dry weight. Ruminants grazing RCG can be debilitated when the RCG alkaloid level exceeds 0.3%. The levels generated in our experiments have greatly exceeded this value.

RANGE FORAGE PRODUCTION

July grazing of pinegrass critical

Pinegrass is the most important grass on summer range in the southern part of British Columbia. It provides over one-half the weight of forage for cattle in the Douglasfir and spruce-subalpine fir zones. Pinegrass has fibrous roots, 1.5–5 cm below the mineral soil surface, with small clumps or crowns in the duff layer. The clumps are easily pulled out, at certain times, by grazing cattle. Pinegrass begins growing early in May and goes into summer dormancy by early August. Regrowth takes place in late August to early September depending on timing of fall rains.

It is important to know how much grazing pinegrass can tolerate and when it is most susceptible to grazing. Clipping trials near Kamloops demonstrated that 1 yr of heavy grazing (clipping to 5 cm) decreased the yield and vigor of pinegrass significantly. The effect appeared to be less in years of high rainfall and/or cool weather than those with either low rainfall or hot weather. Environmental conditions and/or previous grazing strongly influenced plant response to foliage removal.

The most severe treatment involved clipping every 2 wk at 5 cm height from June 1 to September 15. The greatest amount of damage was done to those plots that were clipped throughout July, near the time growth stops for the summer regardless of when clipping started or stopped. These preliminary results suggest that pinegrass is best grazed either from mid-July to fall or during June and again in fall if necessary. Fields that must be grazed throughout July

should be rested during that period the following year. Rotational grazing appears to be as important on pinegrass range as it is on bluebunch wheatgrass range.

Improved range seeding equipment

Seeding depleted British Columbia rangeland to grasses and legumes has always been difficult because there were no machines that could till and seed this type of rangeland effectively. The Agricultural Engineering Branch, British Columbia Ministry of Agriculture, in cooperation with the Kamloops Research Station has developed machines that will do a thorough job of shallow tillage on undulating topography containing significant amounts of rocks or shrubs such as that found on our rangelands.

This equipment has two basic units: a flexible heavy-duty double offset disc for control of vegetation and soil tillage, and a free-floating seeder-packer to compact the soil and place the seed accurately in the soil. The two units are pulled in tandem for a once-over operation.

The unique feature of the offset disc is the floating gang design. Each 3.6 m gang is made up of four individually suspended subgangs. The subgangs are controlled and loaded by a hydraulically operated cylinder. The seeder-packer consists of two sets of rollers each with four sections. Each section is individually suspended from the frame to provide ± 0.3 m vertical displacement. Seed is broadcast between the rollers. A D6C crawler tractor has adequate power to propel the 9072 kg disc and 6350 kg seeder-packer except on severe slopes where a late-model D7 or equivalent crawler tractor should be used.

Interaction between mule deer and cattle on summer range

In a study of competition between deer and cattle for food on summer range, both ungulates showed a high preference for clover, willow, and fireweed. When the availability of these forages was not limited, the percentage of diet overlap was high. As the availability of these forages declined, diet overlap decreased since both deer and cattle were forced into their individual food niche. For cattle the niche was grass while for deer it was shrubs. The effect of declining availability of preferred forages on the diet composition was less for deer than for cattle.

WEED CONTROL

Knapweed invades range in good condition

Stands of six grasses were tested for diffuse and spotted knapweed invasion and seedling establishment and were found susceptible to invasion. Bluebunch wheatgrass (*Agropyron spicatum*) was the most susceptible species.

Preliminary results of knapweed invasion into native stands of bluebunch wheatgrass indicate that this grass, even under good range conditions, offers little resistance to knapweed invasion. Diffuse and spotted knapweed growing at moderate densities among bunchgrass was more vigorous than when growing alone. Inhibition of the bunchgrass may not occur until threshold densities of knapweed are reached.

Insects that destroy the seed of knapweed will not control knapweeds unless all seeds are destroyed for a number of years. The released insects (*Urophora affinis* and *U. quadrifasciata*) are not able to destroy more than 80% of the seed in any one year. This alone will not bring about knapweed control.

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Research Station

Sidney, British Columbia

PROFESSIONAL STAFF

Administration

J. M. MOLNAR, B.S.A., M.Sc., Ph.D.	Director
D. D. JONES	Office Manager
M. A. WATSON, B.A., M.Lib.	Librarian

Horticultural Crops

R. G. ATKINSON, B.S.A., Ph.D.	Plant pathology
R. E. HARRIS, B.S.A., M.S.A., Ph.D.	Plant physiology — Tissue culture
W. C. LIN, B.S., M.Sc., Ph.D.	Plant physiology — Ornamentals
N. V. TONKS, B.S.A., M.S.	Entomolgy
D. R. BERTOIA, ¹ B.S.A.	Officer-in-Charge, Post Entry Quarantine Station
C. M. POLLARD, ¹ B.S.A.	Post Entry Quarantine Station

Extension Services

G. S. EMMOND, ² B.S.A., M.Sc.	Greenhouse and Vegetable crops
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Departures

H. ANDISON, B.S.A. Retired December 1976	Director
R. M. ADAMSON, B.A., B.Sc., M.Sc. Retired August 1977	Weed control and vegetables

¹Food Production and Marketing Branch.
²British Columbia Ministry of Agriculture.

INTRODUCTION

The Saanichton Research Station, Sidney, is the ornamental and greenhouse vegetable center for British Columbia, and most of the Station's programs are oriented to solving problems and giving direct service to the ornamentals and vegetable industry.

Emphasis in research is being given to nutritional and physiological problems in floriculture; plant propagation, postrooting development, and long-distance shipping of plants for the nursery industry; the eradication of viruses and rapid multiplication of grapes and ornamentals by tissue culture; and the control of pests and diseases in vegetables and ornamentals.

The Post Entry Quarantine Station, a joint venture between the Food Production and Marketing Branch and the Research Branch, made a significant contribution to Canadian agriculture.

Requests for information or publications should be addressed to the Saanichton Research Station, Research Branch, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

J. M. Molnar
Director

ORNAMENTALS

Alstroemeria. The Peruvian lily is native to South America where it is used as a garden perennial. The new hybrids developed in Europe have received a great deal of interest as a possible cut flower for greenhouse production. Six new cultivars are being evaluated to determine their commercial feasibility under Canadian growing conditions. Cultivars are tested for their response to day length and temperature in order to control flowering periods.

Growth and flowering of geraniums. Sixteen cultivars of seed geraniums (*Pelargonium hortorum*) were sown February 13, 1978, and 2 wk later transplanted into 7.5 cm pots containing either peat-vermiculite (PV 1:1) or soil-peat-vermiculite (SPV 1:1:1). Half the plants received 4600 lm for 16 h from high-pressure sodium (HPS) lamps while the other half were grown under natural daylight. On June 1, plants grown on PV 1:1 were 32.0 cm tall and 27.1 cm in diameter compared to 29.6 and 24.6 for plants grown in SPV 1:1:1. Media had no effect on blooming while HPS advanced flowering but had little effect on plant size.

Accelerated growth of ornamental plants. Studies were initiated in the greenhouse to examine the possible use of supplementary lighting and CO₂ enrichment to accelerate the growth of woody ornamental plants.

High-pressure sodium (HPS) and low-pressure sodium (LPS) lamps providing 4600 and 5500 lm, respectively, were used from 4 a.m. to 8 p.m. daily. Whenever the ventilation was closed, CO₂ was maintained at 1000–1300 ppm between 4 a.m. and 7 p.m. Treatments of light and/or CO₂ were given from late January 1978 to early May 1978 and again in late October 1978. A minimum night temperature of 15.5°C was maintained.

Different responses have been observed with various species or cultivars. Vegetative growth was primarily increased with lighting, alone or combined with CO₂. Carbon dioxide alone had little or no effect. In 10 months *Picea glauca* with HPS lamps was 72% wider and 35% higher than the control. *Pseudotsuga menziesii* with HPS lamps produced more new shoots (3.3 vs. 0.6) and the total length of the new shoots was greater (26.5 vs. 3.9 cm) than for the control in 3 mo. *Ilex aquifolium* 'Golden Queen' with HPS lamps produced more new shoot length per plant than the control in 2 mo (28.3 vs. 15.5 cm). Fuchsia plants produced more fresh weight (56%) and dry weight (46%) than the control in 2½ mo. Little or no response to treatments was observed with *Pinus mugo*, *Skimmia* sp., *Viburnum davidii*, and *Rhododendron* spp. after 10 mo.

Control of black vine weevil larvae. Soil drenches of acephate, diazinon, malathion,

methoxychlor, naled, and permethrin controlled early-instar black vine weevil larvae on container-grown fuchsia. Granule applications of a 10% medium, or a fast release acephate on the soil surface, also gave good control. However, malathion and naled soil drenches and acephate granules provided less than 4 wk of residual control.

Winter moth control on apple. The presence of winter moth in heavy infestations on southern Vancouver Island was confirmed in 1977. Sprays of permethrin, acephate, diazinon, malathion, endosulfan, methoxychlor, Imidan (Chemagro), and naled applied once in the tight cluster bud stage on apple gave effective temporary control of larvae. However, considerable defoliation occurred in most treatments from late hatching and from ballooning larvae from adjacent heavily infested trees. One exception occurred with permethrin, where no defoliation occurred following one spray application.

Dimilin spray applied at the pink bud stage also gave effective temporary control, but there was considerable defoliation from later reinfestation.

TISSUE CULTURE

Basic procedures for in vitro propagation of 12 grape genotypes, Mazzard F12/1 cherry, *Pieris* cv. Mountain Fire, *Arctostaphylos* spp., *Amelanchier alnifolia*, *Fuchsia* cv. Swingtime, and tuberous begonia, have been developed.

Cultures are prepared from 0.5 cm² leaf sections of begonia and 0.2–0.4 cm long shoot tips of all other plants. After an initial period on a medium solidified with 0.7% agar the explants are transferred to liquid medium in flasks or sealer jars. Two devices, one to tilt the flask and the other to roll the sealers, were designed and built by Station staff. The tilting and rolling ensures that the medium is being mixed and that the explants are alternately submerged in the liquid and exposed to the air. After proliferation starts, it can be continued for 6 mo or more by reculturing the proliferated shoots on new media at intervals.

Amelanchier alnifolia. Rapid bud proliferation was obtained on Murashige's minimal organic medium (Mmo) with naphthalene acetic acid (NAA) at 0.1 mg/L and N⁶ benzylamino purine (BAP) at 4 mg/L.

Arctostaphylos sp. Optimum proliferation occurred on a modified Gamborg B5 medium with BAP at 3 mg/L and rooting was highest on one-third strength B5 with indoleacetic acid (IAA) at 1.0 mg/L.

Begonia, tuberous. Leaf sections of 62 of the 84 selections cultured proliferated moderately to heavily on three-quarters strength Mmo with either N⁶ isopentyl amino purine (2iP) at 22 mg/L or BAP at 5 mg/L. Rooting of the dissected shoots was promoted when the cytokinins were omitted and IBA at 0.3 mg/L was added to half-strength Mmo medium.

Cherry, Mazzard F12/1. Shoot tips proliferated readily on half-strength Mmo with 2iP at 15 mg/L and NAA at 0.01 mg/L or on a modified B5 medium with BAP at 3 mg/L. The addition of sodium orthophosphate (170 mg/L), adenine sulfate (80 mg/L), and phloroglucinol (162 mg/L) increased rate of proliferation.

Fuchsia cv. *Swingtime.* Shoot tips were established and grown on B5 agar medium for 2 wk and then transferred to liquid B5 medium with 2iP or BAP at 5 mg/L. After 4 wk the cytokinin was omitted to promote shoot elongation, and NAA at 0.5–1.0 mg/L was added for rooting. A 50-fold increase was obtained every 4 wk after initial establishment on liquid medium.

Grapes. Fifteen genotypes have been established on proliferating medium and considerable differences in response have been found between genotypes. Baco is capable of producing 100 000 plants in 6 mo from one shoot tip cultured on three-quarters strength Mmo with BAP at 2–4 mg/L and rooted in one-third strength Mmo with IAA at 0.3 mg/L. Other genotypes produce masses of buds on the above medium but the buds do not develop into shoots. Different rooting requirements are also indicated in other genotypes.

Pieris cv. *Mountain Fire.* Moderately rapid proliferation was obtained on a Mmo medium in which the ammonium nitrate was increased to 2000 mg/L and the potassium nitrate reduced to 9500 mg/L, and to which 2iP at 25 mg/L was added. Limited rooting occurred on two-thirds strength Mmo with IAA at 0.3 mg/L.

VEGETABLE CROPS

Micronutrients in the soilless culture of greenhouse tomatoes and cucumber. The yields and growth of Vendor tomato and Long English cucumber were not affected by the concentration (10, 33, 67, and 100% of normal) of a standard commercial mixture of micronutrients containing 3.5% Mn, 0.1% Cu, 5% Fe, 0.4% Zn, 0.33% Bo, and 0.06% Mo. There was no evidence of deficiency or toxicity symptoms but at the highest concentration of micronutrients the amount of Mn and Bo in the leaf tissue increased and Cu, Fe, and Zn decreased. The increase in Mn was 127% and 78% and in Bo 79% and 48% for tomatoes and cucumbers, respectively.

High temperature effects on greenhouse tomatoes in a soilless medium. Exposure of Vendor tomatoes to a 36°C day and 21°C night temperature for 1 wk caused abortion of flowers on three to four trusses and the elongation of the style on other flowers that were formed after the high temperature treatment. The elongated style placed the stigma outside the antheridial cone and the flowers either did not set or produced parthenocarpic fruit.

Biological control of twospotted spider mite. Early and repeated release of the predator (*Phytoseiulus persimilis* Athias-Henriot) on young cucumber plants in a commercial greenhouse provided satisfactory season-long control. Late predator releases on heavily infested mature plants eventually controlled mites, but large areas of intolerable damage occurred. Predators released in a heavily infested succession planting trial controlled mites within 6 wk, but all the first-crop plants and part of the second crop were heavily damaged. However, the third crop was clean.

During 1978, a cooperative trial was conducted with two growers to assess the effectiveness of grower-managed predator releases. Both growers reported localized outbreaks of mites during the season, but both obtained effective control with multiple releases of predators, without recourse to insecticides.

Cooperative rearing program for greenhouse biological agents. During 1978 a cooperative rearing program was initiated with the B.C. Ministry of Agriculture to rear predacious mites and the whitefly parasite, *Encarsia formosa* Gahan. The objective is to supply these biocontrol agents in quantity for

commercial greenhouse vegetable growers in British Columbia.

Black root rot of greenhouse cucumbers. In previous experiments two 100-ppm (active ingredient) drenches of Benlate 50 WP 2, 3, or 4 wk apart nearly always prevented infection of long English cucumbers grown in soil infested with *Phomopsis sclerotoides*. Four drenches at 25 ppm were less effective. In recent experiments, few or no plants became infected when two drenches of 50 ppm Benzate 50 WP were applied 28 days apart. In the few plants which became infected, the symptoms were mild. A single 50 ppm drench did not consistently reduce either the incidence of infection or the severity of the symptoms.

Two drenches, 28 days apart, or a single drench with Cercobin Methyl 70 WP at 50 ppm were less effective in reducing infection and severity of symptoms than similar drenches of Benlate.

POST ENTRY QUARANTINE STATION

In 1978, 85 tree fruits, 93 grapevines, and 116 audit samples were received from foreign and domestic sources for indexing. In one shipment from Denmark, Little Cherry Virus was found in two sweet cherry cultivars, and Necrotic Rusty Mottle, Necrotic Ring Spot, and Raspleaf viruses were detected in other cultivars. In total, 50% of the uncertified tree fruits and grape plants received from all sources were infected.

Sixty-seven tree fruit accessions, of which 37 were heat-treated, and 55 grapevines were indexed clean and released. Most of the releases will be included in the National Repository for distribution to research stations, budwood schemes, and other parties. The repository now contains a total of 473 tree fruit and 164 grape cultivars. Budwood of 292 tree fruits and 155 grape cultivars was distributed in 1978.

The ELISA method for Necrotic Ringspot virus was introduced into the indexing program through the assistance of the Vancouver Research Station.

Three of the four grape host indicators were indexed in controlled growth chambers which duplicated field conditions and induced early virus symptoms. One more year is needed to evaluate the method and ensure reliability.

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Summerland, British Columbia

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INTRODUCTION

The research programs at the Research Station, Summerland, are concerned with all aspects of production, protection, and utilization of tree fruits and grapes. A substation at Kelowna, an experimental area at Creston, and numerous off-station sites are used for field research in pomology, soils and irrigation, plant pathology, and entomology.

In studies of little cherry disease two potential vectors were identified. A new type of dehydrated fruit product, fruit nuggets, was developed. High-quality fruit sauces for flavoring yoghurt were prepared which have a high potential for domestic and export markets. In 1978 a total of 520 ha of apples and pears in the Similkameen Valley came under the codling moth sterility program with results equal to or better than chemical control. Control of San Jose scale by control of adult males at petal fall has been as effective as methods of control at the crawler stage. Fertilizer experiments showed that practices need not be altered under trickle irrigation compared to conventional irrigation. A method to align asparagus spears so that all spears point in the same direction for ease in trimming and packing has been developed. A self-balancing 40-can demonstration model of a circular oscillation can agitator was constructed and tested with asparagus puree and cream-style corn. Five new grape selections were named and introduced: Sovereign Rose, Sovereign Coronation, Sovereign Charter, Sovereign Noir, and Sovereign Tiara.

This report contains highlights of our research during 1977–1978. Detailed information and reprints of published papers are available on request from Agriculture Canada, Research Station, Summerland, B.C. V0H 1Z0.

G. C. Russell
Director

ENTOMOLOGY

Control of codling moth by mass release of radiation-sterilized moth

Codling moth control by release of sterile (35 krad dose) moth was continued in 520 ha of apples and pears. Approximately 12 500 sterile moths per hectare were released during the first brood and 20 000 in the second. At harvest, no codling moth damage was found in 101 commercial apple orchards, less than 0.1% damage in 10, and 0.2–0.3% damage in five orchards.

The codling moth population increased slightly in a semi-isolated 32 ha apple orchard that received no sterile moths or other control measures since 1976. The percentage of damaged fruit at harvest increased from 0 in 1976 and 1977 to 0.005 in 1978. These results indicate that if codling moth populations are brought close to extinction, and the orchards are isolated from outside sources of reinfestation, control measures can be omitted for the next 2 or 3 yr.

Control of codling moth by elimination of males by using sex pheromone traps

Several years of data from three orchards differing in degree of initial population density and isolation from outside sources of reinfestation indicate that under conditions of low populations and isolation, male removal alone is an effective method of codling moth control.

Chemical control of codling moth

Diflubenzeron at 0.14 kg/ha, trichlorfon at 1.9 kg/ha, and azinphos-methyl at 0.75 kg/ha (active ingredient basis) were compared in a three-spray program for control of codling moth and fruit-tree leafroller. Diflubenzeron and azinphos-methyl gave good control of codling moth. Control by trichlorfon was poor. Leafroller control was acceptable with azinphos-methyl and trichlorfon, but not with diflubenzeron.

San Jose and European fruit scale

In 1977, 200 second Neutrol oil applied in the delayed dormant period to control overwintered San Jose scale nymphs followed by diazinon at petal fall to kill adult male scales

was as effective as a delayed dormant oil spray plus two or three applications of diazinon in June and July against the crawler stage. In 1978, diazinon at petal fall was as effective as 200 second Neutrol oil applied at the 1.25 cm green-bud stage.

Emergence of adult European fruit scale was observed to occur significantly earlier than the San Jose scale males, and to continue for a longer period. Diazinon applied at the pink bud stage gave good control of European fruit scale and was as effective as 200 second Neutrol oil applied at the 1.25 cm green-bud stage.

Orchard mites

Of the five fungicides used for powdery mildew control on apple, only quinomethionate gave good control of European red mite. Dinocap did not cause an increase in the red mite population density as did wettable sulfur, thiophanate-methyl, and especially benomyl. Benomyl was highly toxic to the mite predator, *Typhlodromus occidentalis*.

Pear psylla

Dormant oil, 67.4 L/ha, applied prior to the start of oviposition by overwintered pear psylla followed by permethrin, 0.83 kg/ha, after migration of adults back to pear trees from overwintering sites was complete and gave outstanding early-season control. Fenvalerate gave excellent control of overwintered adults at rates as low as 0.03 kg/ha. In summer sprays, fenvalerate at 0.14 kg/ha provided an excellent control of pear psylla nymphs and adults plus good control of pear rust mite.

Little cherry disease vector studies

The evidence shows that the apple mealybug is a vector of little cherry disease. In 1977 and 1978, 22 and 19% of Sam variety trees tested with apple mealybug developed early red-leaf symptoms indicative of little cherry disease transmission. Buds from positive trees grafted onto mature Lambert trees in September 1977 induced little cherry fruit symptoms in Lambert fruits in 1978. In 1977, two of 18 trees tested with the plum rust mite developed red-leaf symptoms but buds from these trees did not induce fruit symptoms on Lambert. From 1974 to 1978, over 2500 tests with 40 other species, primarily leafhoppers, aphids, and mites, were all negative.

Peach pests

Sex pheromone traps were highly effective for scheduling pesticide treatments for control of peach twig borer. Timing spray applications at peak emergence of moths by trap catches resulted in fruit injury at harvest of 0-1.2% in 1977 and 0% in 1978. Sprays timed according to calendar dates resulted in fruit injury of 0-80.0% in 1977 and 0-9.9% in 1978.

Grape pests

For control of the grape erineum mite, lime sulfur sprays applied 2 wk prior to the woolly-bud stage were more effective than applications at the woolly-bud stage. Against the Virginiacreeper leafhopper, single treatments of carbaryl at 0.28 kg/ha, azinphos-methyl at 0.28 kg/ha, and permethrin at 0.20 kg/ha gave equivalent and highly effective control.

Pesticides

Orchard workers were monitored in 1977 and 1978 for indication of pesticide exposure. Urinary alkyl phosphates were in all cases low or nondetectable, but a positive relation was indicated between their appearance in urine samples and degree of pesticide exposure of the donors. Electromyogram and blood cholinesterase determinations were all within normal ranges but individual variations did not correlate well with degree of pesticide exposure.

FOOD PROCESSING

Apple juice color

The relationship of various objectively measurable factors to quality (as indicated by taste panel ratings) in commercial apple juice color was investigated. No significant correlation was found between taste panel rating and any of the following factors: color, pH, total acid, refractometer reading (i.e. total solids), or hydroxymethyl furfural content. Juice made from fresh apples was significantly better than that made from reconstituted concentrate.

Aspartylphenylalanine synthetic sweetener

Aspartylphenylalanine (Aspartame) is a material with approximately 200 times the sweetness of sugar. It has the disadvantage of

being rather heat sensitive. Tests using Aspartame as a sweetener in low-calorie fruit spreads show some promise. Considerable sweetness is lost during the filling and cooling operation; however, storage at cool temperatures appears to allow a suitable shelf life.

Improved apple aroma concentrator

The capacity of a pilot vacuum aroma-concentration column has been increased by a factor of two by installation of an improved design of vapor-liquid separator. The design reduces vapor flow to the column without significantly changing the composition of the product. Analysis of column feed and final 30 000-fold essence concentrate showed the column's recovery efficiency to be approximately 98%.

Apple waxing problems

The problem of a gray, dull appearance developing in some lots of apples coated with carnuba or shellac waxes was studied. Freshly picked, red apples have a dull, gray appearance due to a thin layer of natural waxes covering the skin. By polishing, the appearance of the fruit can be brought to a glossy shine, but the apples continue to synthesize more waxes, and after 1-2 days at room temperature, they again resume a gray, dull appearance. At refrigerated temperatures, about 6°C, the glossy appearance can be maintained for about 1 mo. The fruit-packing industry, however, is obliged by market competition to supply artificially waxed apples, which, if properly coated, stored, and transported, will maintain their glossy appearance for 7 days at room temperature. Recommendations for avoiding problems arising from variable application of coating included development of a technique for measuring the thickness of applied coating and a device for signaling nozzle plug-ups.

Winemaking trials of wine grape varieties

Fifty-three varietal wines were prepared from the 1977 harvest and evaluated chemically and organoleptically. Seventeen of these were also evaluated by a 10-member taste panel from industry and government. The best white wine was selection 5, Aurora × Portland, and the best red was selection 88, Erie × NY33873. Both of these varieties have become available just this year in

sufficient quantity for evaluation and offer considerable promise.

Inhibition of secondary fermentation of wines by potassium sorbate

Recently packaging wine in flexible polyethylene containers created a storage spoilage problem for wineries and retail outlets. Oxygen permeated the plastic walls, oxidized the sulfite preservative to sulfate, and allowed wine spoilage by secondary fermentation. Sorbic acid preservation is sufficient to inhibit many common yeasts and bacteria at the legally permissible level of 200 ppm. A contaminant yeast (*Dekkera* sp.) was isolated from a commercial wine sample containing 200 ppm sorbic acid. In a model wine system, this contaminant grew in the presence of 500 ppm sorbic acid and CO₂ evolution occurred in the presence of 700 ppm sorbic acid. Higher levels of sorbic acid were inhibitory.

Asparagus sorter

A method to align asparagus spears so that all spears point in the same direction for ease in trimming and packing has been developed. The device uses the difference in reflectance to distinguish between butt and tip ends of a singulated line of asparagus spears moving on a conveyor belt. Spears with butt ends first activate an electronic sensing circuit which triggers a jet of air to move the spear into an adjacent lane of travel. Spears with tips forward do not activate the sensor. The result is two separate lanes of spears — one, tips forward and the other, butts forward. A commercial model is under development.

Agitation processing

A self-balancing 40-can demonstration model of the circular oscillation can agitator was constructed and tested with asparagus puree and cream-style corn in the pilot plant. In addition, the model was used for 1 wk in a commercial processing plant to process test runs of cream-style corn.

PLANT PATHOLOGY

Crown rot of apple trees

The numbers of propagules of *Phytophthora cactorum* per gram of soil were low compared to other root pathogens, even in orchards using irrigation water contaminated

with the pathogen, and at sites from which diseased apple trees were removed. The amount of infection in 5-yr-old MM III rootstock with Spartan scions was not increased by severe moisture stress before or after inoculation, and varied little with date of inoculation. Aliette fungicide (aluminum ethyl phosphite) was not as effective as Dexon or CGA 48988 in a soil treatment to suppress *P. cactorum*. Thirteen mycoparasites of *P. cactorum* were isolated from soil. The addition of cultures of some of these hyperparasites to orchard soils reduced trunk infection with *P. cactorum*.

Little cherry disease in British Columbia

A fluorescence microscopic method, which revealed the frequent occurrence of wall deposits in phloem cells of cherry trees affected by the little cherry disease, was not reliable for detecting infection in trees before little cherry fruit symptoms developed. Many trees of the native bitter cherry (*Prunus emarginata*) are carrying the little cherry agent in the Kootenays. Eriophyid mites, insects, pollen, and soil are being tested as possible carriers. There is a suspicion that the disease could be caused by a viroid spread on pruning tools. Several old cherry trees, including the Kootenay Bay Lambert, which remained free from the little cherry disease for many years although growing near diseased trees in the Kootenays, appear to have been fortuitous escapes which are not immune.

Expansion of British Columbia's virus-free tree fruit and grape program

British Columbia's virus-free budwood and grape program differs from other similar Canadian schemes in that its main functions are to serve as a basis for tree certification and to provide growers and nurserymen with budwood and cuttings from as many cultivars as possible. The bulk of the material distributed is obtained from 20 pome fruit and 46 stone fruit cultivars which are free of all known viruses and are certified as to trueness-to-name. Fifteen percent of total sales consist of 76 cultivars which are infected with minor viruses and have not yet been heat treated, or which are of minor commercial importance. These are distributed on a "best available" basis. The program has recently been expanded to include virus-free grape vines.

The program is managed jointly by the British Columbia Fruit Growers' Association, the Association of British Columbia Grape Growers, participating nurserymen, and the provincial and federal ministries of agriculture. Budwood is sold to growers and nurserymen for production of orchard trees, while grape cuttings will initially be distributed for the establishment of mother vineyards only. Demand for budwood has been steadily increasing and reached a high of 900 000 buds in 1978.

Control of postharvest rots of stone fruits

Benlate-resistant strains of *Monilinia* spp. are present in other regions but this fungicide remains effective against "brown rot" in the Okanagan. Benlate does not offer protection against *Alternaria* spp., which cause green mold on cherries, or against *Rhizopus* on peaches. Although initial experiments indicate that there is no immediate threat of a resistance problem, the possibility does exist. Rovral has been effective against both *Alternaria* and *Rhizopus* in laboratory trials and will now be tested in extensive packinghouse trials as a possible replacement for Benlate.

A rapid, semiquantitative biological test was devised to permit packinghouses to check fungicide residue levels on fruit to ensure that adequate coverage is being achieved on the line.

POMOLOGY AND VITICULTURE

Grape selections named

Five Summerland grape selections adapted to Okanagan conditions were named. They are Sovereign Rose, a pink midseason fresh-market or Muscatel wine grape tested as selection 80; Sovereign Coronation, a black seedless midseason fresh-market and juice grape tested as selection 361; Sovereign Charter, a seedless, late blue table grape tested as selection 375; Sovereign Noir, a midseason blue wine grape tested as selection 180; and Sovereign Tiara, a green, midseason to late white wine and fresh-market grape tested as selection 123.

Pollination of self-fertile sweet cherry

Prunus avium L. 'Stella' was shown to be fully self-fertile but bee pollination improved set and yield compared to casual pollination

by wind and gravity. Pollination of individual flowers by their own pollen was at least six times more frequent than by pollen originating from more distant flowers.

Apple rootstocks

A cultivar by rootstock interaction trial involving Harrold Red Delicious, Golden Delicious, Spartan, McIntosh, Tydeman, and Quinte on M 26 and M 7 rootstocks was recently completed. Ten-year cumulative yields of trees spaced 2.45×4.6 m indicate that M 7 is the most productive rootstock for Harrold Red Delicious, Spartan, Tydeman, and Quinte. Golden Delicious and McIntosh performed best on M 26.

Growth regulators affect size, shape, and quality of Spartan apples

Two plant growth regulators, benzyladenine (BA) and gibberellins A_4 and A_7 , were applied in combination in tests conducted in 1976 and 1977. Sprays applied at petal fall increased fruit length but were otherwise ineffective. Sprays applied 1–4 wk after petal fall increased average fruit weight 10–15%, depending on concentration between 20 and 80 ppm of the active ingredients. Fruit quality at harvest was not reduced by these treatments but calcium content (on a tissue dry weight basis) was consistently reduced and in 1977 fruits treated with 25 or 50 ppm of the chemical mixture, 3 days after full bloom, developed more breakdown after cold storage.

Cluster thinning improves quality and stabilizes yield of de Chaunac grapes

Berry quality of de Chaunac wine grapes grown in south central British Columbia is marginal in some seasons and appears to be inversely related to yield. Increasing soluble solids and tannins and reducing juice acidity would improve quality in most seasons. Cluster thinning before bloom to an average of two or less clusters per fruitful shoot increases juice soluble solids and tannins at harvest. Acidity is only slightly reduced by thinning. In tests conducted over four seasons this practice has not appreciably reduced yield in the year of treatment because of improved berry set on the retained clusters. Furthermore, thinning in one season often increases the crop the following season on vines which tend to overcrop.

Endogenous growth substances and heritable compaction in apple

Apple seedlings arising from controlled crosses involving the Wijcik mutant of McIntosh apple segregate reliably into normal and compact growth types. The compact or "spur type" seedlings have shorter, thicker stems; shorter internodes; and a strong upright growth habit. Compact seedlings have less abscisic acid (ABA) per shoot tip but they also have lower levels of several gibberellin-like (GA-like) growth promoters. An examination of seeds arising from crosses involving or not involving McIntosh Wijcik (50% or 0% compact seedlings expected, respectively) showed that all seed lots underwent the same changes in ABA and GA-like substances during stratification. The mechanism of heritable compaction probably does not involve ABA and if gibberellin levels are involved, these differences are manifested some time after seed germination.

Regeneration of apple plants from shoot meristem-tips

Plants of apple were regenerated from proliferating meristem-tips grown on nutrient medium. Only benzyladenine (BA), at an optimum of 5×10^{-6} M, was required for initial growth and development of meristem-tip explants which proliferated shoots at high frequency. Naphthaleneacetic acid (NAA) at 10^{-3} M was used to initiate roots. Plantlets were transferred to a growth-regulator-free medium where roots developed fully before potting. Temperatures below 20°C and high salt concentration decreased rooting efficiency.

Metabolism of ^3H -gibberellin A_4 in relation to flower initiation in apple

Partial defruiting of spur-type Golden Delicious trees at 5 or 21 days after full bloom and/or succinic acid-2,2-dimethylhydrazide (SADH) applied 14 days after full bloom created a gradient in the tendency for "on-year" biennial trees to flower again the next season. The percentage of spurs flowering in 1977, and the rate at which spurs on the same trees converted tritiated gibberellin A_4 (^3H -GA $_4$) to more polar products in 1976, appeared to be positively related. Vegetative growth was in general negatively related to return flowering but was not clearly related to rate of ^3H -GA $_4$ metabolism by the spurs.

Factors associated with surface pitting of sweet cherries

The presence of surface defects, particularly surface pitting, has been the cause of extensive losses in marketing sweet cherries in the last few years. Surface pitting is most difficult to avoid. It is caused by impact or pressure that injures fruit tissue and is complicated by the fact that symptoms are not apparent for 4 or 5 days after tissue damage is inflicted. There are observed seasonal, orchard, and tree-to-tree variations in injury susceptibility which have not been explained. It is apparent, however, that modern packing and handling procedures are contributory factors.

Results of extensive studies in 1977 led to the following conclusions. (1) Substantially more damage occurred to cherries during packing than picking and increasing damage was observed with each handling procedure on the packing line. (2) Packing systems using a cluster cutter and fruit sizer incurred considerably more damage than simple belt packing. (3) Large fruits, fruits with high sugar content, fully mature fruits, and fruits packed while warm were more resistant to surface pitting. Lambert cherries showed less pitting than Vans. (4) Gibberellic acid sprays reduced surface pitting.

Effects of prestorage CO₂ treatments on storage behavior of Golden Delicious apples

A 3-yr study of prestorage CO₂ treatments to British Columbia grown Golden Delicious apples showed beneficial effects on firmness retention but injury from the treatments was often at unacceptable levels. Treatment with 20% CO₂ for 10–14 days was best for firmness retention but injury was high. Lower CO₂ values resulted in little or no injury but had no beneficial effect on firmness. Injury appeared to be related to maturity. Less mature fruit were more prone to surface injury and more mature fruit showed more internal injury.

When British Columbia grown and Washington grown Golden Delicious apples were compared, considerably less injury occurred in the Washington fruit. Susceptibility to injury was not related to skin color, fruit size, soluble solids, titratable acidity, leaf N, K, Mg, Ca, Zn, Fe, or B, or fruit N, K, Mn, Mg, Ca, or Zn. Washington fruits had higher K, Mg, and soluble solids and lower N, Mn, Zn,

and flesh chlorophyll. How, or if, these differences relate to susceptibility to CO₂ injury is not yet known.

SOIL SCIENCE AND AGRICULTURAL ENGINEERING

Trickle irrigation

Flow rates of emitters receiving nonchlorinated water decreased by 29% during the season whereas there was no decrease for emitters using water treated with 50 ppm active chlorine. The high level of filtration currently being recommended may not be necessary if chlorine treatment is used. Intermittant flow did not prevent plugging. Air continuously injected through a venturi into a trickle irrigation system totally prevented plugging. In a larger block, this method was only partially effective in preventing plugging. Effectiveness of this method appears to depend on air/water ratio.

Herbicides for nurseries and first year plantings

In 1st-year trials, promising results were obtained with two residual herbicides applied posttransplant of grape cuttings and irrigated into the surface soil. These two chemicals plus sequential applications control a wide spectrum of nursery weeds germinating throughout the season.

Mobility of residual herbicides in soil columns

In soil columns, recovery of dichlobenil from the silt soil was higher than from the sandy loam but movement of the chemical and its main breakdown product was similar in both sides. Movement of simazine and diuron was greatest in the sandy soil. In all cases, appreciable amounts of chemicals leached beyond the 10 cm depths, hence into the upper root zone of fruit trees.

Rooting of hardwood peach cuttings

The best rooting media for peach tree cuttings were the perlite – peat moss and perlite – vermiculite mixtures. IBA at 4000 ppm gave the highest rooting percentages, but the roots were abnormally short and large. The roots on cuttings treated with 1000 ppm IBA appeared normal. Some basal rot

occurred mainly on cuttings in pure vermiculite and those treated with the commercial hormone preparation.

Lysimeter studies: leaf nitrogen and shoot growth of spur McIntosh

Neither the rates of N application nor the cultivation versus grass cover have shown large or consistent effects. On sandy loam in 1975 and 1977 the higher application of nitrogen showed significantly higher leaf N than the lower rate. In 1976 leaves of the trees under cultivation had significantly higher N than those under grass. On silt loam neither N application nor cultivation had any effect on leaf N. Shoot growth was not affected by nitrogen application rates, or by grass versus cultivation on either of the soil types.

For 12 mo of below normal precipitation (1976–1977) return flows fell to zero, starting again only in the fall of 1977 and only from sandy loam without grass cover. This indicates that 50% level of irrigation (50% of peak rates) is an absolute minimum for most conditions and may be inadequate for prolonged high evapotranspiration.

Application uniformity from undertree sprinklers

In hedgerow plantings sprinklers placed in every tree-row in a triangular arrangement

had uniformity coefficients (CU) up to 30% higher than when placed in every second tree-row in a rectangular pattern. With one exception CU was below the generally accepted level of 85% for 3.5 m row spacing, but was above 85% for sprinkler areas up to 100 m² for 4.5 and 5.5 m row spacings. CU decreased as sprinkler spacing increased.

When uniformity coefficients for the region along tree-rows and the region between rows were calculated separately, values were up to 30% higher than the overall CU. Application rates along tree-rows were as much as two times application rate in the area between rows. This differential in application rates could result in improved water use efficiency.

Harvesting aids

In 1977, a new self-propelled harvesting aid was constructed that was lighter, cheaper, and simpler in operation than were previous models. In harvesting trials in hedgerow plantings of apples and pears, the picking crew picked 15% faster with this harvesting aid than with ladders.

Comparison of spray drift from two airblast sprayers

With an experimental sprayer designed for spraying smaller-than-standard trees, there was much less drift to the atmosphere above the tree than with a conventional airblast sprayer.

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Root maggots; toxicology
Aphid ecology
Berry insects; leafhopper vectors
Soil insects
Stored-product insects

Plant Pathology

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INTRODUCTION

The Research Station, Vancouver, is the national center for plant virus research. Therefore much of this report deals with investigations of the viruses themselves, their mode of transmission, and their interaction with the host plant at all levels; the total plant, the tissue systems, the cells, and the cell organelles.

The report also contains the results of research aimed at helping to solve regional problems in plant pathology and entomology. This function has been strengthened by the recent addition to the staff of a plant bacteriologist, who is working on bacterial problems of potatoes and small fruits.

Brief summaries of current research at the Station were published in 1976 and 1977. The present report combines the results obtained in 1977 and 1978. Requests for details of our research activities, for copies of the 1976 and 1977 reports, or for reprints of any of the publications listed at the end of this section should be made to individual scientists or to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Physical, chemical, and serological properties of viruses in vitro

The action of low levels of trypsin on southern bean mosaic virus particles (SBMV) at pH 8.0 in 10 mM ethylenediaminetetraacetic acid resulted in the degradation of the SBMV coat protein (29 000 daltons) into proteins of 27 600, 26 200, 24 900, and 23 700 daltons. Treatment of SBMV particles at higher trypsin levels resulted in a loss of RNA, a decrease in the diameter of some virus particles, and the formation of smaller particles. The smaller particles sedimented at 30 S and contained a protein of 22 100 daltons; the larger particles sedimented at 60 S and contained two proteins (23 700 and 22 100 daltons). Twelve peptides were isolated from the tryptic digests, and their compositions indicated the cleavage of 63 of the 270 amino acid residues of SBMV protein. These peptides, comprising 23% of the SBMV protein molecule, contained 54% of the strongly basic amino acid residues of the total protein and lacked cysteine, tryptophan, phenylalanine, histidine, and tryptophan. Subtraction of the amino acid analysis of the degraded proteins (23 700 and 22 100 daltons) from that of the virus protein yielded 68 amino acid residues with a composition

similar to the sum of the peptide compositions.

The amino acid composition, behavior in SDS - polyacrylamide gel electrophoresis, and electrophoretic patterns of cyanogen bromide peptides were studied for the protein subunits of different preparations of potato virus X (PVX). The results indicated that the protein subunits of PVX can be partially degraded in the intact virus at the N-terminus by reducing agent-dependent proteases in crude plant sap and by trypsin, and at the C-terminus by reducing agent-independent proteases occurring in some virus preparations.

From sodium dodecyl sulfate (SDS), dissociated carnation ringspot virus (CRSV), RNAs of different sizes were separated by density gradient centrifugation. Preparations of the smaller RNA-2 (0.5×10^6 daltons) were not infectious; preparations of the larger RNA-1 (1.5×10^6 daltons) were only moderately infectious. Mixtures of the two kinds of preparations were very infective. The genetic information controlling irreversible virus particle aggregation and dissociation of virus particles by SDS at pH 5 were contained in RNA-1. Virus-infected tissue contained ds-RNA replicative forms corresponding to RNA-1, RNA-2, and a minor ss-RNA component.

Virus infection

Attempts were made to obtain *in situ* evidence for virus receptor sites on leaf surfaces by chemical, enzymatic, and electron microscopic means. Three different proteases did not affect leaf susceptibility to virus, but preinoculation treatment of leaves with Mg, HCl, NaOH, aldehydes, or HIO_4 did affect infection; and preinoculation treatment with Mg or aldehydes also affected virus inhibition by the inhibitor from carnation. Several of these interactions support the earlier proposed mechanism of virus receptor involvement in virus establishment. Electron microscopy of leaves treated before fixation revealed a close association of the plasmalemma and outer epidermal cell wall and may suggest plasmalemma extensions into the latter.

The virus inhibitory constituents of egg yolk and egg white were investigated in order to establish their mode of action and their physical-chemical properties. Inhibition of virus occurred when egg proteins were applied to test hosts simultaneously with the virus or prior to it. The inhibitory components of egg white were heat stable up to 60° and 80°C, respectively, accumulated in the course of fractionation procedures in the globulin and ovomucoid fractions, and had molecular weights in the range 10 000 – 100 000.

Ultrastructural responses to virus infections

Plants with a C_4 -type photosynthetic CO_2 assimilation were found to produce massive amounts of virus, although the host response was a typical hypersensitive reaction and these plants are characterized by an inherently low photorespiration.

Ultrastructural changes were studied in mesophyll cells of leaf disks of *Nicotiana glutinosa* that were allowed to senesce under continuous light in water or kinetin. In water, swelling of thylakoids was noticed earliest followed by a considerable increase in the size and number of lipid bodies, starch grains, and the "pseudocrystalline bodies" in the chloroplast. Degeneration of membranes and some of the organelles followed these early events. The lipid bodies continued to increase in size until they occupied nearly the entire volume of the chloroplasts. However, the hypertrophied starch grains and the chloroplastic "pseudocrystalline bodies" disappeared during later phases of senescence.

The nucleus, plasmalemma, and outer membranes of chloroplasts appeared to be most resistant to the changes that take place during senescence. Although the tonoplast is most vulnerable to degenerative changes, the thylakoid material seems to undergo extensive rearrangement. Kinetin considerably delayed all these changes as well as inhibited the formation of crystalline bodies in the chloroplast. In addition it induced an increase in rough endoplasmic reticulum and free cytoplasmic ribosomes.

Virus transmission by seed and pollen

Immunodiffusion in gels containing 0.5% sodium dodecyl sulfate, enzyme-linked immunosorbent assay (ELISA), and serologically specific electron microscopy (SSEM) were evaluated for the detection of pea seed-borne mosaic virus (PSbMV) in pea tissues. The virus was detected readily by immunodiffusion of leaf homogenates from single infected plants but not in homogenates from composite samples containing less than 25% PSbMV-infected leaves. In contrast, detection of PSbMV in composite samples of leaves containing 5–10% PSbMV-infected leaves was obtained using ELISA or SSEM. Each of these latter methods also detected the virus in homogenates of seed from a seed lot containing 25% infected seed; levels of 1% seed infection were detected consistently by SSEM.

Aster yellows disease

Several forms of mycoplasma-like bodies (MLBs) were observed in electron micrographs of phloem cells from explants infected with aster yellows disease. The structures were found only in explants 11–25 days old when the degenerating MLBs were first observed. They resembled those described by Anderson and Barile in 1965 for *Mycoplasma hominis*.

In carrot explants infected with aster yellows, MLBs were seen only in the phloem of the primary cultures. During subsequent transfers of the cultures, MLBs underwent gradual degeneration and disappeared within 80 days. Electron microscopy showed three stages of degeneration. In the first stage, which started after about 30 days in culture, MLBs changed from a round to a filamentous shape and became electron opaque. During the second stage, the MLB membrane ruptured and numerous unusual

structures were observed. In the final stage, the MLB particles disrupted and the cells plasmolyzed. Differentiation occurred earlier in infected than in healthy cultures, and the new phloem tissue contained no MLBs.

Little cherry disease (LCD)

A nucleic acid with the staining properties of ds-RNA, which was also resistant to RNase in high salt and susceptible in low salt, was associated with known LCD-infected trees as well as with trees suspected to be infected with LCD. It was not found in leaves of trees not known to be infected with LCD. The correlation between the presence of the RNA and the phloem limited cytopathic structures (vesicles and filaments) that are characteristic of LCD-infected sweet cherry was 100%; no such structures were seen in the phloem of LCD-free trees. The RNA was detected in samples collected biweekly from late May to early September. It could be extracted from frozen tissue as well as from fresh tissue.

To correlate the presence of cellular inclusions in cherry trees experimentally infected with LCD and maintained under greenhouse conditions and fruit symptoms, artificial pollination was attempted. It was found that young artificially pollinated trees at various times of the year produced fruits, which ripened within 8–10 wk after pollination. With 1-yr-old pollen from Stella the efficiency of pollination was 3%, based on 12 trees and about 450 blossoms. Electron microscopy revealed that fruit stems contained all three cellular inclusions, viz. rods, vesicles, and barrels, in large amounts as early as 2 wk after blooming. Therefore fruit stems may be an excellent source for purifying the LCD agent. Despite the large-scale presence of cellular inclusions in fruit stems of the variety Sam, fruits were normal in shape, color, and size, indicating that inclusions may also not be directly responsible for abnormal fruits in other varieties.

PLANT PATHOLOGY

Virology

Little cherry disease. The presence of electron microscopic inclusions in phloem tissues continues to be one of the most reliable laboratory methods for detecting LCD. They consist of three structures, rods, vesicles, and hexagonal tubules, which are

found in petioles, peduncles, roots, and both actively growing and dormant bark. These structures were found in a number of previously unsuspected sources, including several supposedly virus-free F 12/1 understock in a nursery near Langley, B.C. However, the inclusions could not be found in suspected alternate hosts such as plum, chokecherry, Saskatoon, or apple.

Virus identification and characterization.

Lilac chlorotic leafspot virus is a newly recognized virus of the closterovirus group. In *Chenopodium quinoa* and *Phaseolus vulgaris*, it induced ovoid cytoplasmic inclusions 3–4 μm in diameter in phloem parenchyma cells and up to 8 μm in diameter in mature mesophyll cells. The inclusions contained the filamentous virus particles and extensively proliferated endoplasmic reticulum. In immature mesophyll cells the virus particles were associated with endoplasmic reticulum in the cytoplasm.

Hypochoeris mosaic virus was found to have rod-shaped particles usually 120–140 nm long but sometimes 240–260 nm. In *Nicotiana clevelandii* the particles were scattered through the cytoplasm, loosely aggregated in spherical cytoplasmic masses, arranged in regular arrays, or associated with crystalline inclusions. The inclusions were often rectangular, up to 2.3×1.5 nm, and enclosed by membrane. Virus particles were usually found between the crystal and its membrane and rarely within the crystal.

Raspberry. Raspberry bushy dwarf virus, a pollen-transmitted virus, was found in two cultivars in experimental plots. In Skeena it reduced yield and caused crumbly fruit; in Meeker it caused an oak leaf pattern on the leaves. Willamette, the main commercial cultivar, was shown to be immune.

Virus-free potatoes

Virus-free stock plants were developed from infected plants of 29 potato cultivars and seedling selections. The virus-free collection now includes all of the 52 cultivars now licensed for seed certification in Canada and 61 nonlicensed cultivars and seedlings. In 1977 and 1978, 253 tuber samples from the collection were sent on request to growers, potato improvement agencies, and research establishments in all 10 provinces, 10 states, Czechoslovakia, Malaysia, Peru, USSR, and Venezuela.

Comparisons of two or three virus-free clones of each of 10 potato cultivars revealed consistent clonal differences in only one. In three successive years one clone of Norchip produced fewer and larger tubers than two other clones.

Annual surveys of 250 ha of seed potatoes for potato viruses X and S, showed that both viruses are being gradually eliminated from three seed-potato control areas. In the Pre-elite and Elite 1 classes, in which every plant is tested, no infected plants were found in either 1977 or 1978. In the lower classes, in which 250 plants per 4 ha are tested, the results indicated that most of the fields had less than 5%-infected plants in 1977 and less than 2.2% in 1978. Of 31 farms surveyed in 1978, 26 had no infected plants in any class.

Bacteriology

Eighteen serogroups of *Erwinia carotovora*, the soft rot and black leg bacteria, have been established by double diffusion serology. The strains in two groups were biochemically identified as *E. carotovora* var. *atroseptica*; the strains in all other groups were *E. carotovora* var. *carotovora*.

An indirect fluorescent antibody method was developed to identify *Corynebacterium sepedonicum*, the cause of bacterial ring rot. The method was useful as a confirmatory test for the disease.

Crucifers

In 1977 experimental evidence indicated that the herbicides Surflan and Treflan (to a lesser degree) applied broadcast and incorporated by rototilling reduced the incidence of clubroot, *Plasmodiophora brassicae* Wor., in direct-seeded cauliflower. In 1978 the experiment was repeated and enlarged. The results showed that regardless of treatment, Surflan, Treflan, and ammonium hydroxide had no significant effect on diminishing clubroot damage, which was severe in all plots.

Small fruits

Laboratory tests of 61 isolates of *Botrytis cinerea* for fungicide tolerance showed that some were resistant to benomyl at up to 1000 ppm and others to captan at 1000 ppm; none were tolerant to both fungicides. Tolerant isolates were from plants grown in fields with

and without previous sprays of the fungicides, suggesting that tolerance is a natural variation among isolates.

An evaluation of 116 genetically diverse strawberry clones for fruit rot resistance showed that there was little relationship between postharvest resistance to fruit rot caused by *Botrytis cinerea* and that caused by *Rhizopus* spp. Only five clones showed some resistance to both organisms. Fruit firmness was correlated with resistance to *Rhizopus* and *Penicillium* but not to *Botrytis*. As the sugar content increased *Botrytis* resistance in raspberry increased, but *Penicillium* resistance in strawberry decreased. Pectin content had little effect on resistance to *Botrytis* in strawberry but, in combination with fruit firmness, accounted for 32–36% of the variation in resistance to *Rhizopus*.

Strawberry. Totem, the strawberry cultivar released from the British Columbia breeding program in 1971, now occupies about 75% of the strawberry hectareage in British Columbia, and large hectarages in Washington and Oregon. Selection 70-17-12 will probably be named in 1979. It appears to be superior to Totem in most respects and is suitable for either fresh fruit or processing. Selection 70-22-82 is also a candidate for the fresh market. It ripens 10–14 days earlier than Totem and the plants are more virus tolerant than most early cultivars.

Different strawberry selections were shown to influence the fecundity of black vine weevils when adults were fed on foliage from one of seven sources. Weevils feeding on selections BC 70-17-12 or BC 73-9-79 laid significantly fewer eggs than those on the other five sources, and the proportion of eggs that hatched was also significantly lower than on the other sources. The influence of BC 70-17-12 on fecundity is of special interest because this is the most promising of the advanced selections in the program. The other foliage sources in order of increasing number of eggs and increasing number of larvae hatched were: BC 70-22-82, Totem, BC 69-5-34, Shuksan, and BC 70-20R-15.

Raspberry. Three new raspberry cultivars were released from the British Columbia breeding program in 1978. All outyielded Willamette, the main cultivar throughout the Pacific northwest, and are more disease resistant. Each also exceeds Willamette in other respects. Chilcotin has the highest yield, the earliest harvest, and the longest

harvest season; its attractive fruit is especially suitable for the fresh market. Skeena is a multipurpose cultivar with very firm fruit, is suitable for mechanical harvesting, and has smooth, upright canes, which are easily pruned and trained. Nootka fruit shakes off the receptacle very easily and is very resistant to postharvest fruit rot; it is therefore well adapted for machine harvesting.

Raspberry bushy dwarf virus, a pollen-transmitted virus, has been found in 25 of 75 cultivars in the British Columbia red raspberry breeding program. Depending on the cultivar, the virus may reduce yield and fruit size, or cause crumbly fruit or leaf abnormalities. Willamette and Haida appear to be immune.

Blueberry. Three spray applications of difolitan 4F to highbush blueberry at 2.2 kg/ha once a month from early May until early June reduced the incidence of new Godronia canker infections to negligible levels.

Cranberry. Aerial application of triforine 1.9 EC on cranberry at the rate of 1 L per 96 L of water greatly reduced *Monilinia oxycocci* infections and significantly increased yield.

ENTOMOLOGY

Vectors

Little cherry disease. The electron microscopic inclusions characteristic of LCD were found in test trees that had been fed on by mealybugs, rust mite, thrips, and the leafhopper *Keonolla confluens*. The inclusions were also readily transmitted by dodder and could be detected in seedlings 90–125 days after attachment of the dodder to the seedlings. Transmission by such a wide spectrum of vectors suggests possible contamination of test trees during propagation or by natural vectors in field plots.

Morphology and fine structure. The mouthparts of possible vectors of little cherry disease were studied by scanning and transmission electron microscopy. The stylets of the apple mealybug, *Phenacoccus aceris* (Signoret), have the same basic structure previously reported for aphids and leafhoppers. The two pairs of stylets form a compact bundle. The inner faces of the maxillary stylets lock together in a complex fashion forming a large food canal and a smaller

salivary canal. A central duct containing three dendrites runs from the base to the tip of each mandibular stylet. Each maxillary stylet also contains a cavity; we are not yet certain whether or not they contain nerves. There are six or seven more or less concentric, curved, barblike ridges on the outer surface of each mandibular stylet near the tip. The mouthparts of the eriophyid mites *Diptacus gigantorhynchus* (Nalepa) and *Aculus fockeui* Nalepa & Trouessart consist of an inner pair of auxiliary stylets surrounded by a pair of interlocking cheliceral stylets that are enclosed within a cheliceral guide protruding from the rostrum. *D. gigantorhynchus* has very long mouthparts and a sucking pump similar to that of aphids.

Further studies of the labium of the leafhoppers *Colladonus geminatus* (Van Duzee), *Fieberiella florii* (Stal), *Macrosteles fascifrons* (Stal), and *Scaphytopius delongi* Young revealed several types of sensilla. These included tactile hairs, thick-walled chemoreceptors with a single terminal opening, thin-walled chemoreceptors with walls perforated by small openings, sensory hairs containing two lumina with dendrites, and grooved or stellate hairs or scales.

Aphid survey. Thirty-one species of aphids were added to the catalog of the aphids of British Columbia; 288 aphid-host plant associations were added to the host records. The number of aphid species now known in British Columbia is 311, collected from 581 different host plants.

Alate green peach aphids were trapped in yellow pan water traps to help set the date for top killing of potatoes being grown for seed.

Aphid ecology. A population dynamics model of cereal aphids was developed from laboratory-derived data on fecundity and mortality as a function of aphid age. This model, which was used to simulate observed changes in aphid densities in field plots of oats and barley in 1977 and 1978, mimics the early season's rapid increase of aphid numbers when natural mortality is low but not later when natural enemies inflict heavy mortality.

A similar model for the cabbage aphid on Maris Kestrel forage kale accurately mimics the entire season's pattern of aphid densities in field plots.

The hunger level of individual ladybeetles was assessed throughout the summer along

with their densities and the density and distribution of pea aphids in alfalfa. A relationship between these factors and the rates of aphid increase and beetle dispersal was found that may eliminate the need to obtain greater accuracy in estimating beetle densities. This should be applicable to many other pest management situations.

The check lists of British Columbia aphids, their host plants, and the hosts of barley yellow dwarf virus and three strawberry viruses were keypunched. A FORTRAN program was written to determine the possible role of native plants and their aphids in the 'flow' of viruses from them to cultivated crops. Early runs of the program strongly suggested that aphids of wild plants are as important as the normally accepted pest species of aphids in promoting plant virus outbreaks.

The model of the population dynamics of pea aphids on alfalfa accurately simulates spring and early summer densities as affected by temperature and ladybeetle predation. It simulates the summer patterns very poorly because the impact densities and voracities of a large assemblage of predators is not known. In 1978 the role of emigration and immigration by this assemblage was assessed by periodically placing cages 6×6 m by 1 m high over parts of a field. The aphid density always rose and when the cage was removed the density declined due to the influx of predators.

Aphid vector - virus relationships. Both potato leaf roll virus (PLRV) and pea enation mosaic virus (PEMV) particles have been found by electron microscopy in the honeydew from viruliferous *M. persicae*. Similar particles were observed in the honeydew of *M. persicae* that fed on a purified preparation of PLRV through a membrane. There were no apparent differences in relative growth rates between nonviruliferous aphids and those carrying either PLRV or PEMV. However, the virus-free mothers produced significantly more nymphs. In aphids doubly infected with PLRV and PEMV there was a reduction in the transmission rates of PLRV but not of PEMV.

Pest control

Leatherjackets. Populations of the leatherjacket *Tipula paludosa* Meigen have increased for three consecutive years in the lower Fraser Valley, but chemical control has

seldom been required. Damaging populations of this pest did occur in Victoria and Port Alberni. Most of the leatherjackets from the lower Fraser Valley were heavily parasitized with up to five species of Protozoa; at Victoria and Port Alberni only three species were found. The introduced tachinid fly *Siphona geniculata* is well established, but the level of parasitism remains low, about 4% by each of the two generations. No *Tipula iridescent* virus was found in leatherjackets in the area where it was introduced in 1974 and 1975.

Weeds. Larvae of *Longitarsus jacobaeae*, a flea beetle that attacks the poisonous weed tansy ragwort and first released at two sites in British Columbia in 1972, were found in 40% of the roots examined at Nanaimo and 32% of those in Abbotsford in 1978. Adults were collected in October 1978 and 700 were released at two other sites in the lower Fraser Valley; 450 were sent to Prince Edward Island for release there.

A small gall fly, *Urophora styllata*, which oviposits in the flowers of bull thistle, was released at two sites in 1973. It soon became well established at Cloverdale and infested 85% of the thistle heads by 1977 and 92% in 1978. It became established more slowly at Ladner and infested only 5% of the thistle heads in 1977 but 32% in 1978. About 2000 adults were released near Williams Lake in 1978.

Ceutorhynchus litura, a European weevil whose larvae bore into the stems and crowns of Canada thistle, was released at Ladner in 1975. The proportion of thistles there showing feeding damage increased from 11% in 1976 to 35% in 1977 and to 58% in 1978. Damaged thistles were found up to 100 m from the release site.

Root maggots, aphids, and caterpillars on brassicas. Combinations of soil-incorporated insecticides (carbofuran, chlorfenvinphos, and isofenphos) and foliar-applied insecticides (ethiofencarb/Thuricide, methamidophos, and permethrin) were applied to study their effects on cabbage maggot and its parasites, various caterpillars and aphids in the bed-system production of broccoli, Brussels sprouts, cabbage, and cauliflower. Carbofuran and chlorfenvinphos allowed the least maggot damage. Ethiofencarb and methamidophos were the best aphicides. Permethrin was ineffective as an aphicide but

very effective against caterpillars. The numbers of overwintering puparia of *H. brassicae* were greatest from untreated plants and least from chlorfenvinphos-treated plants. Parasitism by the staphylinid beetle *Aleochara bilineata* Gyll. averaged 32% in untreated plots but only 5.5% in treated plots.

Root maggots of brassicas. Transplanted cauliflower plants in plots enclosed by plastic barriers had granules of carbofuran, chlorfenvinphos, and isofenphos incorporated into the silt loam around the plant. The effect of the insecticides was measured against the cabbage maggot and carabid beetle populations and parasitism by *A. bilineata*. The overall effect was expressed in plant mortality. Beetle populations were highest in chlorfenvinphos-treated plants and lowest in isofenphos-treated plots. The number of puparia per plant root system was 0–12 (untreated) for first generation, 0.2–9 for second generation, and 0.5–16 for the third generation. Parasitism was 0–76% and plant mortality varied from 6% (chlorfenvinphos) to 46% (untreated).

The effects and persistence of the three insecticides applied broadcast, band, in the furrow, and by spray at the seeding of broccoli and the availability to carrots seeded 50 days later were measured as above by determining residues in the soil and in the carrots. Although reductions in beetle populations appeared insignificant in 1977, broadcast treatments in 1978 had fewer beetles than the other methods. The numbers of puparia per root system ranged from 0.1 (chlorfenvinphos spray) to 11.5 (untreated). As in 1977, residues in soil 200 days after application were greatest after treatment with isofenphos and least with carbofuran. The same relationship applied for residues in carrots harvested 150 days after seeding.

In a third experiment the efficacy of carbofuran, chlorfenvinphos, diazinon, fensulfothion, fonofos, isofenphos, and terbufos applied in a band at the seeding of cabbage was measured by their effects on seedling emergence and by assessing cabbage maggot damage at midseason and after harvest. Serious reduction in the numbers of seedlings occurred in three or four replicates treated with isofenphos. Carbofuran, fensulfothion, and terbufos afforded good protection at midseason, but by September 1 differences were not significant.

Potato pests. In 1977 plots treated with terbufos applied in a band, incorporated by rototilling, and supplemented by three foliar sprays of carbofuran, methamidophos, or permethrin to protect potatoes from tuber flea beetle produced 80–85% marketable tubers. In 1978 the best treatments, fensulfothion, fonofos, isofenphos, and terbufos in band treatments, and fonofos applied broadcast, supplemented as above with three foliar sprays, produced 90–99% marketable tubers. Wireworm damage was severe and ranged from 16% (fonofos broadcast) to 67% (untreated) of the tubers having one or more tunnels. Aldicarb gave satisfactory aphid control but was ineffective against tuber flea beetle and wireworms. Methamidophos was the best aphicide. Permethrin was ineffective and allowed 10 times more aphids than on the untreated plants.

Onion maggots. In laboratory tests onion flies, *Hylemya antiqua* (Meig.), were allowed to oviposit on onions dipped in one of four insecticides or a mixture of Dimilin and Juvenile Growth Hormone. The effectiveness in order of increasing survival of newly hatched maggots was: Carbofuran (none), Miral, isofenphos, fonofos, and Dimilin/JGH. Unfortunately both carbofuran and Miral have been withdrawn by the manufacturers. When onion maggots were added to treated onions, the four insecticides were all effective at 800 ppm, but Dimilin/JGH at that rate allowed 40% of the maggots to pupate.

Stored products and household pests

Grain elevators, flour warehouses, and feed plants were inspected in 27 centers in northern British Columbia, the Peace River area, the east and west Kootenays, the Okanagan Valley, and central British Columbia. The large pale clothes moth was the worst problem in country elevators in the Peace River area. Mediterranean flour moths were the most serious in feed mills. In the order of decreasing severity other pests found were: black carpet beetles, yellow meal worms, granary weevils, cadelles, larder beetles, brown house moths, saw toothed grain beetles, Australian spider beetles, meal moths, rust red flour beetles, large pale clothes moths, golden spider beetles, and *Dermestes tristis* Fall.

In a cooperative study of the role of house dust mites in allergic reactions in children,

dust obtained at monthly intervals from mattresses at three locations in Vancouver was examined for mites. There was a seasonal variation in the mite population with peak numbers occurring in the autumn. This is related to the indoor relative humidity. Both *Dermatophagoides farinae* (Hughes) and *D. pteronyssinus* (Trouessart) were found in the samples.

Residue chemistry

Dissipation rates of atmospheric concentrations of the greenhouse fumigants sulfotep and nicotine were measured. The current practice of fumigating overnight and ventilating for 1 h next morning was shown to be more than adequate to provide safe working conditions.

Residue methodology was developed for the insecticides terbufos, fonofos, and their major metabolites. When this was applied to the analysis of field-treated potatoes, no significant residues were found. When field-fresh samples were used in two replicated studies on the degradation of permethrin in British Columbia soils, the degradation rates were faster than in a previous experiment with similar soils. This change is attributed to greater microbial activity in the fresh samples.

The rate of release of soil-applied encapsulated diazinon was measured over a 6-wk period. Maximum concentration of free diazinon was achieved 4 wk after application, and more than half this concentration was still present after 6 wk.

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PROGRAM STRUCTURE OF THE RESEARCH BRANCH

Departmental aim

To develop a viable and self-sustaining agricultural industry based on free trade and international prices.

Branch objectives and goals

LAND

1 Soil management and protection

To obtain an understanding of the properties that limit the productivity of selected soils.

GOAL 1: SOIL PROBLEMS. By 1982, to have produced information that will provide a basis for improved management of selected problem soils, by studying their chemical, biological, and physical properties.

2 Land use and capability

To obtain a reliable inventory of Canadian soils and to develop improved methods for their characterization, classification, and evaluation.

GOAL 1: SOIL SURVEY AND CLASSIFICATION. By 1980, to have promoted better utilization of the soil resources in selected regions of Canada, by developing a soil inventory and more reliable methods and criteria for classifying and mapping soils.

GOAL 2: LAND EVALUATION. By 1982, to have developed procedures for evaluating the capability of Canadian soils for agricultural production.

WATER

1 Irrigation, drainage, and desalination

To improve water management, irrigation, and drainage on Canadian soils in order to increase productivity.

GOAL 1: IRRIGATION, DRAINAGE, AND DESALINATION. By 1982, to have increased the production potential of selected soils, by improving water use efficiency and by developing superior methods of irrigation, drainage, and desalination.

2 Meteorological and climatic indices

To increase the use of climate resource information.

GOAL 1: METEOROLOGICAL AND CLIMATIC INDICES. By 1980, to have increased the use of climate resource information in weather-sensitive agricultural operations, in assessing productivity, and in research applications, by improving methodology, assessing and interpreting available data, and deriving selected meteorological and climatic indices.

ENERGY AND ENVIRONMENTAL QUALITY

1 Energy

To improve on-farm production and the use and conservation of energy.

GOAL 1: ENERGY UTILIZATION AND CONSERVATION. By 1982, to have reduced the farmer's dependence on fossil fuels and to have reduced energy costs in production, by applying known technology and developing and applying new technology.

2 Environmental quality

To develop agricultural management practices consistent with production and environmental requirements.

GOAL 1: RESIDUES AND PLANT NUTRIENTS. By 1982, to have provided information and to have developed and applied technology for controlling pollution from the plant nutrient and residue components of selected animal and crop production systems, by conducting field and laboratory studies and by developing and evaluating equipment.

GOAL 2: PESTICIDE MANAGEMENT. By 1980, to have established economic criteria for and to have

determined the environmental acceptability of existing and new pesticide management systems, by using models, studying pesticides and their residues in soil, and developing and improving methods and equipment.

PRODUCTION DEVELOPMENT—ANIMALS

1 Beef cattle

To improve the efficiency of beef production and the quality of beef products.

GOAL 1: SELECTION AND CROSSBREEDING. By 1982, to have provided new information that will make possible a 5% increase in beef yield per breeding cow, while maintaining or improving carcass and meat quality, through a program of selection and crossbreeding.

GOAL 2: COW-CALF SYSTEMS. By 1982, to have provided new information that will make possible increases of 7% in calf yield per cow and 25% in calf yield per hectare, by conducting multidisciplinary research on cow-calf systems, rangeland, forage crops, and crop residue utilization.

GOAL 3: FEEDLOT SYSTEMS. By 1982, to have developed more economical feeding and management systems, superior methods for processing and utilizing crop by-products and residues as feed, preventive measures against metabolic disorders and deficiencies, and greater control of carcass composition.

2 Dairy cattle

To improve the efficiency of milk production.

GOAL 1: BREEDING, GENETICS, AND MANAGEMENT. By 1980, to have provided new information that will make possible a 10% improvement in overall efficiency of milk production, by improving crossbreeding and intensive management systems.

GOAL 2: NUTRITION AND MANAGEMENT FOR MILK PRODUCTION. By 1981, through a systems approach, to have provided new information and superior techniques that will make possible more economical utilization of feed resources for milk production under various geographic and economic environments.

3 Swine

To improve the efficiency of swine production and the quality of pork and pork products.

GOAL 1: SWINE. By 1981, to have provided new information that will make possible a 5% increase in yield of pork per unit feed energy, while improving pork quality, through research on breeding, reproductive physiology, and superior feeding and management systems.

4 Poultry

To improve the efficiency of production of eggs and poultry meat and the quality of the products.

GOAL 1: POULTRY. By 1982, to have provided new information on breeding, feeding, and management of laying hens that will make possible increases of 4% in the weight of eggs and 10% in yield of meat per unit feed energy, and new information on the factors influencing interior and shell quality of eggs, through breeding and selection, reduction of metabolic disorders, and development of superior feeding and management systems.

5 Sheep

To improve the efficiency of sheep production and the quality of mutton and lamb products.

GOAL 1: SHEEP. By 1982, to have provided new information that will make possible increases of 15% in lamb production per ewe and 5% in growth rate of lambs, through breeding, improved reproductive efficiency, and development of superior feeding and management systems.

6 Honey bees and other animals

To improve the efficiency of production of honey bees and other animals, and the quality of their products.

GOAL 1: HONEY BEES. By 1982, to have provided new information that will make possible a 2% increase in the productivity of honey bees, by applying knowledge of pheromone chemistry, controlling disease, and improving management practices.

GOAL 2: FUR-BEARING ANIMALS. By 1979, to have made possible a 5% increase in the productivity of fur-bearing animals, by improving feeding systems, reducing losses caused by disease, and increasing understanding of reproductive processes. (Extramural research only.)

PRODUCTION DEVELOPMENT—CROPS

1 Wheat

To increase production, protection, and utilization of wheat through multidisciplinary research.

GOAL 1: WHEAT. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of durum, winter, and spring wheats, while maintaining the quality of each crop to meet market demand, by developing superior varieties and improving management practices.

2 Other cereal crops

To increase production, protection, and utilization of other cereal crops through multidisciplinary research.

GOAL 1: BARLEY. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of barley, while maintaining quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 2: OATS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of oats, while maintaining quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 3: CORN. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of grain corn or silage corn, while maintaining quality to meet market demand, or a 1% increase in the area cropped with corn, by developing superior inbred or hybrid varieties of grain and silage corn and improving management practices.

GOAL 4: RYE. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of winter rye, by developing superior varieties and improving management practices.

3 Oilseed crops

To increase the efficiency of production, adaptability, and quality of oilseed crops and their products through multidisciplinary research.

GOAL 1: RAPESEED AND MUSTARD. By 1981, to have provided new information and technology that will make possible a 3% increase in unit yield of rapeseed and mustard, and an improvement in the quality of the seed and processed products to meet market demand, by developing superior varieties, improving management practices, and conducting utilization research.

GOAL 2: SUNFLOWERS. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of sunflower seed in the Black soil zones, and will enable the commercial production of sunflowers in the Brown soil zones, while maintaining or improving the quality of the seed and processed products to meet market demand, by developing superior inbred and hybrid varieties and improving management practices.

GOAL 3: SOYBEANS. By 1979, to have provided new information and technology that will make possible a 5% increase in unit yield of soybeans, and will give an indication of their value as a crop in nontraditional regions, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 4: FLAX. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of flax, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

4 Forage crops

To increase the efficiency of forage crop production systems and the quality of forage crops through multidisciplinary research.

GOAL 1: FORAGE LEGUMES. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of digestible dry matter in forage legume crops, by developing superior varieties, improving management practices, and increasing seed production.

GOAL 2: FORAGE GRASSES. By 1982, to have provided new information and technology that will make possible a 10% increase in unit yield of digestible dry matter in forage grasses, by developing superior varieties, improving management practices, and increasing seed production.

5 Horticultural crops

To improve the efficiency of production and the quality of horticultural crops through multidisciplinary research.

GOAL 1: TREE FRUITS. By 1982, to have developed new information and technology that will make possible a 10% increase in unit yield of tree fruits, while maintaining or improving their quality for fresh and processed use, by developing superior cultivars and improving management and utilization practices.

GOAL 2: BERRIES. By 1982, to have developed new information and technology that will make possible a 5% increase in berry yield, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars with greater winterhardiness and disease resistance,

and improving management practices.

GOAL 3: VEGETABLES. By 1982, to have developed new information and technology that will make possible a 5% increase in unit yield of vegetable crops, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars and improving management practices.

GOAL 4: POTATOES. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of potatoes, while achieving higher standards of quality for fresh and processed use, by developing superior cultivars and improving pest control and management practices.

GOAL 5: ORNAMENTALS. By 1982, to have developed and introduced 12 new and improved cultivars of greenhouse crops, nursery stock, and turf grasses that are needed by the ornamentals trades; to have achieved a 5% increase in the yield of commercial ornamental crops, by improving cultural practices; and to have reduced energy consumption in greenhouses to 15% lower than previous levels.

6 Field crops

To improve the efficiency of production and quality of field crops such as tobacco, field peas, buckwheat, new crops, and field beans.

GOAL 1: TOBACCO. By 1982, to have provided new information and technology that will make possible a better understanding of tobacco quality and make possible a 10% increase in unit yield of tobaccos improved to meet market demand, by developing superior cultivars, improving management practices, and applying knowledge of tobacco quality characteristics.

GOAL 2: FIELD PEAS. By 1981, to have provided new information and technology that will make possible a 5% increase in unit yield of field peas, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 3: BUCKWHEAT. By 1982, to have provided new information and technology that will make possible a 5% increase in unit yield of buckwheat, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management practices.

GOAL 4: NEW CROPS. By 1982, to have determined the potential and suitability for commercial production of 10 selected new crops, through assessment of their production and market aspects, and to have demonstrated the method of growing, protecting, and utilizing 5 new crops previously identified as having this potential.

GOAL 5: FIELD BEANS. By 1979, to have provided new information and technology that will make possible a 5% increase in unit yield of field beans, while maintaining or improving quality to meet market demand, by developing superior varieties and improving management and post-harvest storage practices.

PRODUCTION SUPPORT

1 Supportive research and development

To provide new research information on crops, animals, and soils.

GOAL 1: WINTERHARDINESS. By 1980, to have defined and described selected physiological activities in plants, by completing biochemical and physiological studies, and to have shown how these properties can be used to improve efficiency of crop production.

GOAL 2: NITROGEN FIXATION. By 1979, to have developed information on new or more effective ways of fixing atmospheric nitrogen, by studying hosts, bacteria, and the biological processes.

GOAL 3: CYTOGENETICS. To develop methods of producing doubled haploids for breeding cereal and crucifer species; to establish cell and protoplast cultures for more efficient selection of useful mutants, for parasexual hybridization, and for whole-plant regeneration in several crop species; and to analyze cytogenetic relationships that facilitate interspecific transfer of genes in cereal and brome grass species.

GOAL 4: RESEARCH SERVICES. On a continuing basis, to maintain a Canadian collection of plant gene resources and a storage and retrieval system for gene data; to produce and distribute special seed for plant breeders; and to provide research and service in electron microscopy and analytical chemistry.

GOAL 5: ENGINEERING AND STATISTICS. On a continuing basis, to support branch and departmental research and development, by providing services in statistical design, analysis, and interpretation, and by developing instruments, apparatus, and equipment.

2 Protection support

To provide new general research information on the protection of crops from diseases, insects, and weeds.

GOAL 1: BIOLOGICAL CONTROL OF WEEDS. By 1982, to have developed new information and technology for determining the potential for biological control of 25 major weeds, by selecting, establishing, and assessing suitable biotic agents.

GOAL 2: INTEGRATED CONTROL OF INSECT PESTS IN RAPESEED CROPS. By 1982, to have provided new information and technology that will make possible the development of one or more management systems for controlling insect pests in rapeseed crops, by studying insects and their natural control factors, and evaluating the benefit-to-cost and benefit-to-risk relationships and the impact of control procedures on environmental quality.

GOAL 3: DISEASE AND INSECT CONTROL. By 1982, to have achieved a better understanding of the mode of action, degradation, and side effects of selected insecticides and fungicides, and to have improved the control of injurious insects and fungal diseases with the use of chemical pesticides and with the development of more effective chemical agents.

GOAL 4: CONTROL OF PLANT VIRUSES AND MYCOPLASMS. By 1982, to have improved control of plant viruses and mycoplasmas, by developing further information on their biochemistry and ultrastructure, their vector-host relationships, and their mechanisms of movement and infection in plants.

GOAL 5: CONTROL OF NEMATODE DISEASES. By 1982, to have improved control of nematode diseases, by identifying the species on major agricultural crops, studying their host-parasite relationships, and improving the effectiveness of nematocide use in integrated control systems.

GOAL 6: WEED CONTROL WITH HERBICIDES. By 1982, to have developed environmentally safe and effective methods for controlling selected weeds with herbicides, by studying their mode of action, methods of application, and persistence in the environment.

GOAL 7: WEED ECOLOGY. By 1981, to have provided technological information that will make it possible to reduce crop losses caused by weeds, by studying the ecology of 30 selected weeds and gathering information on their biological importance, interaction with other plant species, life cycles, reactions to herbicides and cultural management practices, and other biological characteristics.

3 Biosystematics

To clarify the taxonomy of and provide identification services for vascular plants, insects, arachnids, nematodes, and fungi found in Canada.

GOAL 1: VASCULAR PLANTS. By 1980, to have resolved the taxonomy of selected groups of vascular plants, particularly those relating to Canadian agriculture, by completing floristic surveys and inventories of selected areas, developing and maintaining a National Vascular Plant Herbarium and a collection of living plants, and providing an efficient identification and information service.

GOAL 2: INSECTS, ARACHNIDS, AND NEMATODES. By 1980, to have completed the taxonomy of selected groups of insects, arachnids, and nematodes, particularly those relating to Canadian agriculture, by making faunal surveys and inventories of selected areas, developing and maintaining a national collection of these biota, and providing an efficient identification and information service.

GOAL 3: FUNGI. By 1980, to have improved the taxonomy of selected groups of fungi, particularly those relating to Canadian agriculture, by completing fungal surveys and inventories of selected areas, developing and maintaining a National Herbarium and Culture Collection, and providing an efficient identification and information service.

FARM INPUT SUPPLY

1 Machinery and structures

To provide information and technology needed for improving and better utilizing farm structures and machinery.

GOAL 1: MACHINERY AND STRUCTURES TECHNOLOGY. On a continuing basis, to support branch and departmental programs on farm machinery and structures, by providing, developing, and assessing new and existing technology.

PROCESSING

1 Processing technology

To develop new food processing technology and to improve the efficiency and effectiveness of food processing systems, including background research on the chemical and physical changes that take place during processing, and evaluation at a pilot-plant scale, as required.

GOAL 1: FOOD PROCESSING. By 1982, to have developed or improved technology and equipment for extracting and utilizing components of selected plant and animal agricultural products and converting fresh material into attractive and stable processed foods.

GOAL 2: FOOD QUALITY. By 1982, to have developed new or improved technology for measuring and improving the quality of selected food products at intermediate and final stages of processing, and to have improved food quality in the finished product, by studying the reactions that take place during processing.

2 New-product development

To develop and characterize useful new ingredients or products for presentation to private industry for evaluation and application, and to develop the technology required to produce them, including evaluation at a pilot-plant scale, as required.

GOAL 1: NEW INGREDIENTS. By 1982, to have developed methods and processes of interest to industry for new food ingredients with valuable functional or nutritional properties.

GOAL 2: NEW FOODS. By 1982, to have developed methods and processes of interest to industry for new food products with commercial potential.

DISTRIBUTING

1 Stored products

To improve the technology and effectiveness of off-farm storage of fresh fruits and vegetables, and to reduce losses in stored grains and oilseeds by controlling insects.

GOAL 1: STORAGE OF FRUITS AND VEGETABLES. By 1982, to have developed new information and technology that will make possible a 10% extension of the storage life of fresh fruits and vegetables, while maintaining or improving product quality, through physiological studies and the development of optimum storage conditions.

GOAL 2: STORAGE OF GRAINS AND OILSEEDS. By 1982, to have developed methods and provided recommendations that will make possible a 10% reduction in losses caused by infestation of insects, mites, and fungi in cereals, oilseeds, and their products during storage, by conducting surveys of pest populations and research on control measures.

FOOD SAFETY AND NUTRITION

1 Food safety

To increase consumer protection by conducting research to reduce antinutritional factors and microbiological and chemical contaminants in agricultural products and foods.

GOAL 1: TOXICANTS AND CONTAMINANTS. By 1982, to have defined potential hazards caused by selected undesirable material in feedstuffs and foods (pathogenic organisms, mycotoxins, heavy metals, pesticide residues, and selected food additives), by studying their occurrence and their interactions in the food system, and to have developed control procedures to prevent their occurrence or remove them.

2 Nutrition

To assist in improving the general level of nutrition of Canadian consumers.

GOAL 1: FOOD COMPOSITION AND NUTRIENT AVAILABILITY. By 1982, to have provided new information and technology that will make it possible to improve nutrition, by breeding crops and animals, monitoring the composition of animal and plant material, formulating food products derived from them, and determining the availability of selected nutrients.

STRUCTURE DU PROGRAMME DE LA DIRECTION DE LA RECHERCHE

Objectif du Ministère

Développer une industrie agricole viable et autonome basée sur le libre-échange et les prix internationaux.

Objectifs et buts de la Direction

TERRE

1 Gestion et protection des sols

Trouver les principales causes qui nuisent à la productivité de certains sols.

BUT 1: PROBLÈMES PÉDOLOGIQUES. D'ici 1982, chercher de nouveaux moyens d'améliorer la pratique de sols sélectionnés, par l'étude de leurs caractéristiques chimiques, biologiques et physiques.

2 Utilisation et ressources des terres

Constituer un inventaire complet des sols canadiens et améliorer des méthodes pour mieux les caractériser, les classer et les évaluer.

BUT 1: PROSPECTION ET CLASSIFICATION DES SOLS. D'ici 1980, rendre possible une meilleure utilisation des ressources pédologiques dans certaines régions du Canada en constituant un inventaire et en établissant des méthodes et des critères plus efficaces de classification et de cartographie des sols.

BUT 2: ÉVALUATION DES TERRES. D'ici 1982, élaborer des méthodes d'évaluation des ressources pédologiques canadiennes pour la production agricole.

EAU

1 Irrigation, drainage et dessalinisation

Améliorer les techniques d'utilisation des ressources hydriques, l'irrigation et le drainage des sols canadiens dans le but d'en améliorer la productivité.

BUT 1: IRRIGATION, DRAINAGE ET DESSALINISATION. D'ici 1982, augmenter le potentiel de production de sols sélectionnés en accroissant l'efficacité de l'utilisation des ressources hydriques et en mettant au point de meilleures méthodes d'irrigation, de drainage et de dessalinisation.

2 Indices météorologiques et climatologiques

Accroître l'utilisation des données météorologiques.

BUT 1: INDICES MÉTÉOROLOGIQUES ET CLIMATOLOGIQUES. D'ici 1980, accroître l'utilisation de l'information climatologique, particulièrement en ce qui a trait aux opérations agricoles tributaires du climat, au chapitre des prévisions sur la productivité et dans le domaine de l'application des recherches, grâce à l'amélioration des méthodes, l'évaluation et l'interprétation des données disponibles obtenues à la suite d'une sélection d'indices météorologiques et climatologiques.

ÉNERGIE ET QUALITÉ DE L'ENVIRONNEMENT

1 Énergie

Améliorer la production, l'utilisation et la conservation de l'énergie sur l'exploitation.

BUT 1: UTILISATION ET CONSERVATION DE L'ÉNERGIE. D'ici 1982, atténuer la dépendance de l'agriculteur envers les combustibles fossiles et réduire les coûts de l'énergie utilisée dans la production par l'application des techniques actuelles et par le développement et l'application de techniques nouvelles.

2 Qualité de l'environnement

Élaborer des pratiques de gestion agricole correspondant à la production et respectant l'environnement.

BUT 1: RÉSIDUS ET ÉLÉMENTS NUTRITIFS VÉGÉTAUX. D'ici 1982, grâce à des études sur le terrain et en laboratoire ainsi qu'à la mise au point et à l'évaluation du matériel nécessaire à cette fin, mettre

au point des données et des techniques nouvelles de contrôle de la pollution causée par les éléments nutritifs végétaux et les résidus de divers systèmes de production animale et végétale.

BUT 2: UTILISATION DES PESTICIDES. D'ici 1980, déterminer les critères économiques et l'acceptabilité pour l'environnement des systèmes actuels et futurs d'utilisation des pesticides, par l'emploi de modèles, par des études sur les pesticides et leurs résidus dans le sol ainsi que par l'élaboration et l'amélioration des méthodes et du matériel utilisés.

PRODUCTION AGRO-ALIMENTAIRE (ANIMAUX)

1 Bovins de boucherie

Accroître l'efficacité de la production bovine et améliorer la qualité des produits.

BUT 1: SÉLECTION ET CROISEMENT. D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de 5% les rendements en viande par vache reproductrice, tout en maintenant ou en améliorant la qualité des carcasses et de la viande, grâce à la mise en oeuvre d'un programme de sélection et de croisement.

BUT 2: SYSTÈME D'ÉLEVAGE VACHE-VEAU. D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de 7% la production de veaux par vache et de 25% celle de veaux par hectare, grâce à des recherches multidisciplinaires sur les systèmes d'élevage vache-veau, les prairies, les cultures fourragères et les déchets des cultures.

BUT 3: PARCS D'ENGRAISSEMENT. D'ici 1982, développer des systèmes plus économiques d'alimentation et de conduite des troupeaux, améliorer les méthodes de transformation et d'utilisation des sous-produits et des déchets de culture comme aliments, adopter des mesures préventives contre les troubles et les déficiences métaboliques et améliorer le contrôle de la composition des carcasses.

2 Bovins laitiers

Accroître l'efficacité de la production laitière.

BUT 1: REPRODUCTION, GÉNÉTIQUE ET CONDUITE DES TROUPEAUX. D'ici 1980, mettre au point des données qui permettront d'accroître de 10% l'efficacité globale de la production laitière grâce à des techniques de croisement et des systèmes de production intensive.

BUT 2: NUTRITION ET GESTION DE LA PRODUCTION LAITIÈRE. D'ici 1981, mettre au point des techniques améliorées et des données nouvelles permettant l'utilisation optimale des aliments dans la production laitière en fonction des diverses conditions géographiques et économiques.

3 Porcs

Accroître l'efficacité de la production porcine et améliorer la qualité de la viande et des produits du porc.

BUT 1: PORCS. D'ici 1981, mettre au point de nouvelles données qui permettront d'accroître de 5% le rendement de porc par unité d'énergie alimentaire tout en améliorant la qualité de la viande par des recherches sur l'amélioration génétique, la physiologie de la reproduction et la mise au point de meilleurs systèmes d'alimentation et de gestion.

4 Volailles

Accroître l'efficacité de la production des oeufs et améliorer la qualité des produits.

BUT 1: VOLAILLES. D'ici 1982, mettre au point de nouvelles données sur l'amélioration génétique, l'alimentation et la conduite des pondeuses qui permettront d'accroître de 4% le poids des oeufs et de 10% la production de viande par unité d'énergie alimentaire, en plus de mettre au point de nouvelles données sur les facteurs déterminants de la qualité intérieure de l'oeuf et de sa coquille, par la reproduction et la sélection, et aussi par la diminution des troubles du métabolisme et la mise au point de meilleurs systèmes d'alimentation et de conduite des troupeaux.

5 Moutons

Améliorer l'efficacité de l'élevage ovin et la qualité des produits du mouton et de l'agneau.

BUT 1: MOUTONS. D'ici 1982, grâce à l'amélioration des races et à l'efficacité de la reproduction ainsi qu'à l'élaboration de meilleurs systèmes d'alimentation et de conduite des troupeaux, mettre au point de nouvelles données qui permettront d'accroître de 15% la production d'agneau par brebis et de 5% le taux de croissance des agneaux.

6 Abeilles et autres animaux

Accroître l'efficacité de la production des abeilles et des autres animaux et améliorer la qualité de leurs produits.

BUT 1: ABEILLES. D'ici 1982, mettre au point de nouvelles données qui permettront d'accroître de

2% la productivité des abeilles, grâce à des recherches sur les phéromones, à la réduction de l'incidence des maladies et à l'amélioration de la conduite des ruchers.

BUT 2: ANIMAUX À FOURRURE. D'ici 1979, accroître de 5% la production d'animaux à fourrure en améliorant les systèmes d'alimentation et l'efficacité de la reproduction et en réduisant l'incidence des maladies. (Recherches extra-muros seulement)

DÉVELOPPEMENT DE LA PRODUCTION (CULTURES)

1 Blé

Poursuivre des recherches multidisciplinaires pour améliorer la production, la protection et l'utilisation du blé canadien.

BUT 1: BLÉ. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire des blés durs, d'hiver et de printemps, tout en maintenant la qualité de chaque culture pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

2 Autres cultures céréalières

Poursuivre des recherches multidisciplinaires pour améliorer la production, la protection et l'utilisation des autres cultures céréalières du Canada.

BUT 1: ORGE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire d'orge, tout en maintenant la qualité pour satisfaire la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 2: AVOINE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire de l'avoine, tout en maintenant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

BUT 3: MAÏS. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire du maïs-grain ou du maïs d'ensilage, tout en maintenant la qualité pour satisfaire la demande du marché, ou accroître de 1% la superficie cultivée de maïs, grâce à la création de variétés autofécondées supérieures et d'hybrides supérieurs de maïs-grain et de maïs d'ensilage et à l'amélioration des pratiques culturales.

BUT 4: SEIGLE. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront d'accroître de 10% le rendement unitaire du seigle d'hiver, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

3 Oléagineux

Mener des recherches multidisciplinaires pour améliorer l'efficacité de la production, l'adaptabilité et la qualité des oléagineux et de leurs produits.

BUT 1: COLZA ET MOUTARDE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 3% le rendement unitaire du colza et de la moutarde et d'améliorer la qualité de la graine et de ses produits pour répondre aux besoins du marché, grâce à la création de variétés supérieures, à l'amélioration des pratiques culturales et à des recherches axées sur l'utilisation du produit.

BUT 2: TOURNESOL. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront d'accroître de 10% le rendement unitaire des graines de tournesol dans les zones de sol noir et la production de graines de tournesol dans les zones de sol brun, tout en maintenant ou en améliorant la qualité de la graine et de ses produits pour répondre à la demande des marchés, par la création de variétés autofécondées supérieures et d'hybrides supérieurs et l'amélioration des pratiques culturales.

BUT 3: SOJA. D'ici 1979, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du soja et de déterminer sa valeur comme culture possible dans de nouvelles régions, tout en maintenant ou en améliorant sa qualité pour répondre aux besoins du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 4: LIN. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du lin, tout en conservant ou en améliorant la qualité pour répondre aux besoins du marché, par la création de variétés supérieures et l'amélioration des pratiques culturales.

4 Cultures fourragères

Poursuivre des recherches multidisciplinaires pour augmenter l'efficacité des systèmes de production de cultures fourragères ainsi que la qualité de ces dernières.

BUT 1: LÉGUMINEUSES. D'ici 1982, mettre au point des données et des techniques nouvelles

permettant d'accroître de 10% le rendement unitaire en matière sèche digestible des légumineuses, grâce à l'amélioration des pratiques culturales, à la création de variétés supérieures et à l'accroissement de la production de semences.

BUT 2: GRAMINÉES. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire en matière sèche digestible des graminées, grâce à l'amélioration de pratiques culturales, à la création de variétés supérieures et à l'accroissement de la production de semences.

5 Horticulture

Améliorer, par le biais de la recherche multidisciplinaire, l'efficacité de la production et de la qualité des cultures horticoles.

BUT 1: FRUITS DE VERGER. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 10% le rendement unitaire des fruits de verger, tout en maintenant ou en améliorant les normes de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

BUT 2: PETITS FRUITS. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement des petits fruits, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de cultivars supérieurs résistant mieux au froid et à la maladie et grâce à l'amélioration des pratiques culturales.

BUT 3: LÉGUMES. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'augmenter de 5% le rendement unitaire des légumes, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et à l'amélioration des pratiques culturales.

BUT 4: POMMES DE TERRE. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pommes de terre, tout en respectant des normes plus élevées de qualité des produits frais et transformés, grâce à la création de meilleurs cultivars et de meilleurs moyens de lutte contre les ravageurs et à l'amélioration des pratiques culturales.

BUT 5: PLANTES ORNEMENTALES. D'ici 1982, créer et introduire 12 nouveaux cultivars améliorés de plantes de serre, de pépinière et de graminées à gazon correspondant à la demande de ce marché; accroître de 5% la productivité du secteur commercial des plantes ornementales par l'amélioration des pratiques culturales; enfin, réduire de 15% la consommation d'énergie dans les serres.

6 Grandes cultures

Améliorer l'efficacité de la production et la qualité des grandes cultures comme le tabac, les pois, les haricots, le sarrasin et les nouvelles cultures.

BUT 1: TABAC. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'élargir les connaissances sur la qualité des tabacs et d'accroître de 10% le rendement unitaire des variétés de tabac améliorées en vue de répondre à la demande du marché, par la création de meilleurs cultivars, l'amélioration des pratiques culturales et l'application des connaissances acquises dans le domaine de la qualité du tabac.

BUT 2: POIS DE GRANDE CULTURE. D'ici 1981, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des pois, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 3: SARRASIN. D'ici 1982, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire du sarrasin, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales.

BUT 4: NOUVELLES CULTURES. D'ici 1982, déterminer les possibilités d'implantation de 10 nouvelles cultures par l'évaluation des conditions de production et de mise au marché, et mettre au point les méthodes de production, de protection et d'utilisation de 5 nouvelles cultures dont les possibilités ont déjà été reconnues.

BUT 5: HARICOTS. D'ici 1979, mettre au point des données et des techniques nouvelles permettant d'accroître de 5% le rendement unitaire des haricots, tout en maintenant ou en améliorant la qualité pour répondre à la demande du marché, grâce à la création de variétés supérieures et à l'amélioration des pratiques culturales et des méthodes d'entreposage.

APPUI À LA PRODUCTION

1 Recherches et développements

Fournir de nouvelles données concernant les recherches sur les cultures, les animaux et les sols.

BUT 1: RUSTICITÉ. D'ici 1980, définir et décrire diverses activités physiologiques des végétaux par des études biochimiques et physiologiques et montrer comment ces caractéristiques peuvent être utilisées pour améliorer l'efficacité des productions culturales.

BUT 2: FIXATION DE L'AZOTE. D'ici 1979, mettre au point des données sur les méthodes nouvelles ou améliorées de fixation de l'azote dans l'atmosphère, par l'étude des hôtes, des bactéries et des fonctions biologiques.

BUT 3: CYTOGÉNÉTIQUE. Élaborer des méthodes de production de cultivars diploïdes à partir d'haploïdes, y compris les céréales et les cruciféracées; progresser dans l'établissement de cultures cellulaires et de protoplastes pour une meilleure sélection des mutants en demande, pour la création d'hybrides parasexuels et pour la régénération de plantes entières appartenant à plusieurs espèces culturales; élucider les relations cytogénétiques facilitant le transfert génétique entre diverses espèces de céréales et de luzerne.

BUT 4: SERVICES DE RECHERCHES. Maintenir de façon permanente une collection canadienne des ressources phylogénétiques ainsi qu'une banque et un système de récupération de données génétiques; produire des semences spéciales à l'intention des phytosélectionneurs et assurer leur distribution; assurer un service de microscopie électronique et de recherche chimio-analytique.

BUT 5: GÉNIE ET STATISTIQUE. Appuyer de façon permanente les programmes de recherches et de développements de la Direction et du Ministère par l'élaboration, l'analyse et l'interprétation des statistiques et la conception d'instruments, d'appareils et d'équipement.

2 Protection

Mettre au point de nouvelles données de recherches applicables de façon générale à la protection des cultures contre les maladies, les insectes et les mauvaises herbes.

BUT 1: LUTTE BIOLOGIQUE CONTRE LES MAUVAISES HERBES. D'ici 1982, mettre au point des données et des techniques nouvelles permettant de déterminer les possibilités de succès de la lutte biologique contre 25 des plus importantes mauvaises herbes, par la sélection, la création et l'évaluation d'agents biotiques appropriés.

BUT 2: LUTTE INTÉGRÉE CONTRE LES INSECTES DU COLZA. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront l'élaboration d'un ou de plusieurs systèmes de lutte contre les insectes du colza, en menant des recherches sur ces insectes et leurs prédateurs et en évaluant les rapports coût-bénéfice et risque-bénéfice et l'impact des méthodes de lutte sur la qualité de l'environnement.

BUT 3: MALADIES ET LUTTE CONTRE LES INSECTES. D'ici 1982, élargir les connaissances des modes d'action, de dégradation et des effets secondaires de divers insecticides et fongicides et rendre possible la lutte améliorée contre les insectes dangereux et les maladies fongiques par les pesticides chimiques, tout en développant des agents chimiques plus efficaces.

BUT 4: LUTTE CONTRE LES VIROSES ET LES MYCOPLASMES. D'ici 1982, améliorer les méthodes de lutte contre les virus et les mycoplasmes des végétaux en menant des études plus poussées sur leur biochimie et leur ultrastructure, les rapports vecteur-hôte et les mécanismes de propagation et d'infection.

BUT 5: LUTTE CONTRE LES NÉMATODES. D'ici 1982, améliorer les méthodes de lutte contre les maladies causées par les nématodes en identifiant les espèces qui s'attaquent aux principales cultures, en étudiant les rapports hôte-parasite et en déterminant les méthodes d'utilisation les plus efficaces des nématicides dans la lutte intégrée contre les ravageurs.

BUT 6: LUTTE CONTRE LES MAUVAISES HERBES PAR LES HERBICIDES. D'ici 1982, mettre au point des méthodes de lutte efficaces et non dommageables à l'environnement, capables d'éliminer certaines mauvaises herbes au moyen d'herbicides, grâce à des études sur leur mode d'action, les façons de les appliquer et leur persistance dans l'environnement.

BUT 7: ÉCOLOGIE DES MAUVAISES HERBES. D'ici 1981, mettre au point des données et des techniques nouvelles permettant de réduire les pertes de récoltes causées par les mauvaises herbes, grâce à l'étude écologique de 30 mauvaises herbes sélectionnées et à la collecte de données sur leur importance biologique, sur leur interaction avec d'autres espèces végétales, sur leur cycle vital, sur leur réaction aux herbicides et aux pratiques culturales et sur leurs autres caractéristiques biologiques.

3 Biosystématique

Clarifier la taxonomie et assurer un service efficace d'identification des plantes vasculaires, des insectes, des arachnides, des nématodes et des champignons du Canada.

BUT 1: PLANTES VASCULAIRES. D'ici 1980, résoudre les problèmes relatifs à la taxonomie de groupes sélectionnés de plantes vasculaires, en particulier celles qui intéressent le secteur agricole canadien, en effectuant des relevés floristiques et en constituant des répertoires de la flore pour les régions choisies, en montant et en conservant un herbier de plantes vasculaires ainsi qu'une collection de plantes vivantes et en fournissant, à partir de ces travaux, un service efficace d'information et d'identification.

BUT 2: INSECTES, ARACHNIDES ET NÉMATODES. D'ici 1980, compléter la taxonomie de groupes sélectionnés d'insectes, d'arachnides et de nématodes, particulièrement ceux qui intéressent le secteur agricole canadien, en effectuant des relevés de la faune, en dressant des répertoires pour les régions choisies, en montant et en conservant une collection nationale de ces biotes et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

BUT 3: CHAMPIGNONS. D'ici 1980, améliorer la taxonomie de groupes sélectionnés de champignons, surtout ceux qui intéressent le secteur agricole canadien, en effectuant des relevés mycologiques et en constituant des répertoires des champignons pour les régions choisies, en montant et en conservant un herbier national et une collection des cultures de champignons et en fournissant, à partir de ces travaux, un service efficace d'identification et d'information.

FACTEURS DE PRODUCTION AGRICOLE

1 Machinerie et structures

Mettre au point des données et des techniques nécessaires à l'amélioration et à une meilleure utilisation des structures et de la machinerie agricoles.

BUT 1: TECHNOLOGIE DE LA MACHINERIE ET DES STRUCTURES. Appuyer de façon permanente les programmes de la Direction et du Ministère concernant la machinerie et les structures agricoles en fournissant, développant et évaluant les techniques courantes et nouvelles.

TRANSFORMATION

1 Technologie de la transformation

Élaborer de nouvelles techniques de transformation alimentaire et améliorer l'efficacité des systèmes de transformation, en favorisant la recherche de base sur les modifications chimiques et physiques que subissent les aliments au cours de la transformation ainsi que l'évaluation à l'échelle des établissements, le cas échéant.

BUT 1: TRANSFORMATION ALIMENTAIRE. D'ici 1982, mettre au point ou améliorer des techniques et de l'équipement afin d'extraire et d'utiliser des composantes de produits agricoles sélectionnés, d'origine végétale ou animale, et afin de convertir des produits frais en aliments transformés qui se conservent bien et ont une apparence savoureuse.

BUT 2: QUALITÉ DES ALIMENTS. D'ici 1982, mettre au point des techniques nouvelles ou perfectionnées de mesures et d'amélioration de la qualité de divers produits alimentaires sélectionnés au niveau intermédiaire et final de leur transformation et rehausser la qualité des produits alimentaires finis par une meilleure connaissance des réactions qui surviennent au cours de la transformation.

2 Développement de nouveaux produits

Mettre au point et caractériser des ingrédients ou produits nouveaux et utiles en vue de les soumettre au secteur privé pour évaluation et fabrication, et mettre au point également la technologie nécessaire à leur production, y compris leur évaluation par des projets-pilotes, le cas échéant.

BUT 1: NOUVEAUX INGRÉDIENTS. D'ici 1982, mettre au point des méthodes et des procédés intéressant le secteur chargé de trouver de nouveaux ingrédients alimentaires qui pourraient offrir des propriétés fonctionnelles et nutritionnelles valables.

BUT 2: NOUVEAUX ALIMENTS. D'ici 1982, mettre au point des méthodes et des procédés qui permettront aux secteurs intéressés de développer de nouveaux produits alimentaires commercialisables.

DISTRIBUTION

1 Produits entreposés

Améliorer les techniques et l'efficacité de l'entreposage des fruits et des légumes frais hors des exploitations; dans les entrepôts, réduire les pertes de céréales et d'oléagineux par une lutte soutenue contre les insectes.

BUT 1: ENTREPOSAGE DES FRUITS ET DES LÉGUMES. D'ici 1982, mettre au point des données et des techniques nouvelles qui permettront une prolongation de 10% de la conservation en entrepôt des fruits et légumes frais, tout en maintenant ou en améliorant leur qualité, grâce à des études physiologiques et à l'élaboration de meilleures conditions d'entreposage.

BUT 2: ENTREPOSAGE DES CÉRÉALES ET DES OLÉAGINEUX. D'ici 1982, élaborer des méthodes et faire les recommandations permettant de réduire de 10% les pertes que causent les insectes, les acariens et les champignons aux céréales, aux oléagineux et à leurs produits en entreposage, grâce à des études sur les populations de parasites et des recherches sur les moyens de lutte.

SALUBRITÉ DES ALIMENTS ET NUTRITION

1 Salubrité

Augmenter la protection du consommateur par des recherches visant à diminuer les facteurs antinutritionnels et les contaminants microbiologiques et chimiques dans les produits agricoles et les aliments.

BUT 1: PRODUITS TOXIQUES ET CONTAMINANTS. D'ici 1982, définir les dangers possibles de divers produits indésirables que renferment les aliments de consommation animale et humaine (organismes pathogènes, mycotoxines, métaux lourds, résidus d'antiparasitaires et additifs alimentaires divers), grâce à des recherches sur leur taux dans les aliments et leur interaction sur le circuit alimentaire, et élaborer des méthodes de contrôle pour leur prévention ou leur retrait.

2 Nutrition

Contribuer à l'amélioration du régime alimentaire général du consommateur canadien.

BUT 1: COMPOSITION ET VALEUR NUTRITIVE DES ALIMENTS. D'ici 1982, mettre au point des données et des techniques nouvelles permettant de rehausser la valeur nutritive des aliments par l'amélioration végétale et animale, par le contrôle de la composition des sources alimentaires animales et végétales, par la formulation des produits alimentaires qui en sont dérivés et par l'évaluation de la disponibilité de divers éléments nutritifs dans les aliments.

