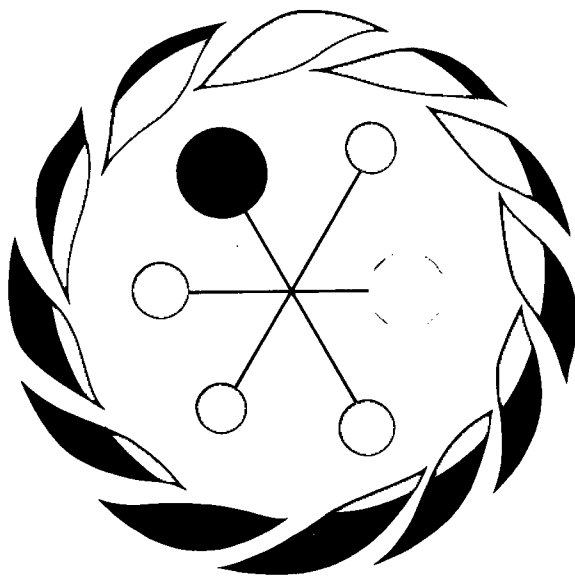


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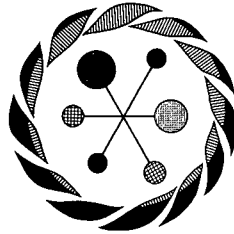
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RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE



The symbol on the cover depicts the inlay on the floor of the lobby of the K. W. Neatby Building, Central Experimental Farm, Ottawa. The center of the symbol is composed of an asymmetrical arrangement of the basic chemical elements of agricultural science as represented by Daltonian symbols. The colors stand for the following atom models: black for carbon, light blue for oxygen, dark blue for nitrogen, and orange for hydrogen. The wreathlike ring with constantly changing proportions of light and dark green symbolizes growth.





research report
1970

Research Branch

CANADA DEPARTMENT OF AGRICULTURE

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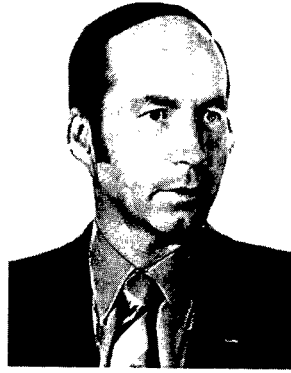
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Dr. B. B. Migicovsky



Dr. A. E. Hannah



Dr. R. A. Ludwig



Dr. D. G. Hamilton



Dr. E. J. LeRoux



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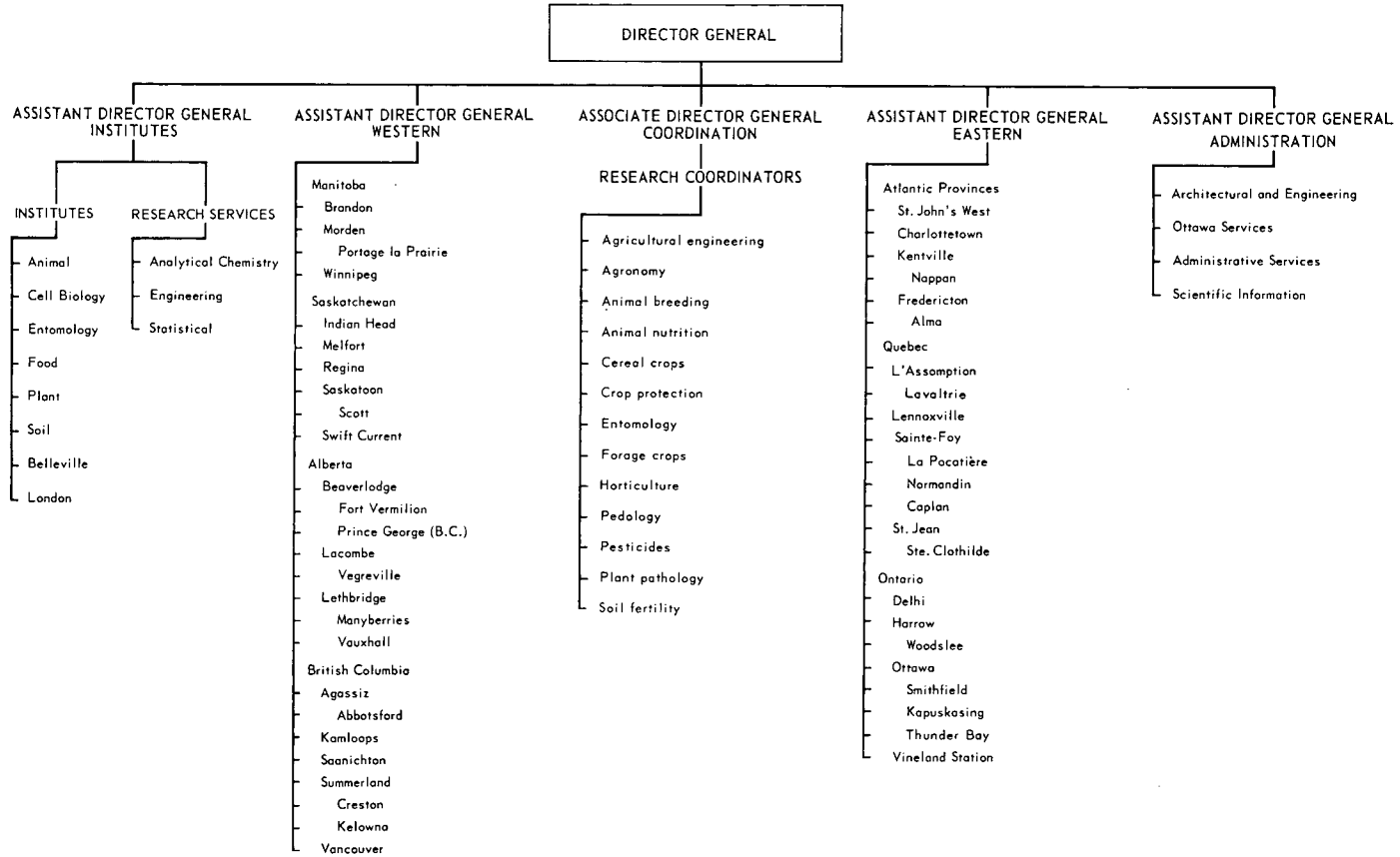
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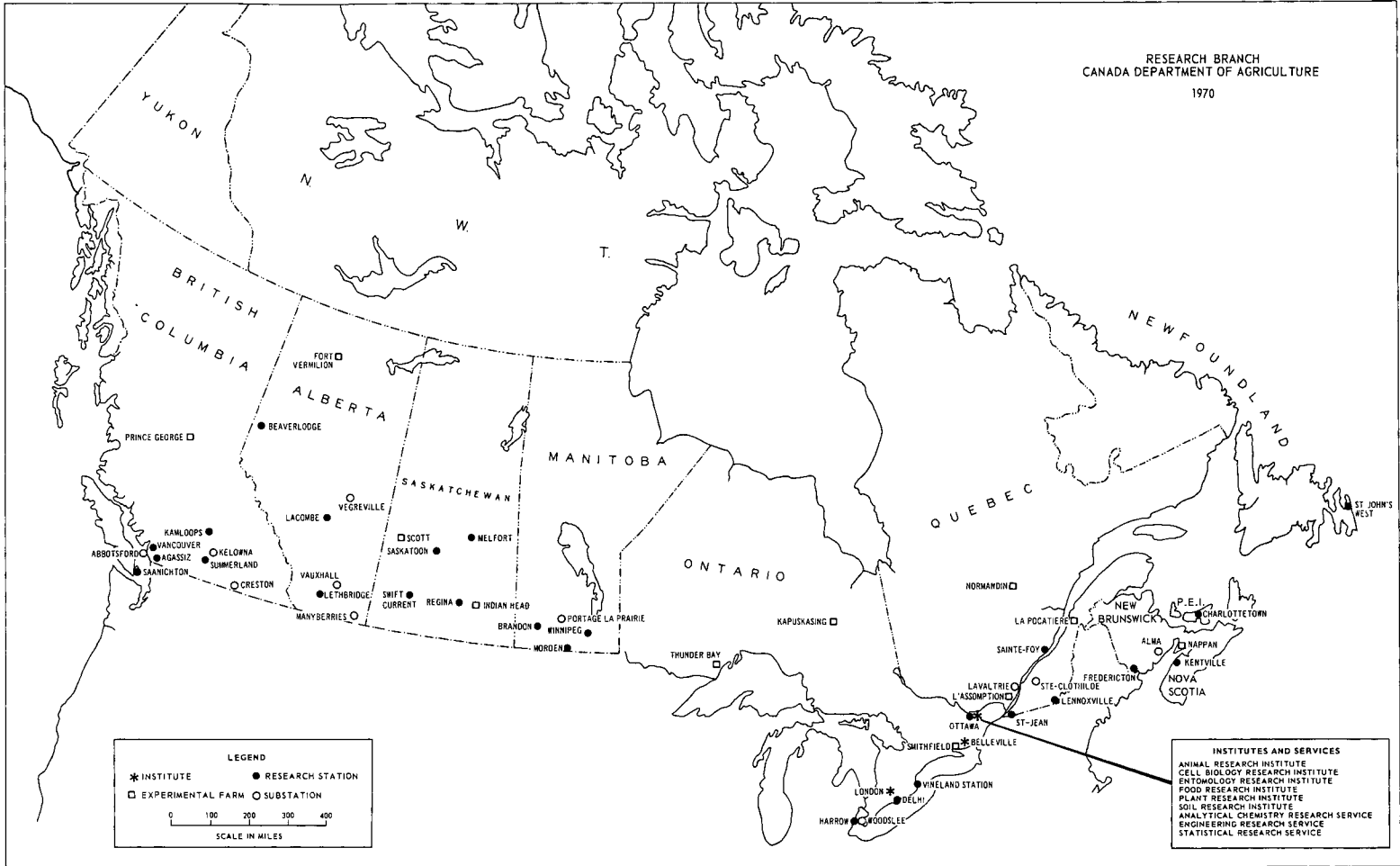
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CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH





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□ EXPERIMENTAL FARM ○ SUBSTATION

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- CELL BIOLOGY RESEARCH INSTITUTE
- ENTOMOLOGY RESEARCH INSTITUTE
- FOOD RESEARCH INSTITUTE
- PLANT RESEARCH INSTITUTE
- SOIL RESEARCH INSTITUTE
- ANALYTICAL CHEMISTRY RESEARCH SERVICE
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COORDONNATEURS DES RECHERCHES

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C. G. E. DOWNING, B.E., M.Sc., F.A.S.A.E., F.E.I.C.	Agricultural Engineering Génie agricole
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H. HURTIG, B.Sc., Ph.D.	Pesticides Antiparasitaires
A. S. JOHNSON, B.S.A., M.Sc., Ph.D.	Animal Breeding Elevage des animaux
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C. E. CHAPLIN, B.Sc., M.Sc., Ph.D.	Chief of Scientific Information Section Chef de l'information scientifique
A. I. MAGEE, B.Sc. (Agr.), M.S.A.	Chief of Ottawa Services Section Chef des services techniques (Ottawa)

FOREWORD

This report is an account of the activities of the Research Branch for the year 1970. During the past few years a concerted attempt has been made to relate all the projects or activities to regional and national goals and objectives. I am pleased to report that a high degree of success has been achieved. More than merely providing a means of administering and operating the research program, the "objectives and goals" system provides a philosophy of operation.

The national objectives and goals that we set are pragmatic and realistic. They spell out the *raison d'être* of the Research Branch. No attempt has been made, or should be made, to control "how" the scientist conducts his research to achieve the goals and objectives. It is clear to him and to the Branch as a whole that he must direct his efforts to achievement of the objective.

The important part of the objectives and goals system is the program review, which is conducted by the Planning and Coordination group and the Executive, with cooperation from all directors. This review provides the information and recommendations for changes in the activities of the Branch. Frequently, circumstances prevent promulgation of recommended changes; nevertheless, the recommendations are before us and we are in a position to act when circumstances permit.

The program review also provides an evaluation of current programs and considers the introduction of new programs. I am indeed pleased with the progress we are making in the application of the "objectives and goals" management system. It clearly delineates why we operate and provides the flexibility we need with respect to how we operate.

Appended to this report is a brief summary of the Objectives and Goals we set for ourselves in 1970. These are amended every year as a result of the deliberations of the program review.

There have been several changes in the personnel structure of the Branch. Dr. A. E. Hannah has assumed the duties of Assistant Director General (Planning and Coordination), replacing Dr. K. Rasmussen who retired. Dr. H. J. Atkinson retired as Research Coordinator (Soil Fertility) and was replaced by Dr. W. S. Ferguson from Swift Current. Dr. L. B. MacLeod was appointed Director of the Research Station at Charlottetown. Dr. G. C. Russell, the former Director at Charlottetown, was transferred to Harrow, replacing Dr. L. W. Koch who retired. Dr. W. C. McDonald was appointed Director of the Research Station at Winnipeg, replacing Dr. A. E. Hannah. Dr. R. H. Handford retired as Director of the Research Station at Kamloops and was succeeded by Dr. J. E. Miltimore from Summerland. Dr. D. V. Fisher has been appointed Director of the Research Station at Summerland, a vacancy created by the untimely death of Dr. C. C. Strachan. Mr. R. B. Carson retired as Director of the Analytical Chemistry Research Service. Mr. J. E. Ryan was appointed Chief, Administrative Services Section, upon the retirement of Mr. J. P. McCrea.

It is obvious that change is constant and adaptation to it is most important.

B. B. Migicovsky
Director General

AVANT-PROPOS

Ce rapport résume les activités de la Direction de la Recherche pour l'année 1970. Au cours des dernières années, il y a eu un effort de fait à la Direction en vue de coordonner tous nos projets et nos activités vers des «objectifs et buts» régionaux et nationaux. Je suis heureux de pouvoir affirmer qu'il y a eu beaucoup de progrès dans ce domaine. Au delà de l'administration et de l'opération des programmes de recherche, le système de gestion par «objectifs et buts» situe la gestion de la recherche sur un plan philosophique différent.

Nos objectifs et buts nationaux sont à la fois pragmatiques et réalistes. Ils résument la raison d'être de la Direction de la Recherche. Nous n'avons pas essayé d'indiquer aux scientifiques comment ils doivent réaliser leurs recherches en vue d'atteindre les objectifs et buts. Il est clair qu'ils ont la responsabilité entière et l'appui de la Direction dans l'orientation de leur travail en vue d'atteindre l'objectif.

La gestion par objectifs repose sur une phase importante, soit la révision des programmes. Celle-ci incombe au groupe de la Planification et de la Coordination et au bureau de Direction en collaboration avec tous les Directeurs des Stations de Recherches. Cette révision sert de base aux recommandations portant sur les changements à apporter aux diverses activités de la Direction. Il arrive que les circonstances nous empêchent de promulguer ces changements; cependant, nous demeurons prêts à les mettre en vigueur dès que les circonstances le permettent.

La révision des programmes comporte aussi une évaluation des programmes en cours et les projets concernant les nouveaux programmes. Je suis particulièrement satisfait des progrès réalisés dans l'application du système de gestion par «objectifs et buts». Il définit clairement les raisons pour

lesquelles nous travaillons et nous assure aussi un degré suffisant de souplesse dans nos opérations.

On trouvera rattaché à ce rapport un bref résumé des Objectifs et Buts fixés pour l'année 1970. Ils sont amendés chaque année à la suite de la révision annuelle des programmes.

Il y a eu plusieurs changements dans le personnel de la Direction. Le Dr A. E. Hannah est devenu Directeur Général Adjoint (Planification et Coordination) en remplacement du Dr K. Rasmussen qui a pris sa retraite. Le Dr H. J. Atkinson Coordonnateur de Recherches (Fertilité des Sols) a pris sa retraite et fut remplacé par le Dr W. S. Ferguson de Swift Current. Le Dr L. B. MacLeod a été nommé Directeur de la Station de Recherches de Charlottetown. Le Dr. G. C. Russell, auparavant Directeur de la Station de Recherches de Charlottetown, a été transféré à Harrow en remplacement du Dr L. W. Koch qui a pris sa retraite. Le Dr W. C. McDonald a été nommé Directeur de la Station de Recherches de Winnipeg en remplacement du Dr A. E. Hannah. Le Dr R. H. Handford, Directeur de la Station de Recherches de Kamloops, s'est retiré et a été remplacé par le Dr J. E. Miltimore de Summerland. Le Dr D. V. Fisher a été nommé Directeur à Summerland à la suite du décès prématuré du Dr C. C. Strachan. M. R. B. Carson, Directeur du Service de Recherches en Chimie Analytique, s'est retiré. M. J. E. Ryan a été nommé Chef de la Section des Services Administratifs à la suite de la retraite de M. J. P. McCrea.

Il est évident qu'il s'opère un changement constant et qu'il est très important de s'y adapter.

B. B. Migicovsky
Directeur général

Research Station St. John's West, Newfoundland

PROFESSIONAL STAFF

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Horticulture Section

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

Plant Breeding and Pathology Section

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

Soils and Agronomy

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

INTRODUCTION

The objectives of the Research Station at St. John's West are to solve regional agricultural problems as they occur and to carry out continuing research on the reclamation and use of peat soils, potato breeding for resistance to wart disease and the golden nematode, and the biology and behavior of the potato wart fungus. Studies on insect control and plant diseases, and those concerning plant nutrition, storage, and suitable varieties, together with soil survey work, make up the total research program.

Research work on poultry nutrition at this station was concluded in October 1970. Future poultry research requirements will be handled by the Research Station at Kentville, N.S.

H. W. R. Chancey
Director

SOIL SCIENCE

Soil Survey

Soil survey and land capability mapping of the Avalon Peninsula was completed during 1970 and the relevant maps were sent to Ottawa for checking and printing. Approximately 1,000,000 ha (2,400,000 acres) were mapped. The soils consisted of the following categories: 120,000 ha (300,000 acres) of organic soils, 168,000 ha (420,000 acres) of thin iron pan soils, and 74,000 ha (185,000 acres) of poorly drained soils. In the land capability classification 13,800 ha (35,000 acres) are suitable for crop production (Classes 3 and 4), 74,000 ha (187,000 acres) are suitable for rough pasture (Class 5), and 680,000 ha (1,686,000 acres) are not suitable for agricultural production (Classes 6 and 7).

The better agricultural soils are located north and south of St. John's and in the center of the peninsula, southwest of Conception Bay. Tree growth is most vigorous along the east coast, the shores of Conception and Trinity bays, and in the west central area. Black spruce stands are dominant in the North and balsam fir outnumbers other species in the South. Larch is quite prevalent in the North, but does not grow in the South.

Soil Test Calibrations

Results of soil N incubation tests on samples (stored at -18 C) from turnip and potato fertilizer experiments conducted from 1961 to 1967 showed that incubation N ranged from 9 to 121 kg/ha (8 to 108 lb/acre). Large differences occurred between stations and between years at the same stations, but there was excellent agreement between samples taken from different field replicates.

Previous observations from the P calibration series showing that St. John's and Doyles soils produced similar values were verified by the N incubation tests except for the soil test values for turnips. Conversely, the Lethbridge and Cormack sites did not show the same degree as previously.

Peat Soils

Fertility. The interactions of limestone rates and P rates and sources as they affect pH and the growth of oats, turnips, radishes, and carrots were further studied in the greenhouse following previous field tests. Excessively high rates of superphosphate (4,500 kg/ha) buffered the pH in the range 4.7 to 5.4; the lower pH was for the fast-maturing radishes and the higher for slow-maturing carrots. Although oats appeared to benefit from a high P rate where medium rates of limestone were used, other crops were generally suppressed. Half the rate of superphosphate in combination with limestone at 7,850 kg/ha produced maximum yields of radishes and turnips at pH levels of 4.8 and 5.1 respectively, and almost maximum yields in oats at pH 5.8. A lower rate of limestone, 4,500 kg/ha at pH 5.1, produced near maximum yields of carrots. With a high rate of rock phosphate, oats yielded close to maximum values with only 1,120 kg/ha of limestone at pH 4.6, whereas yields of turnips and carrots were not adversely affected. Radishes produced high yields with the rock phosphate and 2,250 kg/ha of limestone at pH 5.4. Because field tests have shown beneficial responses from rock phosphate used on peat soils previously treated with superphosphate, further investigations of rock phosphate - superphosphate combinations will be

conducted with different crops and limestone treatments.

In experiments to determine the optimum levels of preplanting applications of N, P, and K for late cabbage, increasing N or P levels beyond 336 and 224 kg/ha respectively did not significantly increase yields of cabbage in the 0.68 to 1.82 kg range nor total marketable yields. K at 336 and 448 kg/ha produced significantly higher yields in the 0.68 to 1.82 kg range and in total marketable yields with 224 and 336 kg/ha of P. There was, however, no significant difference between 336 and 448 kg/ha of K. Cabbage was spaced 30.5 cm apart in rows 76.2 cm apart.

In similar experiments to determine optimum levels of side-dressed N, P, and K on peat soils previously treated with preplanting applications of the same nutrients, increasing the preplanting P or K levels beyond 224 and 336 kg/ha respectively did not significantly increase yields of cabbage in the 0.68 to 1.82 kg range nor total marketable yields. N, P, and K side-dressings did not significantly increase yields.

Mineral Soils

Fertility. In trials on mineral soil using late cabbage spaced 25.4 cm apart in the row, four levels of preplant N and side-dressed N were tested in row spacings of 35.6 and 71.1 cm. P and K levels were 403 kg/ha for all treatments. Yields from 35.6 cm spaced rows were significantly lower than those at 71.1 cm and increasing preplant N beyond 224 kg/ha did not significantly increase yields in the 0.68 to 1.82 kg range nor marketable yields.

N side-dressing significantly increased total marketable yields at both row spacings, but 112 kg/ha was as effective as 224 or 336 kg/ha.

PLANT SCIENCE

Weed Control in Vegetables

Studies were conducted on a shaley clay loam and treatments are expressed in kilograms of active ingredient per hectare for the vegetables noted.

Rutabaga (var. York). Treatments tested included: preplanting incorporated applications of vernolate, EPTC, cycloate, butylate, and trifluralin; preemergence applications of

chlorthal; and postemergence applications of nitrofen. Postemergence applications of N were also tried in combination with chlorthal and trifluralin. Chlorthal at 11.20 kg/ha and trifluralin at 1.68 kg/ha were considered to be the best treatments.

Cabbage transplants (var. Houston Evergreen). Treatments tested included: preplanting incorporated applications of bensulide and trifluralin; preemergence applications of chlorthal and C-7019 (Green Cross Products); and postemergence applications of nitrofen. C-7019 caused temporary plant injury at all rates. Trifluralin at 1.68 kg/ha, chlorthal at 11.20 kg/ha, and C-7019 at 2.80 kg/ha gave the best control.

Beet (var. Detroit Dark Red). Treatments tested included: preplanting incorporated applications of pebulate and cycloate and preemergence applications of pyrazon and CP53619 (Monsanto Co.). None of the treatments appeared to have any effect on germination. All herbicides except CP53619 gave good weed control, but pyrazon at 5.04 and 5.60 kg/ha gave the best compromise between weed control and yields.

Lettuce transplants (var. Premier Great Lakes). Treatments tested included: preemergence applications of sulfallate and C-7019. None of the treatments caused any visible plant injury. Sulfallate at 8.96 or 11.20 kg/ha gave better weed control and higher yields than the C-7019 treatments.

Forage Crops

Peat soil swards composed of Ladino clover in mixture with tall fescue and timothy, tall fescue and reed canarygrass, and reed canarygrass alone were grazed for the third consecutive season by lambs. In 1968 and 1969, tall fescue - timothy swards produced the highest animal gains, but in 1970, because of the dominance of tall fescue, highest gains were obtained on swards containing only reed canarygrass.

These combined results were probably caused by low palatability and reduced intake of tall fescue where previously there had been sufficient timothy or reed canarygrass to sustain animals throughout the season. Despite these changes in response to grasses, the responses to trace elements (including Cu) applied to the soil and to Cu injected into individual lambs showed that different grasses absorbed different amounts of Cu, or

in some other respect differentially affected the trace element balance. These results were similar to those obtained in previous years.

Hay produced on peat soil was compared with that produced on mineral soil in a preliminary feeding trial. Twenty-two long yearling steers of mixed breeding (predominantly Hereford) were divided into two comparable groups and fed the respective hays along with a light grain supplement during the 5-month winter period December to April. Although the hay from peat soil was somewhat better in chemical analysis (in vitro digestibility 55.4% compared with 53.6% and total N 1.76% compared with 1.28%), the gains of the group fed hay from the peat soil averaged 0.57 kg/day compared with 0.65.

ENTOMOLOGY

Cabbage Maggot

Pelleting of rutabaga seed with wettable powder insecticides for root maggot control was continued in 1970. Maggot control was directly related to the distance between pelleted seeds sown in the soil. Carbofuran (Furadan 75 W.P.; Niagara Chemicals) at 1-inch spacings was most effective with 74% control. At spacings of 2 and 4 inches, control was reduced to 50% and 43%. There were no phytotoxic effects and carbofuran pelleted seeds were held for 4 weeks without affecting germination.

Twenty insecticide treatments were tested for root maggot control at St. John's and St. Davids. Carbofuran (Furadan 5G. and 10G.; Niagara Chemicals) was most effective when applied over the row at seed leaf stage at 2.26 kg (80 oz) and 1.13 kg (40 oz) respectively per 305 m (1,000 ft) of row. Fensulfothion (Dasanit 6 lb E.; Chemagro Corporation) applied at seeding, seed leaf stage, and as a split application gave 89%, 88%, and 86% control. Fonofos (Dyfonate 20G. and 4 lb E.; Stauffer Chemical Co.), trichloronat (B37289 15G.; Chemagro Corporation), and organo phosphoric acid ester (HOE 2960 5G.; FMC Corporation) were less effective.

In cabbage trials, 13 insecticides were tested for root maggot control. Both carbofuran (Furadan 4.8 F.; Niagara Chemicals) and fonofos (Dyfonate 4 lb E.C.; Stauffer Chemicals) at 62 g (2.2 oz) per 305 m (1,000 ft) of row gave complete control and the highest plot yields. Fensulfothion (Dasanit 6

lb E. and 15G.; Chemagro Corporation) gave satisfactory control, whereas trichloronat (B37289 15G.; Chemagro Corporation) and organo phosphoric acid ester (HOE 2960 5G.; FMC Corporation) were ineffective.

Blowflies

Pyrethrum dip concentrations of 0.062%, 0.031%, and 0.016% were tested at Bauline South and Dildo to control the blowfly *Calliphora terraenovae* Macq. on light-salted, sun-dried codfish. All treatments gave satisfactory control during periods of good weather, when 8% of the untreated fish were infested. Under less favorable conditions, when drying required 6 to 8 days exposure, infestations in the lower treatments were as high as 100%. However, infestations occurred 4 to 5 days after treatment, whereas untreated controls were infested immediately. Pyrethrum concentrations of 0.062% and 0.031% were more effective than those at 0.016%.

Moths

A single first specimen of the noctuid moth *Erebus odorata* L. was captured at St. John's on August 27, 1970. This great moth, known as the Black Witch, is very common in tropical America, but does not normally breed north of the Gulf Strip. Possibly it was blown to Newfoundland by a storm of tropical origin that passed over the Avalon Peninsula on August 25, 1970.

Golden Nematode Control

In a greenhouse pot experiment nematocides DPX 1410 (2 lb/gal (active); Du Pont of Canada Ltd.), methomyl (Lannate 90 WD; Du Pont of Canada Ltd.) and Mocap (10G.; Pfizer Co. Ltd.) were compared at equivalent rates of 3, 6, and 12 lb/acre (active) for golden nematode control in potatoes. In preplanting soil treatments cyst numbers were significantly reduced by all treatments of DPX 1410 and Mocap but only by 6- and 12-lb applications of methomyl. The difference between levels of Mocap or DPX 1410 was not significant, but 6 and 12 lb/acre significantly reduced cyst numbers compared with the 3-lb methomyl application.

Where the chemicals were applied as a spray to the young plants at 3 lb/acre (active), methomyl caused a significantly lower cyst population, but spraying with DPX 1410

had no effect on cyst numbers. A split application, 2 lb/acre preplanting and 3 lb/acre spray, reduced cysts significantly with DPX 1410 but not with methomyl.

Although statistically significant differences between treatments in tuber yield could not be established, preplanting incorporation of Mocap reduced yield by 25% compared with the control. Spray applications of methomyl and DPX 1410 also caused reduction in yield.

DPX 1410 as a tuber piece dip solution at 1 lb/gal (active) of water was phytotoxic. At 0.5 lb/gal (active) of water only 6 cysts/100 g soil were produced as compared with 52 cysts/100 g soil for control tuber pieces dipped in water.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and Golden Nematode

One hundred and thirty-six successful crosses were made during the year and 60 of these were between wart-resistant material and varieties or selections with golden nematode resistance. Approximately 6,000 tubers selected from 18,500 seedlings grown under glass were retained for field evaluation in 1971.

In single-plant tests for resistance to the golden nematode at Cupids, 155 out of 252 selections became infected. Plants that had been free from cysts in previous field or greenhouse tests were retested and found to be resistant. Soil samples taken from plots after harvesting gave cyst counts of more than 12 cysts/g of soil, but the numbers of cysts recovered from the soil used to grow the resistant varieties Amelio and Wauseon were less than those recovered from plots containing susceptible varieties.

Biotypes of Potato Wart

Tubers of the varieties Ultimous, Urgenta, Pink Pearl, Sebago, Arran Victory, and Hilla were planted at five centers where warted tubers of the resistant variety Urgenta had been found in 1969. At two centers wart developed only on Arran Victory, but at the other localities all varieties except Hilla were infected. These results confirm the probable presence in Newfoundland of the European

type 8 race and specific identification tests will be undertaken in 1971. Further infections by this race were not reported in 1970, although weather conditions were conducive to heavy wart infection.

Germination and Infectivity of Potato Wart Sporangia

In experiments designed to recover resting sporangia of *Synchytrium endobioticum* (Schilb.) Perc., and to explain the mechanism of resting sporangia germination, methods were developed to extract sporangia from soil and tissue samples by sieving through micron size sieves and membrane filters. These procedures made possible the direct examination of the material retained on the dried membrane to determine sporangia populations, immediate microscopic examination, and the determination of the reaction to ultraviolet and blue light illumination. In addition, fluorochroming procedures to establish sporangia viability can be carried out directly on sporangia retained on membrane filters. It is now possible to collect resting sporangia quite rapidly, estimate numbers, and examine them for viability. By placing the membrane filter and the filtrate in an inoculation tube set around a potato sprout, we can infect a tuber and by retrieving the filter, examine it for sporangial dehiscence and cell membrane alteration.

The difficulty in readily and accurately determining the susceptibility of potato varieties and selections to potato wart infection has previously depended on field trials for final decisions. Obviously, rapid tests for susceptibility under controlled conditions would allow massive screening of selections and varieties and reduce costs considerably. A controlled-environment growth room was therefore constructed, based on an adaptation of a British bedding plant house. Preliminary tests on growth-room plantings produced 92% infection with half tubers and 100% infection with seed pieces. There were tuber and seed-piece losses in the first tests, but plant loss has since been reduced to negligible levels by using whole or pregerminated tubers.

Comparison of wart inocula of different ages showed an apparent increase in infectivity with age. Little difference was observed between inoculum densities; 5 mg wart/g of potting mix appeared to induce more wart production than 20 mg wart/g of potting

mix. Differences could not be seen between sprouts germinated 1, 2, or 3 weeks before

inoculation, but prior germination ensured that tissue was readily available for infection and that damping off hazards were reduced.

PUBLICATIONS

Research

Proudfoot, K. G. 1970. Control of potato wart by chemical means. Proc. Trienn. Conf. Eur. Ass. Potato Res. 205.

Proudfoot, K. G. 1970. The present status of breeding varieties resistant to potato wart and golden nematode in Newfoundland. Proc. Trienn. Conf. Eur. Ass. Potato Res. 139-140.

Rayment, A. F., and Cooper, D. J. 1968. Drainage of Newfoundland peat soils for agricultural purposes. Proc. Int. Peat Congr. 345-349.

Miscellaneous

Morris, R. F. 1970. *Erebus odorata* L. An interesting visitor. Osprey, Nfld. Nat. Hist. Soc., Sept.-Oct.

Rayment, A. F. 1970. Newfoundland peat bogs: drainage techniques. Can. Agr. 15(3):24-25.

Research Station Charlottetown, Prince Edward Island

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F. M. CANNON, B.Sc., M.Sc. Retired February 4, 1970	Insects (potato)
A. C. FLEMING, B.A. Appointed Administrative Officer, Research Station, Beaverlodge, Alta., November 27, 1970	Administrative Officer
R. B. MACLAREN Retired September 30, 1970	Breeding (oats)

INTRODUCTION

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

During 1970, three research scientists, Dr. H. T. Kunelius, Dr. H. G. Nass, and Dr. J. H. Lovering, were provided, through the Department of Regional Economic Expansion under the Prince Edward Island Development Plan, to increase the research capability of the Station.

L. B. MacLeod
Director

CEREALS

Breeding

Development of immunity to powdery mildew, *Erysiphe graminis* DC. ex Mérat f. sp. *tritici* Marchal, in the Maritimes, seems probable by using the wheat variety Kolibri as the source of resistance. Several oat lines from hybrids involving Egdolon 26 as one parent gave unusual promise of having the desired combination of early maturity, good yield, and high resistance to lodging.

The six-rowed barley variety Keystone was superior to the traditionally grown varieties in most trials. Apparently Keystone possesses considerable tolerance to conditions of late seeding and high incidence of *Helminthosporium sativum* Pamm., King & Bakke, which prevailed in the Maritimes in 1970.

Nutrition and Management

Spring N boosts winter wheat yields. Early spring fertilization with 34, 68, and 102 kg N/ha (30, 60, and 90 lb/acre) increased grain yields by 1,143, 1,614, and 1,749 kg/ha (17, 24, and 26 bu/acre) over the 3,094 kg/ha (46 bu/acre) yield of the control. Yorkstar was the highest yielding winter wheat, followed by Genessee, Talbot, and Richmond. Richmond showed an economic response to 68 kg N/ha, whereas with Yorkstar and Genessee, 102 kg N/ha can be economically applied in early spring.

Winter wheat seeded at 168 and 202 kg/ha (2.5 and 3 bu/acre) produced higher grain yields than when 135 kg/ha (2 bu/acre) were seeded alone or with 34 kg N/ha. With 68 and 102 kg N/ha the increase in grain yield

was not significant beyond a seeding rate of 168 kg/ha.

Decreasing N-rate affects barley yield. In a hydroponic experiment with Herta barley, a 75 ppm concentration of N was supplied for 1, 2, 3, 4, 5, 6, and 7 weeks after emergence and was then reduced to 20 ppm until maturity. Grain yield increased with the length of period of high N supply up to 5 weeks after emergence. Prolonging the high N supply for longer than 5 weeks, however, resulted in decreases of grain yield. Plants supplied with 75 ppm N for 5 weeks produced the highest grain yield and contained the lowest percentage of total N in the upper two leaves and in the grain.

Copper requirement of cereals. In a greenhouse experiment, an application of 0.5 ppm Cu (1.0 lb/acre) to the soil resulted in increases of 40%, 180%, and 500% in the grain yield from wheat, barley, and oats. Without applied Cu, wheat and barley heads emerged 10 to 14 days later. For maximum yields under greenhouse conditions, the optimum content of Cu in plant tissues at the boot stage was 3.2 to 3.3 ppm for wheat and oats, and 4.8 ppm for barley. Exchangeable Cu levels in the soil of 1.2 to 1.8 ppm were in the deficiency range.

Control of annual sow-thistle in undersown oats. Early application of herbicides to oats (15 to 20 cm tall) failed to control late-emerging annual sow-thistle, *Sonchus oleraceus* L. The application of 2,4-DB sprays, at 1.12 liters/ha (16 oz/acre) active ingredient and above, when oats were 20 to 25 cm high,

gave optimum control of the weed, but increased the number of false blossoms in the oats resulting in an average yield reduction of 157 kg/ha (5.2 bu/acre). Injury to alfalfa, red clover, and alsike clover was slight except at the higher levels of application. Other butyric forms of the herbicide tested, namely MCPB and MCPB-MCPA (15:1), had no physiological effect on the oat plants. When applied as a delayed spray, at rates of 1.12, 1.40, and 1.68 liters/ha (16, 20, and 24 oz/acre), each herbicide gave good weed control, but caused some injury to legume seedlings. The alfalfa stand was greatly reduced, but little injury was sustained by red and alsike clovers except at the higher levels.

Diseases and Insects

It has been shown that powdery mildew on winter wheat acts as an inoculum source for infestation of spring-seeded wheat. Systemic seed dressings used on fall-seeded wheat delayed the appearance of powdery mildew the following spring. Milstem (Chipman Chemicals Ltd.) and benomyl appear to be the most promising materials to date.

Septoria avenae Frank infection of oats was severe in 1970 and disclosed a decrease in the percent of kernel tissue, although the weight of hull remained constant. When infection took place before flowering, the loss in grain was considerably greater than when infection took place after flowering.

Disease loss assessment in 1970 indicated yield decreases in excess of 19%, 27%, and 17% because of leaf diseases of barley, oats, and wheat. An examination of the effects of the use of fungicides on plots of wheat, oats, and barley in 1970 showed that gains from the use of these chemicals, if they had been applied to the entire acreage of these crops in Prince Edward Island, would be valued at about \$1.7 million, or about 28% of the value of the 1970 crop.

Bird cherry oat aphids, *Rhopalosiphum padi* (L.), reduced the weight of barley kernels in growth chamber studies, even when placed on plants that had begun to head. Most barley plants infested prior to heading were killed by the aphids. It was estimated, on the basis of small plots, that aphids and barley yellow dwarf damage resulted in a loss of about \$1.08 million in Prince Edward Island. This loss could have been reduced by the proper use of malathion. It is further estimated that the use of this insecticide

would have resulted in a return of about \$2.50 per dollar of expense incurred in buying and applying the chemical.

FORAGES

Nematology

Fungus and nematode interact. A greenhouse study confirmed the synergistic relationship between the effects of *Fusarium oxysporum* Schlecht. and *Pratylenchus penetrans* (Cobb) Filip. & Stekh. alone and in combination. Empire birdsfoot trefoil plant mortality, in particular, was greater when both organisms were present than that expected from the additive effects of the organisms alone.

Soil pH affects nematode reproduction. Greenhouse studies showed that an introduced population of *P. penetrans* increased most on Empire birdsfoot trefoil growing in a soil with a high pH. After 27 weeks in the greenhouse, nematode numbers had increased 19×, 20×, 33×, and 44× at soil pH values of 4.7, 5.4, 6.5, and 7.4. Even though nematode increase was least at a pH of 4.7, forage yield reduction from nematode infestation was greatest.

Potassium affects nematode reproduction. Greenhouse studies showed that an introduced population of *P. penetrans* increased less on Vernal alfalfa growing in soil with a high rate of added K. After 29 weeks in the greenhouse, nematode numbers had increased 112×, 80×, and 43× when K at 0, 185, and 375 kg/ha was applied as a pre-plant application.

Nematicides increase forage legume yields. Preplant applications of the nematicides Nemacur (Chemagro Corporation) and fen-sulfothion increased seeding-year forage yields by 27%, 86%, and 93% from Vernal alfalfa, Lakeland red clover, and Empire birdsfoot trefoil. When the same rates of nematicide application were compared, Nemacur provided better control of *Pratylenchus* spp.

Physiology and Management

Gibberellic acid increases forage yield. A highly significant, stimulating effect of gibberellic acid A3 on the vegetative growth of alfalfa, birdsfoot trefoil, clovers, timothy,

HORTICULTURAL CROPS

Potato Nutrition and Management

and brome grass was found in the greenhouse. Birdsfoot trefoil responded most to the gibberellic acid application, whereas red clover showed the least response. Although the stimulating effect was observed regardless of the time of application, the most effective application time for increasing dry matter yield was 2 weeks before harvest. Gibberellic acid treated plants required supplementary nutrients, and the K supply was particularly important.

Automated analyses of food reserves. Analyses of the total available carbohydrates in the storage tissues of forage crops and of fructosan, the main carbohydrate reserve of forage grasses, were automated. The water-soluble protein in alfalfa roots was fractionated and detected automatically with an ultraviolet monitor coupled with a gel-filtration column. The above automations resulted in improved speed and quality of analyses.

Molybdenum nutrition of legumes. Application of 0.5 ppm Mo (1.0 lb/acre) to the soil, under greenhouse conditions, resulted in yield increases of 100% for first-cut alfalfa, 300% for second-cut alfalfa, and 50% for red clover. When 1 ppm Mo was applied to the soil, alfalfa and red clover forage contained more than 10 ppm Mo, a level that is considered to be toxic to cattle. Optimum tissue levels of Mo in alfalfa and red clover were found to be 0.12 to 0.46 and 0.46 to 1.08 ppm.

Corn yield response related to soil tests. N, P, and K studies with corn showed yield responses to 56 kg N/ha and 25 kg P/ha banded, plus 25 kg P/ha broadcast, as well as to 123 kg P/ha broadcast alone. No yield response occurred with either broadcast or banded K. Harvested corn silage removed 112 kg N, 25 kg P, and 127 kg K/ha. At another location, yields were increased with 56 kg N/ha, 48 kg P/ha banded, and up to 492 kg P/ha broadcast, but there was no response to applied K. Apparently, 100 ppm exchangeable K and 150 ppm P (Bray-acid soluble plus adsorbed) in these soils provided sufficient fertility for corn silage.

Production, storage, and feeding costs. Production, storage, and feeding costs were estimated for alfalfa-brome grass hay, alfalfa-brome grass silage, and corn silage. The cost per metric ton of dry matter for these feeds, stored and fed, was \$28.70, \$26.50, and \$24.20 respectively.

Potato nutrition studies showed that yield response to banded P and K fertilizer decreased as soil test levels increased, owing to previous broadcast treatments. High rates of N, applied for the previous potato crop, did not affect yields of the current crop. Specific gravity of tubers decreased as rates of N and KCl increased. Fertilization increased Mn release in low-pH soils. Liming and available Mn studies emphasized the importance of keeping soil pH above 5.0. Potato monoculture did not result in declining yield when adequate fertilizer was applied. Mineral fertilizer was as good as manure or manure plus fertilizer for maintaining yields. Manure did not decompose rapidly enough to supply sufficient N for good yields of potatoes.

Production, storage, and grading costs were estimated for potatoes. Costs per kilogram of potatoes delivered to storage at harvest, stored for 4 months and graded were 2.09 cents and 3.06 cents respectively. A simulation model of potato production was constructed. Preliminary investigation was made of the relationships between per acre management returns and rates of performance of harvesters and planters, potato acreage, and distance between harvest and storage sites. Harvest rate and potato acreage were the most important variables: a decrease in harvest rate of 1.7 hr/ha had about the same influence as did an increase of 40 ha in enterprise size: an increase in return to management of about \$50/ha.

Potato Insect and Disease Control

Six chemical dusts for treating seed were tested for the control of wilt caused by *Verticillium albo-atrum* Reinke & Berth. and fusarium decays caused by *Fusarium coeruleum* (Lib.) Sacc. and *Fusarium sambucinum* Fckl. f. 6 Wr. Seed was artificially contaminated with respective disease organisms and then chemically treated at the rate of 10 g dust/kg seed. Benlate 10% dust (DuPont of Canada) proved highly effective in the control of verticillium wilt and significant increases in yield were recorded following the use of this chemical on seed contaminated with the two fusaria. Mertect 10% dust (Merck Chemical Co.) gave effective control of verticillium wilt, but was phytotoxic at the rate employed.

Polyram 7% dust (Niagara Chemicals) provided effective control of seed-piece decay caused by *F. coeruleum*, but gave little, if any, control of wilt. The susceptibility rating of Kennebec (24.8%) to the pink eye disease, caused by *Pseudomonas fluorescens* (Flügge) Migula, was twice that of Irish Cobbler and Sebago in tubers from plants that had shown field wilt.

Under a severe attack of late blight, caused by *Phytophthora infestans* (Mont.) de Bary, the best fungicides in the 1970 screening test were Daconil 2787 (Diamond Alkali (Canada) Ltd.), mancozeb, captafol (Difolatan 4.8 Flowable; Chevron Chemical Co.), Siaprit (Green Cross Products), and Polyram (Niagara Chemicals).

A study to devise a method for estimating the losses in tuber yield, caused by late blight on the foliage, indicated that the "Large" equation, used in Great Britain, underestimates the losses that occur in Eastern Canada. Consequently, the benefit of operating a successful spray program to keep the disease at a very low level may have been underrated.

For killing potato vines before harvest, diquat, paraquat, and dinoseb can be recommended as replacements for poisonous sodium arsenite products.

Crucifer Nutrition and Management

Potassium for Brussels sprouts. Brussels sprouts responded to applied K at 3 of 12 locations studied. No response to applied K occurred when exchangeable soil K exceeded 100 ppm. Below 75 ppm exchangeable K, 185 kg/ha fertilizer K was necessary for maximum yields, and between 75 and 100 ppm exchangeable K, 93 kg/ha fertilizer K was adequate. Leaf tissue that contained less than 1.7% total K at the beginning of sprout formation was K deficient.

Effect of K on rutabaga yields. Applications of K generally have not increased rutabaga yields in experiments conducted at six locations. Soil tests indicated that initial K levels were low at two locations, medium at three locations, and high at one location. The K was applied in bands on either side of the row at 0, 124, 248, and 372 kg/ha of K. At one location, where the initial K level was low, the yields of marketable rutabagas were increased from 29.3 to 34.9 metric tons/ha by the application of 124 kg K/ha. At the

remaining five locations, marketable yields were slightly reduced where K was applied.

Molybdenum increases the yield of vegetable crops. In the absence of added Mo, Brussels sprouts and spinach plants were extremely stunted and the yields were very poor. An application of 0.5 ppm Mo (1 lb/acre) to the soil corrected the Mo deficiency. The optimum tissue levels of Mo in Brussels sprouts and spinach were 0.11 to 0.22, and 0.15 to 0.24 ppm.

Control of Insects on Crucifers

Bioactivity of soil insecticides. When banded 2.5 cm deep in a mineral soil, carbofuran, fensulfothion, phorate, thionazin, propoxur, and pirimiphos-methyl (granular) were highly bioactive in field plots within a week. Toxicity of carbofuran and fensulfothion increased during the next 30 to 50 days and gradually decreased thereafter, whereas the other compounds were steadily deactivated after 5 or 6 days; phorate toxicants disappeared after 2 months, thionazin in about 3 months, and toxicants of propoxur and pirimiphos-methyl disappeared in about 30 days. Trichloronat, chlorfenvinphos, fonofos, N2596 (Chipman Chemicals Ltd.), and pirimiphos-ethyl were slowly bioactivated, toxicity increased during the growing season, remained constant over winter, and then gradually decreased. Trichloronat was the most persistent. All materials persisted longer in greenhouse tests than in the field.

At 3 to 5.6 kg actual/ha, toxic residues of all the insecticides, except thionazin, N2596, and pirimiphos-ethyl, were absorbed by rutabagas. Carbofuran, fensulfothion, and phorate toxicants increased to a peak in the roots about 70 to 90 days after planting and decreased thereafter. Carbofuran was not detected at harvest. Fensulfothion and phorate toxicants were present in roots at harvest, but disappeared after a month in storage. Toxicity of chlorfenvinphos and fonofos increased in rutabagas during the growing season, decreased slowly after harvest, and disappeared in 3 to 4 months. Trichloronat toxicants also increased gradually up to the time of harvest and remained at a constant level for more than a year in roots stored at 3.5 C. Toxicants of N2596 and pirimiphos-ethyl were not correlated with increased application of the parent compound in the soil. Bioactivity of all of the materials, except fensulfothion, decreased more quickly when the

granules were mixed with the upper 2.5 cm of soil than when banded at a depth of 2.5 cm, and even more rapidly when insecticides were applied on the soil surface; the placement of fenfuthion did not influence its bioactivity. Toxicants of carbofuran were more persistent when banded 4 cm deep in the soil than at depths of 2.5 cm or less.

Control of the cabbage maggot. In field experiments, preplanting band applications of all the above insecticides gave good to excellent control of cabbage maggots attacking rutabagas. Spot treatments of thionazin, fenfuthion, phorate, or carbofuran around plant stems also gave good control in stem crucifers. No organophosphorus or carbamate resistance has occurred after 5 successive years of testing in the same field.

Control of foliage-feeding pests of crucifers. In a field test in 1970, natural enemies of the imported cabbageworm and the cabbage looper maintained sufficient control of foliage injury before head formation to prevent reduction in yield of cauliflower and broccoli. A single spray of endosulfan, followed by one drench application on cauliflower and two on broccoli (one drench between early and late harvesting) of Phosvel (Velsicol Chemical Corporation), methomyl, chlorphenamide, chlorphenamide hydrochloride, and Padan (Chevron Chemical Co.) gave at least 85% reduction of larvae in the harvested crops. Phosvel, methomyl, and chlorphenamide gave more than 95% control, and mevinphos gave 81%.

TOBACCO

Cation balance in tobacco. Yield and quality of flue-cured tobacco were improved by applied K up to 45.2 kg/ha where soil K levels were high and up to 73.6 kg/ha where soil K levels were low. At the highest rate of K fertilization, the K in cured leaves was

increased by 1.3%, Ca was reduced by 0.43%, and Mg was reduced by 0.2%. Despite this reduction, caused by high K applications, Ca in the leaf was still within acceptable levels. At several locations, Mg in the leaf was depressed by K fertilization to lower than acceptable levels, which suggests that the lack of Mg could become a limiting factor in production where high K applications are being used.

ANIMAL NUTRITION

Potatoes and urea for growing steers. Daily gains of 1.2 kg were made by Holstein steers fed potatoes, free choice, plus 0.9 kg hay and 1.3 kg protein supplement. Three supplements, based on soybean meal, urea, or biuret as the crude protein source, gave identical gains and feed conversion. The urea-based supplement was considerably cheaper than the others. Up to 29 kg of potatoes were consumed daily by 270 kg steers. The value of the potatoes in this feeding program was calculated to range from 0.59 cent to 0.75 cent per kg when corn silage values ranged from 0.62 cent to 0.86 cent per kg. High levels of potatoes, along with a less costly crude protein source such as urea, provided an economical feeding program for growing steers.

Urea and biuret were compared as sources of crude protein in complete calf starter feeds for ad libitum consumption by calves weaned at 5 weeks of age. Biuret reduced calf performance significantly as compared with the urea-supplemented starters. For the urea- and biuret-supplemented starters, daily gains were 0.61 and 0.45 kg, and feed-to-gain ratios were 3.60 and 4.54, during the 8-week test period; feed intake was not significantly affected. Biuret does not appear useful in calf starter diets, because it is poorly utilized by calves and results in reduced feed conversion and weight gains.

PUBLICATIONS

Research

Chipman, E. W., MacKay, D. C., Gupta, U. C., and Cannon, H. B. 1970. Response of cauliflower cultivars to molybdenum deficiency. *Can. J. Plant Sci.* 50:163-167.

Cutcliffe, J. A. 1970. Effect of time of disbudding on single-harvest yields and maturity of "Jade Cross" Brussels sprouts. *HortScience* 5:176-177.

- Gupta, U. C. 1970. The effect of limestone, molybdenum, and incubation upon the extractable molybdenum in soils of Eastern Canada. *Plant Soil* 33:497-500.
- Gupta, U. C. 1970. Molybdenum requirement of crops grown on a sandy clay loam soil in the greenhouse. *Soil Sci.* 110:280-282.
- Gupta, U. C., Chipman, E. W., and MacKay, D. C. 1970. Influence of manganese and pH on chemical composition, bronzing of leaves, and yield of carrots grown on acid sphagnum peat soil. *Can. J. Soil Sci.* 34:762-764.
- Gupta, U. C., and MacLeod, L. B. 1970. Response to copper and optimum levels in wheat, barley, and oats under greenhouse and field conditions. *Can. J. Soil Sci.* 50:373-378.
- Johnston, H. Winston. 1969. Diseases of cereals in the Maritime Provinces in 1969. *Can. Plant Dis. Surv.* 49:122-125.
- Johnston, H. Winston. 1970. Control of powdery mildew of wheat by soil applied benomyl. *Plant Dis. Rep.* 54:91-93.
- Johnston, H. Winston, and Cannon, F. M. 1970. Reoccurrence and severity of barley jointworm infestations in Prince Edward Island. *Can. J. Plant Sci.* 50:352-354.
- Johnston, H. Winston, and Cutcliffe, J. A. 1969. Root rot of peas in Prince Edward Island in 1969. *Can. Plant Dis. Surv.* 49:140.
- Munroe, D. C., and Cutcliffe, J. A. 1970. Effect of available soil nitrogen on yields and response of Brussels sprouts to applied nitrogen in the field. *Can. J. Plant Sci.* 50:261-266.
- Read, D. C. 1970. Controlling the cabbage maggot: *Hylemya brassicae* (Diptera: Anthomyiidae), with chemical pesticides. *Can. Entomol.* 102:667-678.
- Sobey, D. G., MacLeod, L. B., and Fensom, D. S. 1970. The time-course of ion and water transport across decapitated sunflowers for 32 hours after detopping. *Can. J. Bot.* 48:1625-1631.
- Suzuki, M., and MacLeod, L. B. 1970. Effect of N source, and rate of N, P, and K on the ammonium, amino, and amide nitrogen levels in vegetative tissue of barley grown in hydroponic culture. *Can. J. Plant Sci.* 50:445-450.
- Thompson, L. S., and Willis, C. B. 1970. Effect of nematicides on root lesion nematodes and forage legume yields. *Can. J. Plant Sci.* 50:577-581.
- Thompson, L. S., and Willis, C. B. 1970. Reproduction of *Pratylenchus penetrans* and growth of birdsfoot trefoil as influenced by soil moisture and cutting management. *Can. J. Plant Sci.* 50:449-504.

Miscellaneous

- Cutcliffe, J. A. 1970. Broccoli responds to close spacing. *Country Guide*, October. p. 27.
- LeLacheur, K. E. 1970. Phosphorus and potassium levels for tobacco in the Atlantic Provinces. *Lighter* 40(1):14-15.
- Lovering, J., MacMinn, D., and Ryle, G. 1970. Maritime forage production costs. Atlantic Farm Management Committee, Bull. No. 120.821. 26 p.
- Lovering, J., MacMinn, D., and Ryle, G. 1970. Maritime grain production costs. Atlantic Farm Management Committee, Bull. No. 110.821. 24 p.
- Lovering, J., MacMinn, D., and Ryle, G. 1970. Maritime potato production costs. Atlantic Agricultural Economics Committee, Bull. No. 161.821. 21 p.

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INTRODUCTION

This report gives the principal research results for 1970 of the Research Station at Kentville and the associated Experimental Farm at Nappan. During the year significant progress was made in organizing the research effort into a number of programs, each associated with a specific crop or animal objective. Another highlight was the installation of a remote terminal connected to a time-sharing computer system. This facility will markedly increase the ability of the research staff to process and analyze data.

J. R. Wright
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush Blueberries and Cranberries

In crop years the levels of N in lowbush blueberry leaves decreased during July to September. In sprout years the opposite effect was observed. This suggests that in crop years N is being translocated from the leaves to the fruit. For the other nutrients studied the trend was the same in both crop and sprout years. On the basis of this study, the suggested optimum nutrient levels at the time of fruit bud initiation are: N, 1.50–2.00%; P, 0.08–0.12%; K, 0.40–0.55%; Ca, 0.40–0.65%; and Mg, 0.15–0.20%.

Evidence that NH_4 as a source of N is essential for optimum growth of the lowbush blueberry was found in an experiment measuring reductase activity in leaves and roots of plants grown in water culture. Nitrate reductase activity was not detected in leaves or roots of plants fed NH_4 at pH 4.0, but was detected in roots at pH 6.0. Activity was detected in roots of plants fed NO_3 as a source of N at both pH levels. Significant correlation coefficients were found between reductase activity and total plant weight, total shoot length, and shoot number.

Lowbush blueberry plants grown at warmer temperatures had greater flower bud formation with more primordial meristems and more advanced floret primordia, and had lower concentrations of anthocyanins in leaves than those grown under cooler conditions. This occurred whether a 10-hr or an 8-hr day was maintained in the growth chamber. These results may help to explain why lowbush blueberry fields at the high elevations on Cape Breton Island and along the seacoast of Newfoundland have not been as productive as those on mainland Nova

Scotia and in Maine, where temperatures during the growing season are somewhat higher.

Of seed extracted from fresh fruit of *Vaccinium vitis-idaea* var. *minus* Lodd (foxberry or rock cranberry) 76% germinated, but storage for 37 days at 2 C or treatment for 5 min with 0.1 N H_2SO_4 almost completely suppressed germination. These observations were made in a preliminary study of *V. vitis-idaea*, which appears to have considerable potential as a fruit crop in Nova Scotia. Other observations were that cross-pollination produces about twice as much fruit as self-pollination and that *V. vitis-idaea* var. *minus* has a taproot rather than the fine-matted root system that is typical of *Vaccinium* sp.

The results of two experiments show that the growth of the cranberry is strongly influenced by the apical dominance of the terminal buds. When the vine is allowed to grow in a perpendicular direction the existing shoot continues to grow, whereas when the shoot is bent over, lateral buds begin to develop all along the vine. In the field any condition (such as a heavy growth of tall weeds) that encourages upright growth of newly planted shoots will decrease the number of lateral buds and ultimately the number of vines available for fruit production.

Sprays of 2.8 kg/ha (2.5 lb/acre) of malathion applied 2–3 weeks before harvest increased the anthocyanin content of McFarlin, Early Black, and Searle cranberries. This work was part of a cooperative test conducted in seven commercial cranberry areas from the Atlantic to the Pacific coast of North America.

Highbush Blueberries

In a field experiment with the cultivar Bluecrop, N and K levels in leaves and fruit increased, but Ca levels decreased as the rate of $(\text{NH}_4)_2\text{SO}_4$, urea, or NH_4NO_3 increased. There were no differences due to source of N. During a 3-year period, application of 142 g/bush of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ had no effect on Mg levels in leaves or fruit. Median levels of nutrients found in leaves taken at mid-July over a 3-year period were: N, 2.01%, P, 0.11%, K, 0.56%, Ca, 0.43%, Mg, 0.14% of dry matter. The Ca and Mg levels are low compared with accepted levels in other highbush blueberry growing areas of North America. The levels of the other nutrients are normal.

Strawberries

A single application of GA (gibberellic acid) 4 weeks after planting increased runner and total crop yields of the strawberry cultivar Redcoat, compared with single applications at other dates. Plants sprayed twice at 5 and 10 weeks after planting increased marketable runner plant production, compared with single applications 5 or 10 weeks after planting. Crop maturity time and amount of fruit produced were not influenced by the treatments. Compared with the controls, there were no significant vegetative or cropping differences due to rate of GA application. Increasing the rate of applied N from 2 to 120 ppm increased runner, runner plant, and percent leaf N values in greenhouse-grown plants. Plants given a GA spray of 50 ppm combined with 120 ppm N gave the highest runner plant yield.

Ornamentals

Two selections from a breeding program to select compact, hardy rhododendrons appear very promising and are undergoing propagation prior to naming and release. One of the seedlings is a *Rhododendron catawbiense compactum* × *Rhododendron Williamsianum* cross. The leaves are small on this compact, floriferous, elepidote rhododendron. At 9 years, it is about 0.76 m high and 0.76 m in diameter. The bell-shaped flowers are soft pink and are held above the foliage in a rather loose cluster.

The second selection is a *Rhododendron* cv. Dr. Dresselhuys × *Rhododendron smirnowii* cross. At 12 years this compact, elepidote

rhododendron is about 0.91 m high and 0.91 m in diameter. The flowers are borne above the typical rhododendron foliage in large compact trusses. The florets are deep pink and ruffled.

Apples

Shade treatments increased elongation and decreased stem-cavity depth of McIntosh apples. Full shade was more effective than partial shade, and shading all year and early in the growing season affected apple shape more than shading after July 15. These results support the hypothesis that McIntosh apples on wood exposed to sunlight are less elongate than those on wood in the shade. Cultural practices aiming at maximum light penetration should reduce the incidence of off-shape McIntosh apples.

With McIntosh, on a tree-size basis, trees sprayed with zineb gave the highest yields, followed in descending order by trees sprayed with captan, dodine, dichlone, ferbam, glyodin, and bordeaux. The favorable response with zineb appeared to be associated with an increase in the Zn content of the foliage. These results were obtained over a 5-year period in apple trees just coming into bearing.

Increased P fertilization increased the rate of ethylene production of McIntosh apples stored for 111 and 158 days, reduced the output of most of the other volatiles, and increased the levels of scald and core-browning. Increased K supply had little effect other than to decrease the C_2H_4 production in the 111-day storage period. In this experiment, the production of carbon dioxide, ethylene, acetaldehyde, ethyl acetate, ethyl alcohol, ethyl propionate, ethyl-*n*-butyrate, and caproaldehyde was measured by infrared gas analysis and gas chromatography. The fruit was from 4-year-old McIntosh apple trees on EM 26 rootstocks grown in sand culture supplied with three levels of P and two levels of K in all combinations.

Vegetable Crops

A new jointless tomato was released and named Kenmor. The plant is determinate and vigorous. The fruit is even-ripening, medium-sized, and smooth. The removal of the calyx does not tear the flesh unless the fruit is overripe. The season is a few days later than for Fireball, and the average yield is 6.4 kg per plant.

Bronze symptoms appeared on carrot leaves when the Mn content of the tops was more than 2600 ppm. Such symptoms were associated with lower yields of carrots only when the Mn content of the tops exceeded 8000 ppm. This reduction in yield was also associated with low pH and a water-soluble Mn content of 37 ppm, or 5%, of total Mn in the peat obtained after the harvest of carrots. These results were obtained in greenhouse experiments to determine the direct effects and interactions of pH and Mn on the growth of carrots, and the Mn and Fe content of carrots grown on an acid sphagnum peat soil. The highest content of Mn in carrot tops occurred at pH values of 4.4 to 5.0, and the lowest at pH 6.2 and 6.4. The Mn content was lower at pH 4.0 than at pH 5.0. There was a significant interaction of pH and applied Mn on the Mn content of tissues. At low pH, a high rate of applied Mn increased the Mn content of tissue several times more than it did at high pH. In other treatments where no Mn was added or where 100 ppm Mn was added, the water-soluble Mn content ranged from 0.6 to 3.0 ppm. The Mn content of roots varied from 133 to 236 ppm. The Fe content of tops was lower at higher pH values.

Field Crops

Fertilizer trials with spring wheat and barley indicate that N, P, and K at approximately 135, 39, and 37 kg/ha, respectively, should generally be adequate. These trials were conducted at seven locations with wheat and nine locations with barley during a 3-year period. Treatments consisted of three rates of N, P, and K in all possible combinations. Although the soils varied in their chemical properties, grain yields increased with the second increment of N in some years and the crude protein content of the grain increased with the third increment in all years. Grain yields were not increased by the second increment of either P or K. Although the effects of increasing rates of N, P, and K on the levels of these nutrients in plant tissue were predominantly linear, increases in N levels had a much greater effect than increases in levels of either P or K.

In fertilizer trials carried on at six locations over a 2-year period with the corn hybrid Haapala 175, increasing rates of N increased grain yields at two locations and total dry matter at four locations. In these experiments

N was applied at 45, 90, and 135 kg/ha. Both grain and total dry matter increased at two locations as P increased from 19.5 to 58.5 kg/ha. Increases in K had no effect on grain or total dry matter yield.

In trials over a 4-year period, barley seeded early on frozen ground outyielded barley seeded later on a prepared seedbed. In 1967 two areas were seeded on April 17 and April 26 on frozen dikeland. Conventional seeding was very late in 1967 and the earliest seeding on dikeland was June 9. The frost-seeded area had a yield of 2909 kg/ha of Herta barley, whereas on the conventionally seeded area the yield was 1933 kg/ha. In 1968, seeding dates on the frost varied from March 27 to April 3, and conventionally seeded plots were seeded May 13. Yields varied from 4964 kg/ha to 2727 kg/ha for Herta barley seeded on the frost. Conventionally seeded plots gave yields varying from 4250 kg/ha to 3453 kg/ha. Applying 0-20-20 at 560 kg/ha in the fall and ammonium nitrate at 336 kg/ha in the spring, after the ground was firm enough, gave the best results for frost-seeding in 1968. In 1969, Herta barley was frost-seeded on April 9 and yielded 3459 kg/ha. An area conventionally seeded on May 13 yielded 3170 kg/ha. In 1970, Herta barley frost-seeded on April 6 yielded 2914 kg/ha, whereas barley conventionally seeded on May 26 yielded 1793 kg/ha.

In experiments to compare the effects of actual and simulated grazing on pasture productivity, the grazed areas produced more yield than the clipped. Related parameters of the grazed and clipped plots showed positive and statistically significant correlations, but the coefficients were not high enough for the clipping technique to provide reliable predictions of performance under grazing. The levels of N, K, and Mg in the separated fractions (grass, legumes, and weeds) were determined for each sward and N was applied under both grazing conditions. The greatest difference between the actual and simulated grazing treatments was in K content.

The highest yields of dry matter and total digestible nutrients (TDN), calculated from animal maintenance requirements and body weight gains, were from a grass-legume sward fertilized with N at 140 kg/ha annually in five equal applications. This treatment produced 8479 kg/ha dry matter and 2514 kg of TDN/ha. The lowest yield was from

grass without N, 5029 kg/ha dry matter and 1809 kg of TDN/ha. Applications of N had little effect on TDN production from legume swards, but significantly increased that from the grass and grass-legume swards. The average responses to N for all swards during the 3-year experiment were 42, 367, and 431 kg of TDN/ha for the legume, grass-legume, and grass swards, respectively. This is sufficient to double the monetary returns on the grass sward and return one and one-half as much on the grass-legume sward.

An increase in soil pH resulted in an increase in Mo and Cu content and a decrease of B, Mn, and Zn of plant tissue in experiments to test the effect of five rates of limestone and four rates of fertilizer on the micronutrient content of forage and soil. The micronutrient content of the tissue increased as the season progressed. Increasing rates of fertilizer did not affect the micronutrient content of the forage or soil. Liming to pH 5.6 and above reduced the availability of Mn and Zn in the soil. In general, the available B was low at pH values greater than 6.1. Lime did not affect the quantities of Mo and Cu in the soil. However, addition of B and Zn may be required on high pH soils. Where the soil was limed to a pH of 6.0 or greater, Mo was adequate. The dry matter yield of forage increased significantly with successive increases in lime up to pH 6.6 and with each increase of fertilization.

In experiments with birdsfoot trefoil grown in the greenhouse, harvesting at the maximum growth stage produced the most dry matter, the lowest digestibility, the greatest etiolated regrowth, and the most nodulation. The cultivars Empire, Leo, Viking, and Wallace were evaluated. Harvesting at the vegetative stage produced the least forage, which was the most digestible, and plants were as cold hardy as plants harvested at any other growth stage. Empire was the most productive and also the most cold hardy. At the 10% and 50% bloom stages Wallace equaled Empire in production, and there was no difference between the four cultivars in forage production when harvested at the vegetative stage. Viking appeared to be the least hardy of the cultivars examined, but it produced more etiolated regrowth than Empire and Wallace, though not as much as Leo. This experiment shows that criteria other than total production must be examined in evaluating birdsfoot trefoil.

PROTECTION OF CROPS AGAINST PESTS

Insect Pests

Subsequent capture of adults of a natural population of *Rhagoletis pomonella* (Walsh) labeled with Sr⁸⁹ indicated that about 5% of the population could be marked by this method. The flies were labeled by allowing them to feed on apple and other foliage sprayed with an enzymatic soy hydrolysate bait solution containing Sr⁸⁹Cl₂, and then capturing them on sticky board traps. The adults dispersed readily from their emergence sites to feed on apple and other foliage, and later returned to oviposit in or near the original breeding sites. Dispersal flights were within 300 ft of emergence sites in most instances, and the prevalence of adults on apple trees was influenced by the amount of fruit and the variety. Adults were more abundant on early and mid-season varieties, particularly when the trees were bearing fruit. The data suggest that the adult is distracted from flight depending upon age and needs; newly emerged adults respond to foliage for food and gravid females to fruit for oviposition.

A 6-year study of an apple orchard in Nova Scotia revealed that there were over 35 pest species on the fruit and foliage of the test block, but 91% of the injuries to the fruit were caused by only seven of these species. On the 25% of the McIntosh crop injured, 83% of the injuries were caused by biting insects and 8% by stinging insects. The injuries to Delicious apples were 39% and 52% for the two groups. This orchard received all the normal cultural treatments, including fungicides, but no insecticides or miticides were used. Natural factors provided 75% of the crop free from insect injury. Another study in this orchard showed the presence of about 200 species on the foliage. If the bark-inhabiting species and the parasites are included, it is estimated that over 400 species use the apple tree as habitat. The species complex includes pests, potential pests, parasites, predators, and a large number of species of no known importance. The functions of the latter group are not fully known, but in general, they serve as food for a reservoir of natural enemies of pests.

In a commercial orchard where the regular scab control program was followed but where no insecticides were used, the trend

index of the winter moth, *Operophtera brumata* L., was 50% for 1967, 519% for 1968, and 30% for 1969. This pest had never been limited by its food supply in this orchard. The trend indicates that natural controls, such as parasites, bird predation, larval dispersion, and diseases, will reduce it below economic levels. In most commercial orchards a low dose of lead arsenate once a year provides adequate supplementary control.

Plant Pathology

Perithecia of *Venturia inaequalis* (Cke.) Wint. did not form in a basal medium to which ammonium sulfate, chloride, phosphate, or tartrate was added as the sole source of N when the pH of the medium was allowed to fall to inhibitory levels (3.5–4.0). Perithecia formed when calcium carbonate was added to control the pH. With ammonium carbonate and oxalate there was no appreciable change in pH and perithecia formed with these salts as sources of N. Perithecia did not form in media with leucine as a source of N. Formation of perithecia with other amino acids depended on the concentration of amino-nitrogen in the media. A substance toxic to perithecial formation may form in cultures containing leucine. This substance is produced in different amounts by the two isomers and the racemic mixture of this amino acid.

At temperatures simulating spring growing conditions, an unknown *Typhula* species induced poor growth and killed strawberry plants growing in a peat-soil mix in a growth chamber. The simulated environment consisted of a 16-hr day at 10 C and an 8-hr night at 4 C with 90% relative humidity. Small dark lesions were observed on the roots of alsike clover grown under the same conditions and inoculated with the same *Typhula*. This species, which resembles *Typhula variabilis* Riess, was isolated from the surface of strawberry plants under straw mulch in April. It reduced the growth of timothy, but had no effect on the growth of red clover, oats, rye, or peas.

A leaf spot found in 1968 and 1969 on the highbush blueberry was apparently caused by *Godronia cassandrae* Pk. f. *vaccinii* Groves. The cultivar Bluecrop was more susceptible than the cultivars Berkley or Coville. There appeared to be a direct relation between the severity of leaf spot infection

and the susceptibility of the cultivars to canker caused by *G. cassandrae*.

The fungus *Gibbera compacta* (Pk.) Shear was successfully isolated from the characteristic black spots on cranberry leaves when a 0.5% Cl solution was used to sterilize the surface of the leaves. Ascospores developed best in asci of leaves held on filter paper flooded with water at a temperature of 22 C.

Pesticide Residues

Disulfoton at 1.1, 2.2, 4.5, and 17.9 kg/ha and menazon at 2.2 kg/ha worked into the soil with a rotovator all provided effective control of *Acyrtosiphon pisum* Harris on peas up to the time of bloom on both sand and clay soils. As the crop matured, the treatment of 1.1 kg/ha disulfoton became less effective on the clay loam soil but retained its effectiveness on sandy loam. The treatment of 2.2 kg/ha menazon was equivalent to the treatment of 2.2 kg/ha disulfoton. Menazon or disulfoton did not directly affect plant growth or crop yields.

In an investigation of the persistence of organochlorine insecticides applied as single sprays to grassland in Nova Scotia, about 25% of the dieldrin and chlordane was found 12 years after application. Lindane could not be detected after 12 years and aldrin and heptachlor were completely converted to their epoxides. Fall applications of insecticides resulted in larger residues than spring applications. Over 80% of the total residues were found at the 0–10-cm depth but traces had penetrated to the 20–25-cm depth in some plots. The plots from which the samples were taken were established 9 to 13 years ago at four locations in Nova Scotia to test the effectiveness of the insecticides against wireworms (*Agriotes* sp.) in grasslands. The maximum rate of application for chlordane was 11.2 kg/ha, for lindane 1.7 kg/ha, and for the others 6.7 kg/ha.

Sixteen years after the last application, about 0.10% of the applied parathion remained in a plot of sandy soil at Kentville. The field plots in which the parathion was found were established in 1949 and received four annual surface applications of 34.2 kg/ha of parathion incorporated with a rotovator to a depth of 15 cm. All the parathion was found in the top 20 cm of the soil. Parathion was determined by gas chromatography using a flame photometric detector,

and confirmed by thin-layer chromatography using several solvent systems.

Storage

The average loss from rots in cold-stored McIntosh apples in Nova Scotia for the 7-year period 1962-1968 was found to be 4.8%. *Gloeosporium album* Osterw. was the most common cause of rots, followed by *Penicillium* spp., *Botrytis cinerea* Pers., and *G. malicorticis* Cordley. This information was obtained in a survey of 12 orchards in various parts of the Annapolis Valley. Samples, usually 100 but sometimes 500 apples, from each orchard were brought to the Research Station and stored at 0 C for 6 months prior to examination for rots.

There was less decay and more physiological breakdown in cranberry fruit stored at 3.3 C in an atmosphere of N than in those stored in air. The influence of N was largely during the first 3 weeks of storage. Less decay developed in cranberries that had been initially stored for 3 weeks in N and then stored in air than in berries stored continuously in air. In this experiment, freshly harvested cranberries of the cultivar Howe, free from decay, were taken from a local bog and stored in opaque containers holding 13.5 kg of fruit. Decay and physiological breakdown were recorded on 200-g samples removed at 3-week intervals.

The presence of 2000 ppm ethylene depressed the growth in vitro of *Fusarium oxysporum* Schlecht. both in air and in a mixture of 5% CO₂ and 2.5% O₂. High concentrations of ethylene significantly reduced the development of fusarium rot in inoculated tomatoes both in the presence and absence of CO₂. The development of fusarium rot was less in the absence of CO₂ than at a 3% concentration. The effect of the high ethylene concentrations and the removal of CO₂ in reducing the development of rot was additive. Significantly high concentrations of ethylene in 3% CO₂ were as effective in suppressing rot development as was the removal of CO₂ at low ethylene concentrations. Since the presence of high concentrations of ethylene and 3% CO₂ were as effective as low concentrations of ethylene and the absence of CO₂ in reducing rot development caused by *F. oxysporum*, it is concluded that the addition of ethylene can be beneficial in reducing development of fusarium rots on tomatoes in a controlled atmosphere.

FOOD TECHNOLOGY

Sauce from cranberries stored at 3.3 C for 6 weeks in an N atmosphere was superior in flavor to sauce made from berries stored in air and equal in flavor to sauce made from freshly harvested berries. Color measurements indicated a significant enhancement of the color of the N-stored berries. With non-enzymic juice extraction, N-stored berries yielded darker juice than air-stored berries, but with enzymic extraction there was no difference. Nitrogen storage significantly increased the titratable acidity of the juice.

A yellow discoloration that appears after heat processing in canned Clapp's Favorite pears was traced to improper storage. Freshly harvested pears were subjected to alternating storage temperatures between 0 C and 4.5 C, with control samples kept at 0 C. After 8 weeks of storage, samples were canned in 30% sugar syrup and heat-processed. The pears subjected to alternating storage temperatures exhibited the yellow discoloration of the commercial samples. Those stored at 0 C were normal in color. Although the discolored pears were normal in flavor and texture, the yellow color was the basis for downgrading the product from Fancy to Choice.

A tendency of white beans grown in Prince Edward Island to gel in the can after processing was shown to be due to a higher than normal concentration of pectic material and lower than normal Ca. Beans brought in from central Canada do not show this characteristic. The addition of calcium chloride or calcium lactate to the soak water inhibits the gelling and produces an acceptable commercial beans-with-pork pack.

Cooking loss, color, fat, and moisture content and texture of broiler meat were not significantly affected by diets containing various amounts of fish meal, with or without the addition of activated charcoal. In this experiment, diets containing 0%, 3%, 9%, 14%, and 19% whitefish meal and a diet containing 15% high-fat fish meal were fed to the females of a commercial strain of broilers for 63 days. Activated charcoal at 5% was added to the six diets for half the birds.

Significant differences were found between the control (0% fish meal) broilers and the 15% high-fat and 19% fish meal broilers in acceptability and flavor intensity. There were no significant differences in acceptability and flavor intensity between birds fed charcoal

and birds that were not, or between different days of cooking. Starving the birds for 24 hr prior to killing did not affect the acceptability and flavor intensity, but starving for 72 hr did.

ANIMAL SCIENCE

Poultry

Hatchability of eggs stored at 16 C was significantly higher than at 23 C (the common air flight temperature), whether the storage period was 7 or 14 days. Eggs stored 14 days at 23 C and cooled either 24 hr or 48 hr at 11 C, followed by 18-hr prewarming, hatched better than eggs not prewarmed or eggs held at a constant 23 C. However, eggs stored 14 days at 23 C, cooled for 24 hr at 11 C, and set directly into incubators had a significantly lower hatchability than eggs maintained at a constant 23 C. These experiments show that if it is not possible to maintain hatching eggs at 16 C during air transport, then air-flight temperatures of 23 C appear adequate if the preincubation time for eggs does not exceed 7 days. If preincubation time is longer than this and eggs are not immediately placed in incubators on arrival, hatchability may be improved if after delivery they are cooled at 11 C for 24 hr or longer, then prewarmed for 18 hr before being placed in incubators, rather than being held at 23 C.

In experiments to test the effect of preincubation fumigation, embryo viability of hatching eggs was not impaired when 1.5 cc of formalin was used with 1 g KMnO_4 per 0.02832 m^3 of the fumigation chamber, provided fumigation time was 20 to 30 min, the egg pack was adequately ventilated immediately following fumigation (at least 24 hr of ventilation prior to packing in a case), relative humidities ranged from 49% to 58% or from 60% to 78% when fumigating at a maximum temperature of 37 C, and temperatures of either 23 C or 37 C were used with relative humidities ranging from 60% to 78% during fumigation. These fumigation procedures did not affect hatchability even when eggs were prewarmed at 37 C for 3 hr prior to fumigating at 23 C for 20 min, or when the pre-fumigation egg temperatures were 11 C or 16 C prior to fumigating at 37 C, a condition which resulted in considerable condensation of moisture on the eggs. Fumigation was

usually conducted within a day or two from time of lay, but hatchability was unaffected when eggs were stored up to 3 weeks and fumigated at the time of setting.

Mortality due to Marek's disease was significantly lower in groups of chicks fed 0.5 g of fecal matter compared with the groups that consumed 1.0 g per chick. In this experiment, fecal matter was collected from the survivors of a flock of adult Leghorn birds in which mortality due to Marek's disease was 33%, and was fed to Leghorn chicks at 7, 21, 35, and 49 days of age at the rate of 0.5 g and 1.0 g per bird. It is evident that the quantity of fecal matter fed to young chicks may be important in altering the mortality due to Marek's disease in domestic chickens.

A significant difference among genotypes for mortality due to Marek's disease was demonstrated. Results of these experiments revealed no advantage in rearing birds on old litter rather than on new litter. When birds were transferred from the high- to the low-exposure environments, mortality was higher than when birds were transferred in the opposite direction, indicating that if birds are to be moved to a clean, low-exposure locale it may be desirable to transfer some of the litter from the rearing quarters to the clean premises.

Cattle and Sheep

Sheep readily consumed 1100 g of hay daily to which 10% bunker C oil had been added. The oil had a depressing effect on feces dry matter and the digestibility of dry matter and N. It is probable that oil consumed over a long period could be a contributing factor in weakening sheep already in poor condition and subsisting on a minimum diet. However, it appears that the decrease in digestibility caused by feeding oil at 100 g/day is not enough to have any immediate effect. This experiment was carried out at the request of the task force cleaning up oil from the tanker Arrow in Chedabucto Bay. Some sheep were fed seaweed from the contaminated beach, but insufficient seaweed was available to complete the feeding trial. Oil used to contaminate the hay was obtained from Chedabucto Bay.

Dietary diethylstilbestrol (DES) in the diet of steers increased the effectiveness of grass silage much more than alfalfa-grass or corn silage. Consumption of the silages did not differ significantly on a dry-matter basis.

Corn silage produced much better gains than grass alone or alfalfa-grass, and much less corn silage was required per unit of gain. Shipping loss, dressing percentage, eye muscle, and grade favored corn silage; DES had no significant effect on these factors. The value of silage based on the price received for the steers was greater for the corn than for the grass or grass-legume.

Pregnant cows were successfully kept over winter in a wooded area without any other shelter and fed on hay alone. In this experiment 40 Shorthorn cows kept in the wooded area were compared with a similar group kept in a loose-housing pole barn. The experiment lasted for 3 winters, with the animals

kept in the experimental areas for about 5 months each winter. Mean winter temperatures varied from -3.0 C to -1.7 C, with the lowest temperature of -33 C occurring during the first winter. The type of shelter did not have a significant effect on body weight during the winter. The cows remained healthy and dropped healthy calves. There was no particular problem at calving time in the woods. Managing cows in the woods presents problems not encountered in barns. The rough terrain presents hazards that may lead to loss of cows, so close observation is necessary. There was some indication that the woods environment had an adverse effect on breeding.

PUBLICATIONS

Research

- Bishop, R. F., Craig, D. L., and MacEachern, C. R. 1970. Observations on the performance of grape cultivars in Nova Scotia. *HortScience* 5:154-156.
- Blatt, C. R., and Crouse, D. N. A. 1970. Effects of gibberellic acid and nitrogen on the strawberry cv. 'Redcoat'. *HortScience* 5:437-438.
- Calder, F. W. 1970. Effect of barley supplement to the ration of donor animals used in *in vitro* digestibility determination. *Can. J. Anim. Sci.* 50:265-267.
- Calder, F. W. 1970. The use of cattle and sheep for evaluating grass and legume swards, a comparison of methods. *J. Brit. Grassland Soc.* 25:144-145.
- Calder, F. W., and Smith, H. J. 1970. The role of irrigation in the development of gastrointestinal parasitism in cattle on dikeland and upland pastures. *Proc. XI Int. Grassland Congr.* 884-887.
- Calder, F. W., Nicholson, J. W. G., and Carson, R. B. 1970. Effect of actual vs. simulated grazing on pasture productivity and chemical composition of forage. *Can. J. Anim. Sci.* 50:475-482.
- Calder, F. W., and Nicholson, J. W. G. 1970. Pasture productivity of three swards with and without nitrogen fertilization. *Can. J. Anim. Sci.* 50:467-473.
- Chipman, E. W., MacKay, D. C., Gupta, U. C., and Cannon, H. B. 1970. Response of cauliflower cultivars to molybdenum deficiency. *Can. J. Plant Sci.* 50:163-167.
- Craig, D. L., Gass, D. A., and Fenson, D. S. 1970. Red raspberry growth related to electrical impedance studies. *Can. J. Plant Sci.* 50:59-65.
- Eaton, G. W., Zuckerman, B. M., Shawa, A. Y., Eck, P., Dana, M. N., Garren, R., and Lockhart, C. L. 1969. The effect of preharvest malathion sprays upon cranberry fruit color. *J. Amer. Soc. Hort. Sci.* 94:590-592.
- Friend, D. W., and MacIntyre, T. M. 1970. Paired feeding and metabolism trials comparing barrows with gilts. *J. Anim. Sci.* 30:931-934.
- Friend, D. W., and MacIntyre, T. M. 1970. Effect of rye ergot on growth and N-retention in growing pigs. *Can. J. Comp. Med.* 34:198-202.
- Friend, D. W., Gorrill, A. D. L., and MacIntyre, T. M. 1970. Performance and proteolytic activity of the suckling piglet creep fed at one or three weeks of age. *Can. J. Anim. Sci.* 50:349-354.
- Hall, I. V. 1970. Cranberry shoot morphology as influenced by orientation of vines. *Natur. Can.* 97:351-355.
- Hall, I. V., and Beil, C. E. 1970. Seed germination, pollination and growth of *Vaccinium vitis-idaea* var. *minus* Lodd. *Can. J. Plant Sci.* 50:731-732.
- Hall, I. V., and Butler, K. P. 1970. The relation between seed number and berry weight in the foxberry. *Cranberries* 35(8):16.
- Hall, I. V., Forsyth, F. R., and Lightfoot, H. J. 1970. Volatiles from developing fruit of *Vaccinium angustifolium*. *Can. Inst. Food Technol. J.* 3:1-3.

- Hall, I. V., Forsyth, F. R., and Newberry, R. J. 1970. Effect of temperature on flower bud and leaf anthocyanin formation in the lowbush blueberry. *HortScience* 5:272-273.
- Herbert, H. J. 1970. Limits of each stage in populations of the European red mite, *Panonychus ulmi*. *Can. Entomol.* 102:64-68.
- Idler, D. R., Safe, L. M., MacKinnon, G. A., and Proudfoot, F. G. 1970. Scallop sterols are hypocholesterolemic relative to cholesterol for the chick. *J. Fish. Res. Board Can.* 27:601-603.
- Idler, D. R., MacKinnon, G. A., and Cox, A. C. 1970. Further studies on scallop sterols in relation to cholesterol in the chick. *J. Fish. Res. Board Can.* 27:1329-1331.
- Lockhart, C. L. 1970. Suppression by ethylene of *Fusarium oxysporum* growth in culture and rots on tomatoes in controlled atmosphere storage. *Can. J. Plant Sci.* 50:347-349.
- MacIntyre, T. M. 1970. Effect of bunker "C" oil on sheep. *Can. J. Anim. Sci.* 50:748-749.
- Neilson, W. T. A., Wood, G. W., and Maxwell, C. W. 1970. Dimethoate sprays for apple maggot and their effect on predaceous insects and mites. *J. Econ. Entomol.* 63:764-766.
- Proudfoot, F. G. 1970. The influence of different pre-incubation holding temperatures on the hatchability of chicken eggs. *Poultry Sci.* 49:812-813.
- Proudfoot, F. G. 1970. Influence of photoperiod and method of decreasing photoperiod on mortality attributed to Marek's disease among meat parent female chickens. *Can. J. Anim. Sci.* 50:205-207.
- Proudfoot, F. G. 1970. Effects of genotype, age and environment on the incidence of mortality due to Marek's disease. *Can. J. Anim. Sci.* 50:499-506.
- Proudfoot, F. G., and Stewart, D. K. R. 1970. Effect of pre-incubation fumigation with formaldehyde on the hatchability of chicken eggs. *Can. J. Anim. Sci.* 50:453-465.
- Rasmy, A. H., and MacPhee, A. W. 1970. Mites associated with apple in Nova Scotia. *Can. Entomol.* 102:172-174.
- Rasmy, A. H., and MacPhee, A. W. 1970. Studies on pear psylla in Nova Scotia. *Can. Entomol.* 102:586-591.
- Ross, R. G., Crowe, A. D., and Webster, D. H. 1970. Effect of fungicides on the performance of young McIntosh and Cortland apple trees. *Can. J. Plant Sci.* 50:529-536.
- Ross, R. G., and Gourley, C. O. 1969. *Phytophthora syringae* fruit rot of apples. *Can. Plant Dis. Surv.* 49:33-35.
- Ross, R. G., and Sanford, K. H. 1969. Arsenical injury to apple foliage from spray mixtures containing lead arsenate. *Can. Plant Dis. Surv.* 49:67-69.
- Sanford, K. H., and Herbert, H. J. 1970. The influence of spray programs on the fauna of apple orchards in Nova Scotia. XX. Trends after altering levels of phytophagous mites or predators. *Can. Entomol.* 102:592-601.
- Specht, H. B. 1970. The apple aphid, *Aphis pomi* (Homoptera: Aphididae) populations on apple under autumnal conditions in a controlled environment cabinet. *Can. Entomol.* 102:623-627.
- Specht, H. B., and Chisholm, D. 1970. Influence of soil type on the efficacy of disulfoton and menazon in control of pea aphid on canning peas. *J. Econ. Entomol.* 63:1588-1589.
- Specht, H. B., and Rasmy, A. H. 1970. A new phytoseiid (Acarina: Mesostigmata) from apple in Nova Scotia. *Can. Entomol.* 102:1022-1024.
- Townsend, L. R. 1970. Effect of form of N and pH on nitrate reductase activity in lowbush blueberry leaves and roots. *Can. J. Plant Sci.* 50:603-605.
- Townsend, L. R., and Hall, I. V. 1970. Trends in nutrient levels of lowbush blueberry leaves during four consecutive years of sampling. *Natur. Can.* 97:461-466.

Miscellaneous

- Craig, D. L. 1970. New rhododendrons and azaleas. *Can. Agr.* 15(3):17.
- Forsyth, F. R., and Eaves, C. A. 1970. Firmer McIntosh apples. *Can. Agr.* 15(2):12-13.
- Hall, I. V., and Aalders, L. E. 1970. Rooting lowbush blueberry cuttings under nutrient mist. *Can. Agr.* 15(2):16.
- MacIntyre, T. M., and Nicholson, J. W. G. 1970. Winter shelter for beef cows. *Nappan. Exp. Farm Proc. Publ.* 18 p.
- MacLellan, C. R. 1969. Present status of codling moth and its control. *Nova Scotia Fruit Growers' Ass. Annu. Rep.* 106:57-61.
- Neilson, W. T. A. 1970. Research on apple maggot control. *Nova Scotia Fruit Growers' Ass. Annu. Rep.* 106:125-127.
- Proudfoot, F. G. 1970. La lutte des sexes. *Can. Agr.* 15(1):16-17.
- Ross, R. G. 1969. Root and crown rots of apple trees. *Nova Scotia Fruit Growers' Ass. Annu. Rep.* 106:71-72.

Ross, R. G. 1970. Spraying for scab costly but worthwhile. *Can. Fruit Grower* 26(3):16.

Webster, D. H., and Crowe, A. D. 1970. Nutrition and factors affecting growth. Nova Scotia Fruit Growers' Ass. Annu. Rep. 106:51-57.

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INTRODUCTION

As in previous years this report very briefly summarizes work completed at the Station during 1970 and the progress made on other projects. We welcome requests for more detailed information on work completed or under way. The main emphasis of our work is on all aspects of potato production, and on animal nutrition, agricultural engineering, and soils.

F. Whiting
Director

ANIMAL NUTRITION

Heated Soybean Meal and Methionine-hydroxy Analogue Fed to Steer Calves

Three feeding experiments with weaned crossbred steer calves were completed to study methods of improving the utilization of the crude protein from silages high in nonprotein N. In the first experiment soybean meal was heated in an autoclave at 1 kg/cm² steam pressure for 1 hr and compared with unheated soybean meal in a supplement with corn silage with urea added at ensiling or grass silage. Weight gains were identical for the two supplements over a 92-day feeding period.

The same two silages and corn silage without urea were used in an experiment to compare supplements containing methionine-hydroxy analogue (MHA) to supply 3 g/day or an equivalent amount of inorganic S. Supplementary crude protein was supplied as urea. There was no increase in the rate of gain caused by adding MHA to any of the three silages.

Another experiment was conducted to compare MHA and S additions to the rations of steers fed hay and 6.8 kg of rolled barley or an equivalent amount of dry matter from ensiled high-moisture barley. The average daily gain by the steers receiving MHA was 0.84 kg compared with 0.80 kg by the steers receiving S. It was concluded that MHA supplementation did not improve the performance of steers fed either high-silage rations or high-concentrate rations.

Selection Index for Corn

In areas where the climate makes it difficult to mature corn for silage, it is important to consider factors such as dry-matter content and grain yield along with dry-matter yield when evaluating varieties. A selection index

was developed, based on measurements obtained in routine variety evaluation trials, to objectively rate the varieties. The quality factors used in the index were dry matter (DM) of the whole plant, as a measure of maturity, and the percentage of total DM contributed by the ear. The latter is related to the grain yield and total digestible nutrient (TDN) value. The index is as follows:

$$\text{Index value} = \text{DM yield (kg/ha)} + (\text{DM\% of whole plant} \times 250) + (\% \text{ of total DM contributed by the ear} \times 50).$$

The index was checked by animal feeding studies and is being used to rank commercial hybrids included in the regional trials set up by the Atlantic Provinces Corn Committee.

Corn and Pole Beans for Silage

Trials on small plots at the Station and Nappan, N.S., showed that growing corn and pole beans together increased the dry-matter yield and the crude-protein content of the crop. Satisfactory fermentation and preservation occurred when various combinations of corn and pole beans were ensiled in plastic bag silos. Corn and pole beans were grown on a small area and ensiled in a conventional concrete stave silo on top of corn silage. The silage was accepted readily when fed to Holstein heifers. Although the silage was superior to straight corn, the problems of seeding, weed control, and harvesting the tangled crop make the growing of corn and pole beans together questionable in the Maritime Provinces.

Effects of Palatability and Digestibility on Intake of Silage

A "steer stuffing" experiment with four rumen-fistulated steers was conducted to separate the effects of palatability and digestibility on the intake of corn and grass silages (Nature (London) 214:744, 1967). Each silage was fed ad lib. to one steer and at half

ad lib. to another. The second steer was given an equivalent amount of dry matter from the other silage by stuffing it through a rumen fistula. The steers fed grass silage ad lib. consumed 9.2 kg of dry matter per day, those fed grass and stuffed with corn 10.0 kg, those fed corn and stuffed with grass 10.3 kg, and those fed corn ad lib. 10.4 kg. The dry-matter digestibility coefficients were 62.8% for grass silage and 66.3% for corn silage.

Cereal Silages for Dairy Cows

Forage oats and barley whole crop silages were compared with corn silage as the sole forage for dairy cows during a 16-week trial. Each group of eight cows received a 20% crude protein meal mixture according to milk production, and silage was fed ad lib. Daily silage dry-matter intake averaged 9.9, 10.0, and 9.8 kg/cow and milk production was 16.9, 18.4, and 21.4 kg/cow for each group. Blood urea, rumen fluid ammonia, and volatile fatty acid values were similar for the three groups. The lower performance of the cows fed forage oats was attributed to the high fiber content in this material.

Rapeseed Meal for Dairy Cows

Rapeseed meal as a protein supplement for dairy rations was evaluated with lactating dairy cows over a 12-week period. Three groups of eight cows were fed a 16% crude protein meal mixture containing either 22.5% rapeseed meal, 1.75% urea, or 15% soybean meal and grass hay ad lib. Hay consumption was similar for the three groups. Daily fat-corrected milk yields averaged 19.2, 18.3, and 21.0 kg/cow respectively. Fat, protein, and solids-not-fat yields were also higher for cows receiving soybean meal. It was concluded that rapeseed meal was less efficiently utilized for milk production than soybean meal when included at high levels in a dairy ration.

Milk Replacer for Calves

Whole milk or milk replacers containing only milk protein or 50% of the protein from a fish protein concentrate were fed either once or twice a day to 34 Holstein heifer calves from the time they were 3 days of age. The calves were weaned when they consumed 500 g/day of starter, or were 35 days old. Average weaning ages of calves fed

whole milk, the all-milk protein milk replacer, or the milk-fish protein milk replacer were 25, 27, and 24 days. Weight gains to weaning were 398, 368, and 365 g/day and to 180 days were 690, 697, and 689 g/day respectively. Daily gains to 180 days for calves fed the liquid diets once or twice a day to weaning were 692 g/day for both groups.

Body weight gains to 6 weeks of age for bull calves fed milk replacers containing 0, 23%, and 52% acid whey powder were 635, 515, and 452 g/day. The growth rate of calves increased by 15% (590 g/day) when the pH of the 23% whey formula was adjusted from 5.8 to 6.8. Adjustments of the pH of the 52% whey formula from 5.0 to 6.8 increased gains by only 6% (478 g/day). Adjusting the pH of the whey had little or no effect on nutrient digestibilities.

Average daily gains during a 7-week period for calves fed milk replacer with no bulk or with sawdust or wood shavings added were 702, 716, and 571 g. Two calves fed shavings died from severe indigestion and rumen compaction.

Diarrhea and Gastrointestinal Functions in Calves

Previous research on calves at the Station showed that soybean trypsin inhibitor (SBTI) reduced pancreatic enzyme secretion and caused diarrhea. Neostigmine methyl sulfate (0.04 mg/kg body weight) and magnesium sulfate (0.05 M in the liquid diet) were used to induce diarrhea in calves with reentrant intestinal cannulas and to simulate the effect of SBTI. During the first 15 min after treatment with neostigmine methyl sulfate, the flow rate of digesta increased 2.7-fold, and total activities of trypsin and chymotrypsin increased 2.3-fold. Magnesium sulfate caused profuse diarrhea, but had little effect on proteolytic enzyme activity in the digesta. Apparently, it is not the diarrhea induced by SBTI but some other effect of the inhibitor that reduces enzyme secretion from the calf pancreas.

Milk Replacer for Lambs

A simple low-cost teat bar was built for ad lib. feeding of cold milk replacer to lambs. A plastic shield was placed around the nipples to prevent the lambs from chewing them. The milk replacer was kept cold in a refrigerated milk dispenser and flowed under gravity to the teat bar.

An insoluble soybean protein concentrate was readily dispersed in 0.05 N NaOH. The soybean concentrate did not settle out when the liquid diet was neutralized before or after the remaining milk replacer ingredients were added. Treatment of the soybean concentrate with NaOH increased *in vitro* protein digestion by pepsin, but not by trypsin and chymotrypsin. Incubating the soybean - sodium hydroxide mixture for 5 hr at 37 C before neutralization did not further increase *in vitro* protein digestion by pepsin.

AGRICULTURAL ENGINEERING

Mechanical Apple Harvester

A mass removal system for harvesting apples was tested in 1970 at Kentville, N.S. A new catch frame constructed in 1969 effectively caught and placed apples in bulk bins. The amount of damage was under the limit for processed apples, and the damage may be reduced further. Tests in 1970 were carried out by shaking the trees by hand, but the estimated cost of harvesting with a complete unit including a mechanical shaker is low enough that work on the harvester is continuing. In 1971 a mechanical shaker will be developed for use with the new catch frame.

Potato Harvesting

The system of windrowing potatoes before a harvester picks them up and separates them from stones and soil was evaluated. Potatoes from two rows were dug and deposited between two adjacent undug rows by a windrower; the two-row harvester was able to pick up four rows of potatoes simultaneously. Tests showed that the efficiency of the harvesting operation was increased significantly with no change in the amount of potato injury.

Low-cost Storage for Silage

A low-cost horizontal silo was constructed by using fence posts at 1.5-m spacings and 5 × 10 cm wire mesh fencing. Polyethylene was used to line the walls and as top covering. To test ways of preventing freezing near the side walls, portions of the side walls were lined with straw bales as insulation. To reduce filling costs, silage was blown into the silo with a forage blower and no packing was

done. The silo was filled to the top as the forage blower was moved along the length of the silo. The plastic cover was put into place as filling progressed, and the partially filled space was covered during the night to reduce the exposure time to air. Monitoring of temperatures in the silage during the fermentation period indicated no excessive heating. Readings after 2 weeks in which the temperature reached -25 C showed a 5 to 10 degree higher temperature in silage protected by a wall insulated with straw.

ENTOMOLOGY

Potato-infesting Aphids

Plants that might be potential reservoirs of potato-infesting aphids were examined during the first week of June in 10 plastic or glass houses in Carleton and Victoria counties, the main potato-growing areas of New Brunswick. Aphids were found in five houses. Three potato-infesting species, *Macrosiphum euphorbiae* (Thomas), *Myzus persicae* (Sulzer), and *Aulacorthum solani* (Kltb.) were collected. These and *Aphid nasturtii* Kltb. are the commonest aphids on potatoes in New Brunswick. *Myzus ornatus* Laing and *Aulacorthum circumflexum* (Buckton), pests of potatoes in Europe, were found at two locations. During the growing season, *A. nasturtii* and *M. euphorbiae* were the most abundant species on potatoes in these two counties.

Potato Flea Beetles

In 1969, potato yields were not significantly affected by flea beetle populations of 0, 5, 10, 20, 30, and 40 per plant at emergence as assessed on individually caged plants. In 1970, five plants were placed under each cage with populations of 0, 10, 20, 40, and 80 flea beetles per plant. There was a straight line reduction in yield of 450 kg/ha for each increase of five flea beetles per plant. It was estimated that in 1970 it would have paid the growers to have sprayed for control of the flea beetle when the population exceeded 10 per plant.

Wireworms in Potato Fields

In a survey made in selected fields in the potato-growing area of New Brunswick, wireworms were found in 4 of the 21 fields

where potatoes had been grown continuously for 2 to 15 years. The average number of wireworms in these four fields was 0.32/m², and the wheat wireworm, *Agriotes mancus* (Say), was the only species present.

Blueberry Casebeetle

Following a successful spraying operation in 1969, populations of the blueberry casebeetle, *Chlamisus cribripennis* (LeConte), increased significantly in lowbush blueberry fields at Farmington, N.S., during 1970. At the present rate of increase they could easily reach prespray levels by the summer of 1971. But in New Brunswick and Prince Edward Island, where no sprays were applied, the populations of casebeetles showed very little change except for one field at Sackville, N.B., where there was a significant decrease.

Collections of adult beetles on flight traps set out in the Farmington area have been almost negligible since the 1969 spray operation, indicating that the population buildup there was not caused by immigration from surrounding unsprayed areas. There is some evidence that a larval parasite is relatively scarce in the fields at Farmington, and so a more intensive survey will be carried out in 1971 to determine its prevalence and relationship to host density.

Blueberry Pollination

In a 3-year study under field conditions in New Brunswick, the addition of up to 20 hives of honey bees per ha did not increase the size or rate of ripening of lowbush blueberries. The addition of honey bees to the native bee population may make a contribution to pollination, but it is not large enough to be measured under the highly variable conditions that occur in stands of this native fruit.

POTATO PATHOLOGY

Virus-tested Potato Stocks

One-acre plots of virus-tested potato stocks were multiplied at the Elite Seed Farms in Prince Edward Island and New Brunswick. Smaller quantities were multiplied on a private farm in each province. Serological and plant indicator tests on foliage juice during the summer detected some reinfection with potato virus S but little or none with potato

virus X. Large numbers of tuber tests that will detect potato viruses X, S, or Y are under way to ensure clean stocks for the plantings in 1971.

Leaf Roll Virus of Potatoes

High levels of leaf roll virus resistance have been found in certain potato varieties and seedlings by using a greenhouse technique recently developed at this station. This technique should prove valuable to plant breeders in developing varieties with resistance to this virus.

Characterization of a Plant Virus Inhibitor

The virus inhibitor, previously isolated from the mycelium of *Phytophthora infestans* (Mont.) de Bary, was characterized as a B-(1→3) D-glucan, having an average degree of polymerization of 23 glucose units and one branch. An enzyme, B-(1→3) glucanase, was also found in the culture filtrate of the fungus. The enzyme was partially purified and specific activity was determined. The relationship between the yield of polysaccharide and the age of the fungus culture was determined. The maximum yield of 4.5% occurred in 7 days and decreased to 1% in 20 days. The activity of the inhibitor was not affected by the age of the culture.

Potato Spindle Tuber Virus Reduces Yield

Plants of the potato variety Saco infected with the mild strain of the potato spindle tuber virus (PSTV) yielded 22% less than the noninfected controls. The severe strain of the virus caused a 64% reduction in yield. Most of the tubers infected with either strain were distorted and unmarketable. The mild strain, which is more difficult to diagnose and predominates in the field, is the more troublesome.

The Nature of Potato Spindle Tuber Virus

Sap from tomato plants infected with the severe strain of PSTV showed three main antigenic components when tested by means of immunoelectrophoresis. Two of these moved toward the anode in veronal buffer, pH 8.6, and the third toward the cathode (basic). The latter was difficult to detect in

sap of healthy plants and appeared to correspond to the PSTV-related protein previously detected in gel-diffusion tests.

Incidence of PSTV in Table-stock Fields of New Brunswick

The potato-growing area of New Brunswick, divided into four sections by natural boundaries, represented by 80 randomly selected fields of the main varieties: Kennebec, Katahdin, and Netted Gem, was surveyed for the incidence of PSTV. The amount of PSTV ranged from 0 to 16% in individual fields, but the average for the province was 3.8%. The average incidence of PSTV in the variety Kennebec was 3.3%, in Katahdin 2.4%, and in Netted Gem 4.6%.

Indicator Plants for PSTV

One hundred and twenty-five solanaceous species were screened as indicator plants for mild and severe strains of PSTV. Eighty-five species were susceptible to both strains and the other 40 were resistant to infection. Of the susceptible species, 75 carried the virus symptomlessly and 10 reacted with visible symptoms to the severe strain. Four species that reacted with visible symptoms to the severe strain also reacted to the mild strain. Of these, one tomato variety, Allerfruheste-Freiland, produced veinal necrosis with both strains in 12 to 18 days and appears to be useful as a diagnostic host plant. Another plant, *Scopolia sinensis* Hemsley (syn. *Atropanthe sinensis* Pascher), reacts by formation of local necrotic lesions with both strains. Later the systemic veinal necrosis and leaf drop symptoms are produced. This species appears to be a useful quantitative assay plant for PSTV.

Effect of Manganese on Symptoms of PSTV

Tomato plants grown in sand cultures containing 5 to 10 ppm of Mn showed intensified veinal necrosis symptoms caused by both mild and severe strains of PSTV.

Other Viruses

Clones of several wild tuber-bearing species of *Solanum* were found to possess strong resistance to one or more potato viruses. The species resistant to virus M included: *S. microdontum* Bitter, *S. polytrichon* Rydb., and *S. vernei* Bitter & Wittm.; to virus S: *S.*

chacoense Bitter, *S. megistacrolobum* Bitter, *S. microdontum* Bitter, and *S. tarijense* Hawkes; to virus S: *S. acaule* Bitter, *S. kurtzianum* Bitter & Wittm., *S. phureja* Juz. & Buk., *S. sparsipilum* (Bitter) Juz. & Buk., *S. sucrense* Hawkes, *S. tarijense* Hawkes, and *S. vernei*.

Aerial Photography Detects Plant Diseases and Nutritional Disorders

During the summer studies were made, in cooperation with the Interdepartmental Committee on Air Surveys, to determine the possibility of using aerial photography for the detection and measurement of diseases and disorders of potatoes and other crops. Photographs were taken of experimental plots at the Station and of a commercial potato-growing area near Florenceville, N.B. Also, detailed ground surveys were made. Three types of film were used: infrared color, infrared black and white, and normal color. Photographs were taken on three dates during the growing season at altitudes from 300 to 2,000 m. Preliminary results indicated that early infections of potato late blight can be detected on infrared film. The results from experimental plots suggested that by using this film it may be possible to determine not only the amount of blight present, but also its effect on yield. Aerial photographs were shown also to be of potential value in the detection of other disorders of the potato including verticillium wilt, virus Y, leaf roll virus, spindle tuber virus, manganese toxicity and other nutritional disorders, and for the estimation of the number of missing plants resulting from disease and other causes. The presence of barley yellow dwarf virus in fields of barley, oats, and wheat was also detected on aerial photographs.

Biochemistry of Resistance to Late Blight in Potatoes

Further investigation on the relationship between resistance to *P. infestans* and activity of the host enzyme, adenosinase, resulted in the development of a rapid and convenient test for enzyme activity and provided further insight into the mode of activation of this enzyme. To obviate the tedious and lengthy extractions essential for the assay of adenosinase, a procedure involving measurements on intact leaf tissue was developed. Small leaf discs (13 mm diam) that had been chilled briefly to "activate" the enzyme were

incubated in a measured volume of the substrate adenosine. The extent of adenosine cleavage was determined by measuring the absorption at 250 and 280 nm of an appropriate dilution of the reaction mixture in 0.1 N NaOH solution.

Studies on the activation of adenosinase indicated that it is either bound to a membrane or contained in a lysosomallike particle; activation of the enzyme depends upon its release as mediated by the appropriate conditions. Three main lines of evidence support this conclusion: (i) the increased activity of the enzyme noted on freezing and thawing of leaf tissue; (ii) the 4- to 5-fold higher activity in the particulate over the soluble fraction of leaf extracts; and (iii) the release of activity in the particulate fraction by deoxycholate. Analysis of the purified enzyme by density-gradient centrifugation and column chromatography indicated that it has a molecular weight of 55,000 and may consist of at least three different components.

POTATO BREEDING

A New Potato Variety

The potato variety Raritan (F5459) was introduced in 1970 by Rutgers University, The State University of New Jersey. This seedling, bred and selected within the potato breeding program at Fredericton, had been evaluated in New Jersey for 7 years. Raritan is unique in its ability to produce high yields of tubers of high specific gravity despite the relatively high temperatures in New Jersey. It is also quite resistant to air pollutants. Raritan scores relatively high in boiling, baking, and French-fry quality and has moderate resistance to verticillium wilt. The introduction of this variety is an interesting example of the continental nature of potato research and variety development in North America.

Evaluating Potato Texture

One of the problems encountered in a potato breeding program when large numbers of samples of cooked potatoes have to be evaluated for texture by subjective methods is the ability of panel members to maintain a high degree of selectivity.

Tests were conducted over a 2-year period on 53 advanced seedlings and 2 varieties to

compare the scores given to duplicate samples of boiled potatoes when texture was evaluated by taste and by sight. (The scoring system ranged from 0 points for very soggy texture to 40 points for very mealy texture.)

The results from both years showed higher scores when rated visually. But the differences were not large. The average score by taste was 23.0 and by sight 24.7. The correlation between the two systems was +0.94. The results indicated that an experienced panel of at least three persons can evaluate potato texture by visual means as accurately as by taste.

First Clonal Generation Potato Seedling Selection

Selection in potato seedling progenies is conditioned by the selector, the soil, and climate. When working with single plants of first clonal generation seedlings, some differences are caused by microclimate and planting conditions. Several trials were carried out over a 7-year period to compare selections made from two replicates of the same clones of unselected first clonal generation seedlings, and to compare selections made by different individuals from the same clones. Two hundred seedlings were planted each year and during the last 3 years 10 varieties were added. Over the 7-year period eight persons took part in the selection procedures. All of them were experienced potato research workers, who were familiar with seedling selection procedures. Of 1,303 selections made, only 143, or 11%, were selected in both replications. Of the varieties, 55 were selected over the 3-year period but only 9, or 16%, in both replications.

The small number of duplicate selections of identical clones points out the shortcoming of single-clone evaluation. Several modifications were suggested to improve the system: using replication where possible; modifying the basis of selection and discarding only the obviously poor hills; limiting the number of hills grown the second year in order to evaluate a greater population; and using the same planting distances between single-hill clones as is used in subsequent multiplication plantings.

Relationship Between Yield and Specific Gravity

Data were assembled from 54 potato yield trials conducted in the Atlantic Provinces

during the past 10 years. The correlations between specific gravity and marketable yield of all entries in these trials showed that the coefficients ranged from -0.68 to +0.49. A homogeneity test showed that the correlation coefficients derived from different trials were not homogeneous. These results indicated that, contrary to common belief, correlations between yield and specific gravity are not always negative.

A Comparison of Tuberosum and Andigena Potatoes

Recently it has been recognized widely that most potato breeding stocks, which are essentially inbred lines of tetraploid *Solanum tuberosum* L., have an extremely narrow genetic base and so the amount of variability is limited. One method of broadening the genetic base of the breeding stocks is to use the Andean tetraploid *S. andigena* Juz. & Buk., believed to be the progenitor of *S. tuberosum*. Work at the Scottish Plant Breeding Station, Pentlandsfield, demonstrated the potential of the Andigena material and showed that Andigena-Tuberosum progenies yielded up to 50% more than typical Tuberosum-Tuberosum progenies.

A field progeny of Andigena was grown at Fredericton in 1970 from seed obtained from the Scottish Station. To select forms adapted to Canadian requirements a mass selection procedure was followed. During the summer, seedlings were selected on the basis of acceptable plant type, and pollinations were carried out among the selected seedlings using bulked pollen. At harvest time true seed was collected only from plants that also had acceptable tubers. Extensive data on plant type and tuber characteristics were collected from a random sample of the Andigena population and, for comparison, from an unselected sample of Tuberosum hill seedlings. Compared with the Tuberosum material, Andigena tends to have a larger root system, more stolons, and later maturity. Tuber number per plant varied more widely in Andigena (19.2 ± 11.5) than in Tuberosum (14.9 ± 7.5). For total yield per plant and average tuber weight the Andigena population had a smaller mean and variation than Tuberosum: $1,084.8 \pm 545.2$ g and 66.6 ± 32.5 g for Andigena, and $1,936.6 \pm 853.6$ g and 145.5 ± 64.8 g for Tuberosum. Sixty-eight percent of the Andigena seedlings had round tubers, 55% had deep eyes, 47% had colored skin, or

eyes, or both, and 35% had flesh that was strongly yellow or had red or purple pigmentation. Of the Tuberosum seedlings, 57% were oval, 29% had deep eyes, 24% had colored skin, or eyes, or both, and only 3% had flesh that was not white. The mean specific gravities of the two populations were almost the same, 1.073 ± 0.025 for Andigena, and 1.075 ± 0.014 for Tuberosum, even though there was significantly greater variation in Andigena. Only one of seven Andigena samples that were boiled and baked had scores over 80, an acceptable score.

POTATO PHYSIOLOGY AND WEED CONTROL

Breaking Dormancy in Seed Potatoes

In a preliminary study, gibberellic acid and 2-chloroethylphosphonic acid were compared with Rindite (Contrib. Boyce Thompson Inst. Plant Res. 14:1-14. 1945) for breaking dormancy in seed potatoes for export. Both preharvest sprays and postharvest dips were used. Preharvest sprays of 2-chloroethylphosphonic acid at 0.11, 0.44, and 1.76 kg/ha reduced yields significantly and acted to prolong dormancy in the tuber. Preharvest sprays of gibberellic acid were ineffective. Rindite-dipped seed broke dormancy 2 weeks ahead of untreated seed. Seed dipped in 25 and 100 ppm gibberellic acid solutions was approximately a week ahead of control lots, but growth following treatment at the 100 ppm level was very spindly. Seed dipped in a 1 ppm gibberellic acid solution sprouted simultaneously with the controls. Dip treatments with 2-chloroethylphosphonic acid at 10 and 50 ppm prolonged dormancy significantly.

Killing Potato Vines

In experiments to determine the efficiency of vine killers applied with and without the addition of several surfactants, none of the surfactants increased the desiccating action of the vine killers. Fuel oil added to either dinoseb or to low rates of sodium arsenite increased the speed of desiccation. Also, urea added to sodium arsenite increased the speed of kill. Of the herbicides tested, dinoseb gave the most rapid desiccation. Generally, it is best for a desiccant to give a slow but complete kill of both leaves and vines to obtain the highest quality and quantity of potatoes.

Control of Barnyard Grass in Potatoes

Experiments on the control of barnyard grass, *Echinochloa crusgalli* (L.) Beauv., conducted cooperatively with the New Brunswick Department of Agriculture, indicated that a new herbicide Bay 94337 (Chemagro Ltd.) is very promising for the control of barnyard grass and other weeds in potatoes. This herbicide appears to be useful both as a preemergence and as an early postemergence treatment on potatoes. No injurious effects showed on Netted Gem or Sebago potatoes. It is expected that this herbicide will be available to growers by 1972.

SOILS

Influence of Aluminum on Plant Growth and Mineral Nutrition of Potatoes

Eight potato varieties (Netted Gem, Sebago, Katahdin, Green Mountain, Kennebec, Keswick, Huron, and Irish Cobbler) were grown in nutrient solution cultures. The addition of 20 ppm Al to the culture solution reduced yields of plant tops and roots for all varieties. At lower Al levels (1 to 5 ppm), a differential Al tolerance was found among four potato varieties. Al (1 to 5 ppm) stimulated plant top and root growth of Netted Gem, did not affect Sebago, and depressed Green Mountain. With Katahdin, 1 ppm stimulated growth and 5 ppm depressed growth. P, Al, Mn, Fe, and Cu accumulated within plant roots grown in Al solutions. Ca, Mg, and Zn absorption by plant roots was inhibited by Al. K absorption by plant roots was stimulated at low Al levels (1 to 2 ppm), but inhibited at higher Al levels (5 to 10 ppm). Aluminum tolerance among potato varieties appeared to be related to the ability of plant roots to absorb Mg and K.

Fertilizer Nitrogen Transformations in Podzols

Recent work has shown that ammonification is rapid in New Brunswick soils, but nitrification proceeds at a much slower rate than might have been anticipated from results reported by other workers. The equivalent of 100 kg/ha of N as urea was converted to $\text{NH}_4\text{-N}$ in 1 week even at 4 C; however, a treatment of 100 kg/ha $\text{NH}_4\text{-N}$ required 34 days for 70% conversion to $\text{NO}_3\text{-N}$ at 18 C and no $\text{NO}_3\text{-N}$ was encountered at

4 C. We are investigating these transformations in a broader range of soils and the effect of previous cropping practices and N fertilization on the rate of conversion.

A concomitant phase of this work relates to nitrification inhibition as a factor in efficiency of the use of N fertilizer. With $\text{NH}_4\text{-N}$ plus N-Serve (Dow Chemical Co.) at a rate where formation of $\text{NO}_3\text{-N}$ could not be detected, vegetative growth of oats, barley, and timothy in the greenhouse increased more than when $\text{NH}_4\text{-N}$ or $\text{NO}_3\text{-N}$ was used alone. The vegetative growth of the potato plant under these conditions as well as in the field was restricted and appeared abnormal. The reasons for this anomaly and the effects of various $\text{NH}_4\text{-N}$ to $\text{NO}_3\text{-N}$ ratios on the growth of the potato plant are being investigated by nutrient culture techniques.

Effect of Mechanically Induced Compaction on Potato Yield

Soil bulk density changes observed during the growing season indicated that the use of farm equipment on potato soils increases soil compaction. Also the longer a field is continually in potatoes the more easily it compacts due to traffic. One year's results with the Kennebec variety showed that on Holmesville loam soil that had been in potatoes each year for 20 years, there was a 14% decrease in yield in the traffic rows, whereas there was a slight increase in yield due to traffic in another field of the same soil type that had been in potatoes only 1 year. Total yield (traffic + nontraffic rows) from the field in potatoes for 20 years was 14% lower than the yield (traffic + nontraffic rows) from the field in potatoes for only 1 year.

Maritime Soil Survey

During 1970, approximately 20,600 ha were mapped in Colchester County, N.S.; 4,050 ha in the O'Leary area of Prince Edward Island, and 40,500 ha in Gloucester County, N.B. The soil survey report for Annapolis County, N.S., and the Fredericton, Annapolis, and Truro soil capability for agriculture map sheets were published. The Woodstock, Moncton, and Campbellton soil capability for agriculture map sheets are being processed.

One year of measurements for five instrumented hydrosequence sites in Cumberland County, N.S., was completed. Water table and temperature records confirm fairly well

the classification assigned to the soils on morphological evidence alone. About 40 wells

will be established at suitable sites in 1971 to obtain further data on the soil moisture regime.

PUBLICATIONS

Research

- Adams, Jean B., and Fyfe, Forest W. 1970. Stereoscopic views of some aphid mouthparts. *Can. J. Zool.* 48:1033-1034.
- Adams, Jean B., and Wade, Chester V. 1970. The size and shape of the salivary glands in some aphid species. *Can. J. Zool.* 48:965-968.
- Burgess, P. L., and Wood, F. A. 1970. Design of a low-cost artificial rumen fermentor. *Can. J. Anim. Sci.* 50:401-402.
- Calder, F. W., and Nicholson, J. W. G. 1970. Pasture productivity of three swards with and without nitrogen fertilization. *Can. J. Anim. Sci.* 50:467-473.
- Calder, F. W., Nicholson, J. W. G., and Carson, R. B. 1970. Effect of actual vs. simulated grazing on pasture productivity and chemical composition of forage. *Can. J. Anim. Sci.* 50:475-482.
- Campbell, John C., and Young, Donald A. 1970. Raritan, a potato with high specific gravity. *Amer. Potato J.* 47:264-267.
- Friend, D. W. 1970. Comparison of some milling products of barley and rye when fed in diets to rats. *Can. J. Anim. Sci.* 50:345-348.
- Friend, D. W., Gorrill, A. D. L., and MacIntyre, T. M. 1970. Performance and proteolytic enzyme activity of the suckling piglet creep-fed at one or three weeks of age. *Can. J. Anim. Sci.* 50:349-354.
- Friend, D. W., and MacIntyre, T. M. 1970. Effect of rye ergot on growth and N-retention in growing pigs. *Can. J. Comp. Med.* 34:198-202.
- Friend, D. W., and MacIntyre, T. M. 1970. Paired feeding and metabolism trials comparing barrows with gilts. *J. Anim. Sci.* 30:931-934.
- Gorrill, A. D. L. 1970. Addition of sawdust or shavings to milk replacer for calves. *Can. J. Anim. Sci.* 50:385-386.
- Gorrill, A. D. L. 1970. Physical and chemical characteristics of soybean and milk proteins before and after treatment with dilute alkali. *Can. J. Anim. Sci.* 50:745-747.
- Gorrill, A. D. L., and Friend, D. W. 1970. Pancreas size and trypsin and chymotrypsin activities in the pancreas and intestinal contents of pigs from birth to 5 weeks of age. *Can. J. Physiol. Pharmacol.* 48:745-750.
- MacDougall, J. I., Nowland, J. L., and Hilchey, J. D. 1970. Soil survey of Annapolis County, Nova Scotia. Report No. 16, Nova Scotia Soil Survey, Truro, N.S.
- MacKinnon, J. P. 1970. Comparative levels of leaf roll virus resistance in potato varieties and seedlings. *Amer. Potato J.* 47:444-446.
- MacKinnon, J. P. 1970. Potato clones remain free from leaf roll virus after repeated attempts to infect them. *Amer. Potato J.* 47:268-271.
- Neilson, W. T. A., Wood, G. W., and Maxwell, C. W. 1970. Dimethoate sprays for apple maggot and their effect on predaceous insects and mites. *J. Econ. Entomol.* 63:764-766.
- Pond, D. D., and Moore, C. A. 1970. *Apamea finitima* (Lepidoptera: Noctuidae) infesting barley. *Can. Entomol.* 102:510-511.
- Pond, D. D., Moore, C. A., and Howe, D. E. 1970. Photographic prints for assessing potato flea beetle damage. *J. Econ. Entomol.* 63:1709-1710.
- Saini, G. R. 1970. Aluminum in salt-affected coastal alluvial soils. *Plant Soil* 32:538-539.
- Saini, G. R. 1970. Further studies on the effect of stones on potato yields. *Amer. Potato J.* 47:227-228.
- Schingoethe, D. J., Gorrill, A. D. L., Thomas, J. W., and Yang, M. G. 1970. Size and proteolytic enzyme activity of the pancreas of several species of vertebrate animals. *Can. J. Physiol. Pharmacol.* 48:43-49.
- Singh, R. P. 1970. Seed transmission of potato spindle tuber virus in tomato and potato. *Amer. Potato J.* 47:225-227.
- Singh, R. P., Finnie, R. E., and Bagnall, R. H. 1970. Relative prevalence of mild and severe strains of potato spindle tuber virus in Eastern Canada. *Amer. Potato J.* 47:289-293.
- Singh, R. P., and O'Brien, Muriel J. 1970. Additional indicator plants for potato spindle tuber virus. *Amer. Potato J.* 47:367-371.
- Singh, R. P., Wood, F. A., and Hodgson, W. A. 1970. The nature of virus inhibition by a polysaccharide from *Phytophthora infestans*. *Phytopathology* 60:1566-1569.

- Sutton, J. D., Storry, J. E., and Nicholson, J. W. G. 1970. The digestion of fatty acids in the stomach and intestines of sheep given widely different rations. *J. Dairy Res.* 37:97-105.
- Wood, G. W. 1970. Survival of blueberry casebeetle adults in burned blueberry fields. *J. Econ. Entomol.* 63:1364.
- Wood, G. W., and Small, D. N. 1970. A method of sampling for adults of *Chlamisus cribripennis*. *J. Econ. Entomol.* 63:1361-1362.
- Wood, G. W., Wood, F. A., and Dickinson, R. A. 1970. Carbon dioxide output of individual small insects measured with a gas chromatograph. *Can. J. Zool.* 48:902-903.
- Hilchey, J. D., and MacDougall, J. I. 1970. Soil capability for agriculture, Truro 11-E. ARDA, Canada Land Inventory.
- Kemp, J. G., and Saini, G. R. 1970. Stones: Curse or blessing to New Brunswick potato growers? *Can. Agr.* 15(1):21-23.
- Langmaid, K. K., and Veer, C. 1970. Soil capability for agriculture, Fredericton 21-G. ARDA, Canada Land Inventory.
- Lopez-Abella, D., and Bradley, R. H. 1970. The stylet path of aphids that acquire cucumber mosaic virus. *Septième Congrès International de Microscopie Electronique, Grenoble, France* 1:319-320.
- MacDougall, J. I., Hilchey, J. D., and Nowland, J. L. 1970. Soil capability for agriculture, Annapolis 21-A. ARDA, Canada Land Inventory.
- Saini, G. R. 1970. Adsorption of herbicides on clay materials. *Soil Sci. Soc. Amer. Proc.* 34:156-157.

Miscellaneous

- Hilchey, J. D., and MacDougall, J. I. 1970. Soil capability for agriculture, Annapolis 21-A. ARDA, Canada Land Inventory.

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Génétique et amélioration du
tabac à cigare

Départ

J. GENEST, B.S.A., M.Sc.

Céréales et plantes fourragères

Permuté à Lennoxville en juin 1970

INTRODUCTION

La production du tabac ayant tendance à augmenter dans la Province de Québec, une réorganisation du travail de recherche s'imposait. Durant l'année 1970, le programme de recherche sur les plantes fourragères a été transféré à Lennoxville et la section avicole, qui était sous la direction de l'Institut de recherches en zootechnie, a été fermée. Actuellement toutes les données expérimentales ne sont pas disponibles. On pourrait obtenir des renseignements supplémentaires sur le tabac en s'adressant aux agents de recherches de la Ferme. En juin, M. J. Genest a été transféré à Lennoxville.

P. P. Lukosevicius
Directeur suppléant

TABAC

Tabac à cigare

Hybridation. En 1970, 13 nouveaux croisements impliquant quatre cultivars provenant de Puerto-Rico, trois de France et trois cultivars commerciaux canadiens ont été effectués au champ. Les cultivars reçus de Puerto-Rico sont résistants à la mosaïque causée par le virus nicotiana 1 et au chancre noir causé par le champignon *Phytophthora parasitica* Dast. Les cultivars de France sèchent bien, donnent de bon rendement et une feuille de qualité satisfaisante.

Sélection. En 1970, 706 lignées hybrides de six générations différentes et trois cultivars commerciaux (Ottawa 705, R.H. 211 et Penbell 69) composaient le groupe de sélection. Après observation visuelle, 88 lignées (12.4%) ont été éliminées dans le champ et de ce nombre 86% avaient Ottawa 705 comme parents. Lorsque nous posséderons les données de classification du tabac séché, d'autres lignées seront probablement enlevées du groupe.

Test préliminaire. Cet essai en 1970, comprenait les mêmes cultivars et lignées que celui de 1969, soit 14 cultivars connus et 26 lignées. Après l'écimage des plants, la hauteur maximum fut atteinte par le cultivar Wisconsin Havana 503 (124.4 cm [49 pouces]) et la hauteur minimum par le cultivar Zimmer Spanish (87.7 cm [34.5 pouces]). Le cultivar Wisconsin Havana 307 a donné le plus grand nombre de feuilles (24.7), tandis que la lignée 258 × 705 a donnée le plus petit nombre, soit 16.8. Même si pour l'ensemble de l'essai la hauteur moyenne des plants après l'écimage ne fut que de 107.7 cm (42.4 pouces) en 1970, soit 10.5 cm (4.1 pouces) de moins qu'en 1969, les plants ont

produit en moyenne 20 feuilles, soit une augmentation de 1.1 feuilles par plant comparativement à l'année précédente. L'indice le plus élevé de feuilles (60.7%) vient d'une lignée provenant de France et introduite en 1966 (IL 66-06) alors que le cultivar Belge amélioré 807 a donné l'indice le plus bas avec 39.4%. En 1970, l'indice moyen pour ce même essai fut de 52.8% comparativement à 50.2% en 1969. Cette augmentation fut causée surtout par une feuille plus courte. Dans cet essai, le cultivar Belge amélioré 807 fut le plus hâtif (55.8 jours) tandis que le cultivar Wisconsin Havana 503 fut le plus tardif (62.2 jours). Nous ne possédons pas encore les résultats complets sur les feuilles séchées.

Test avancé. Dans cet essai en 1970, 12 cultivars ou lignées hybrides ont été comparés. Trois lignées ont produit des plants plus longs que les deux cultivars témoins, R.H. 211 et Ottawa 705. La lignée S 11-3X a donné les plants les plus longs (122.3 cm [48.1 pouces]) et la lignée 973 P₃X les plus courts (90.4 cm [35.6 pouces]). La lignée 290, la plus tardive (60.5 jours), a donné le plus grand nombre de feuilles, soit 21.6; tandis que la lignée Strain 607, la plus hâtive (55 jours), en a produit le plus petit nombre, soit 15.8. Par contre, celle-ci a donné des feuilles plus larges et également plus longues.

Dates de plantation. En 1970, un essai comprenant trois dates de plantation (le 25 mai, le 8 et le 26 juin), deux cultivars (L 64-169 F₇ et Ottawa 705), trois taux d'espacement sur le rang (36, 41 et 46 cm [14, 16 et 18 pouces]) et répété quatre fois fut introduit dans le but d'améliorer les façons culturales existantes. La précocité des dates de plantation a influencé positivement la hauteur des plants avant l'écimage et la longueur d'entre-nœuds. Une prépondérance de la deuxième

date sur la troisième et de la troisième sur la première a été obtenue pour le nombre de feuilles. Il n'y a pas eu de différence marquée entre la première et la deuxième date de plantation sur la hauteur des plants après l'écimage et sur la longueur de la feuille. Par contre, la troisième date de plantation a donné des plants beaucoup plus courts après l'écimage et une feuille beaucoup plus longue que les deux premières dates. L'indice de la hâtivité n'a été abaissé sensiblement que par la première date de plantation. Les taux croissants d'espacement sur le rang ont eu pour effet de produire une feuille plus large et plus longue. L'indice de la feuille n'a pas varié sensiblement dans cet essai.

Essais de dégustation. Neuf épreuves de différents cultivars ont été soumises aux 50 membres de notre jury de dégustation en 1970. Afin d'avoir une évaluation plus représentative des fumeurs à travers le Canada, un certain nombre de nos membres actuels seront remplacés par des chercheurs attachés au Service de la recherche du ministère de l'Agriculture du Canada. Le nombre des épreuves sera plus considérable en 1971.

Résistance aux maladies. Trois cultivars commerciaux témoins et 225 lignées hybrides de différentes générations ont été cultivés au champ dans le but d'évaluer principalement leur résistance à la pourriture noire de la racine causée par le champignon *Thielaviopsis basicola* (Berk. & Br.) Ferr. Le cultivar R.H. 211 a montré plus de résistance à la pourriture noire qu'Ottawa 705 et Penbell 69.

Séchage. Un essai préliminaire sur le séchage du tabac à cigare, comportant des plants de tabac disposés sur des charpentes amovibles de 122 × 224 cm (48 × 96 pouces) à l'intérieur d'une bâtisse, fut fait cette année. Durant la période de séchage, deux charpentes furent recouvertes, l'une d'une toile à moissonneuse, l'autre d'un film de polythène et une troisième fut laissée sans couverture. Ces traitements de séchage ont donné trois indices de qualité (¢/kg) sensiblement différents. L'indice le plus élevé fut obtenu par le tabac séché sous une toile à moissonneuse et le plus bas par le tabac séché sous un film de polythène. Le tabac séché sous une toile à moissonneuse a aussi donné un pourcentage plus élevé de filasse que le tabac séché sous un film de polythène, mais ce pourcentage fut sensiblement le même que celui donné par le tabac séché

sans couverture. Un pourcentage comparable de déchets fut obtenu pour le tabac séché sous une toile à moissonneuse et celui séché sans couverture, mais ce pourcentage fut plus élevé sous un film de polythène.

La qualité du tabac séché à l'aide de chauffage et de ventilation supplémentaire fut supérieure au tabac séché sous des conditions naturelles, mais n'a pas montré de supériorité significative sur le tabac séché à l'aide de ventilation supplémentaire seulement. Contrairement aux résultats de l'année précédente, la qualité du tabac séché, en utilisant comme source de chaleur du charbon de bois, fut inférieure à la qualité obtenue avec les autres méthodes de séchage.

Répression des drageons du tabac. Cette année, nous avons fait une expérience sur la répression des drageons du tabac à cigare avec cinq produits appliqués à deux stades différents: Delspray T-148 (Procter & Gamble Co. of Canada), Emtrol 1630B (Emery Industries [Canada] Ltd), Sucker-Plucker (Fisons [Canada] Ltd), T-504 (Fisons [Canada] Ltd) et TSC-350 (Pfizer Co. Ltd). Les résultats de cette expérience ne sont pas encore disponibles.

Répression des mauvaises herbes. La classification du tabac n'étant pas terminée, seules les observations faites au champ sont rapportées. Les mauvaises herbes dominantes sont *Amaranthus retroflexus* L., *Carex* spp. et *Portulaca oleracea* L. L'herbicide de préémergence (pébulate) et celui de postémergence (diphenamid) ont tous deux amélioré les opérations culturales, soit le sarclage et le binage. Pour la répression des mauvaises herbes, pébulate semble être supérieur à diphenamid et les binages semblent être plus efficaces que les sarclages. L'amarante s'est avérée un très bon hôte pour la punaise terne et là où il y avait une forte population de cette plante, le tabac a été sévèrement attaqué par l'insecte.

Tabac jaune

Évaluation des cultivars et des hybrides. Cette année, nous avons comparé la valeur agronomique de différents cultivars et lignées. Le cultivar Strain 205 s'est avéré le meilleur pour le rendement et le revenu brut à l'hectare et moyen pour la qualité de la feuille et l'indice de maturité. Le cultivar NC-3847 fut le meilleur pour la qualité de la feuille. Coker 319 a produit le tabac le plus

mûr mais s'est classé au dernier rang pour le rendement à l'hectare. Le cultivar Strain D-15 a assuré le moins bon revenu par hectare. Pour les hybrides, la lignée L 69 × E-23-1 s'est avérée la meilleure pour le rendement et fut supérieure à la moyenne pour la qualité de la feuille et le revenu brut. Comme en 1969, la lignée L 69 × 138 P₁X a produit la meilleure qualité de feuilles et a aussi donné le meilleur revenu à l'hectare.

L'effet du pH et de la fertilisation sur la croissance du tabac. En 1970, six niveaux de pH différents ont été comparés: 4.5, 5.0, 5.5, 6.0, 6.5 et 7.0. Le niveau de pH désiré a été atteint dans les cinq premiers traitements seulement. Pour le dernier traitement, un niveau de pH 6.8 seulement a été obtenu alors que l'objectif était de 7.0. Le meilleur rendement à l'hectare a été obtenu avec un niveau de pH 6.0. Par contre, le meilleur revenu et la meilleure qualité ont été obtenus avec un pH de l'ordre de 5.5. En ce qui concerne les différentes doses d'engrais chimique, une application de 1 345 kg/ha (1 200 lb/acre) a assuré le meilleur revenu alors qu'avec 2 017 kg/ha (1 800 lb/acre) on a obtenu le meilleur rendement. La meilleure qualité de tabac fut produite avec une application de 672 kg/ha (600 lb/acre).

Méthodes culturales. En 1970, nous avons étudié le comportement de trois cultivars de tabac jaune soumis à trois degrés de compacité et trois taux de fertilisation. Le cultivar Virginia 115 s'est révélé supérieur à Delhi 34 et Yellow Gold pour le rendement et le revenu brut. Pour la qualité, Delhi 34 fut le meilleur. Une fertilisation de 1 120 kg/ha (1 000 lb/acre) a assuré le meilleur revenu et la meilleure qualité de tabac. Un espacement de 56 cm (22 pouces) sur le rang a donné le meilleur rendement, alors qu'un de 61 cm (24 pouces) a assuré le meilleur revenu brut et une bonne qualité.

Répression des drageons du tabac. L'année 1970 a vu naître une nouvelle expérience sur la répression des drageons. Trois produits ont été comparés: Delspray T-148 (Proctor & Gamble Co. of Canada), Emtrol 1630B (Emery Industries [Canada] Ltd) et Sucker-Plucker (Fisons [Canada] Ltd). L'essai comprenait aussi deux stades et deux méthodes d'application. Tous les produits ont donné un bon contrôle des drageons et ont assuré un bon rendement. Une application manuelle des produits avant l'écimage semble le moyen le plus efficace de contrôler les bourgeons.

Répression des mauvaises herbes. En 1970, on a essayé les différentes combinaisons suivantes: 0, 1, 2 sarclages avec 0, 1, 2, 3 binages, sans herbicide ou avec herbicides de préémergence (pébulate) ou de postémergence (diphenamid). La combinaison diphenamid avec deux sarclages et trois binages a donné le meilleur rendement et le meilleur revenu brut. On a obtenu le meilleur indice de qualité avec diphenamid, deux sarclages et un binage. Le moins bon rendement et le moins bon revenu ont été obtenus avec pébulate, 0 sarclage et 0 binage. La digitale a été la mauvaise herbe la plus compétitrice pour le tabac.

Répression des nématodes. En 1970, on a procédé à un relevé systématique chez 60 producteurs de tabac à cigarette. Les échantillons de 26 producteurs ont été analysés et les résultats révèlent la présence des nématodes suivants: *Pratylenchus penetrans* (Cobb) Filip. & Stekh., *P. crenatus* Loof, *P. minyus* Sher & Allen, *Paratylenchus projectus* Jenkins, *Meloidogyne* spp. Les deux premières espèces ont été observées dans la grande totalité des fermes alors que *Meloidogyne* spp. était présent dans 60% des échantillons seulement.

Station de recherches Lennoxville, Québec

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Retraité en décembre 1970

INTRODUCTION

Ce bref rapport résume les principaux résultats obtenus en recherches sur les productions animales et les cultures fourragères, en 1970. Un autre ouvrage, disponible sur demande, détaille les programmes de recherches et les ressources dont dispose la Station.

En 1970, il s'est produit un changement considérable parmi le personnel. D'abord le Dr Heinz Gasser a été muté à la Station de recherches, Sainte-Foy, Qué. M. Alain Pesant a repris ses fonctions après un stage d'étude de deux ans, tandis que M. Jean Genest, de la Ferme expérimentale de l'Assomption, s'est joint aux chercheurs en phytotechnie. Puis nous avons recruté deux nouveaux professionnels, M. Wesley Mason et M. Paul Flipot. Finalement, M. Émile Ouellette a pris sa retraite après 34 ans de service en recherche céréalière.

En plus de leur travail expérimental, les chercheurs collaborent étroitement avec d'autres agronomes du Québec dans la formulation de recommandations, tant pour les cultures que pour les élevages.

C. S. Bernard
Le directeur

ZOOTECHE

Élevage du veau au succédané du lait

En général, l'alimentation conventionnelle du veau de lait se fait d'une façon contrôlée et avec du lait dont la température se rapproche de celle du corps, soit environ 38°C.

Température et concentration. Dans une première expérience, on a voulu déterminer s'il était possible d'alimenter des veaux à volonté avec un succédané du lait à 18°C, 7°C et 2°C, les concentrations étant les suivantes: 1) celle recommandée par le manufacturier; 2) 10% plus élevée et 3) 20% plus élevée.

Le lait servi à 18°C a favorisé la croissance quotidienne de 0.90 kg/tête, comparativement à 0.74 kg pour le substitut servi à 7°C et 2°C. C'est chez les veaux nourris au lait à 7°C qu'on a eu le moins de mortalité, soit 20.1%. Par contre, les indices de consommation ont été sensiblement les mêmes, soit 1.69, 1.78 et 1.71 kg de lait par kg de gain aux températures de 18°C, 7°C et 2°C respectivement.

La concentration recommandée par le manufacturier a donné une augmentation quotidienne en poids de 0.77 kg/tête. Elle fut de 0.85 kg et de 0.68 kg pour les rations à une concentration plus élevée de 10% et 20%. Le taux de mortalité le plus bas a été de 22.9% chez les veaux alimentés au succédané à la concentration recommandée par le manufacturier. L'indice de consommation fut de 1.62 pour les veaux recevant le succédané aux concentrations 1) et 2) et de 1.93 pour la concentration 3).

Température et régime alimentaire. Dans une deuxième expérience on a comparé l'influence du succédané du lait aux températures de 38°C, 18°C et 2°C servis soit à volonté, soit suivant un régime contrôlé.

Les veaux alimentés à volonté ont fait un gain moyen quotidien de 0.85 kg/tête, comparé à 0.79 kg pour ceux qui ont été soumis à un régime contrôlé. De plus, l'alimentation à volonté avec un succédané à 38°C a donné un gain quotidien de 1.1 kg, le plus élevé de tous les traitements mis à l'épreuve.

L'efficacité alimentaire est en faveur des veaux au régime contrôlé. Elle a été maximum avec le succédané à 18°C. Toutefois, les températures du succédané n'ont pas influencé les gains journaliers des veaux à ce régime.

Engraissement des bouvillons au pâturage

Depuis deux ans, on étudie l'influence de la fumure, de la charge de paissance et de la moulée sur l'engraissement de bouvillons antenais au pâturage. On utilise 450 (F₁), 900 (F₂) ou 1 350 (F₃) kg de 10-10-10 à l'hectare. Les animaux paissent à raison de 2.5 (C₁) ou 5 (C₂) têtes à l'hectare, la charge de 5 têtes étant répétée avec moulée (MC₂).

Les fertilisants sont épandus en deux applications de 225 kg chacune dans le cas de la dose minima et de quatre applications de 225 ou 337.5 kg dans le cas des deux autres doses.

La production totale de matière sèche à l'hectare a varié en fonction de l'augmentation des doses de fertilisants et en raison

inverse du nombre de bêtes à l'hectare. Cependant, lorsqu'on a ajouté de la moulée à la charge C₂, la production de matière sèche à l'hectare a augmenté par rapport à la charge C₂ sans moulée.

La consommation de matière sèche à l'hectare a augmenté avec le degré de fertilisation. Elle n'a pas beaucoup varié d'une charge de paissance à l'autre, avec ou sans moulée, sauf dans le cas de C₂ F₁, où la consommation a été de 325 kg inférieure au plus proche traitement, C₁ F₁. Au début de la saison de paissance, il y a eu un surplus d'herbe dans tous les champs. On en a fait de l'ensilage. Les quantités récoltées ont varié de 1 050 kg/ha pour la charge de paissance et la fertilisation C₂ F₃ à 5 517 kg/ha pour C₁ F₃.

Une observation très nette ressort du comportement général des animaux, c'est que le degré de fumure n'a pas toujours exercé un effet positif sur leur augmentation journalière moyenne en poids. Il a même eu un effet décroissant dans le cas de la charge C₁.

De même, la production de viande à l'hectare n'a pas été influencée par le degré de fertilisation, excepté quand on a servi de la moulée aux bêtes de la charge C₂. Ainsi, en appliquant 1 350 kg de fertilisants à l'hectare, on a augmenté la production de viande de 23.6 kg par rapport au résultat obtenu avec une fertilisation de 450 kg.

L'influence de la moulée sur la production de viande à l'hectare a été très prononcée.

Effet des concentrés sur l'utilisation de l'ensilage de maïs

On a ensilé, ou bien au début de septembre, avant la première gelée, ou bien à la fin de septembre, deux variétés de maïs fourrager: le Pride 5, variété semi-hâtive et le Warwick 600, variété tardive. On a servi ces quatre ensilages à des bouvillons et on a répété l'expérience pendant trois années consécutives.

Les bouvillons nourris uniquement à l'ensilage ont fait un gain moyen quotidien de 0.16 kg. Par contre, les bouvillons recevant des concentrés à raison de 1.5 kg par 100 kg de poids vif, en plus de l'ensilage, ont fait un gain quotidien de 0.81 kg. L'effet des concentrés sur le taux de gain était supérieur lorsque l'ensilage provenait d'une récolte hâtive; toutefois, ces différences n'étaient pas significatives au point de vue statistique.

Les bouvillons ingéraient 18.1 kg de matière sèche par unité de gain, lorsqu'ils ne

recevaient que de l'ensilage, et 6.7 kg lorsqu'ils recevaient des concentrés. L'addition des concentrés diminuait la consommation quotidienne de matière sèche de 2.9 à 2.3 kg par bouvillon. Cette diminution était moins prononcée avec la récolte tardive de Warwick 600 qu'avec la récolte hâtive de Pride 5; elle ne variait pas selon les dates de coupe lorsqu'il s'agissait de la variété Warwick 600.

La faible consommation de matière sèche sous forme d'ensilage, dont la moyenne se chiffrait à 2.6 kg par tête par jour, provenait sans doute de la courte durée de la période d'alimentation, puisque les bêtes n'avaient accès aux aliments que pendant 2.5 heures le matin et le soir. En effet, un groupe de bouvillons ayant libre accès à ce même ensilage pendant la période expérimentale en consommait chacun 3.2 kg par jour.

Valeur alimentaire des foins de mil, brome et dactyle

Lorsqu'on a récolté la première coupe de mil, de brome et de dactyle au stade de début-floraison, les rendements en matière sèche totale et en matière sèche digestible ont été dans l'ordre d'énumération des graminées ci-haut mentionnées. Aux stades d'épiaison et de mi-floraison, le mil demeurait en tête, mais le dactyle prenait le deuxième rang.

On a fait une deuxième coupe de foin environ deux mois après la première. Les foins de première et de deuxième coupes ont été servis à des agneaux, afin de mesurer leur croissance par unité de surface de terrain. Un retard de la première coupe jusqu'au stade de début-floraison a augmenté le rendement en matière sèche totale et celui de matière sèche digestible, mais a diminué la croissance animale à l'hectare. Un retard plus prononcé de la première coupe, c'est-à-dire jusqu'au stade de mi-floraison, a relativement peu amélioré les rendements du mil et du dactyle et la croissance des bêtes, tandis qu'il a occasionné une diminution de croissance des agneaux, alimentés en brome.

Sélection en vue d'un agnelage hâtif

Le but de cette expérience est de développer une lignée de brebis capables de concevoir en été comme à l'automne, lorsqu'elles sont gardées dans les conditions normales de clarté du jour et de température. C'est par la sélection que l'on recherche ce caractère de fertilité ininterrompue au cours de l'année.

Il y a 4 ans, on a formé une population de

brebis à partir de croisements entre les races Dorset, Leicester et Suffolk. Cette population compte au delà de 700 têtes adultes.

À chaque année, on expose les brebis aux béliers à partir du début de juin jusqu'à l'automne. On garde dans le troupeau celles qui conçoivent les premières, ainsi que leurs descendants, mâles et femelles, en nombre suffisant pour remplacer les sujets éliminés.

En 1970, 250 brebis restèrent avec les béliers pendant les mois d'été. De ce nombre, 44 ont conçu en juin et juillet et agnelé en novembre et décembre.

Cette expérience se poursuit à la Ferme expérimentale de La Pocatière, où elle se continuera encore quelques années, afin d'obtenir des résultats plus définitifs.

Croisement de races de porc

On a continué l'étude des croisements entre les races Yorkshire, Landrace, Lacombe, Hampshire, Duroc, Berkshire, Large Black et Tamworth. Bien que l'expérience ne soit pas terminée, il est possible de dégager certaines tendances.

Performance des truies de race. La race de la truie a une influence significative sur le nombre et le poids des porcelets, mais l'influence de la race du verrat est négligeable. Les portées les plus nombreuses et les plus lourdes à la naissance et au sevrage étaient issues de truies de race Yorkshire et de race Lacombe, tandis que les truies des races Large Black et Berkshire donnaient les plus petites portées.

Valeur marchande des porcs de marché de 28 croisements. On a enregistré l'âge au marché de tous les porcs destinés à l'abattoir. On a mesuré l'épaisseur de gras dorsal de leurs carcasses. Les croisements les plus avantageux d'après ces deux critères sont: Duroc × Landrace, Hampshire × Lacombe, Hampshire × Yorkshire, Hampshire × Landrace et Duroc × Lacombe. Les porcs issus de parents Duroc ou Hampshire ont les taux de croissance les plus élevés; ceux provenant de parents Hampshire ont moins de gras dorsal que ceux des autres races.

Performance reproductrice des truies de 28 croisements. L'âge et le poids à la puberté, ainsi que le nombre et le poids des porcelets à la naissance et au sevrage sont les critères d'évaluation de la performance reproductrice des truies croisées. Les résultats préliminaires, d'après les données de mise bas de la

moitié des truies, démontrent une supériorité des truies Landrace × Yorkshire, Berkshire × Landrace et Hampshire × Landrace.

PRODUCTION VÉGÉTALE

Étude des courbes de croissance des graminées

On a comparé les courbes de croissance du mil, d'alpiste roseau, de pâturin du Kentucky et de la fétuque élevée. On a pratiqué 10 coupes successives à intervalle d'une semaine, à partir de la fin mai jusqu'à la fin juillet, afin de déterminer le taux d'accumulation de la matière sèche, le changement de qualité au cours de la saison et l'effet des dates de coupe sur le rendement annuel.

Pour les fins de cette étude, le mil servait de point de repère, car une expérience semblable avait déjà été faite en le comparant au brome et au dactyle.

Il y a eu une augmentation constante de rendement au cours du premier cycle de croissance, celle-ci étant plus rapide au début de juin. Les rendements totaux annuels augmentaient au fur et à mesure qu'on retardait la première coupe. Cette tendance était la plus accentuée chez l'alpiste et le mil, où il y avait une augmentation de rendement de 59% et 53% respectivement à la suite d'un retard de coupe de la fin mai à la fin juillet. Pendant la même période, le pâturin n'augmentait que de 14%.

Les résultats de 2 années indiquent peu de différence entre les graminées dans leur rendement aux coupes hâtives, mais des différences appréciables aux coupes plus tardives. L'alpiste est alors supérieur au mil, au pâturin et à la fétuque dans l'ordre de 25%, 59% et 22% respectivement.

Mélange de graminées pour pâturage

On a cultivé quatre graminées, le mil, le brome, le dactyle et l'alpiste roseau en semis purs et en association, sous des conditions de pâturage simulées. La première année, 1969, le mil a donné la plus forte production de matière sèche, soit 6 294 kg/ha. Il a dépassé de 6%, 10% et 14% respectivement le brome, l'alpiste roseau et le dactyle. La deuxième année, l'alpiste roseau était en tête avec un rendement de 6 604 kg/ha; il était de 3%, 10% et 20% supérieur au mil, brome et

dactyle. Il faut noter que le plus fort rendement provient du mélange mil et alpiste roseau, dont la production était de 6 838 kg/ha. En général, le rendement des mélanges a varié selon celui des graminées qui les composaient lorsqu'elles étaient en semis purs. Il n'y eut donc pas d'interaction importante entre les espèces de graminées.

Chaulage et fumure des sols en vue de la culture du chou fourrager

Depuis quelques années, on a commencé des essais d'adaptation du chou fourrager dans le Québec. Comme on ne connaissait pas les exigences minérales de cette plante, on a entrepris des études de fumure. On a fixé le pH du sol à 5.0, 6.0 et 6.5. On a appliqué des doses d'azote de 0, 100 et 200 kg/ha, des doses de phosphore de 0, 75 et 150 kg/ha et des doses de potassium de 0, 100 et 300 kg/ha. Les sols représentaient trois séries de la région, soit le loam Greensboro, le loam limoneux Coaticook et l'argile Sainte-Rosalie. L'expérience s'est effectuée en serre avec la variété Maris Kestrel.

Le pH. L'action de la chaux a été très marquée sur les trois types de sol. En sols acides, on a observé des symptômes de toxicité de manganèse et d'aluminium. Les rendements ont été augmentés de 49% sur l'argile Sainte-Rosalie, triplés sur le loam limoneux Coaticook et quintuplés sur le loam Greensboro. La production maximum du chou a été enregistrée à pH 7.0 sur le loam Greensboro et l'argile Sainte-Rosalie, tandis qu'elle a eu lieu à pH 6.0 sur le loam limoneux Coaticook. Il semblerait que le chou fourrager exige un pH du sol variant de 6.0 à 7.0.

Le phosphore. Le phosphore s'est avéré l'élément fertilisant le plus important dans la production du chou sur les trois types de sol. Sur le loam de Greensboro, les rendements ont pratiquement été nuls sans apport de phosphore, tandis qu'une application de P au taux de 200 kg/ha les ont augmentés de 20 fois. La même application de P a triplé les rendements sur le loam limoneux Coaticook et les a augmentés de 24% sur l'argile Sainte-Rosalie. On a observé une interaction entre le pH du sol et les doses de phosphore sur le loam Greensboro et le loam limoneux Coaticook. En sols acides à pH 5.0, les rendements se sont accrus à mesure qu'on a augmenté les applications de phosphore tandis qu'en sols

chaulés à pH 7.0 l'augmentation due au phosphore s'est arrêtée à la dose de 100 kg/ha.

L'azote. L'azote a été très profitable à la culture du chou fourrager, mais les augmentations de rendements ont été moins élevées que celles dues au phosphore. Les augmentations dues à l'azote se chiffrent comme suit: 48% sur l'argile Sainte-Rosalie, 40% sur le loam Greensboro et 18% sur le loam Coaticook. Les applications d'azote ont été beaucoup moins efficaces en sols acides qu'en sols chaulés au pH 6.0. L'interaction du pH et de N était significative.

Le potassium. Le potassium s'est montré l'élément le moins nécessaire à la production du chou fourrager. Aucune augmentation de rendement n'a été enregistrée sur l'argile Sainte-Rosalie, mais les rendements ont été accrus de 10% sur le loam Greensboro et de 39% sur le loam limoneux Coaticook.

En résumé, le chaulage et l'application de phosphore sont les deux principaux facteurs dans la fertilisation des sols de la région en vue de la culture du chou fourrager.

Lessivage d'engrais chimiques par les eaux de drainage

Une expérience sur la fumure intensive des pâturages a permis de mesurer la concentration en éléments nutritifs des eaux qui s'écoulaient par les drains souterrains. Ces pâturages étaient fertilisées à raison de 3 610 kg/ha de 10-10-10. L'eau des drains tombait dans un ruisseau qui à son tour se déversait dans la rivière Saint-François à environ 1 500 mètres du drain. L'eau a été échantillonnée à la sortie du drain, puis à plusieurs endroits dans le ruisseau jusqu'au confluent de la rivière et enfin dans la rivière même. L'eau du ruisseau en amont du drain servait de témoin.

On a analysé l'eau pour en déterminer la teneur en azote nitrique, azote ammoniacale, phosphore et potassium.

D'une façon générale, ces minéraux étaient de 3 à 5 fois plus concentrés dans l'eau sortant des drains que dans l'eau du ruisseau soustrait à l'influence des engrais chimiques. Cependant, on a observé un effet de dilution très rapide. Par exemple, l'eau à la sortie du drain contenait 0.284 p.p.m. de phosphore. La concentration en phosphore de cette même eau n'était plus que de 0.056 p.p.m. alors qu'elle atteignait la rivière Saint-François. La concentration en phosphore de l'eau

soustraite à l'effet des engrais se chiffrait à 0.049 p.p.m.

Des trois éléments, azote, phosphore et potassium, c'est le dernier qui a accusé le plus fort lessivage dans les eaux de drainage. On a mesuré 37 p.p.m. de potassium dans l'eau à la sortie du drain, tandis que l'eau à 350 mètres en amont n'en contenait que 1.82 p.p.m. Le potassium dans le sol à 46 cm et à 60 cm de profondeur avait une teneur plus élevée qu'à l'ordinaire. On y a enregistré du K au taux de 225 kg/ha, alors que ces sols en contiennent environ 60 kg/ha à cette profondeur.

Il est à remarquer que les quantités d'azote, de potassium et de phosphore utilisées dans la fumure des pâturages étaient très élevées et occasionnaient une forte perte par lessivage. Dans la pratique agricole ordinaire, on utilise beaucoup moins d'engrais et les pertes d'éléments sont sans doute moindres. D'ailleurs à 900 mètres en aval du drain, en un point soumis à l'influence d'une fertilisation normale, la teneur de l'eau en azote, phosphore et potassium n'était pas beaucoup plus élevée que celle de l'eau en amont du drain où l'influence des engrais ne jouait pas.

PUBLICATIONS

Recherches

Bernard, C., et Fahmy, H. M. 1970. The effect of selection on feed utilization and carcass score in swine. *Can. J. Anim. Sci.*, 50:575-584.

Bouchard, R., Brisson, G. J., et Bernard, C. 1970. A refrigerated milk feeder for lambs weaned at three days of age. *Can. J. Anim. Sci.*, 50:213-214.

Cameron, C. D. T., et Lachance, C. E. L. 1970. Effects of cultivar and maturity of ensiled corn plant fed with and without concentrates on the performance of group and individually fed Hereford and Angus steers. *Can. J. Anim. Sci.*, 50:513-519.

Fahmy, M. H. 1970. Homogametic heterosis in crossbreeding experiments with sheep. *Can. J. Anim. Sci.*, 50:377-387.

Fahmy, M. H., et Bernard, C. 1970. The effect of selection for carcass score on the genetic improvement of its components in swine. *Can. J. Anim. Sci.*, 50:585-592.

Fahmy, M. H., et Bernard, C. 1970. A genetic and phenotypic study of pre- and post-weaning weights and gains in swine. *Can. J. Anim. Sci.*, 50:593-599.

Fahmy, M. H., et Hidiroglou, M. 1970. Body weights and gains of calves from purebred and crossbred Shorthorn cows. *Can. J. Anim. Sci.*, 50:621-629.

Divers

Cameron, C. D. T. 1970. High- or low-cut silage for steers. *Canadex* 420.61.

Cameron, C. D. T., et Lachance, C. E. L. 1970. Nutritional value of corn silages from early- and late-maturing varieties harvested at two stages of maturity. *Canadex* 420.61.

Fahmy, M. H. 1970. Crossbreeding for multiple births in sheep. *Canadex* 430.35.

Fahmy, M. H., et Hidiroglou, M. 1970. Reproductive performance of purebred versus crossbred Shorthorn cows. *Canadex* 420.35.

Lachance, C. E. L., et Cameron, C. D. T. 1969. Rendement du maïs fourrager suivant la date de récolte. *Can. Agr.*, 14(2):18-20.

Lachance, C. E. L., et Cameron, C. D. T. 1970. Harvesting date affects corn silage yields. *Can. Agr.*, 15(2):22-23.

Lalande, G. 1970. La production de bouvillons de marché. *Bull. des Agr.*, Mai.

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Départs

E. GODBOUT, B.A., B.S.A. Retraité en 1970
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1. Détaché de la Direction de l'économie du ministère de l'Agriculture du Canada.

INTRODUCTION

En 1970, nous avons aménagé dans notre nouvel édifice renfermant d'excellentes facilités pour les recherches en plantes et en sols. Des travaux importants de construction et de réparation ont été réalisés aux Fermes expérimentales de Normandin et La Pocatière.

Ce rapport présente un résumé de la recherche accomplie durant l'année 1970 par nos équipes multidisciplinaires. Le personnel scientifique de la Station collabore également avec les autres institutions de recherches et d'enseignement gradué au Québec.

S. J. Bourget
Le directeur

LES PLANTES

Les céréales

Amélioration génétique. Le bon comportement de la nouvelle variété d'avoine Yamasaka indique qu'elle pourra remplacer Glen et Garry dans plusieurs régions du Québec. Le blé Opal a donné des rendements supérieurs aux autres variétés à toutes les stations du Québec. Elle est cependant plus tardive que Selkirk. Quatre lignées d'orge ont donné des rendements supérieurs à Champlain à toutes les stations du Québec. Deux lignées d'avoine ont donné des rendements supérieurs à la moyenne mais toutefois inférieurs à Dorval dans l'Est du Canada. Au Québec, les rendements de ces lignées étaient égaux à Dorval et de maturité plus hâtive.

Cytogénétique. On a poursuivi des recherches sur le phénotype nucléaire chez les espèces d'avoine diploïdes, tétraploïdes et hexaploïdes. La détermination de la masse sèche des noyaux isolés et celle du volume des chromosomes sont maintenant terminées chez 19 espèces. Même en augmentant à 6 le nombre d'espèces hexaploïdes, nous n'avons pas obtenu de différence significative du volume des chromosomes. Cependant, cette différence est significative chez les diploïdes tant pour ce caractère que pour la masse sèche des noyaux. Les données de cette étude concordent avec les résultats obtenus par d'autres chercheurs avec des méthodes classiques. Les premiers pas ont été faits pour évaluer la quantité d'ADN (acide désoxyribonucléique) et de protéine totale dans les noyaux par le balayage de chaque cellule au moyen d'un microspectrophotomètre.

Persistence des plantes fourragères

Physiologie et biochimie. L'étude de la composition en lipides de plants de luzerne de la variété Rambler, pendant un durcissement artificiel en chambre de croissance, a livré des premiers résultats intéressants. Les acides gras totaux et les acides gras des classes de lipides, extraits des parties aériennes et des racines ont été analysés par chromatographie sur couche mince et gazeuse. Nous avons observé principalement: 1) une forte augmentation en lipides dans les parties aériennes et les racines; 2) une augmentation appréciable de la teneur en triglycérides dans les parties aériennes; 3) une très forte augmentation des phospholipides (classe riche en acide linoléique) dans les racines; 4) une forte augmentation d'acide linoléique dans les triglycérides des parties aériennes, surtout au niveau des couronnes, ainsi que de la teneur en acide linoléique des racines. Ces résultats évoquent la possibilité de la synthèse d'acide linoléique dans les feuilles pendant l'endurcissement, de son transfert via les triglycérides et de son incorporation dans les phospholipides des racines.

Induction chimique. Des travaux préliminaires nous ont permis de constater que des comptages de racines par quadrats étaient aussi valables que le comptage des racines après leurs prélèvements pour déterminer le pourcentage de survivance des plants de luzerne. L'erreur est moins de 5% et le comptage par quadrats offre l'avantage de laisser la parcelle intacte pour d'autres déterminations.

La variation inhérente à la situation des parcelles dans les champs ne nous a pas permis à date d'observer l'influence des retardants de croissance sur la survivance des

plants de luzerne. Cependant, dans les cabinets de croissance, le chlormequat, un retardant de croissance, semble avoir une influence positive très nette sur l'endurcissement au gel de la luzerne.

Pathogénéicité des champignons du sol

En serre. Les études faites avec des champignons isolés de la rhizosphère des racines malades de luzerne ont révélé que *Gliocladium roseum* (Link) Bainier et *Trichoderma viride* Pers. ex Fr. attaquent les plantules de luzerne. De plus, ils stimulent la pathogénéicité de *Pyrenochaeta terrestris* (Hans.) Gorenz, Walker & Larson et *Rhizoctonia solani* Kühn en diminuant le poids sec des racines. *T. viride* et *G. roseum* diminuent significativement la quantité d'azote totale dans les tiges lorsqu'ils sont inoculés seuls; par contre, la réaction contraire s'est produite dans les racines.

En laboratoire. Des études sur le rôle des champignons du sol envers *Rhizobium meliloti* Dangeard ont démontré que *P. terrestris* produit des substances bactériostatiques qui arrêtent la croissance du *Rhizobium* lorsqu'il croît sur milieu gélosé à base d'extraits de racines de luzerne.

En champ. Avec des plants de trèfle rouge (Dollard, Hungaropoli et Lakeland) provenant de graines ensemencées au printemps de 1970, la pourriture sur les racines augmente à mesure que le plant approche de la floraison.

Trèfle rouge

Maladies des feuilles. En vue d'établir une méthode pratique de déterminer les pertes causées au trèfle rouge par les espèces de *Stemphylium sarcinaeforme* (Cav.) Wiltsh., on a ensemencé en parcelles les variétés Dollard, Ottawa, Lakeland et Hungaropoli. Afin d'obtenir différents degrés d'infection au cours de la période de croissance, différents traitements de fongicide Dyrene (Chemagro Corporation) ont été appliqués. Dès l'apparition des premiers symptômes, l'intensité de la maladie fut évaluée chaque semaine par comparaison à des standards établis. Bien que la longue période de sécheresse durant l'été n'ait favorisé qu'un degré d'infection minime, l'intensité de la maladie fut beaucoup plus faible sur la variété Hungaropoli que sur les autres.

Morphologie des espèces de *Verticillium*

Des expériences ont été conduites pour démontrer l'influence de la température, des milieux de culture et de la durée d'incubation sur le développement et la forme des structures de réserves de *Verticillium dahliae* Kleb. et de *Verticillium nigrescens* Petybr. Les structures de réserve des isolats étudiés diffèrent grandement selon les milieux de culture, la température et la période de croissance. Le développement des structures de réserve est gouverné par le milieu de culture utilisé.

Pomme de terre

Flétrissure bactérienne. Des travaux ultérieurs ont montré que *Corynebacterium sepe-donicum* (Spieck. & Koth.) Skapt. & Burkh., l'agent responsable du flétrissement de la pomme de terre, pousse beaucoup moins rapidement dans un milieu où l'on remplace l'asparagine par l'acide aspartique. De plus, en présence d'asparagine-¹⁴C il y a un fort dégagement de CO₂ radioactif, ce qui indique que l'asparagine serait métabolisée via le cycle des acides tricarboxyliques (cycle de Krebs), alors qu'en présence d'aspartate-¹⁴C le dégagement du CO₂ radioactif est très faible. Les voies métaboliques indiquent que la décomposition de l'asparagine se fait normalement via l'aspartate, laissant supposer que normalement la croissance de l'organisme devrait être au moins tout aussi bonne en présence d'aspartate qu'en présence d'asparagine. Deux explications sont possibles: 1) la présence dans les membranes de perméases qui permettraient à l'asparagine de pénétrer plus facilement que l'aspartate; 2) l'animation des acides cétoniques du cycle de Krebs par le groupe amide de l'asparagine en acides aminés correspondants.

Nous avons vérifié la deuxième hypothèse en ajoutant des quantités catalytiques de pyruvate, d'oxalacétate et de x-kétoglutarate en présence d'asparagine ou de glutamine. Les résultats ont démontré que la croissance augmentait considérablement en présence des acides cétoniques, laissant supposer que l'organisme peut facilement, par ce mécanisme, synthétiser les acides aminés essentiels à sa croissance.

Tache argentée. Des essais ont été poursuivis en serres pendant cinq ans pour déterminer le rôle joué par les débris de pommes de

terre infectés par *Helminthosporium atrovi-*
rens (Harz) Mason & Hughes dans la trans-
mission de la tache argentée. Des boutures de
pommes de terre aussi saines que possible ont
été plantées sans leur éclat de semence dans
des boîtes renfermant un volume de terre
égal à celui d'une butte dans le champ. Ce sol
était (a) non contaminé, (b) contaminé par
l'addition de pelures de pommes de terre
infectées, (c) contaminé de la même façon et
débarrassé de ces débris infectés par tamisa-
ge après 3 mois. Ce dernier sol a servi aux
plantations annuelles ultérieures.

Les résultats montrent que la maladie n'est
transmise aux nouveaux tubercules qu'aussi
longtemps que les débris de pommes de terre
infectées sont présents dans le sol. En l'ab-
sence de ces débris le pourcentage de tuber-
cules infectés à la récolte décroît chaque
année; ce qui indique que *H. atrovi-*
rens ne peut se maintenir longtemps dans le sol en
l'absence de débris de pommes de terre, et
indirectement que le sol comme tel ne peut
être regardé comme la source de cette
maladie.

LES SOLS

Étude physico-chimique des horizons indurés

On a pu montrer, par l'analyse des profils
que nous étudions pour définir des critères de
classification des sols à horizons indurés, que
la formation des fragipans était d'origine
génétique. En effet, la présence des minéraux
argileux du type 2:1 gonflant est habituelle-
ment associée à une pédogénèse active. Il
nous reste encore à faire l'inventaire systéma-
tique de ces données pour l'ensemble des
profils.

Nous avons à peu près terminé cette année
les analyses chimiques et les analyses minéra-
logiques par voie chimique portant sur les
échantillons de la Caténa Arago, Garneau,
Lafontaine et provenant de 12 profils. L'ana-
lyse systématique des échantillons par l'ana-
lyse thermogravimétrique et à la thermoba-
lance a déjà porté sur trois profils. Ces
analyses, de même que l'analyse minéralogi-
que par diffraction des rayons X, seront
continuées sur les profils précédents de même
que sur d'autres échantillonnés au cours de
l'été.

Processus de formation des minéraux argileux

Dans le domaine de la genèse des miné-
raux argileux du sol, nous avons étudié une
série d'échantillons par spectroscopie infra-
rouge pour l'ORSTOM et nous poursuivons
une expérience sur la formation des kaolins
en milieu neutre à partir de matériaux amorphes.
Cette collaboration avec l'ORSTOM
nous offre l'avantage de participer à une
étude où les phénomènes d'altération et de
synthèse sont beaucoup plus rapides que sous
des climats tempérés. Nous espérons ainsi
recueillir des données qui sont importantes
pour les propriétés du sol.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes

Les plantes fourragères

Légumineuses. L'établissement des légumi-
neuses sans plante-abri mais avec l'aide des
herbicides semble prometteur. L'emploi du
benefin ou de la trifluraline en préémergence
a donné un bon contrôle des mauvaises
herbes dans la luzerne et le lotier sans effet
phytotoxique. On observe que le 2,4-DB et le
bromoxynil appliqué en postémergence retar-
de temporairement la pousse de la luzerne et
la floraison du lotier de 3 semaines.

La date de semis est un facteur très impor-
tant. Il semble que pour l'établissement des
légumineuses sans plante-abri, le semis doit
se faire très tôt le printemps ou vers la fin
d'août.

Les céréales

Méthodes culturales. Un des facteurs qui
affecte le semis hâtif des céréales est la
préparation du sol au printemps. Toutefois
en faisant cette préparation à l'automne, on
peut semer plus hâtivement au printemps.
Cela résulte dans une diminution des mottes
en surface et un meilleur contrôle de la
profondeur du semis. Si le drainage superfi-
ciel du sol n'est pas adéquat, le semis hâtif ne
peut se pratiquer avantageusement.

Fraisiers. En première année de production, le classement des variétés par ordre de rendement s'établit comme suit: Veestar, Vibrant, Guardsman, Sparkle, Redcoat, Grenadier, Catskill, Surecrop, Cavalier et Midway. Le pourcentage moyen de fruits affectés de pétale vert et de moisissure grise a réduit de 41% l'ensemble des récoltes et des variétés.

Pommiers. La greffe en tête, pratiquée sur *Malus robusta* 5 a été efficace parmi 43% des variétés et semis greffés. La greffe a été nulle avec Coop 1, Coop 2 et Royal Red Delicious.

Pommes de terre. Les cultivars hâtifs F5748 et F5975 offrent de nouveau des possibilités, compte tenu du rendement, du poids spécifique et de la précocité de tubérisation. Les cultivars tardifs Chieftain et F6350 donnent un rendement de qualité comparable à celui de Kennebec et G.M. Le cultivar F6113 est prometteur en sol organique. Malgré un rendement relativement faible, Seminole, Monona et F6119, entreposés à 5° C et sans reconditionnement, donnent en général des croustilles de bonne qualité. Les cultivars Superior, Norland, Huron, Sebago, Wauseon, Monona, F4748, B5236-21 et F6119 sont apparus résistants à *Streptomyces scabies* (Thaxt.) Waks. & Henrici, cause de la gale commune.

La décontamination du couteau par trempage durant une minute dans du Kem-Germ (Kem-San Products) à une concentration de 31.2 g/litre et dans du Potato Guard (Standard Chemicals Ltd) à une concentration de 5 ml/litre ont donné une récolte exempte de symptômes de la flétrissure bactérienne, *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh. Ces deux ingrédients sont également efficaces pour désinfecter les contenants en bois.

Six des 107 cultivars de la série F67 de Fredericton, N.-B., étaient exempts de symptômes de flétrissure bactérienne après inoculation par le couteau ou les racines. F5268, F5814 et F6313 sont apparus résistants. Les variétés européennes: Elsa, Erdmanna et Urgenta sont aussi apparues résistantes après inoculation par les racines.

Les plantes

Les plantes fourragères

Exploitation de mélanges. Un mélange de fléole, trèfle rouge et luzerne, soumis durant 2 ans à des coupes hebdomadaires, a fourni le plus haut rendement de foin sec quand la première coupe a été retardée jusqu'aux deux dernières semaines de juillet. Lors de la deuxième coupe vers le 20 août, on a obtenu le meilleur regain dans les parcelles où la première fauche a été faite vers le 2 juillet.

Ensemencé à nouveau en 1969, le même mélange a mieux produit quand la première coupe est survenue vers le 23 juillet et l'effet de ce régime s'est traduit par le meilleur regain à la troisième semaine d'août.

Dans un autre essai sur la comparaison du brome, de la fléole, de la luzerne, du trèfle alsike et du trèfle rouge en semis purs et en six mélanges différents, le brome (Saratoga) a donné le plus haut rendement de matière sèche lors de la première coupe survenue le 2 juillet. Les mélanges: fléole-luzerne, brome-luzerne et fléole - trèfle rouge - luzerne ont produit, lors de la deuxième coupe, des quantités égales de matière sèche, mais très significativement supérieures aux quantités obtenues des autres espèces et mélanges. La plus forte production saisonnière a été obtenue de l'association brome et luzerne avec 9 800 kg/ha.

Courbe de croissance de trois graminées. Des données de 3 ans sur le comportement des espèces *Phleum pratense* L., *Bromus inermis* Leyss. et *Dactylis glomerata* L. soumises à différents régimes d'exploitation indiquent que: 1) le rendement augmente graduellement jusqu'au stade de floraison chez la fléole et le brome, mais la productivité maximale semble atteinte au stade d'épiaison chez le dactyle; 2) la date de la première récolte affecte le rendement des coupes subséquentes; 3) le rythme d'exploitation influence la repousse des gazons; 4) la qualité de l'herbe varie avec le stade de croissance et le cycle de végétation des plantes.

Le chou fourrager. Avec une fumure uniforme, le semis du 27 mai a produit un rendement de matière sèche supérieur de 9 096 kg/ha au semis effectué le 15 juin; le

semis tardif a augmenté le rapport feuilles/tiges.

Une interaction hautement significative s'est manifestée entre trois dates de semis et trois taux de fumure azotée chez le chou fourrager; les dates étaient le 27 mai, le 5 et le 15 juin et l'azote sous forme de nitrate d'ammoniaque a été apporté dans chaque cas aux taux de 300, 575 et 675 kg/ha. Le meilleur rendement de matière sèche a été obtenu d'un semis effectué le 27 mai, accompagné du plus haut niveau d'azote. Le semis du 5 juin a mieux produit avec 300 kg/ha de nitrate, suivi du plus haut taux d'azote. Dans les semis effectués le 15 juin, la production de matière sèche a été constamment faible, mais la fumure azotée au taux de 575 kg/ha a contribué à un meilleur rendement qu'à 675 kg/ha.

Dans une autre étude, deux apports d'azote sous forme de nitrate d'ammoniaque ont été faits en deux fois aux taux respectifs de 100 et 200 kg/ha, à 5 et 10 semaines après le semis. Ce traitement a contribué à une meilleure obtention de matière sèche qu'un seul apport de ces taux 5 semaines après le semis. Dans les deux cas, on a obtenu une meilleure réponse avec la plus abondante fumure azotée.

Les fruits et légumes

Fraisiers. Les observations recueillies de deux plantations comportant les mêmes variétés ont révélé que la variété Catskill produit les fruits les plus gros. Les meilleurs rendements ont été obtenus des variétés Veestar, Catskill, Redcoat et Vibrant avec plus de 7 000 kg/ha respectivement. La variété Cavalier a produit un peu plus que la moyenne des essais avec 6 652 kg/ha; ses fruits ont cependant mauvaise apparence.

Dates de semis du rutabaga. Les résultats de 3 ans ont démontré que le rutabaga ne doit pas être semé après le 15 juin pour une excellente récolte de racines de qualité.

En effet, on a obtenu des rendements moyens de 71 730 et 39 452 kg/ha de racines pour les semis respectifs du 15 et du 30 juin, soit une différence de près de 45%. La proportion de rutabagas pour la consommation a atteint 88.7% pour la première date et seulement 59% pour le semis le plus tardif.

Mais sucré. Ensemencées sous polyéthylène clair, sept variétés de maïs ont produit un peu plus d'épis qu'un semis en pleine terre; la différence entre la hauteur des tiges, le poids et la longueur des épis a été négligeable.

Tomates. A la première année d'essai, sept sélections développées à Beaverlodge, Alb., ont donné des fruits mesurant en moyenne 3.5 cm de diamètre et un poids moyen de 42.3 grammes.

Les céréales

Blé de printemps. La variété Pitic 62 a rapporté plus de grain à l'hectare, mais d'un poids moindre que les variétés Opal et Selkirk et que la sélection W.B. 8874.

Avoine. Le rendement des nouvelles variétés Yamaska, Harmont et Fraser a dépassé 3 810 kg/ha (100 minots/acre). La variété Dorval a également été de bon rapport à deux endroits dans la région; elle est cependant un peu tridive.

Orge. La nouvelle variété Conquest a continué de se bien comporter quant à son rendement et sa force de paille. Les variétés Bonanza et Paragon ont surpassé en rendement les témoins Parkland et Champlain.

Les oléagineuses

Colza. Les sélections de type *Brassica napus* L. ont produit plus que celles du type hâtif *B. campestris* L.; la teneur en huile s'est maintenue à un pourcentage élevé comme par les années antérieures.

Lin. Le rendement a été inférieur à celui de 1969; la teneur en huile de 10 variétés et lignées a varié de 41.5% à 43.9%.

PUBLICATIONS

Recherches

Aubé, C., et Gagnon, C. 1970. Influence of certain soil fungi on alfalfa. Can. J. Plant Sci., 50:159-162.

Bordeleau, L. M., et Dartha, R. 1970. Azobenzene residues from aniline-based herbicides: Evidence from labyle intermediates. Bull. Environ. Contam. Toxicol., 5:34-37.

- Bullen, M. R. 1970. Genetic and structural control of pairing in two plant genera. *Can. J. Genet. Cytol.*, 12:375.
- Colmet-Daage, F., De Kimpe, C., et al. 1969. Naturaleza de la fracción arcillosa de algunos suelos derivados de cenizas volcánicas de las Antillas, El Ecuador y Nicaragua. Conf. sur les sols dérivés des cendrées volcaniques. OEA/IICA, Turrialba, Costa-Rica, B.2.1 - B.2.12.
- Colmet-Daage, F., De Kimpe, C., et al. 1970. Caractéristiques de quelques sols dérivés de cendres volcaniques de la Côte Pacifique du Nicaragua. *Cahiers ORSTOM*, Vol. VIII, n° 2.
- De Kimpe, C. 1970. Chemical, physical and mineralogical properties of a podzol soil with fragipan derived from glacial till in the Province of Quebec. *Can. J. Soil Sci.*, 50:317-330.
- Deschênes, J. M. 1970. The history of the genus *Acer*, a review. *Natur. Can.*, 97:51-59.
- Dubuc, J. P. 1970. The identification of aneuploid lines and a study of somatic association in *Avena sativa* L. Ph.D. thesis, Univ. of Manitoba, Winnipeg, Man. 50 p.p.
- Dubuc, J. P., et McGinnis, R. C. 1970. Somatic association in *Avena sativa* L. *Science (Washington)*, 167:999-1000.
- Dubuc, J. P., et McGinnis, R. C. 1970. Identification and characterization of three ditelosomic lines in *Avena sativa* L. *Can. J. Genet. Cytol.*, 12:379.
- Paquin, R., et Lachance, R. A. 1970. Sur la nutrition aminée de *Corynebacterium sepedonicum* (Spieck. et Kotth.) Skapt. et Burkh. et la résistance de la pomme de terre au flétrissement. *Can. J. Microbiol.*, 16:719-726.
- Pelletier, G., et Aubé, C. 1970. Conidial size and contents in *Verticillium* as affected by environmental factors. *Can. J. Microbiol.*, 16:231-236.
- Pelletier, G., et Aubé, C. 1970. Rôle des facteurs de croissance dans la formation des structures de réserve de *Verticillium dahliae* et *V. nigrescens*. *Can. J. Microbiol.*, 16:901-904.
- Roelofs, W. L., et Comeau, A. 1970. Lepidopterous sex attractants discovered by field screening tests. *J. Econ. Entomol.*, 63:969-974.
- Roelofs, W. L., Glass, E. H., Tette, J., et Comeau, A. 1970. Sex pheromone trapping for red-banded leaf roller control: theoretical and actual. *J. Econ. Entomol.*, 63:1162-1167.
- St-Pierre, C. A. 1970. Inheritance and selection for yield of large and small grains in two-rowed barley. Ph.D. thesis, Cornell Univ., Ithaca, N.Y., 101 p.p.
- St-Pierre, J. C. 1970. The effect of defoliation on the accumulation of dry matter and the translocation of ¹⁴C-photosynthates in timothy (*Phleum pratense* L.). Ph.D. thesis, Cornell Univ., Ithaca, N.Y. 159 p.p.
- Willemot, C., et Belzile, L. 1970. Incorporation de la radioactivité du chlorure de (2-chloroéthyl)-triméthylammonium-1,2-¹⁴C dans la phosphatidylcholine de folioles de luzerne. *Can. J. Biochem.*, 48:994-998.

Divers

- Aubé, C., et Gagnon, C. 1970. La couleur des graines de luzerne est-elle importante? *Agriculture*, 27:7-9.
- Gagnon, C., et Aubé, C. 1970. La tache stemphylienne du trèfle rouge au Québec. *Can. Agr.*, 15(3):10-11.
- Généreux, H. 1969. Rapport annuel des essais régionaux de pommes de terre au Québec. pp. 1-87.
- Généreux, H. 1969. Desinfection of knives, potato sets and wooden boxes. *Pestic. Res. Rep.*, p. 267.
- Généreux, H. 1969. Potato variety reaction to common scab. *Rep. of the comm. of Hort. Res.*, p. 25.
- Roelofs, W. L., Glass, E. H., Arn, H., et Comeau, A. 1970. Modulating sex attractant reception for insect control. *N.Y. Food Life Sci., Quart.* April-June, Vol. 3(2).

Scientifique en séjour d'étude

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Pomologie

INTRODUCTION

Pour favoriser une approche multidisciplinaire dans les travaux de recherches en horticulture, des changements importants ont été réalisés au cours de l'année comportant le regroupement des chercheurs en deux sections, à savoir: les Cultures fruitières et les Cultures maraîchères. Aussi, ce rapport est présenté en tenant compte de chacune des cultures qui font l'objet de programmes distincts de recherches.

A. A. Beaulieu
Le directeur

POMME

Entomologie

Tétranyque rouge du pommier et phytopte du pommier. Des essais de lutte chimique préventive contre les acariens phytophages ont démontré que chinométhionat, endosulfan-huile et Fundal Forte (Niagara Chemicals) étaient plus efficaces que M 2060 (Montecatini Edison S.p.A.) et éthion-huile pour réprimer le tétranyque rouge du pommier, *Panonychus ulmi* (Koch); d'autre part, Fundal Forte et chinométhionat paraissaient plus efficaces que endosulfan-huile et éthion-huile pour réprimer le phytopte du pommier, *Aculus schlechtendali* (Nal.). Dans des essais de traitements curatifs, Plictran (Dow Chemical) et chinométhionat se sont avérés plus efficaces que Carzol (Niagara Chemicals) et chlorpropylate contre le tétranyque rouge, mais contre le phytopte du pommier, il n'y a pas eu de différence entre ces quatre produits. Des essais en serre ont démontré que bromopropylate, Carzol, chlorphénamidine, R 10044 (Stauffer Chemical) et Hoe 2960 (Hoechst Chemicals) étaient très prometteurs pour la répression du tétranyque rouge du pommier, mais que PP 511 (Chipman Chemicals) n'avait pas d'effet acaricide appréciable.

Dans un programme de lutte intégrée, les acariens phytophages étaient définitivement plus nombreux dans une parcelle expérimentale traitée aux insecticides contre la mouche de la pomme et le puceron vert que dans une autre parcelle exempte d'insecticide.

Charançon de la prune. Après deux saisons d'essais, les insecticides BAY 37344 (Chemagro Ltd), carbofuran, tetrachlorvinphos, phosmet et phosalone, employés comme substituts de la dieldrine contre *Conotrachelus nenuphar* (Hbst.), se sont avérés efficaces en fournissant de 92 à 99% de pommes saines. Les traitements ont comporté deux

applications effectuées à la chute des pétales et au premier traitement de couverture.

Mouche de la pomme. L'action des prédateurs sur les pupes de *Rhagoletis pomonella* (Walsh) en hivernement dans le sol réduirait considérablement leur taux de survie. En effet, ce taux n'a été que de 6% après hivernement lorsque des lots de pupes avaient été laissées sans protection sous un pommier en novembre 1969, tandis qu'il a été respectivement de 21% et de 84% lorsque les pupes, dans des conditions similaires, étaient protégées par des grillages de 4 et de 12 mailles au pouce.

L'emploi de pommes artificielles en polyéthylène recouvertes d'une substance gluante s'est avéré très efficace pour mesurer la période d'activité des mouches dans les vergers, mais l'usage de cages d'émergence demeure nécessaire pour déterminer la période de sortie des adultes.

Dans des essais de traitements contre *R. pomonella*, quatre applications des insecticides carbaryl, BAY 37344, tetrachlorvinphos, carbofuran et pirimiphos-méthyl à intervalles d'environ deux semaines à partir du début de juillet ont fourni à la récolte 98-100% de fruits sains en comparaison de 92% pour les parcelles témoins.

Phytopathologie

Tavelure du pommier. Une application de captafol, effectuée à doses massives (5.7 l/450 l) sur des pommiers de la variété McIntosh, lorsque les feuilles du bourgeon floral avaient 1.3 cm de diamètre et une application de dodine, effectuée à dose normale un mois plus tard, ont assuré une protection des feuilles et des pommes contre *Venturia inaequalis* (Cke.) Wint. dans une proportion de 99%.

Génétique

Cultivars, lignées, clones et hybrides. Dans les pommeraies expérimentales de Sainte-Clotilde et de Frelighsburg, le matériel génétique sous observation comprend: a) trois races dites «Spur type» trouvées au Québec et à l'extérieur; b) deux races de Cortland, trois de Spartan et six de Délicieuse rouge; c) 12 variétés de pommes résistantes à la tavelure maintenant en rapport; d) les clones n° 1, 2, 3, 4, 7, 8, 11, 12 et les hybrides n° 1, 3, 5, 6 provenant de la Station de recherches d'Ottawa; e) des cépées de pommiers indexés des clones MM106, MM26, E.M. VII, MMIII et *M. robusta* 5; f) les cultivars de poiriers les plus prometteurs de la Station de recherches d'Ottawa.

Physiologie

Régulateur de croissance. Le composé Alar-85 (UniRoyal Chemical Co.), appliqué sur le feuillage de pommiers McIntosh adultes au taux de 700 et de 1 400 p.p.m., a retardé la chute des pommes de 12 et de 18 jours respectivement et a augmenté leur coloration et leur fermeté à la cueillette. Le traitement, effectué à la mi-juin, à la mi-juillet ou à la fin d'août, a donné des résultats similaires, mais la dose de 1 400 p.p.m. a diminué sensiblement la grosseur des fruits de l'année en cours et de l'année subséquente.

Régie des pommeraies

Essais de taille en vue d'accroître la rentabilité. Les résultats préliminaires de six traitements de taille sur des pommiers McIntosh âgés de 30 ans ont révélé que a) la taille conventionnelle fournissait les fruits les moins colorés, b) le rabattage des arbres selon la méthode Allen nécessitait les plus fortes coupes de bois mais fournissait les plus gros fruits, c) la taille sévère de juin favorisait la coloration des fruits, d) la taille des branches charpentières selon la méthode de Crowe réduisait la grosseur des fruits mais augmentait les rendements et e) la taille bilatérale en haie de 3 ou 5 mètres de largeur par 5.8 mètres de hauteur ne diminuait pas les frais de cueillette.

Plates-formes mobiles pour la taille et la cueillette. Dans le verger expérimental de Frelighsburg, le temps requis pour la taille des pommiers a été réduit d'au moins 20% et

les frais de cueillette, de 40% en faisant usage de plates-formes mobiles conçues à cette fin.

PETITS FRUITS

Phytopathologie

Mildiou du fraisier. Dans des essais de répression de *Sphaerotheca humuli* (DC.) Burr., les produits dinocap, thiophanate de méthyl et Kolospray (Niagara Chemicals), appliqués sur les variétés de fraises Earldawn et Guardsman, ont assuré une protection du feuillage évaluée à 98% et plus. Sur les plants-témoins traités à l'eau seulement, le taux d'incidence de la maladie était de 5%.

Entomologie

Faune entomologique nuisible. Malgré une distribution inégale, la punaise terne, *Lygus lineolaris* (P. de B.), a sérieusement infesté les récoltes de fraises au Québec, en 1970. Dans certaines plantations, les pertes ont atteint 18%. L'altise à tête rouge, *Systema frontalis* (F.) et la tordeuse *Ptycholoma peritana* Clem., se sont classées au deuxième rang en importance. Les adultes de *P. peritana* ont été actifs de la fin de juin à la mi-juillet, les larves se sont développées du début de juillet à la mi-août tandis que la nymphose et l'éclosion de nouveaux adultes ont pris place durant la dernière quinzaine d'août.

Génétique

Évaluation de lignées et de cultivars de fraisiers. Parmi 13 lignées de fraisiers provenant de la Station de recherches d'Ottawa, quatre ont eu un rendement supérieur à celui des cultivars commerciaux Senga Sengana, Guardsman (fondation et ordinaire), Redcoat, Vineland, Grenadier, Sparkle et Cavalier. Deux lignées sur cinq, provenant de la Station de recherches de Kentville, N.-É., se sont avérées supérieures à la Redcoat. Parmi le matériel fourni par la Station de recherches de Vineland, Ont., le cultivar Guardsman a donné définitivement les meilleurs résultats.

Régie des cultures

Densités de plantation des framboisiers. Les cultivars Comet, Newburgh, Latham, Carnival et Trent, plantés en 1968 à L'Acadie, furent éclaircis au printemps de 1970

selon les densités suivantes: 50, 75, 100, 125, 150 et 175 tiges par rang de 9.14 mètres. Les rendements en 1970 furent directement proportionnels aux densités, soit 28.7 kg de fruits par rang pour la plus forte densité et 20.4 kg pour la plus faible densité.

Conditionnement des plants de fraisiers. Des plants de fraisiers, arrachés à l'automne et conservés à une température de 29°F, ont eu un rendement supérieur à celui des plants arrachés au printemps, soit une moyenne de 19 054 kg à l'hectare comparée à 18 383 kg.

CAROTTE

Régie des cultures

Assolement. Les résultats obtenus au cours des cinq dernières années démontrent que, sans assolement, les rendements de certaines cultures maraîchères en sol organique diminuent considérablement. La carotte, la laitue, l'oignon et le céleri sont, par ordre décroissant, les cultures ainsi les plus affectées. Par ailleurs, les meilleurs rendements de laitue et d'oignons furent obtenus à la suite d'une récolte de céleri et ceux de carottes et de céleri, après une récolte de laitue. La carotte s'est avérée la culture dont les effets furent les plus préjudiciables aux rendements des cultures subséquentes, particulièrement aux productions de céleri et d'oignon.

Densité des semis. Les semis de carotte sur rangs espacés de 15.2 cm ont fourni le rendement le plus élevé qui, cependant, s'est classé au dernier rang quant à sa valeur commerciale; les semis sur rangs espacés de 22.9 cm ont donné le plus haut pourcentage de carottes vendables. Par ailleurs, le plus bas taux de semis, 20 à 30 graines/30.5 cm, sur des rangs espacés de 22.9 cm, a donné un rendement de 93.8 tonnes métriques/ha, soit 25% de plus que le rendement des témoins ayant un taux de semis de 30 à 40 graines/30.5 cm sur des rangs espacés de 45.7 cm.

Désherbage chimique. Au stade de post-émergence des plants de carotte, les herbicides linuron, chlorbromuron et prométryne, appliqués en sol organique au taux de 2.24 ou 4.48 kg/ha de matière active, ont chacun assuré une répression très satisfaisante des mauvaises herbes sans affecter le rendement des carottes. À la dose de 1.12 kg/ha, ils se sont

avérés inefficaces. Au stade de post-émergence, appliqués aux taux de 1.12 et 2.24 kg/ha, ces mêmes produits ont éliminé de façon satisfaisante les mauvaises herbes, tandis que solan, à raison de 4.48 kg/ha et San 6602 (Sandoz Ltd), à raison de 1.12 et 2.24 kg/ha se sont avérés inefficaces. Les produits linuron, prométryne et chlorbromuron, appliqués au stade de post-émergence au taux de 2.24 kg/ha, ont endommagé le feuillage et retardé la croissance des carottes.

Fertilisation

Chaulage des sols organiques vierges. Dans un sol organique vierge nouvellement défriché, une application de pierre à chaux à raison de 26.8 t/ha ou d'un engrais azoté, phosphaté et potassique au taux respectif de 56-56-112 kg/ha a augmenté les rendements de la pomme de terre de 50% environ. Par contre, les rendements de carottes et d'oignons ont été presque nuls, ce qui serait attribuable à la basse teneur en cuivre évaluée à 10 p.p.m. dans un tel sol. Cette quantité de cuivre s'avère quand même suffisante pour la production de la pomme de terre.

Entomologie

Charançon de la carotte. Différentes méthodes de piégeage ont permis d'établir la présence, au Québec, d'un nouveau ravageur, le charançon de la carotte, *Listronotus oregonensis* (Lec.). Bien que son cycle évolutif ne comporte qu'une génération par année, ce ravageur est déjà bien répandu dans les sols organiques du sud-ouest du Québec où les dégâts, évalués au moment de la récolte, ont varié de 2 à 22%. Les semis hâtifs ont été plus sévèrement infestés que les semis tardifs.

OIGNON

Phytopathologie

Charbon de l'oignon. Dans les sols organiques du sud-ouest du Québec, le charbon de l'oignon, *Urocystis magica* (Pass.), a été observé sur 21 des 44 fermes inspectées, soit 47.7%. La superficie affectée couvrait 263.8 ha sur 559.3 ha échantillonnés, soit 42.3%. Le taux moyen d'infection était de 4.3%. En 1970, les pertes causées par cette maladie ont été évaluées à un montant variant de 55 à 65 mille dollars.

Dans une série de 12 traitements fongicides, le traitement de semence Vitavax-thirame, suspension n° 4 (UniRoyal Chemical Co.), employé à 6%, a été le plus efficace contre le charbon. Le thirame 75-W à 37.5%, a été le plus efficace contre la fonte des semis. Le Vitavax 75-W à 1%, trouvé très efficace en 1969, a été médiocre en 1970. Dans un essai préliminaire, le mélange de Vitavax 75-W à 1% et de Cercobin (Cercobin-M: Nippon Soda Co. Ltd), à 0.05% donna d'excellents résultats.

Lutte contre les mauvaises herbes

Traitements herbicides. Appliqué au stade de la préémergence des plants d'oignon et des mauvaises herbes, le propachlore fut le seul des sept herbicides à l'essai qui donna des résultats supérieurs à ceux obtenus avec le traitement recommandé, soit le mélange alidochlore-chlorprophame. Appliqués au stade de postémergence, les herbicides alachlore, C-7019 (Ciba Co. Ltd) et nitroféne n'ont pu éliminer de façon satisfaisante les mauvaises herbes sans endommager les cultures, quel que soit le taux d'application.

MAÏS

Fertilisation

Engrais phosphaté. L'application de phosphate, à cinq taux différents, sur une argile Sainte-Blaise a démontré que cet élément influence le rendement et la date de maturité de la variété de maïs sucré, Seneca 60. Le taux de 28 kg d'acide phosphorique (P) par hectare a favorisé une maturité hâtive mais n'a pas augmenté le rendement. Les taux de 56, 112 et 224 kg de P/ha donnèrent des rendements respectifs de 7.3, 11.5 et 15.3 kg/parcelle, rendements qui se sont tous révélés significativement différents.

Génétique

Résistance à la pyrale du maïs. Douze variétés hybrides et neuf lignées de maïs grain furent évaluées quant à leur résistance à des infestations naturelles et artificielles de la pyrale du maïs, *Ostrinia nubilalis* (Hbn.). Les lignées se sont toutes avérées résistantes à la pyrale, sans toutefois manifester de différences significatives entre elles. Ainsi, les lignées Ottawa 190, 191, 106 et la lignée

Harrow Ch-611-10 se comparèrent avantageusement à des lignées américaines universellement reconnues telles, USA, C131A et Oh43.

Dans une exploitation commerciale de maïs-grain, 20 hybrides présentement cultivés au Québec furent évalués en fonction de leur résistance à des infestations naturelles et artificielles de pyrales. Les infestations artificielles ont abaissé les rendements de 26%, en moyenne, en comparaison de l'infestation naturelle et ont favorisé une maturité plus précoce du maïs qui, à la récolte, avait un taux d'humidité 5% moindre.

Lutte chimique

Pyrale du maïs. Les insecticides carbaryl, trichlorfon, carbofuran et tétrachlorvinphos furent mis à l'essai comme substituts du DDT contre la pyrale du maïs. À l'exception du carbofuran, ils ont permis d'obtenir plus de 96% d'épis sains; les parcelles au carbofuran comportaient 7.3% d'épis pyralés, ce qui est supérieur au seuil de tolérance de 5% généralement accepté par les producteurs du Québec.

Puceron du maïs. En 1970, le puceron du maïs, *Rhopalosiphum maidis* (Fitch), a été abondant à travers tout le Québec. Au moment de la récolte, la proportion de plants infestés de pucerons a été de 10% dans les parcelles traitées avec le carbofuran, de 18.3% avec le trichlorfon, de 22.8% avec le carbaryl, de 31.1% avec le tétrachlorvinphos et de 46.7% dans les parcelles témoins.

Lutte contre les mauvaises herbes

Désherbage chimique. Huit traitements herbicides appliqués sur une variété de maïs sucré, Seneca 60, ont démontré la supériorité des traitements combinés. Les meilleurs traitements furent les mélanges atrazine-alachlore en préémergence et atrazine-butylate en présemis. Employé seul, aucun herbicide ne semble pouvoir être utilisé à des doses suffisantes pour détruire toutes les espèces de mauvaises herbes sans affecter en même temps la récolte de maïs.

CHOU

Génétique

Résistance du chou à la hernie. En 1970, la lignée homozygote partielle 246 s'est montrée résistante à la race 3 de *Plasmodiophora brassicae* Wor. et a produit 91% de choux vendables. L'analyse des amino-acides contenus dans les racines de la lignée résistante 8-41 et de la variété susceptible Pennstate Ballhead démontre que la phénylalanine est présente dans les racines de la variété susceptible seulement et nous permet de formuler l'hypothèse que cet amino-acide serait essentiel au développement de *P. brassicae*.

Chou hybride. L'hybride F₁ résultant du croisement Baby Head et 244 a donné un meilleur rendement de pommes de chou marchandes que plusieurs hybrides commerciaux utilisés; de plus, cet hybride possède des caractéristiques horticoles recherchées telles que uniformité, fermeté et couleur.

DIVERS

Écologie

Betterave sucrière. Parmi cinq variétés de betterave sucrière ensemencées dans un sol inoculé avec *Aphanomyces cochlioides* Drechs., seulement les variétés H.C.-11 et Monogerm ont donné suffisamment de

plantules saines, soit un minimum de 30 par parcelle, pour assurer un rendement normal. Aucune de ces mêmes variétés ensemencées dans des parcelles inoculées avec *Rhizoctonia solani* Kühn n'ont fourni suffisamment de plantules saines pour obtenir un rendement satisfaisant.

Le Dexon (Chemagro Corporation) seul ou en mélange avec le quintozone a contribué à augmenter le nombre de plantules saines chez les variétés de betterave sucrière.

Laitue. Dans des essais parcellaires, la proportion de pommes de laitue non vendables à cause des maladies (pourriture basale, affaissement sclérotique, jaunisse et mosaïque) et de certains autres facteurs (pommes molles, types bâtards, etc.) s'est établie à 14.6%. Ce pourcentage extrapolé représente environ 600 cageots par hectare ou encore des pertes variant entre 600 et 900 dollars/ha.

Pois. Une enquête systématique sur les maladies du pois de conserve au Québec a été entreprise sur 48 champs représentant une superficie totale de 586.6 ha répartis entre cinq conserveurs. Le nombre de champs infestés par les différentes maladies s'est établi comme suit: pourriture des racines, 43 champs; rouille, 37; aschochytose, 30; brûlure aschochytique, 22; tache septorienne et anthracnose, 15. Les pertes les plus onéreuses ont été causées, en fait, par la pourriture des racines.

PUBLICATIONS

Recherches

Beauchamp, E. G., et Hamilton, H. A. 1970. Optimum ratios of nitrogen and phosphorus fertilizers for corn determined by Homès method of systematic variations. *Can. J. Plant Sci.*, 50:141-150.

Chiang, M. S., et Crête, R. 1970. Inheritance of clubroot resistance in cabbage (*Brassica oleracea* L. var. *capitata* L.). *Can. J. Genet. Cytol.*, 12:253-256.

Hamilton, H. A. 1970. Influence of nitrogen, potassium and root zone temperature on the response of timothy in monoculture and in association with alfalfa and birdsfoot trefoil. *Can. J. Plant Sci.*, 50:401-409.

Hudon, M. 1970. European corn borer, *Ostrinia nubilalis*, on sweet corn, *Zea mays*. Crop loss assessment methods, p. 13. In *FAO Manual*

on the evaluation and prevention of losses by pests, diseases and weeds. FAO, United Nations, Rome.

Hudon, M., et Perron, J. P. 1970. First record of *Ciseps fulvicollis* (Hübner) (Lepidoptera: Amatidae) as an economic destructive insect on grain corn in Canada. *Can. Entomol.*, 102:1052-1054.

Lafrance, J. 1970. *Elateridae* (especially *Agriotes* and *Dalopius* spp.) (wireworms) on potato, *Solanum tuberosum*. Crop loss assessment methods, p. 12. In *FAO Manual* on the evaluation and prevention of losses by pests, diseases and weeds. FAO, United Nations, Rome.

- Lafrance, J. 1970. The nocturnal insect catches at predetermined time interval in the organic soil district of Ste. Clotilde, southwestern Quebec. Part III. Ann. Soc. entomol. Qué., 15:53-58.
- Lafrance, J. 1970. Méthodes de capture des taupins (Coléoptères: Elateridae) dans les sols organiques, au sud-ouest du Québec. Ann. Soc. entomol. Qué., 15:66-70.
- Hogue, E. J. 1970. Molecular structure and herbicidal activity of some substituted ureas. Weed Sci., 18:580-582.
- Hogue, E. J., et LaCroix, L. J. 1970. Seed dormancy of Russian olive (*Elaeagnus angustifolia* L.). J. Amer. Soc. Hort. Sci., 95:449-452.
- Hogue, E. J., et Warren, G. F. 1970. Comparisons of dihydroxybenzenes and paraquat. Weed Sci., 18:179-182.
- Hogue, E., Wilcox, G. E., et Cantliffe, D. J. 1970. Effect of soil phosphorus levels on phosphate fractions in tomato leaves. J. Amer. Soc. Hort. Sci., 95:174-176.
- Parent, B. 1969. Influence des facteurs climatiques sur les arthropodes nuisibles aux cultures. Phytoprotection, 50(2-3):95-119.
- Parent, B. 1970. Chemical control of the oystershell scale, *Lepidosaphes ulmi* (L.), in apple orchards in southwestern Quebec. Ann. Soc. entomol. Qué., 15(2):71-79.

Divers

- Granger, R. L. 1970. Progrès dans le domaine des porte-greffes. «Semaine du Cultivateur», Inst. Tech. Agr. St-Hyacinthe, Min. Agr. Qué. pp. 132-136.
- Granger, R. L., et Guay, J. B. 1970. La cueillette semi-mécanisée. «Semaine du Cultivateur», Inst. Tech. Agr. St-Hyacinthe, Min. Agr. Qué. pp. 144-151.
- Granger, R. L., et Hogue, E. J. 1970. L'Alar-85: ses possibilités, ses limites. «Semaine du Cultivateur», Inst. Tech. Agr. St-Hyacinthe, Min. Agr. Qué., pp. 137-143.
- Hudon, M. 1970. The European corn borer goes international. Can. Agr., 15(4):3-6.
- LeRoux, E. J., et Paradis, R. O. 1970. Histoire et perspectives de la protection des plantes au Québec: aspect entomologique. Phytoprotection, 50(3):99-123.
- Parent, B., et Mailloux, M. 1970. Acariens nuisibles aux pommeraies du Québec et leur répression. Can. Agr., 15(3):13-15.
- Parent, B. 1970. Principaux acariens nuisibles aux pommiers. «Semaine du Cultivateur», Inst. Tech. Agr. St-Hyacinthe, Min. Agr. Qué., pp. 126-131.

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INTRODUCTION

This report presents the main findings from research during 1970 at the Research Station, Delhi, to improve the production of tobacco, with special emphasis on reducing the hazards of smoking.

Gibberellic acid applied at the time of topping effectively decreased the reducing sugar content of flue-cured tobacco without causing any noticeable changes in either chemical or physical characteristics of the leaf.

Because Delcrest 66, Yellow Gold, and Strain 205 were found to be lower in total particulate matter than other varieties commonly grown in Ontario, the tar content of tobacco smoke may be reduced by plant breeding.

Two fatty alcohol formulations were accepted for use in Ontario for the control of sucker growth on tobacco. In 1970, over 60% of the acreage in the province was treated with these materials, with good success.

L. S. Vickery
Director

SOIL SCIENCE

Fertilization

Nutrient depletion. A long-term experiment was started in 1967 to study tobacco grown with K, Mg, or P omitted from the fertilizer. These treatments are replicated on two rotations: continuous tobacco and rye-tobacco. The omission of these elements had no effect on yield or grade in the first 3 years. Omitting K decreased the K content of the leaves in each of the 3 years, but increased Ca and tended to increase Mg and P content particularly for the continuous tobacco. Where no Mg was applied, the level of Mg in the leaves was lower, but there was no effect on the other minerals measured. Omitting P from the fertilizer has had little effect on the level of P or other constituents in the leaves.

Broadcasting phosphorus. In a 3-year study, a supplementary broadcast application of P at 122 kg/ha (109 lb/acre) as either superphosphate (8.7% P) or calcium phosphate (20% P) had no effect on grade index or total alkaloids of tobacco. At transplanting time, all plots received a 2-12-16 analysis fertilizer at 1345 kg/ha.

Seedbed. Increasing the rate of a 2-16-6 analysis tobacco seedbed fertilizer from 543 g/m² to 1086 or 1629 g/m² decreased the germination, and the weight of tops and roots of seedlings, and increased soil conductivity. Increasing the proportion of N in the NO₃ form resulted in higher germination and much lower soil conductivity than the 25% NO₃ currently in use. A higher analysis

seedbed fertilizer applied at a rate to give equivalent nutrients (e.g., 3-24-9 at 365 g/m²) gave greater weight of plants and lower soil conductivity than the 2-16-6 analysis at 543 g/m².

PLANT SCIENCE

Transplants

Transplants raised in peat pots containing muck became established more quickly in the field and grew more uniformly than transplants raised in muck seedbeds. Seedbed plants were superior in these respects to readi-pots (vermiculite media), paper pots (muck media), and BR-8 pots (cellulose media). Sphagnum, vermiculite, and compost alone or in combination with muck, vermiculite, or perlite provided satisfactory media for seedbeds.

Grade index, yield, and number of leaves per plant decreased with an increase in size of transplant. Medium and large transplants withstood the shock of transplanting better than small transplants.

Grade index and yield increased when transplanting was delayed from May 25 to June 8.

Paper Mulch

The crop returns from mulched plots differed little from the crop returns from unmulched plots, although mulched plots had higher grade indices and lower yields. When

both types of plots received extra irrigation water after topping time, mulched plots gave higher yields. Mulched plots needed less fertilizer than unmulched plots.

Frost Control

Protein foam applied every other day for 2 weeks to early-transplanted plots prevented premature flowering, and increased yield. The purposely excessive number of foam applications restricted early plant growth, thereby lengthening time to flowering.

Chemical Control of Weather Fleck

Within the period July 21 to August 5, effectiveness of the systemic fungicides Vitavax and Plantvax decreased with delay of spray applications, and increased with rate of application.

Ethrel

Sprays of Ethrel (2-chloroethylphosphonic acid) at rates as low as 10 mg/plant promoted leaf ripening, but the response was not uniform over the entire leaf. Only leaves close to physiological maturity were affected.

Curing

Grade indices were reduced only slightly by yellowing 48 hr longer than usual; yellowing 24 hr longer than usual had no effect. Levels of total sugars decreased, however, when the yellowing phase was prolonged for 24 or 48 hr, particularly in lower primings.

Filling Value

A mechanical means of measuring filling value, which was developed in cooperation with the Engineering Research Service, has reduced the sample size and the testing time, and has provided readings highly correlated with those obtained by a standard manual method.

Sucker Inhibitors

Two fatty alcohol formulations, Delspray T148 and Emtrrol 1630B, were accepted as sucker inhibitors for use on flue-cured tobacco in Ontario. Over 60% of the total crop was treated with these materials, with good success. Results showed that an application of these formulations 3-4 days before topping was more effective in controlling suckers

than an application after topping, and it did not noticeably injure the leaves.

PLANT PHYSIOLOGY

Gibberellic Acid

Gibberellic acid (GA) applied to tobacco plants at 2 mg or less per plant, at time of topping, effectively decreased the reducing sugar content of flue-cured tobacco without any other effects on either the chemical or physical properties of the leaf. The effect was most pronounced for the third priming; the cured leaves of this priming normally contain the highest amount of reducing sugars. The primary effect(s) of GA appears to be the reduction of total starch in the mature leaf. The lower level of starch in the harvested leaf was reflected by the decrease in reducing sugars at the end of curing, since it is the hydrolysis of starch that gives rise to the reducing sugars during curing.

Gibberellic acid applied to tobacco plants at time of topping gave the largest decrease of reducing sugars, 55%, compared with 70% and 60% reductions for GA applications 1 week before and 1 week after topping respectively. These results were obtained at GA levels of more than 2 mg/plant.

Varieties of tobacco may respond differently to the same concentration of GA. Of the five varieties studied, maturity index and yield were generally not affected. Total alkaloids were reduced significantly in the fifth priming for only Delhi 34, whereas other varieties did not differ from the control. The main difference was in the effect on reducing sugars, Delhi 34 showing the least effect.

The use of GA to produce a tobacco containing varying amounts of reducing sugars without affecting other chemical and physical properties has made available a very useful means of studying the contribution of reducing sugars to the formation of smoke tars.

Chemical Changes During Curing

Continuing studies into the chemical changes that occur during curing have verified preliminary results of the past year that indicate 30% to 40% loss of dry weight. The hydrolysis of starch was negatively correlated to the increase in reducing sugars during the initial stages of curing. At this point levels of reducing sugars are at their maximum, and

they decrease gradually throughout the rest of the curing period. All five primings were studied in 1970 to give comprehensive information of chemical interrelationships during curing.

Physiological Maturity and Chemical Uniformity

Sample variability is a very important factor in measuring changes in the carbohydrate and nitrogen fractions during curing. Preliminary studies of physiological maturity in the field by use of the leaf plastochron index have shown a variation of up to six units in a field population: This is similar to 7 days on a chronological scale. The frequency distribution of physiological maturity showed a partial segregation of the plants into two main groups.

Paired-leaf Analysis

A detailed study based on a paired-leaf analysis of the chemical and physical properties of Delhi 34 in relation to smoke characteristics was started. Suitable methods were developed in the field to select a uniform plant population based on vegetative and reproductive growth characteristics.

Smoke Analysis

A subsampling technique has been established to provide uniform cigarettes for machine smoking. Cigarette selection is based on sample mean diameter, pressure drop, and weight.

Thermogravimetric analyses on samples of ground tobacco from several varieties and primings of flue-cured and burley tobacco indicated that the A region (150–350 C) weight loss may be positively related to amounts of tar in the smoke.

GENETICS AND PLANT BREEDING

Nicotine Levels of Tobacco Varieties

Selections have been made for low to high levels of nicotine in varieties of flue-cured tobacco. Within the varieties Hicks Broadleaf, Delcrest 66, and White Gold, selections showed various levels of nicotine, but only small changes in total alkaloids, the

balance of the alkaloids consisting of nornicotine. Varieties containing less than half the total amount of alkaloids in the commercially grown varieties were tested in 1970. Quality evaluation based on color, texture, filling value, shatter, and reducing sugars indicated these varieties to be inferior.

Smoke Evaluation of Varieties

The relative amounts of total particulate matter and nicotine in smoke of cigarettes manufactured from tobacco produced from the variety evaluation studies have shown that the varieties Delcrest 66, Yellow Gold, and Strain 205 are consistently lower in total particulate matter (T.P.M. = tar) than the most commonly grown varieties, Virginia 115 and Delhi 34. Smoke nicotine is lowest in Strain 205 and the variety Speight G7. Varieties with low T.P.M. tend to be rather low in quality as indicated by color, texture, and body, and to have low lamina weight, low reducing sugars, low buying company ratings, high filling value, and high pressure drop.

Crosses Between Burley and Flue-cured Types

Analyses of a diallel cross produced by using four flue-cured and four burley tobacco cultivars were completed according to procedures described by Hayman, Griffing, and Robinson. The mean squares for general combining ability and for Hayman's *a* made up a substantially higher proportion of the total variability than the other subdivisions. The variances for special combining ability were in all instances smaller than those for general combining ability. The statistic due to additive effects of genes (Hayman's *D*) was significant for days to flower, height, and number of leaves, and the statistic due to dominance effects was significant for days to flower and height.

PLANT PATHOLOGY

Black Root Rot

There was a higher level of chlorogenic acid in roots and leaves of the tobacco varieties White Mammoth, Hicks Broadleaf, Delhi 34, and Burley 49 grown to full maturity in a field heavily infested with the black root rot organism, *Thielaviopsis basicola* (Berk. &

Br.), than in the roots and leaves of healthy plants of the same varieties grown at the Research Station. Leaves of healthy plants of these varieties contained a comparable level of chlorogenic acid, whereas roots of the tobacco variety White Mammoth, which is highly susceptible to black root rot, contained lower levels of chlorogenic acid than the other varieties.

Fumigation in the row with chloropicrin at 22.4, 33.6, 44.8, and 56.0 liters/ha greatly reduced the severity of black root rot. Benomyl (Benlate) at 2.24 kg/ha rototilled in the row or applied in the planting water at 250 and 500 ppm also reduced disease severity. Mixing benomyl with the surfactants Tween 20, Tween 80, or Atplus at 1 part benomyl to 1, 2, or 3 parts surfactant did not increase its efficacy in checking black root rot. Soil mulched with craft paper coated with black plastic reduced the severity of black root rot.

In an infested tobacco bed in the greenhouse, dazomet at 890 g per 93 m² gave good control of black root rot and weeds.

Damping-off

Different strains of *Rhizoctonia solani* Kühn could be differentiated on the basis of their morphological and cultural characteristics and their pathogenicity.

Pole Rot of Cigar Tobacco

Analyses of samples collected from the cigar area in two seasons showed that the causal fungus is *Botrytis cinerea* Pers. A commonly associated fungus was *Rhizopus flexus* Bain, but its contribution to pole rot is doubtful.

ENTOMOLOGY

Cutworms

Pupae of the dark-sided cutworm, *Euxoa messoria* (Harris), could be sexed by observing the structures on the ventral side of the terminal abdominal segments. On the male, two pairs of round tubercles, one pair around the genital opening and the other around the anal opening, are present on these segments, and on the female, one pair around the anal opening only.

For studies of larval mortalities from parasites and diseases, larvae of the dark-sided cutworm were collected from fields and reared in the laboratory. Mortality from the fourth instar to pupa was about 66%, mainly because of parasites, and microsporidial and bacterial diseases. Fungus and virus diseases were virtually absent.

In a preliminary trial, two chemicals of six tested in the field showed promise as alternatives for Dursban for use against the dark-sided cutworm.

Continued field trials confirmed 1969 reports that nuclear virus sprayed on the rye, alone or combined with a very low dose of Dursban or *Bacillus thuringiensis* Berliner, gave a significant reduction in cutworm damage over the untreated check, and no significant difference from Dursban at 0.56 kg/ha (0.5 lb/acre) on the rye.

Hornworms

Preparations of *B. thuringiensis* controlled hornworms, larvae of the tomato sphinx moth, *Phlegethontius quinquemaculatus* (Haw.), as did the recommended insecticide, carbaryl. The bacteria used were obtained commercially as Thuricide 90TS, Thuricide-HP, Biotrol, and Dipel. Thuricide 90TS at 1.4 liters/ha (1 pint/acre) has been recommended in 1970 for control of this pest.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	Manufacturer
Atplus	Atlas Chemical Co.
Benlate	DuPont of Canada Ltd.
Biotrol	Thompson-Hayward Chemical Co.
Delspray T148	Proctor & Gamble Company of Canada, Limited
Dipel	Amdal Co.
Dursban	Dow Chemical of Canada Ltd.
Emtrol 1630B	Emery Industries (Canada) Ltd.

Ethrel
Plantvax
Thuricide-HP
Thuricide 90TS
Tween 20
Tween 80
Vitavax

Amchem Products Inc.
Uniroyal (1966) Ltd.
International Minerals & Chemical Corporation
International Minerals & Chemical Corporation
Atlas Chemical Co.
Atlas Chemical Co.
Uniroyal (1966) Ltd.

PUBLICATIONS

Research

- Brown, D. J., Canvin, D. T., and Zilkey, B. F. 1970. Growth and metabolism of *Ricinus communis* endosperm in tissue culture. *Can. J. Bot.* 48:2323-2331.
- Bucher, G. E., and Cheng, H. H. 1970. Use of trap plants for attracting cutworm larvae. *Can. Entomol.* 102:797-798.
- Cheng, H. H. 1970. Characters for distinguishing the sex of pupae of the dark-sided cutworm, *Euxoa messoria* (Harris), (Lepidoptera:Noctuidae). *Can. J. Zool.* 48:587-588.
- Cheng, H. H. 1970. Bayer 37289 for control of the dark-sided cutworm. *Ann. Soc. Entomol. Que.* 15:3-5.
- Cheng, H. H., and LeRoux, E. J. 1970. Major factors in survival of the immature stages of *Fenusa pusilla* in Southwestern Quebec. *Can. Entomol.* 102:995-1002.
- Elliot, J. M. 1970. The effect of topping height and plant spacing on yield, grade and some physical characteristics of bright tobacco. *Tob. Sci.* 14:73-77.
- Elliot, J. M. 1970. The effect of topping height and plant spacing on certain chemical characteristics of bright tobacco. *Tob. Sci.* 14:112-116.
- Elliot, J. M. 1970. The effect of rates of ammonium and nitrate nitrogen on bright tobacco in Ontario. *Tob. Sci.* 14:131-137.
- Gayed, S. K. 1969. Effect of benomyl on black root rot of tobacco caused by *Thielaviopsis basicola*. *Can. Plant Dis. Surv.* 49:70-74.
- Gayed, S. K. 1970. The effect of benomyl on tobacco leaf necrosis induced by *Thielaviopsis basicola*. *Neth. J. Plant Pathol.* 76:125-128.
- Povilaitis, B. 1970. Variance components in tobacco cultivar trials. *Can. J. Genet. Cytol.* 12:331-339.
- Povilaitis, B. 1970. Diallel analysis of crosses between flue-cured and burley tobacco cultivars. *Can. J. Genet. Cytol.* 12:484-489.
- Voisey, P. W., and Walker, E. K. 1970. Apparatus for the measurement of tobacco filling value and cigarette firmness. *Tob. Sci.* 14:40-43.

Miscellaneous

- Elliot, J. M. 1970. The effect of stage of topping, height of topping, and plant spacing on flue-cured tobacco. *The Lighter* 40(4):10-17.
- Gayed, S. K. 1970. Does deep fumigation pay off? *Can. Tob. Grower* 18(1):14.
- Gayed, S. K. 1970. What effect has fumigation on black root rot? *Can. Tob. Grower* 18(2):36-37.
- Povilaitis, B. 1970. Mutation plant breeding with reference to tobacco. *The Lighter* 40(3):9-13.
- Povilaitis, B. 1970. Environmental variability in tobacco cultivar trials. *Proc. 16th Annu. Meet. Can. Soc. Agron.* p. 1-4.
- Rosa, N. 1970. Effect of Benefin (Balan) on tobacco root growth. *The Lighter* 40(2):9-13.
- Rosa, N. 1970. Low temperatures damage germinating tobacco seed. *The Lighter* 40(2):22-23.

Research Station Harrow, Ontario

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Soil Substation, Woodslee, Ontario

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

D. B. GEORGE, B.Sc. (Agr.)	Extension Services: Greenhouse crops
Transferred to Ontario Department of Agriculture and Food, Toronto, Ont., August 4, 1970	
L. W. KOCH, B.A., M.A., Ph.D.	Director
Retired February 23, 1970	

EXTENSION SERVICES¹

J. F. HOPKINS, B.Sc. (Agr.)	Fruit crops
W. E. KAYLER, B.Sc. (Agr.), M. Dipl.	Vegetable crops

¹Provided by Ontario Department of Agriculture and Food.

INTRODUCTION

This report describes some of the new varieties of field and vegetable crops being developed at Harrow and summarizes some of the principal findings of our research programs in the production of tree fruits, and vegetable and field crops. Details of the research results are found in the journals listed under Publications. Reprints are available from the authors.

Dr. L. W. Koch, Director of the Research Station at Harrow since its formation in 1959, retired on February 23, 1970.

G. C. Russell
Director

FIELD CROPS

Burley Tobacco

Fertilization. In a 5-year experiment, manure at 22.41 metric tons/ha (10 tons/acre) and 44.82 metric tons/ha (20 tons/acre) increased the yield but not the grade quality of Burley tobacco. The Cl and K content of the leaf was increased, the S content was decreased, and the N content was essentially unchanged by manure fertilizer. The rate of burn of tobacco leaf was increased slightly but no marked or consistent association was found between "burn" and any of the elements (N, S, Cl, or K) in the leaf that are supposed to affect tobacco "burn."

Cereals and Forages

Insects. Data from alfalfa plots at Harrow in 1969 and 1970 indicate that most of each season's alfalfa weevil population in this region is in the alfalfa when the plant is between 50% bud and first flower, that is, just before the recommended first cutting. Cropping at this time decimates the season's alfalfa weevil population here beyond recovery and little or no damage occurs in subsequent cuttings. Adults of the alfalfa weevil successfully survived the 1969-70 winter, but mortality rates were extremely high. A new alfalfa variety, FFR Syn. W., was less resistant to alfalfa weevil attack than the variety Vernal.

Viruses. The average incidence of wheat spindle streak mosaic in Essex and Kent counties in the spring of 1970 was 23% infected plants, about half that of 1969. Symptoms were clear at the end of April, but they faded during rapid growth in early May. Soil treatments with urea or with the fungicides

Demosan or Benlate on the day before sowing did not affect the disease. When sown in September or early October, both Genesee and 4-71 showed 100% infection in the spring.

Estimates of virus infection from May to July in alfalfa and red clover crops under-sown in the previous season averaged 4%. In crops 1 year older, virus incidence was about 20%.

Corn

Breeding. Based on performance in the Ontario Corn Tests, the Ontario Corn Committee declared three single cross hybrids developed at Harrow eligible for license and the recommended list. All three showed good resistance to stalk rot, which is the main objective of our corn-breeding program. For the second year, one inbred line isolated at Harrow has shown exceptional resistance to the first brood of European corn borer under artificial infestation.

Insects. Predators and parasites did not control the corn leaf aphid before pollination. Because aphids are often the most injurious during this prepollination period, corn must be treated with insecticides before tassel exposure. Tests showed that three granular systemic insecticides registered for rootworm control suppressed aphids throughout the prepollination period when the materials were applied as a side-dressing soon after planting.

Root and stalk rot. Leaves below the ear had little effect on yield and stalk rot resistance when plants were widely spaced and allowed to develop one or more ears. When plants were restricted to one ear only, leaves below the ear still had relatively little effect

on stalk rot from 2 weeks after mid-silk, but substantially increased yield, especially in a resistant hybrid.

Southern corn leaf blight. Southern corn leaf blight, caused by *Helminthosporium maydis* Nisik. & Miyake, occurred for the first time in Canada in 1970. It was present in most fields in southwestern Ontario and occurred as far east as Ottawa. Yield loss assessments from blight did not exceed 5% in the most severely affected fields and were usually under 1%. Susceptibility to blight is associated with Texas (T) male-sterile cytoplasm.

Weed control. Bladex (Shell Canada Ltd.) was the outstanding new herbicide for corn evaluated in 1970. A mixture of Bladex and atrazine applied preemergence effectively controlled a wide range of annual weeds including crabgrass. Belt (Velsicol Chemical Corp.) also showed promise when applied postemergence alone or mixed with atrazine. The antidote 1,8-naphthalic anhydride (Gulf Oil Crop.) gave promising results as a seed treatment to protect field and sweet corn from EPTC injury. The antidote was not phytotoxic to corn.

Soybeans

Breeding. Harwood, a new cultivar developed at Harrow, was licensed and released to seed growers in 1970. It is resistant to phytophthora rot. Harwood has averaged 2.5% higher in yield than Harosoy 63 and 3.4% lower than Beeson. Harwood is 1 day later in maturity than Harosoy 63 and 2 days earlier than Beeson. It is shorter and more resistant to lodging than either Harosoy 63 or Beeson. The seeds contain 20.9% oil and 40.9% protein on a dry weight basis.

Growth analysis. The growth analysis of young soybean plants in the field during 1970 gave results similar to the 2 previous years. Soybean varieties appear to differ slightly in terms of mean net assimilation rate (NAR). There are larger differences between varieties in leaf density, leaf area ratio (LAR), and shoot-to-root ratio. On an individual plant basis, NAR is positively correlated with leaf density and with shoot-to-root ratio, but is negatively correlated with LAR. Judging by varietal pedigrees, previous breeding and selection for yield and other

agronomic characters has resulted in an increase in NAR and leaf density but a decrease in LAR and shoot-to-root ratio.

Weed control. Chloramben was the most effective herbicide evaluated for weed control in soybeans in 1970. Chloroxuron gave excellent control of annual broadleaf weeds. A program of trifluralin applied preplanting followed by chloroxuron applied postemergence was particularly impressive. A time of application study with linuron indicated that soybean yields were reduced if linuron was applied after the soybeans had emerged from the soil. Studies on the influence of herbicides on processing quality of soybeans showed that the recommended herbicides did not affect either the oil or protein content of soybeans.

White Beans

Breeding. One white bean breeding line has performed well at four locations in southwestern Ontario during the past few years. In 20 tests the line 7793-629 gave an average yield of 2419 kg/ha (21.6 cwt/acre) compared with 2262 kg/ha (20.2 cwt/acre) for the variety Sanilac and 2330 kg/ha (20.8 cwt/acre) for the variety Seaway. The original cross and selection for resistance to anthracnose were made at the Ottawa Research Station. The line is a bush type that matures 1 to 2 days earlier than Sanilac. Cooking quality has been rated as good as or better than Sanilac and Seaway by processors and taste panels. One taste panel commented on but did not object to the larger seed size (21.4 g/100 vs. 18.5 g/100 seeds for Seaway). The Ontario Field Bean Committee has recommended that this line be licensed for use in Canada.

Common bacterial blight. Experiments in replicated plots indicated no measurable yield reduction with low levels of this disease. There was a 10% loss with moderate and 50% loss with high levels. In 1969, 37% of the commercial crop had low to moderate amounts of blight.

Root rot. The severity of root disease in commercial crops was assessed. Comparisons of yields from crops with low, medium, and high root rot indicate a 2 cwt (10%) yield difference between crops rated low and high.

HORTICULTURAL CROPS

Field Vegetables

Cucumber

Breeding. Harrow 70 and Harrow 71 were selected from breeding lines that originated at the Ottawa Research Station for use in producing improved, disease-resistant, all-female F_1 hybrid pickling cucumbers. The first is gynocious and resistant to cucumber mosaic virus, *Marmor cucumeris* var. *vulgare* Holmes, and to scab, *Cladosporium cucumerinum* Ell. & Arth. Harrow 71 is monoecious and resistant to bacterial wilt, *Erwinia tracheiphila* (E.F.Sm.) Holland, scab, and cucumber mosaic virus.

Forty-seven breeding lines and genetic stocks were assessed for their reaction to field infection with the prevalent diseases. Results were similar to those at Ottawa. However, Ottawa 68 showed slight susceptibility to powdery mildew caused by *Erysiphe cichoracearum* DC. ex Mérat and *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll., indicating the presence of another race of the fungus. Because Ottawa 47 was resistant to infection with powdery mildew in the field and greenhouse and to cucumber mosaic virus and is nonbitter, it was crossed onto Harrow parthenocarpic lines to improve the distinctive seedless, bitter-free cucumber being developed for the greenhouse industry.

Muskmelon

Control of fusarium wilt of muskmelon with systemic fungicides. Wilt susceptible and resistant cultivars of muskmelon showed different reactions to Benlate (DuPont of Canada) in terms of plant longevity, growth (leaf area), and yield of fruit. Benlate controlled fusarium wilt in susceptible muskmelon and also prevented unexplained mortalities of 5% to 45% in resistant cultivars at 72 days. Treatments increased growth of susceptible and several resistant cultivars, but suppressed growth of the most resistant. In the field, Benlate increased yields of Perfection, Burpee Hybrid, and Delicious 51 by 50%, 38%, and 60%, respectively, at 98 days.

NF-35 was as effective as Benlate in controlling fusarium wilt of muskmelon. Also, it was much less phytotoxic than Benlate and more effective in promoting plant growth.

Soil fumigation. Field plots of sandy loam

fumigated with Vorlex (Morton Chemical) at 560 liters/ha, one late in October 1969, one early in April 1970, and an untreated check were planted with Delicious 51 muskmelon transplants early in June 1970 and evaluated for growth and yield. Early season growth was greatest and most uniform in the fall-fumigated plot. Yields during the first 2 weeks of harvest were 66% and 50% greater in the fall- and spring-fumigated plots than in the check plot. Severity of root rot at the end of harvest was not correlated with yields. The most severe root rot occurred after fall fumigation. Populations of the root lesion nematode (*Pratylenchus* sp.) correlated with melon yields, although populations in check soil were quite low. Early season weed populations were 15 and 10 times higher, respectively, in the untreated and spring-fumigated plots than in the fall-fumigated plot.

Peppers

Insect control. Heavy populations of corn borer led to 51% infestation of pepper fruit over the picking season in untreated plots. Good control was achieved with carbaryl, tetrachlorvinphos (Gardona; Shell Canada), and methomyl (Lannate; DuPont of Canada). Efficacy data was obtained to assist in the registration of the latter two materials. Methomyl provided acceptable control of the green peach aphid on peppers.

Potatoes

Green peach aphids. Four years of studies on flights of the green peach aphid, using suction traps and trap plants showed that these aphids flew in varying numbers from May to November. Four peaks of flight activity occurred each year in early June, early July, late August, and late September. The first two peaks occurred when the aphid invaded, and then left, early potatoes. During the third and largest peak, up to 13 winged aphids arrived on each trap plant each week. The fourth peak occurred when winged male and female aphids flew to peach trees where overwintering eggs were laid.

The correlation ($r = 0.82$) between counts from suction traps and trap plants showed that suction traps can be used to predict the number of winged aphids invading plants. The correlations ($r = 0.74$) between suction traps 3.2 km (2 miles) apart showed that the flight patterns were consistent over short distances.

Verticillium wilt. Early season isolates of *Verticillium* from Irish Cobbler and Kennebec varieties were mostly *V. albo-atrum* Reinke & Berth., and were obtained from wilted plants soon after flowering. Isolates of *V. dahliae* Kleb. were taken 2 to 3 weeks later from plants showing symptoms of early maturity.

When inoculated seed pieces of Kennebec and Irish Cobbler were planted in soil fumigated with-Vorlex (Morton Chemical) at 560 liters/ha (50 imp gal/acre), *V. albo-atrum* and *V. dahliae* caused lower yield reductions than in 1968 and 1969. Since other tests proved that these fungi were highly pathogenic, it was postulated that environmental conditions after the early May planting (1 month later than usual) militated against normal wilt development.

A low percentage of tubers from certified Irish Cobbler stock from P.E.I., planted on fumigated soil, gave rise to wilt caused by *V. albo-atrum*. Isolations from commercial fields planted from similar stocks also yielded *V. albo-atrum*. Results from other experiments supported the conclusion that this species does not overwinter in field soils in southern Ontario.

Velvetleaf (*Abutilon theophrasti* Medic.), clotbur (*Xanthium chinense* Mill.), and common ragweed (*Ambrosia artemisiifolia* L.) were found to be important weed hosts of *V. dahliae* in southern Ontario. Abundant microsclerotia were produced in abscised wilted leaves, stem fragments, and other plant organs of these infected plants lying on moist soil. In late September 40% of the stems of mature ragweed plants taken from cultivated fields devoted to vegetable-growing in the Leamington area yielded *V. dahliae*.

Tomatoes

Black plastic mulch on processing tomatoes. Average yields of marketable fruit increased about 100% or more when a black plastic sheet was used as a mulch on field-seeded Fireball tomatoes grown on clay soil at Woodslee. The 3-ft-wide black plastic film was placed on the soil surface in the tomato row at planting time. Four-year average yields without mulch were 26.59, 21.37, and 11.29 metric tons/ha from transplant, early field-seeded, and late field-seeded tomatoes respectively. With the black plastic, yields were 47.29, 43.41, and 27.72 metric tons/ha

for the three methods of planting. A band application of 168 kg/ha (150 lb/acre) of 11-48-0 fertilizer beside the row at planting time slightly increased the yield of field-seeded tomatoes. Fruit size was increased significantly by black mulch but not by the banded fertilizer.

A striking effect of the black plastic mulch was the protection from flood damage in 1968 and 1969. Yields without and with the mulch were 13.93 and 40.32 metric tons/ha for transplants and 10.95 and 29.66 metric tons/ha for tomatoes field-seeded early. It is not known why the black plastic mulch prevented flood damage.

Nitidulid beetles in tomatoes. Previous work showed that *Glischrochilus quadrisignatus* (Say), a serious pest of processing tomatoes, bred mainly in ears of corn that remained in the field from the previous fall. Tests conducted to determine if burial of the ears prior to beetle activity would prevent oviposition showed that beetles could detect the ears regardless of whether they were buried in the fall or spring and at depths of 3 and 6 inches. Data obtained in 1970 showed that most of the beetles attracted to hampers of tomatoes probably come from outside the tomato field.

Greenhouse Vegetables

Cucumbers

Integrated control. Control of two-spotted spider mites, greenhouse whiteflies, and powdery mildew was demonstrated in commercial greenhouses with an integrated program using the whitefly parasite and oxythioquinox. Fortunately, melon aphids are seldom a problem on the spring cucumber crop because they are not controlled by this schedule, and some aphicides would kill the parasite adults.

Nutrition. Very young small fruits contain relatively high percentages of N, P, K, Ca, and Mg. These rapidly decrease as the fruit grows. After a certain size the percentages are somewhat lower and remain constant throughout the whole sizing process. Nutrient absorption keeps pace with size even though growth may be erratic.

Nematodes

Samples from area greenhouses have shown that the Southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, is the most important and prevalent nematode under either tomato or cucumber. Deep samples from both commercial and Research Station houses indicate that this nematode can be recovered from greenhouse soils at depths over 152.4 cm (5 ft). Preliminary results indicate that this is below the effective depth of steam or chemical treatment. Nematodes from these depths may serve as a source for the subsequent reinfestation of the house.

Tomatoes

Artificial culture. The Cornell mix, made up of ½ peat and ½ vermiculite has proved to be an excellent medium for tomato culture. The yield of fruit in the 1970 spring crop, using the ring culture technique, was 11% higher than that from plants grown in standard ground beds. The fruit quality was higher and the plants were completely free from mosaic virus and other soil-borne diseases. In the 1970 fall crop the corresponding yield increase was 28%.

Nitrogen metabolism. A study of nitrogen conversion after application of five different forms of nitrogen fertilizer to mature tomato seedlings showed that free amino acid accumulation in leaf tissue was highest after NH_4NO_3 treatment. KNO_3 and $\text{Ca}(\text{NO}_3)_2$ had about the same effect, whereas "ammonophos" and urea did not produce any appreciable accumulation of free amino acids.

Whitefly control. A program of biological control of the greenhouse whitefly has been successfully applied in commercial greenhouses. Increasing demands for the parasite, *Encarsia formosa*, were met by mass production. In 1970, 212,000 parasites were released for whitefly control on tomatoes and cucumbers.

Tree Fruits

Apricots

Breeding. Pollen from two large-fruited, late-blooming high-quality varieties from Bulgaria were crossed with the best locally adapted variety, Goldcot, to improve fruit size and later blooming. Twenty selections that ripened from July 10 to August 12 were propagated for second test in 1972. These selections had good quality, better adaptability, and greater disease resistance than commercial cultivars under test.

Rootstocks. A new method of growing apricot seedling rootstocks for commercial nurseries was developed. Ninety percent of the seedlings attained suitable size for budding by August. Seedling rootstocks from 10 apricot cultivars were tested and Goldcot and Veeicot were the most uniform.

Tree paints. Further experiments with the Harrow tree paint containing thiram (75% WP) and exterior white latex paint showed that it was effective as a rodent repellent, provided greater temperature protection from southwest injury (winter sunscald), and retained better coverage on tree trunks than commercially available materials. It will be recommended for general commercial use in Ontario in 1971. The paint was compatible with most spray materials applied in the fall, except Bordeaux mixture.

Winterhardiness. The effect of time of defoliation on fall hardening and winterhardiness of flower buds of six cultivars of apricot was studied by subjecting scions from each variety to controlled freezing stresses at -20°C and -25°C from November to April. Late defoliating cultivars gained hardiness at a slower rate and to a lesser extent than the medium or early defoliating cultivars. Selection for early defoliation may be a valid technique for improving winterhardiness in apricot.

Peaches

Breeding. A new variety named Harken, tested as H2066, was introduced. It ripened 3 days after Redhaven and had excellent appearance, good size, shape, and quality, and good processing quality. Harken had greater flower-bud hardiness than Redhaven in controlled freezing tests and also had greater tissue resistance to *Cytospora cincta* (Fr.) v.

Hohnel based on stem inoculation tests. Harken performed well in Ontario and Kentucky and seemed to be suitable for peach-growing areas in the midwest United States and Ontario.

Forty different hybrid combinations were made within *Prunus persica* (L.) Batsch to significantly improve winterhardiness, extend season of maturity, and increase disease resistance, especially to *Cytospora* spp. and to *Xanthomonas pruni* (E.F.Sm.) Dowson. Emphasis in crossing was also placed on developing hardy, size-controlling seedling rootstocks for peach.

Canker resistance and winterhardiness correlated. Thirty-three named cultivars of peach and nine second test selections were tested for comparative winterhardiness of flower buds, then inoculated with *Cytospora cincta* (Fr.) Honey. A significant correlation ($r = 0.58^{**}$) was obtained for resistance to canker and winterhardiness of flower buds, indicating the possibility of simultaneously selecting for both characters in seedling populations by using a controlled freezing test.

Herbicide effects on winterhardiness. Trees of three cultivars that were treated with the herbicides paraquat, linuron, diuron, simazine, terbacil, and their combinations during the four seasons of tree growth did not show differences in winterhardiness under natural conditions in the fourth year, as assessed by the electric impedance of stem tissue, flower-bud mortality, and wood injury. Because present orchard management involves widespread use of these herbicides, it is significant that they have not affected the winterhardiness of peach shoots.

Weed control in peach orchards. Annual applications during a 5-year period of combinations of paraquat with diuron, linuron, simazine, or terbacil had no effect on tree growth, fruit yield, or processed fruit quality when compared with trees kept weed-free by hand hoeing. Oat bioassays of soil from an orchard treated annually with herbicides for a 7-year period showed no accumulation of residues of either atrazine or simazine and minimal residues of diuron and linuron.

Winterhardiness. The overwintering response of two rootstock varieties Siberian-C and Harrow Blood was studied by subjecting scions to weekly controlled freezing stresses at -20 C and -25 C from November 1969 to

April 1970. Siberian-C, which defoliates earlier in the fall and starts growth earlier in the spring than Harrow Blood, also gained hardiness at a faster rate and to a greater extent than Harrow Blood in November and December. In December, January, and February both rootstocks were significantly harder than any commercial variety of peach tested. In April, Siberian-C lost hardiness at a faster rate than Harrow Blood, and this was also correlated with a faster rate of bud development in Siberian-C.

Pears

Breeding. A total of 4,683 hybrid *Pyrus* seedlings representing 20 different progenies were screened for resistance to fire blight caused by *Erwinia amylovora* (Burr.) Winslow et al. Excellent infection was obtained with unusually severe disease development. Hybrid combinations that yielded the highest proportion of resistant offspring included: NJ 490340020 \times Bosc, Bosc \times Farmingdale, Gorham \times Purdue 77-73, and Magness \times Beierschmidt.

Several pear seedlings from crosses made in 1962 and 1963 that had a high level of fire blight resistance were also found to have good fruit quality and acceptable appearance. At least 10 of these seedlings will be propagated in 1971 for second test.

INSECT PATHOLOGY

Tests in plots at Harrow and in growers' fields near Chatham showed that viruses applied to late cabbage controlled the cabbage looper and imported cabbageworm as well as, or better than, chemical insecticides. Late in the season when chemical insecticides have little or no effect on large cabbage looper larvae and when temperatures are too low for formulations of the bacterium *Bacillus thuringiensis* Berliner to control the looper, the cabbage looper virus retained its effectiveness against its host. Proceedings have been initiated toward registration of the cabbage looper virus for use on cole crops.

Residues of the viruses of the cabbage looper and cabbageworm in soil and on foliage in plots sprayed with the viruses were similar at harvest to residues in plots of virus produced by natural epizootics that were not treated with a virus. These residues in soil persisted and accumulated from year to year

and were at least partly responsible for initiation of epizootics of diseases in populations of host insects. Residues of viruses of the cabbage looper and cabbageworm were found in 60% and 19%, respectively, of samples of soil taken from 116 fields in Ontario in which cole crops were grown commercially. These findings indicate that the viruses are widespread in the environment.

SOIL SCIENCE

Soil Fertility

Nitrogen. The annual N requirement for maximum yield on plots of Fox sandy loam was 56–112 kg/ha N for cucumbers and 112–168 kg/ha for tomatoes and cabbage where each crop was grown at the same site in successive years. Where these vegetables followed alfalfa sod, in 1970, the N contribution from the legume was adequate for tomatoes and cucumbers. Cabbage required an additional 56 kg/ha N at planting time.

Phosphorus and potassium. The P levels in two sandy soils and Brookston clay which had grown five consecutive crops of corn were readily maintained or increased with 19.7 kg/ha of P annually. During the same period the K supply in the clay soil was relatively stable. Where no K was used on the sandy soils, K levels declined annually at the rate of 6.6% of the initial soil test value. The apparent maintenance requirement for K on the sandy soils was 20 to 250 kg/ha K, or more, annually, in amounts proportional to the K level initially present in the soil.

Soil Physics

Nutrient losses from tile drains on Brookston clay. From 1961 to 1967 average losses of nutrients in tile drainage water were small. Where recommended quantities of N were applied for crop production, an average of 14 kg/ha or less of N was lost annually and NO₃-N concentration was below the 10 ppm established as the upper limit of NO₃ acceptable in drinking water supplies.

Results in 1970 and from intervening years supported the earlier data but indicated that excessive precipitation, early in the growing season following N application for corn, could result in relatively high N losses. Nitrate N concentration sometimes exceeded 10 ppm under these conditions, with losses of actual N as high as 20 kg/ha in one storm. Later in the season when corn plants were larger similar amounts of precipitation produced only negligible losses.

Tile drainage experiments were expanded in 1970 to provide additional facilities for measuring nutrient losses at one site and for measuring tile depth and spacing effects at another location.

MISCELLANEOUS

Control of Canada Thistle with Herbicides Applied at Various Stages of Growth

A field study on control of Canada thistle, *Cirsium arvense* (L.) Scop., showed that the growth stage at time of amitrole application had little influence on the level of control obtained. Amitrole also gave more effective thistle control than any other herbicide included in this study. Banvel 3 (Velsicol Chemical Corp.) gave better thistle control when applied either at the early bud or at the full bloom stage of growth than when applied to young shoots. On the other hand, dicamba and, to a lesser extent, 2,4-DB were found to be most phytotoxic when applied to young shoots.

Herbicide Movement in Soil

The movement of several herbicides in soil columns was determined using two different types of soil prevalent in Essex County. The mobility of terbacil and bromacil was equal to that of BAY-94337 and BAY-86791 but greater than that of monuron, which was used as a standard in these tests. The movement in Brookston clay was much slower than in Fox sandy loam, and the recovery was much less.

PUBLICATIONS

Research

- Bolton, E. F., Aylesworth, J. W., and Findlay, W. I. 1970. Residual effect of nitrogen applications on soil pH and lime requirements of a Brookston clay. *Can. J. Soil Sci.* 50:260-261.
- Bolton, E. F., Aylesworth, J. W., and Hore, F. R. 1970. Nutrient losses through tile drains under three cropping systems and two fertility levels on a Brookston clay soil. *Can. J. Soil Sci.* 50:275-279.
- Bolton, E. F., and Erickson, A. E. 1970. Ethanol concentration in tomato plants during soil flooding. *Agron. J.* 62:220-224.
- Buttery, B. R. 1970. Effects of variation in leaf area index on growth of maize and soybeans. *Crop Sci.* 10:9-13.
- Dhanvantari, B. N. 1969. Bacterial blister spot of apple in Ontario. *Can. Plant Dis. Surv.* 49:36-37.
- Elliott, W. M. 1970. The action of some systemic aphicides on the nymphs of *Anthocoris nemorum* (L.) and *A. confusus* Reut. *Ann. Appl. Biol.* 66:313-321.
- Foott, W. H., and Timmins, P. R. 1970. An examination of possible side effects in peppers sidedressed with disulfoton. *Proc. Entomol. Soc. Ont.* 100(1969):97-100.
- Foott, W. H., and Timmins, P. R. 1970. Naled for control of *Tetranychus urticae* Koch in the greenhouse. *Proc. Entomol. Soc. Ont.* 100(1969):101-104.
- Foott, W. H., and Timmins, P. R. 1970. Pepper insects in southwestern Ontario. *Proc. Entomol. Soc. Ont.* 100(1969):105-110.
- Foung, J., and McClanahan, R. J. 1970. Laboratory studies on the toxicity of insecticides to larvae of the Colorado potato beetle. *J. Econ. Entomol.* 63:2006-2007.
- Fulton, J. M. 1970. Relationships among soil moisture stress, plant populations, row spacing and yield of corn. *Can. J. Plant Sci.* 50:31-38.
- Fulton, J. M. 1970. Relationship of root extension to the soil moisture level required for maximum yield of potatoes, tomatoes and corn. *Can. J. Soil Sci.* 50:92-94.
- Gates, L. F. 1969. Incidence and effects of wheat spindle streak mosaic in Essex and Kent Counties, Ontario, 1967-68. *Can. Plant Dis. Surv.* 49:58-59.
- Gates, L. F. 1970. Relationships between pith cell condition as assessed by tetrazolium chloride and incidence of *Gibberella* stalk rot in corn. *Can. J. Plant Sci.* 50:679-684.
- Gates, L. F., and Mortimore, C. G. 1969. Three diseases of corn (*Zea mays*) new to Ontario: Crazy Top, a *Phyllosticta* leaf spot, and Eye-spot. *Can. Plant Dis. Surv.* 49:128-131.
- Guppy, J. C., and Miller, C. D. F. 1970. Identification of cocoons and last-instar larval remains of some hymenopterous parasitoids of the armyworm *Pseudaletia unipuncta*, in eastern Ontario. *Can. Entomol.* 102:1320-1337.
- Haas, J. H. 1970. Relation of crop maturity and physiology to air pollution incited bronzing of *Phaseolus vulgaris*. *Phytopathology* 60:407-410.
- Jaques, R. P. 1970. Application of viruses to soil and foliage for control of the cabbage looper and imported cabbageworm. *J. Invertebr. Pathol.* 15:328-340.
- Jaques, R. P. 1970. Natural occurrence of viruses of the cabbage looper in field plot. *Can. Entomol.* 102:36-41.
- Johnson, P. W., and Boekhoven, L. W. D. 1969. Nematodes associated with tomato and cucumber greenhouse soils in Essex County, Ontario. *Can. Plant Dis. Surv.* 49:132-134.
- McClanahan, R. J. 1970. Cottony maple scale and its natural control. *Entomophaga* 15:287-289.
- McClanahan, R. J. 1970. Integrated control of the greenhouse whitefly on cucumbers. *J. Econ. Entomol.* 63:599-601.
- Miller, C. D. F. 1970. The nearctic species of *Pnigalio* and *Sympiesis* (Hymenoptera: Eulophidae). *Mem. Entomol. Soc. Can.* No. 68. 121 p.
- Ward, G. M., and Miller, M. J. 1970. Relationship between fruit sizes and nutrient content of greenhouse tomatoes and cucumbers. *Can. J. Plant Sci.* 50:451-455.
- Weaver, G. M., and Stroud, F. D. 1970. Canadian Harmony Peach. *Can. J. Plant Sci.* 50:120-121.
- Wensley, R. N. 1970. Innate resistance of peach to perennial canker. *Can. J. Plant Sci.* 50:339-343.
- Wensley, R. N., and Huang, C. M. 1970. Control of *Fusarium* wilt of muskmelon and other effects of benomyl soil drenches. *Can. J. Microbiol.* 16:615-620.

Miscellaneous

- Aylesworth, J. W. 1970. Direct seeding of processing tomatoes. *Can. Agr.* 15(2):26-27.
- Foott, W. H. 1970. Insect pests of peppers in southwestern Ontario. *Can. Agr.* 15(4):32-33.
- Gates, L. F., and Mortimore, C. G. 1970. Root and stalk rot of corn. *Can. Agr.* 15(2):14-15.
- Koch, L. W. 1969. Research Report, Research Station, Harrow, Ont. 10 p.
- McKeen, C. D. 1970. Canadian plant pathology faces the challenge of the future. *Proc. Can. Phytopathol. Soc.* 37:8-12.
- Russell, G. C. 1970. Journals have new look in '70. *A.I.C. Review* 25(3):31.
- Saidak, W. J. 1970. Research Report, Can. Weed Comm., East. Sect. 282 p.
- Wensley, R. N. 1970. Biology and control of Fusarium wilt of muskmelon. *Can. Agr.* 15(3):20-21.

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Departures

H. MILLER Retired July 1970	Wheat quality
V. W. NUTTALL, B.S.A., M.S.A. Transferred to Research Station, Harrow, Ont., March 1970	Vegetables
F. SVEJDA (Miss), Ing. Agr., Ph.D. Transferred to Plant Research Institute, April 1970	Ornamentals

VISITING SCIENTISTS

National Research Council Postdoctorate Fellows

C. S. HSU, B.S., M.S., Ph.D., 1968-70	Fruit genetics
G. FEDAK, B.S.A., M.Sc., Ph.D., 1969-70	Cytogenetics

INTRODUCTION

The year 1970 was an important one for the Ottawa Research Station. In a rearrangement of Research Branch staff at Ottawa to effect closer association between certain basic and applied research groups, part of the Environmental Physiology Section of the Plant Research Institute, the Phytopathology Section and a virologist from the Cell Biology Research Institute, and the Agricultural Entomology Section from the Entomology Research Institute were transferred to the Ottawa Research Station. This reorganization will bring these groups in more direct contact with important agricultural problems and will strengthen our research toward improving the efficiency of production and the nutritive value of crop plants.

In the opposite direction, the decision was made to discontinue horticultural research at Ottawa and to transfer the tree and small fruit projects to the Research Station, St. Jean, Que., and the Experimental Farm, Smithfield, Ont. This move is now under way, but certain orchard and nursery plantings and the tomato breeding and genetics program will be retained for some time. The rose breeding project was transferred to the Plant Research Institute.

The Research Branch now supports an active program to develop and operate a comprehensive catalog of the plant gene resources of importance to Canadian agriculture. Dr. J. G. R. Loiselle, formerly in charge of barley breeding, was appointed permanent secretary of a national committee to lead this program. He will be advised by representatives of universities, federal and provincial governments, and scientific societies appointed by the Canadian Agricultural Services Coordinating Committee, and will remain attached to the Ottawa Research Station.

A. W. S. Hunter
Director

CEREAL CROPS

Breeding and Genetics

Wheat

Winter wheat. The semidwarf lodging-resistant strain 7453 reported last year was outstanding again in 1970 and will be licensed.

Hybrid winter wheat. In combining ability tests, a Russian variety was discovered whose F_1 hybrids with Talbot, Avon, and Genesee yielded 50% more grain than Talbot. Conversion of this variety to the male-sterile condition was started.

Spring wheat mixtures. In 1969, a synergistic yield effect was reported at Ottawa in mixtures of Opal and Pitic 62. The experiment was repeated in 1970 at four locations in Eastern Canada, including Ottawa, but, although the same trend was evident, yield differences were not significant. Important climatic differences between the 2 years may have been responsible.

Quality. Protein content is a useful measure of variation in baking quality within a variety of wheat. The centrifuge absorption

test (Miller, H. Cereal Chem. 45:109-114, 1968.) measures variation in baking quality between varieties. The Protab Index, a combination of protein content and centrifuge absorption value, has been shown experimentally to be a reliable, simple, objective measure of baking strength over the complete range of quality types. The Protab Index is arrived at by solution of the equation $2.5 \times \text{protein content} + \text{centrifuge absorption value} - 50$. Within limited ranges of quality types it is no more useful in evaluating baking quality than protein content alone, but it classifies wheats representing baking qualities ranging from the conventional soft to hard and is a practical replacement for more elaborate measurements for early-generation evaluations in wheat breeding programs.

Barley

Winter barley. The winter of 1969-70 was very hard on winter barleys at Ottawa. Only about 20% of the breeding nursery survived. These plants were mostly dwarfs that tillered

profusely, and had robust straw and productive spikes. Best survival was found in double haploids from the cross *Hordeum bulbosum* L. × *H. vulgare* L. and in the double cross (*H. murinum* L. × (*H. vulgare*) × (*H. bulbosum*) × (*H. vulgare*)).

Resistance to the cereal leaf beetle. Several samples of *H. spontaneum* C. Koch collected in the Middle East by the 1970 Canadian expedition are characterized by pubescent leaves. This character provides resistance to the cereal leaf beetle, which is invading southern Ontario. Crosses have been made to transfer the character to standard varieties and for genetic studies.

Seed irradiation. The cooperative experiment with Atomic Energy of Canada Limited on low-dose (100, 300, and 1,000 rad) irradiation of Herta and Conquest barley was repeated in 1970. As in 1969, no effect on grain yield was observed.

Protein genetics. The isozyme systems in Canadian barleys were examined by starch gel electrophoresis to determine if they can be used as markers to identify varieties. Canadian varieties were classified into three groups corresponding to three alleles at the α -amylase locus, and into nine groups representing 10 alleles at four loci for esterase isozyme banding patterns. The Canadian barleys differ from European varieties in the frequency of the different isozyme patterns. This is due mainly to the difference in ancestry between European and most Canadian varieties and to the preponderance of six-rowed varieties in Canada.

Oats

Breeding. The oat strain OA123-1 has been recommended for licensing based on its performance in Eastern and Western Canada. It is a selection from bulked lines of (*Avena strigosa* Schreb.)² × Victory and (*A. strigosa*)² × Abegweit. Initial selection was for high relative growth rate in nutrient culture under growth-room conditions. OA123-1 is a large-seeded, thin-hulled, tall, leafy oat, equal to Dorval in yield and slightly better in lodging resistance. In the national forage oat test, it is the highest-yielding entry for Eastern Canada and ranks high in Western Canada.

Genetics. Quantitative genetic studies on stem characters and yield components of oats

are aimed at improving the low yields of present lodging-resistant varieties. Genetic variances and covariances among the progenies of nine varieties were estimated by using a factorial (3 × 6) mating design. The F₁, F₂, and F₃ bulk populations were grown in separate years to estimate genotype × environment interactions. Results from F₂ spaced plants in the field were similar to those from F₃'s grown at commercial seeding rates, and both results are useful for identifying outstanding crosses and parents. On the other hand, results from F₁'s grown in screened cages were of little practical value.

The combined F₂ and F₃ data show that additive genetic variance, the kind that can be predicted from parental phenotypes and selected for effectively, made up by far the largest part of the phenotypic variance among progenies. The additive component ranged from 90% for heading date and height, to 70% for kernel weight and yield per panicle, to 50% for stem diameter and yield per plot. Nonadditive (unpredictable) genetic variance was important for yield per plot (25%), stem diameter (21%), and kernel weight (14%).

Strong positive genotypic correlations between plant height, stem diameter, panicle size, and plot yield underlie the difficulties in combining lodging resistance with high yield or even increasing the stoutness of the stem in proportion to its height. Kernel weight showed the least dependence on the other traits. Simultaneous selection for large seeds and shorter straw should therefore give the most improvement in yield and resistance to lodging.

Triticale

Approximately 800 head selections from the CIMMYT (International Centre for Wheat and Maize Improvement) breeding nurseries in Mexico were grown at Ottawa, and it was determined that the fertility mechanism discovered in Mexico is operative at this latitude. The best plants, selected on the basis of seed quality and plant type, were returned to Mexico, where further selection will be made in the spring of 1971 for retesting at Ottawa in 1971.

Winter triticale in the Ottawa breeding program continues to look promising. The best lines tiller profusely, are strong strawed, and have heavy plump seeds. Seed-increase

plots were planted in the fall of 1970 to produce seed for wider testing.

Pathology

Septoria disease of oats. The collection of oat species brought back from the Middle East by the 1970 Canadian expedition is being screened for resistance to *Septoria avenae* Frank f. sp. *avenae*. Several entries showed considerable resistance, but no evidence of immunity has yet been found.

Halo blight of oats. A virulent isolate of the halo blight bacterium, *Pseudomonas coronafaciens* (Ch. Elliott) Stev., from Middlesex County, Ontario, caused symptoms on inoculated oats similar to the severe yellow-leaf condition of undetermined origin observed in 1963 in southwestern Ontario.

Wheat spindle streak mosaic. In 1970 wheat spindle streak mosaic, caused by a low-temperature soil-borne virus, WSSMV, was observed in southwestern Ontario but only in fields adjacent to the north shore of Lake Erie, where temperatures in the spring were substantially moderated by the lake. In growth-room experiments, temperatures fluctuating between 6 and 12 C were more favorable than any of a number of constant temperatures tested for development of the disease in wheat grown in infective soil. Usually all wheat plants were infected before emergence at 6–12 C, but symptoms did not appear for another 3–5 weeks. The zoosporic fungus *Polymyxa graminis* Ledingham is almost always found in the roots of plants infected from soil, but its relationship with WSSMV is not known.

Manual transmission of WSSMV was more successful when inoculum was prepared from the older leaves that had severe yellow mosaic and necrotic blotches than from younger leaves from the same plants that had only mild mosaic symptoms. Higher infection rates resulted if juice inoculum was applied by the artist's airbrush spray technique than by the finger-rub method. Because the virus inactivates quickly in expressed juice, high infection rates were more consistently achieved by a specially devised direct tissue rub technique than by inoculations with juice.

Continuous cropping of barley. Yield reductions resulting from growing barley continuously on the same land were smaller than those reported in 1968 and 1969. In 1970, the lowest yield, a reduction of 8% compared with the first-year crop, occurred on land that had been in barley for 2 years; after 4 years the yield reduction was only 3%. Increased soil fertility had no effect on the yield of first-year barley, but it did improve the yield under continuous cropping; the largest increase occurred on land producing its fourth consecutive crop. As previously, there was no evidence of a disease buildup due to continuous cropping.

Growth and Development

Developmental morphology of the flowering apex. Canadian, Mexican, and European wheat varieties differ in photoperiodic sensitivity and in the time and duration of spikelet initiation (see Plant Research Institute Report for 1969).

Preliminary results suggest that the inheritance of the Canadian (highly daylength sensitive) and Mexican (daylength insensitive) types is complex and that three or more genes are involved. An unexpected developmental type occurred in many of the F₂ offspring. The basal third to half of the spike exhibited Mexican characteristics, and the apical portion showed a sudden and seemingly complete transformation to the Canadian type. Since the Canadian type develops more rapidly, these mixed heads were more advanced at the apex than at the lower or mid regions.

In winter wheat, a correlation was found between elongation of the apical meristem (the beginning of sexual differentiation) at freeze-up in the fall and winterhardiness. The longer and more highly developed the apex, the less winter-hardy the plant.

Grain growth and development in wheat. In a series of studies on grain growth and the control of assimilate utilization in the postear emergence stage in Marquis and Pitic 62 spring wheat and Rosner triticale, no differences were found in growth rates per grain in the 15- to 20-day period after ear emergence. However, during the latter part of the grain-filling period, Pitic 62 and Rosner had higher rates than Marquis, although Marquis had fewer grains per ear. Grain growth continued

longest in Rosner. When plants were defoliated at ear emergence, growth rates of Pitic 62 and Marquis were similar throughout the growth period. When grain number per ear was reduced to eight at 12 days after ear emergence, the difference in growth rate was again apparent.

To measure the quantitative response of equivalent grains of Marquis and Pitic 62 to specific increases in source carbohydrate supply, main-shoot ears were detached at a certain time interval after ear emergence, the grain number per ear was varied by grain removal, the ears were sprayed with a specific inhibitor of photosynthesis, the developing grains were treated with different concentrations of sucrose solution, and the growth rates of grains at particular positions on the ear were measured. The growth rates followed the pattern shown on intact plants; Pitic 62 rates were higher than Marquis after the first 15–20 days after ear emergence. Pitic 62 grains showed a much greater response than Marquis to increase in source carbohydrate level in the post 20-day period. In the pre 20-day period intact plants of both varieties sustained a similar rate of dry-weight increase in the whole shoot, but in Marquis more dry matter was diverted to the stem and less to the grain.

Supplementary greenhouse lighting. As a supplement to natural light in the greenhouse during the winter months, quartz-iodine incandescent lamps produced earlier head emergence in Marquis wheat than cool-white and Gro-Lux W.S. fluorescent tubes, but were inferior for increasing plant growth. There were no differences in dry weight of the mature plants and in seed yield between the plants grown under the two types of fluorescent lamps and sunlight, but the plants grown under the quartz-iodine lamps were significantly smaller than those grown under the fluorescent lamps because of earlier development and less tillering.

FORAGE CROPS

Breeding and Genetics

Alfalfa

Bacterial wilt resistance. Of 34 strains under test in the 1970 Ontario Forage Crop Committee bacterial wilt test, two Ottawa wilt-resistant synthetics were the most resistant. In the first-crop year of yield trials at Ottawa and three locations in Western Canada, six Ottawa resistant synthetics equaled the check varieties in forage yield. Differences due to wilt resistance are not expected until the second or third year.

Hybrid alfalfa. Useful heterosis was exhibited in space-planted yield trials by hybrids from hand-pollinated crosses between male sterile and pollinator lines. The highest-yielding Flemish-type hybrid outyielded its check variety by 14.6%. In material of Rhizoma parentage the yield advantage of the best hybrid was 16.1%, whereas in Vernal-derived crosses it was 20.3%. The frequency of hybrids that outyielded the respective checks by 10% or more was 5% in the Flemish material, 10% in the Rhizoma, and 4% in the Vernal material.

Grasses

Bromegrass. Low seed yield of southern bromegrass varieties, including Redpatch, an Ottawa introduction, has inhibited their utilization in Eastern Canada. Selection for seed production among Redpatch lines was carried out at Ottawa. Data from tests at seven locations, including three in the Prairie Provinces, indicated a 15% to 20% increase in seed yield over Redpatch. A nine-clone crossing block was established in the spring of 1970 to produce seed for agronomic testing.

Creeping red fescue. The variety Durlawn has been licensed as a lawn grass. It is leafy and has a strong creeping habit. The leaves are wide and hold their deep green color throughout the growing season. The plants recover well after cutting and form a dense sod.

Reed canarygrass. Grove, a four-clone synthetic, has been licensed. It is leafy, is 7 to 10 days later in maturity than Frontier, and gives good yields of leafy herbage under conditions of high fertility.

Corn

Two new hybrids qualified for licensing in 1970. One will be grown for grain, principally in eastern Ontario and southern Quebec. The other, which tillers extensively under favorable conditions, will be grown mainly for silage.

Southern leaf blight, caused by *Helminthosporium maydis* Nisikado & Miyake, was found in some eastern Ontario cornfields in 1970, but damage was negligible. Hybrids involving the use of the Texas type of cytoplasmic male-sterility were particularly susceptible. Therefore, conversion of additional Ottawa inbreds to this type of sterility has been suspended until the importance of the disease in the short-season areas has been more accurately determined.

Ten inbred and 10 hybrid genotypes were evaluated for grain and stover yields at a wide range of population densities in systematic spacing plots. A number of genotypes tillered profusely at the lower densities, and the tillers of some genotypes bore large well-filled ears. The tillering characteristic, by increasing production considerably at the lower densities without a concomitant reduction at higher densities, greatly increased the range of densities over which yields were highest.

Soybeans

B-1, the first early-maturing high-protein strain of soybeans developed in the Ottawa breeding program, is lower yielding than the conventional low-protein high-oil varieties. However, it is productive enough that it is being increased for use in feeding trials to compare with current high-oil low-protein varieties.

Pathology

Effects of organic amendments on growth and survival of Fusarium solani in soil. Disease severity due to *F. solani* (Mart.) App. & Wr. emend Snyder & Hans. was more pronounced in soil of pH 5.0 to 6.8 than of 7.9. The beneficial effects of C and N amendments were reduced by ammonium or nitrate nitrogen only at C/N ratios of 10 and 20. At all C/N ratios, the addition of cellulose or starch did not change inoculum density, but glucose or maltose, with or without added N, increased population number manyfold.

The addition of cellulose raised the fungistatic effects in soil by preventing chlamydospore germination. The addition of 0.01% glucose to the cellulose-amended soil did not stimulate chlamydospore germination. Larger amounts, 0.1% to 1.0%, were needed to reduce the fungistatic effect of cellulose.

Coumestrol production in alfalfa. Coumestrols accumulate in alfalfa plants infected with either *F. oxysporum* Schlecht. emend Snyder & Hans. or *F. solani* in amounts related to tissue necrosis. Thus, a lower level of coumestrols is accumulated by resistant than by susceptible varieties.

Introductions

Promising introductions identified in 1970 were a vigorous upright alfalfa that yielded 32% more green forage at the first cut than Vernal; a yellow-flowered, tall, hardy alfalfa from Romania that outyielded Vernal by 20%; a hardy sainfoin, *Onobrychis viciaefolia* Scop., from Lithuania whose green yields compared favorably with the better alfalfas; an orchardgrass, *Dactylis glomerata* L., from Hungary that is early, vigorous, and hardy, and produced 10% more green forage than Rideau.

European forage varieties. Some 130 legume and 115 grass varieties were tested for adaptation and seed production under the Organization for Economic Cooperation and Development plan. Nine alfalfa and seven timothy varieties outyielded their domestic checks, and they appear suitable for contract seed production in this area.

HORTICULTURAL CROPS

Fruits

Apples

Breeding for scab resistance. Fourteen additional scab-resistant seedlings were selected for further trial. Six earlier selections were sufficiently promising in second-test orchards to warrant their release to selected growers for limited commercial trial. These are O-521, O-522, O-531, O-533, O-544, and O-561. None will replace McIntosh. Resistance to apple scab is their outstanding merit, and they are commercially acceptable in fruit size, appearance, and quality. When used as

a parent, O-521 produces large-fruited seedlings that bear fruit at an early age.

Winterhardiness. A diallel cross between size-controlling rootstocks, subjected to artificial freezing stresses produced by a portable low-temperature chamber, showed high positive correlations between the total damage index and ratings of the component morphological characters: leafing percentage 0.93, leafing date 0.78, tip damage 0.96, root damage 0.59, and stem damage 0.86. Correlation of the total damage index with electrical impedance in April was significant (0.56) and somewhat higher than in the previous season (0.33).

Strawberries

Genetics. In cooperation with Laval University, heritability, genetic variance components, and correlations were studied in 64 progenies from 31 North American and one German cultivar. In this group of parents, nonadditive variance (dominance plus epistasis) constituted at least 50% of the total genetic variance for more than half the 20 characters studied; epistasis had an important function in most cases. Heritability estimates were low for total berry yield, and for such fruit-quality characters as firmness, easy capping, pH value, soluble solids, and external and internal appearance. Heritability estimates were high for such yield-component characters as average berry weight, berries per flower stalk, yield per flower stalk, and number of flower stalks. Substantial improvement in total berry yield can probably be achieved by selection for these yield components or a linear function of them.

Positive and significant correlations were found between total marketable yield and average berry weight, berries per flower stalk, yield per flower stalk, leaf area, and petiole diameter. Negative correlations occurred between number of stolons and number of flower stalks. Plant height appeared to be a good indicator of early marketable yield. Number of petioles is the best indicator of soluble solids and easy capping, and total soluble solids may be a useful indicator of late marketable yield. There appear to be no genetic barriers to combining high yield with good berry quality.

Raspberries

New cultivar. The Ottawa seedling 48-26-02 (Muskoka × Trent) described in the 1969 Report has been named Festival and will be released for grower evaluation in 1971.

Vegetables

Tomatoes

Preservation by freezing. The "high pigment" gene (*hp*), found in several Ottawa breeding lines, intensifies pigmentation and is associated with firm, thick central flesh that enables the fruit to retain its structure after liquid nitrogen freezing. Unfortunately, under prolonged storage at -17 C there may be a loss of lycopene (red pigment), but β -carotene (yellow pigment) remains high because of the *hp* gene. A second gene, "crimson" (*og^c*), lowers β -carotene and increases lycopene. By crossing these two types, recombinants have been selected that besides combining *hp* and *og^c*, have the genes *sp* (determinate plant) and *u* (uniform green fruit color). High lycopene and solid structure conferred by *hp* were retained, and the *og^c* gene prevented excessive β -carotene retention in frozen slices stored at -17 C.

Skin strength and fruit cracking. Skin-puncturing equipment was used in 1969 to select plants with tough-skinned fruit from an F₂ population of a cross between crack-resistant and crack-susceptible parents. The parent lines and seven F₃ progenies of the 1969 selections were puncture-tested in 1970. Bulk data showed that the fruit from 28% of the F₃ plants had greater puncture resistance than the resistant parent, a marked increase over the 10% found in 1969 in the F₂ population. In the most resistant F₃ line this proportion increased to 50%. Thus, in only 2 years of selection based solely on puncture resistance there appears to have been a very marked buildup of the factors that increase skin toughness.

Seed irradiation. In experiments conducted since 1967 in cooperation with Atomic Energy of Canada Limited to determine the effect of low-dose (100, 300, and 1,000 rad) irradiation of vegetable seeds before planting, results have been variable and mostly inconclusive. Treatments appeared to have an effect in some years on some characters,

e.g., more flowers in tomatoes and eggplants; earlier flowering in lettuce; earlier and more concentrated maturity in sweet corn, eggplants, lettuce, and pumpkins; and later flowering and reduced yield in cucumbers. However, reliable, positive effects have not been predictable.

Potatoes

An undesirably high content of total glycoalkaloids (TGA) was discovered in certain potato cultivars and species and in segregating progenies from crosses between high and low TGA parents. This discovery emphasizes the importance of carefully screening the promising selections before they are introduced, especially if high TGA parents were used.

AGRONOMY

Effect of crab grass on corn yields. Atrazine, the most effective herbicide for corn, does not control crab grass (*Digitaria* spp.), and heavy infestations may build up on light soils, especially under continuous corn regimes. The effect of heavy crab grass infestation on the yield of grain and silage corn was measured by controlling the grass by mechanical and hand cultivation. Although complete crab grass control increased yield of grain significantly by 10% and yield of silage by 8%, it is questionable if, under conditions of reasonable fertility, these rather small increases in yield would be worth the cost of complete control.

Plant densities in corn. Results in 1970 confirmed the observations of previous years that with early hybrids in eastern Ontario, populations of 22,000 to 29,000 plants/acre give a distinctly higher yield of grain and silage than the recommended 18,000 plants/acre. This higher yield is especially evident when the corn is seeded early.

Response of corn to N fertilization. Results for 3 years at five locations in eastern Ontario have shown that N applied at high rates is often uneconomical. Significant increases of silage and grain usually resulted from applications up to 112 kg N/ha. Higher rates frequently resulted in reduced yields, especially following late planting. Where corn was grown on sod or manured ground, rates

of N in excess of 90 to 100 kg/ha were seldom justified.

Birdsfoot trefoil establishment. Summer seeding of birdsfoot trefoil permits prior cultivation to control weeds, with which young trefoil plants do not compete well, and higher soil temperatures favor seed germination. Results from tests to determine the latest date for satisfactory seeding showed that optimum establishment and first-crop yields were obtained from seedings on July 9 and 23. Dry-matter yields of 3 tons/acre the next year were comparable with those from spring-seeded alfalfa. A nurse crop of oats reduced yields by half a ton.

Seeding dates for hairy vetch. Hairy vetch, *Vicia villosa* Roth, is a palatable, high-protein legume. If sown in the spring it gives green yields comparable with alfalfa, but behaves as an annual and dies out during the winter. If sown about the middle of August it behaves as a biennial, and large, healthy, nonflowering plants are formed by late autumn. The plants survive the winter and produce an abundant crop of forage (and seed) the next summer.

CYTOGENETICS

Middle East collecting expedition. In cooperation with the Research Station, Winnipeg, Man., some 2,700 samples, mostly *Avena* but including other cereal species, were collected in May and June 1970 in Tunisia, Algeria, Israel, Lebanon, Syria, Iraq, Iran, and Turkey. They have been sorted on the basis of spikelet morphology. Chromosome screening is in progress and all *Avena* plants are being tested for resistance to septoria disease. Seed from all plants examined will be multiplied and will be made available to other researchers. A new diploid karyotype, possibly a new species, has been identified in three samples collected near Damascus, Syria.

Polymorphism in Avena ventricosa. The diploid *A. ventricosa* Bal. is a putative donor of the C genome of the hexaploids and the tetraploid *A. magna* Murphy & Terrell. All plants collected from Oran, Algeria, and from Cyprus, and about two-thirds of the plants from the Apsheiron Peninsula, U.S.S.R., have exclusively subterminal chromosomes. About one-third of the plants from Apsheiron have six pairs of subterminals and

one pair of submedians. From karyotypic and meiotic evidence it is inferred that a single pericentric inversion is responsible for the submedian pair.

Results from thin-layer chromatography also suggest the presence of the C genome in *A. magna*, and in the hexaploid *A. sterilis* L. Additiveness of the parental spectra was low in five synthetic allopolyploids. A number of hybrid compounds, synthesized by complementary gene interactions, were detected.

Bromus. An introduction nursery of strains and species of *Bromus* has been established in preparation for a study of species relationships and interspecific hybridization for bromegrass improvement. About 185 accessions have been gathered, and chromosome counts and herbarium specimens are being made.

Protein genetics. The zymogram patterns of leaf esterases from amphiploids showed complete additiveness of the parental species, as was shown by the banding patterns of proteins extracted from seeds, reported in 1969. Differences were found between and within the A and C genome species. High homology was shown between the prominent bands of *A. magna* and those of the C genome diploids, especially *A. pilosa* M. Bieb., and between those of *A. magna* and the A genome diploids *A. hirtula* Lag. and *A. longiglumis* Dur., supporting the indication from seed proteins that *A. magna* is an AC tetraploid. Also, the similarity in esterase patterns between the amphidiploid (*A. hirtula* × *A. magna*)² and the hexaploids supports the hypothesis that the genomes of *A. magna* are components, and that *A. magna* is a progenitor, of the hexaploids.

CROP LOSS ASSESSMENT

Disease Loss Estimates

Late blight of potato. A new method was developed for predicting the loss in yield of tubers caused by late blight in Eastern Canada. A multiple-regression equation was derived from data for disease progress curves with corresponding tuber yields, the increase of disease during 9 weekly periods being used as the independent variable and yield loss as the dependent variable. The empirical equation can be used to estimate the yield loss associated with any disease progress curve. The difference between estimated loss,

computed from the equation, and actual loss, derived by weighing, is less than 5% in 9 cases out of 10.

Field Surveys

Winter wheat. In a survey of foliar diseases of winter wheat in southwestern Ontario conducted in 1970, powdery mildew caused by *Erysiphe graminis* DC. ex Méral f. sp. *tritici* Marchal, leaf rust caused by *Puccinia triticina* Erikss., and wheat spindle streak mosaic virus were the principal diseases observed. Mildew and rust levels were much higher than those recorded in a similar survey in 1969. Average annual loss for the three diseases was approximately 5% and would not warrant the application of control measures.

A relatively high incidence of dwarf bunt, caused by *Tilletia controversa* Kuhn, occurred in southwestern Ontario in 1970. Forty of 249 fields surveyed were infected, at rates as high as 58 heads in 300 ft of row. Visually, these appeared to be heavily infected, but this rate represents less than a 1% yield loss.

Septoria disease of oats. The significance of infection by *Septoria avenae* Frank f. sp. *avenae* was estimated at four locations in Eastern Canada by comparing the yield from unsprayed infected plots with the yield from plots in which the disease was controlled by the application of fungicides. Yield increases of sprayed over unsprayed plots indicated that susceptible varieties may sustain losses up to 60% when infection is heavy. The tolerant variety Dorval seldom showed any difference between treatments, although at Ottawa, where a late attack of septoria occurred, maneb-sprayed plots yielded 15% more grain than untreated plots.

Corn. A preliminary survey of corn diseases in the Ottawa Valley covered 38 fields involving approximately 800 acres. Several diseases were observed, but none appeared to be causing significant damage or yield loss. Of particular interest was the discovery of southern leaf blight, caused by *Helminthosporium maydis* Nisikado & Miyake, in 7 of 17 fields examined in late September and early October. Because of the extensive damage caused by this disease elsewhere in North America, it will be watched with interest in 1971.

Peas. Surveys of diseases of peas were conducted in Ontario and Prince Edward Island. The predominant disease in Ontario

was root rot caused by *Fusarium* spp., whereas in Prince Edward Island it was ascochyta foot rot caused by *Ascochyta pinodella* L.K. Jones or *Mycosphaerella pinodes* (Berk. & Blox.) Vestergr. It was not possible to calculate crop losses due to disease infection mainly because of the importance of moisture stress on symptom expression.

Systemic fungicides. Plots treated with the systemic fungicide Milstem (Chipman Chemicals), applied as a seed dressing or a spray for the control of powdery mildew in Manitou spring wheat and Keystone spring barley, yielded on the average 15% more than untreated plots, although mildew was still found in the treated plots. Vitavax (Uniroyal Ltd.), applied to seed of barley and wheat at 4 oz/100 lb seed, completely controlled loose smut caused by *Ustilago nuda* (Jens.) Rostr. There was an indication that 8 oz/100 lb reduced yields. In barley, although the loose smut was controlled, seed with the highest smut infection had the lowest yield potential.

Pathogen Survival in Soil

Chlamydo-spores of *Alternaria solani* (Ell. & Martin) Jones & Grout, the causal organism of tomato early blight, were discovered in infested tomato tissue buried in soil. These structures are able to withstand Ottawa winter temperatures in soil and in exposed plant tissue, and may serve as an important source of inoculum for the next crop.

ENTOMOLOGY

Insect Population Dynamics

Alfalfa weevil. A life-table study of the alfalfa weevil, *Hypera postica* (Gyll.), was begun in 1970. Sampling techniques were worked out and preliminary information was obtained on egg laying, larval feeding, pupation, and parasitism. No significant mortality was observed in the egg stage, but about 80% mortality, largely due to misadventure, occurred between hatching and establishment of the young larvae in the terminal buds. No further significant mortality occurred until the prepupal stage, which was parasitized by a chalcid, *Tetrastichus* sp. Only the late-developing larvae were seriously affected by this parasite.

Tarnished plant bug. Pilot sampling was

carried out in 1970 to determine population parameters for the tarnished plant bug, *Lygus lineolaris* (Beauv.), on birdsfoot trefoil. This sampling is the beginning of a long-term study aimed at an understanding of the mechanisms of regulating the population of this important pest of legumes.

Colorado potato beetle. Detailed appraisal of population processes in the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), on its principal host plant showed that the insect has no natural agents that prevent it from overshooting its food supply. It is little affected by weather or predators, and its only parasite, the tachinid *Doryphorophaga doryphorae* (Riley), is inversely density dependent in its action. Once the beetle has exhausted its food supply, the larvae starve and the adults move to other hosts. The analysis of age interval survivals showed that populations are both regulated and disturbed by the key factor, adult migration, which is density dependent but overcompensating. A predictive model based on density relationships was found to explain 94% of the variance in population trend.

Imported cabbageworm. Continuing studies on the population dynamics of the imported cabbageworm, *Pieris rapae* (L.), showed that its regulating agent, a soil-borne capsule virus, builds up to epizootic levels within 3 years of its introduction to the environment. In established market garden areas, mortality from virus is a function of 'large larval' density and rainfall during the first half of July.

In a 2-year study of carabid predation, more than 10,000 individuals representing 26 species were captured in pitfall traps set in cabbage plots at Ottawa and Richmond. Despite a detectable numerical response coincident to changes in prey density, experiments using the insecticidal check method showed that these and other predators are a small factor in the life system of *P. rapae*.

Cabbage maggot. Studies on the population dynamics of the cabbage maggot, *Hylemya brassicae* (Bouché), on cabbage were completed in 1970. Analysis of life-table data for nine generations showed that extensive mortalities occurred during the following age intervals: egg stage; between hatching and the second molt; third-instar larvae; and pupal stage. Density-dependent mortality occurred only during the pupal stage. The analysis of age interval survivals

and graphical key factor analysis showed that the key factor leading to population fluctuation was misadventure of the larvae between hatching and the second molt. The mortality process from egg to adult eclosion was density dependent, showing the importance of pupal parasitism as a stabilizing factor. A predictive model based on density relationships was found to explain 62% of the variance in generation survival.

Insect Pest Management

Insect viruses. To determine the range of distribution in Ontario soils of viruses of cabbage Lepidoptera, soil samples were collected and bioassayed from 116 fields of crucifers in 14 counties representing the major vegetable-growing areas of the Province. Residues of viruses of the cabbage looper, *Trichoplusia ni* (Hbn.), were found in soils from 12 counties and in 60% of the samples. Those of *P. rapae* were found in 7 counties and in 19% of the samples. The level of residue was influenced by density of the host, crop rotation, soil pH, and the time of year the samples were taken. This study was carried out jointly with Dr. R. P. Jaques, of the Research Station at Harrow, Ont.

Parasite of the imported cabbageworm. In preliminary studies toward the development of an integrated control program for *P. rapae*, 1,183 specimens of a strain of *Apanteles rubecola* (Hal.) from British Columbia were released in study plots at Richmond, Ont. The parasite competed well with the virus organism and appeared to synchronize with the host, trebling its numbers in two generations.

Ecology of Insect Communities

Fomes fomentarius association. The arthropod fauna of the sporophores of the perennial bracket fungus *Fomes fomentarius* L. has been studied on the basis of systematic collections from dead birch in Gatineau Park, Que. The fauna is very rich, especially in mites, but the most important element is a succession of beetle species. These beetles gradually destroy the spore-producing tissue and kill the sporophores; they may be important in reducing spread of the fungus.

Polyporus betulinus association. The fauna of the sporophores of the annual bracket fungus *P. betulinus* Bull. has been examined in detail and extensive collections have been made from birch in New Brunswick. These collections were made: from forest areas where there had been an annual DDT spray program for the spruce budworm during the past 15 years; and from forest areas that had not received DDT. The total quantity of DDT applied was about 3 lb/acre, far less than that used in general agricultural practice. Surprisingly, the fauna was richer, in both species and individuals, in the DDT-sprayed areas than in the DDT-free areas. However, since the DDT-sprayed areas were in the central part of New Brunswick and the DDT-free areas were peripheral to them, zoogeographical differences may account for some of the discrepancy. But it is clear that DDT spraying, at least at this low rate of application, has not suppressed the cryptic fauna of the sporophores. These findings would not necessarily apply to the more exposed types of forest insect communities.

Aphid associations of goldenrod. There are many species of goldenrod, *Solidago* spp., in eastern North America and together they support a rich and varied aphid fauna. Some 15 members of the genus have been examined in detail. Collections were made in areas ranging from Manitoulin Island to Newfoundland. About 20 species of aphids, including four new ones, have been found in association with goldenrod. Host specificity appears to be more flexible than originally believed, but there is a well-marked pattern of aphid-host distribution.

Honey Bees

Pheromones and attractants. The honey-bee sex pheromone, 9-keto-*trans*-2-decenoic acid, is produced in the mandibular glands of queens of the genus *Apis*. Experiments showed that secretions of the Asian species, *A. cerana* F. and *A. dorsata* F., are attractive to drones of the common European honey bee, *A. mellifera* L. The acid also functions as an attractant for worker bees and partially inhibits queen cell construction and ovary development in workers. Queen rearing and swarm preparation result from a diminished production of pheromone by the queen. However, application of daily doses of 100

μ g synthetic 9-keto-*trans*-2-decenoic acid was only partially effective in inhibiting queen rearing in queenless colonies. The activity of the acid is apparently potentiated by synergists. These are being investigated.

Isomers of 9-keto-*trans*-2-decenoic acid may have synergistic or inhibitory activity. The geometric isomer, 9-keto-*cis*-2-decenoic acid, has been synthetically prepared, but was found to be inactive as a honey-bee pheromone synergist or masking agent.

When alarmed by a predator, worker honey bees release alarm pheromones that alert other bees and initiate attack by them. Experiments showed that two alarm substances, isopentyl acetate and 2-heptanone, have different efficacies.

Further progress has been made in developing a fully adequate substitute diet for honey bees, and in determining why bees have a preference for certain pollens. One attractant, octadeca-*trans*-2-*cis*-9,*cis*-12,tri-enoic acid, has been synthesized. Other substances that stimulate pollen collection and pollen feeding in bees are being investigated.

Diseases. Characterization of the components of spores from *Nosema apis* Zander showed that the spores contain a number of sugars, the most abundant of which is α - α -trehalose, an important storage carbohydrate in the honey bee. The spores also contain the enzyme trehalase, which converts the sugar to glucose, and a number of free fatty acids, sterols, and sterol esters.

During 1970, a number of compounds were screened for effectiveness against *N. apis* by feeding them to bees inoculated with the pathogen. RO-7-0585 (American Cyanamid), puromycin aminonucleoside, a commercial chlorhexidine diacetate formulation, and a preparation from oil of wormwood delayed spore formation for up to 4 days, but development of the disease was as rapid thereafter as in the controls. Griseofulvin, amphoterin B, rifamycin, a commercial ampicillin preparation, sorbic acid, ascorbic acid, isonicotinic acid hydrazide, and WIN 13,146 (Winthrop Sterling) were inactive. Actinomycin D and hedamycin were highly toxic to the bees, but spores were seen in survivors 8 days after inoculation.

Studies of brood diseases in honeycombs showed that spores of *Bacillus larvae* White may be rendered noninfectious by gamma irradiation at levels less than those required

for complete sterilization. Cells of *Streptococcus pluton* White were more resistant to irradiation.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Biennial bearing in apples. Studies begun in 1964 have shown that satisfactory control of the biennial bearing habit of Kinkead Red Spy may be achieved by combining higher N fertilization with an adequate thinning program in the "on" year, and the use of supplemental bees to ensure a high percentage of fruit set in the "off" year. The response to N in promoting flower-bud formation may be indirect through alteration in the level and metabolism of P in the tissue.

Thinning apples. A 4-year study has confirmed that fruit size is a reliable index for timing the application of naphthaleneacetic acid (NAA) to thin the McIntosh, Red Spy, and Red Delicious varieties. Carbaryl thinned Red Spy satisfactorily and the timing for maximum effect was not so critical as with NAA. Carbaryl failed to thin McIntosh adequately unless it was combined with NAA. McIntosh trees that were treated the year before with Alar 85 (Uniroyal Ltd.) to control preharvest drop required higher concentrations of NAA to induce abscission than trees that had received no Alar 85.

Control of preharvest drop in apples. It has been established that Alar 85, applied in late July or early August in eastern Ontario, controls preharvest drop of McIntosh and has little effect on fruit size and storage behavior. Results indicated that the optimum rate of application depends on tree vigor and crop load. In an orchard with a history of adequate fruit size and good fruit color an application of Alar 85 at 3.4 kg/ha gives satisfactory drop control. Trees with a history of high yields, large fruit size, and poor color may require 4.5 kg/ha, whereas 1.7 kg/ha is sufficient for trees of low vigor.

Chemical weed control in strawberries. Sinbar (DuPont) is an effective herbicide for the control of broad-leaved weeds and quack grass. Lenacil at 2.7 kg/ha 3 weeks after planting followed 3 weeks later by Sinbar at 0.54 kg plus lenacil at 2.15 kg/ha is as effective as Sinbar alone and causes less plant injury. In a renovated plantation, the use of

Sinbar alone, or in combination with C6989 (CIBA), resulted in second-year yields of some varieties significantly higher than those from the clean-cultivated check plots.

Chemical weed control in tomatoes. The injury to transplanted tomatoes reported in 1969 following the use of the herbicide Bay 94337 (Chemagro Corporation) at 1.12 and 2.24 kg/ha was not apparent in 1970 at lower rates of application. This herbicide gave good control of weeds at 0.84 kg/ha applied 14 days after transplanting. It also gave good weed control in direct-seeded tomatoes when applied at 0.42 to 0.84 kg/ha as a preemergence treatment 8 days after seeding.

New tomato variety. Selection ST-12 has been well received by growers and processors in eastern Ontario and will be named and released for commercial production in 1971. This high-yielding, high-quality, midseason variety carries the crimson gene, *og^c*, which gives it a more highly colored flesh than any variety now grown in Ontario. It has excellent internal texture and structure and, unlike most tomatoes, the red color develops in the flesh before it does in the skin. The fruit stores well on the plant and needs picking less often than most varieties. ST-12 is not resistant to verticillium wilt.

PUBLICATIONS

Research

- Armstrong, K. C., and Cleveland, R. W. 1970. Hybrids of *Trifolium pratense* × *T. pallidum*. *Crop Sci.* 10:354-357.
- Barr, D. J. S., and Slykhuis, J. T. 1969. Zoospore fungi associated with wheat spindle streak mosaic in Ontario. *Can. Plant Dis. Surv.* 49:112-113.
- Basu, P. K. 1970. Temperature, an important factor determining survival of *Corynebacterium michiganense* in soil. *Phytopathology* 60:825-827.
- Boch, R., Shearer, D. A., and Petrasovits, A. 1970. Efficacies of two alarm substances of the honeybee. *J. Insect Physiol.* 16:17-24.
- Bolton, A. T. 1970. Spread of raspberry leaf curl virus. *Can. J. Plant Sci.* 50:667-671.
- Bolton, A. T., Donaldson, A. G., and Nuttall, V. W. 1970. Variations in isolates of *Fusarium solani* f. sp. *pisi* collected from processing peas in Ontario. *Can. Plant Dis. Surv.* 50:108-109.
- Burrows, V. D. 1970. Absence of lateral transfer within the oat leaf of substances responsible for crown rust resistance. *Can. J. Bot.* 48:198-199.
- Burrows, V. D. 1970. Yield and disease-escape potential of fall-sown oats possessing seed dormancy. *Can. J. Plant Sci.* 50:371-377.
- Chi, C. C. 1970. Phytophthora root rot of alfalfa in Ontario. *Can. Plant Dis. Surv.* 50:109-110.
- Chiykowski, L. N., and Bolton, A. T. 1970. Distribution of a newly reported leafhopper-transmitted clover disease in eastern Ontario. *Can. Plant Dis. Surv.* 50:136-137.
- Clark, R. V., and Wallen, V. R. 1969. Seed infection of barley by *Cochliobolus sativus* and its influence on yield. *Can. Plant Dis. Surv.* 49:60-64.
- Doolittle, R. E., Blum, M. S., and Boch, R. 1970. *cis*-9-oxo-2-decenoic acid: synthesis and evaluation as a honeybee pheromone and masking agent. *Ann. Entomol. Soc. Amer.* 63:1180-1185.
- Fedak, G., and Helgason, S. B. 1970. Somatic association of chromosomes in barley. *Can. J. Genet. Cytol.* 12:496-500.
- Fedak, G., and Helgason, S. B. 1970. The cytogenetics of a ditelotetrasomic line in barley. *Can. J. Genet. Cytol.* 12:553-559.
- Fejer, S. O. 1970. Diallel competition tests in establishing forage stands. *Vegetatio* 21:506-520.
- Fejer, S. O., Johnston, F. B., Spangelo, L. P. S., and Hammill, M. M. 1970. Ascorbic acid in raspberry fruit and leaves. *Can. J. Plant Sci.* 50:457-461.
- Fowler, D. B., and Downey, R. K. 1970. Lipid and morphological changes in developing rapeseed, *Brassica rapus*. *Can. J. Plant Sci.* 50:233-247.
- Furgala, B., and Boch, R. 1970. The effect of Fumidil B, Nosemack and Humatin on *Nosema apis*. *J. Apicult. Res.* 9:79-85.

- Gochnauer, T. A. 1970. Some properties of a bacteriophage from *Bacillus larvae*. J. Invertebr. Pathol. 15:149-156.
- Gochnauer, T. A. 1970. Antibiotic sensitivity patterns of a honeybee pathogen. J. Invertebr. Pathol. 16:153-154.
- Gochnauer, T. A. 1970. Experimental infections with *Bacillus larvae*. III. The effect of carrier on quantitative inoculation of small colonies of honeybees. J. Invertebr. Pathol. 16:305-306.
- Gochnauer, T. A., and Hamilton, H. A. 1970. Disinfection of honeybee combs by gamma irradiation. I. American foul brood disease. J. Apicult. Res. 9:87-94.
- Guppy, J. C., and Harcourt, D. G. 1970. Spatial pattern of the immature stages and teneral adults of *Phyllophaga* spp. in a permanent meadow. Can. Entomol. 102:1354-1359.
- Guppy, J. C., and Miller, C. D. F. 1970. Identification of cocoons and last-instar larval remains of some hymenopterous parasitoids of the armyworm, *Pseudaletia unipuncta*, in Eastern Ontario. Can. Entomol. 102:1320-1337.
- Harcourt, D. G. 1970. Crop life tables as a pest management tool. Can. Entomol. 102:950-955.
- Johnston, G. R., Rowberry, R. G., and Mainprize, L. F. 1970. York, an early potato high in total solids and adapted to organic soils. Amer. Potato J. 47:201-204.
- Lessard, J. R., Hidiroglou, M., Carson, R. B., and Wauthy, J. M. 1970. Copper, molybdenum and sulfur contents of forage crops at Kapuskasing, Ontario. Can. J. Plant Sci. 50:685-691.
- Lyll, L. H., and Bolton, A. T. 1970. Mini-Rose tomato. Can. J. Plant Sci. 50:358.
- McKenzie, R. I. H., Martens, J. W., and Rajhathy, T. 1970. Inheritance of oat stem rust resistance in a Tunisian strain of *Avena sterilis*. Can. J. Genet. Cytol. 12:501-505.
- Miller, S. R. 1970. Effect of Alar on dry weight of various tissues of greenhouse grown apple trees. Can. J. Plant Sci. 50:481-484.
- Mukerji, M. K., and Guppy, J. C. 1970. A quantitative study of food consumption and growth in *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). Can. Entomol. 102:1179-1188.
- Mukerji, M. K., and Harcourt, D. G. 1970. Spatial pattern of the immature stages of *Hylemya brassicae* on cabbage. Can. Entomol. 102:1216-1222.
- Mukerji, M. K., and Harcourt, D. G. 1970. Design of a sampling plan for studies on the population dynamics of the cabbage maggot, *Hylemya brassicae* Bouché. Can. Entomol. 102:1513-1518.
- Murray, B. E., Craig, I. L., and Rajhathy, T. 1970. A protein electrophoretic study of three amphiploids and eight species in *Avena*. Can. J. Genet. Cytol. 12:651-665.
- Pankiw, P., Bailey, L., Gochnauer, T. A., and Hamilton, H. A. 1970. Disinfection of honeybee combs by gamma irradiation. II. European foul brood disease. J. Apicult. Res. 9:165-168.
- Philpotts, L. E., and Wallen, V. R. 1970. The use of color infrared aerial photography in estimating loss in white bean production in Huron County, Ontario, 1968. Can. Farm Economics 5:25-30.
- Rajhathy, T., and Fedak, G. 1970. A secondary trisomic in *Avena strigosa*. Can. J. Genet. Cytol. 12:358-360.
- Reinbergs, E., and Loiselle, R. 1970. Brock barley. Can. J. Plant Sci. 50:205-206.
- Sampson, D. R. 1970. Close linkage of genes for male sterility and anthocyanin synthesis in *Brassica oleracea* promising for F₁ hybrid seed production; multivalents at meiosis not involved in the linkage. Can. J. Genet. Cytol. 12:677-684.
- Shearer, D. A., Boch, R., Morse, R. A., and Liago, F. M. 1970. Occurrence of 9-oxodec-*trans*-2-enoic acid in queens of *Apis dorsata*, *A. cerana*, and SCA. mellifera. J. Insect Physiol. 16:1437-1441.
- Slykhuis, J. T. 1970. Factors determining the development of wheat spindle streak mosaic caused by a soil-borne virus in Ontario. Phytopathology 60:319-331.
- Slykhuis, J. T., and Polák, Z. 1969. Verification of wheat spindle streak mosaic virus as a cause of mosaic of wheat in Ontario. Can. Plant Dis. Surv. 49:108-111.
- Spangelo, L. P. S., Hsu, C. S., Fejer, S. O., and Watkins, R. 1970. Combining ability analysis and interrelationships between thorniness and yield traits in gooseberry. Can. J. Plant Sci. 50:439-444.
- Sutton, M. D., and Wallen, V. R. 1970. Epidemiological and ecological relationships of *Xanthomonas phaseoli* and *X. phaseoli* var. *fuscans* on beans in Southwestern Ontario. Can. J. Bot. 48:1329-1334.
- Voisey, P. W., Lyll, L. H., and Kloek, M. 1970. Tomato skin strength—its measurement and relation to cracking. J. Amer. Soc. Hort. Sci. 95:485-488.

- Wagenaar, E. B. 1970. Studies on the genome constitution of *Triticum timopheevi* Zhuk. III. Segregation of meiotic chromosome behavior in backcross generations. *Can. J. Genet. Cytol.* 12:347-355.
- Wallen, V. R. 1969. Incidence of common and fuscous blight of field beans in Southwestern Ontario. *Can. Plant Dis. Surv.* 49:142.
- Wallen, V. R., and Philpotts, L. E. 1970. Evaluation of crop disease losses from aerial photography. *Proc. VII Int. Congr. Plant Prot.* 53-54.
- Watkins, R., and Spangelo, L. P. S. 1970. Components of genetic variance for plant survival and vigor of apple trees. *Theor. Appl. Genet.* 40:195-203.
- Watkins, R., Spangelo, L. P. S., and Bolton, A. T. 1970. Genetic variance components in cultivated strawberry. *Can. J. Genet. Cytol.* 12:52-59.
- Wood, P. J., Siddiqui, I. R., Vandermeer, J. W., and Gochnauer, T. A. 1970. Carbohydrates of *Nosema apis* spores. *Carbohyd. Res.* 15:154-158.
- Zitnak, A., and Johnston, G. R. 1970. Glycoalkaloid content of B5141-6 potatoes. *Amer. Potato J.* 47:256-260.
- Gochnauer, T. A. 1970. The possibilities and problems of package bees. *Amer. Bee. J.* 110:52-53.
- Gochnauer, T. A. 1970. A personal view of the 22nd International Apicultural Congress in Munich. *Amer. Bee J.* 110:96-98.
- Harcourt, D. G. 1971. Population pressure and regulation, p. 27-30. *In* R. Klein [ed.] *Man and the ecosystem*. Queen City Printers, Inc., Burlington, Vt.
- Helson, V. A. 1970. Growth and flowering of african violets under artificial lights. *Indoor Light Gardening* 5(2):51-53.
- Mohr, W. P., and Adair, R. G. 1970. Processing qualities of apple varieties and selections. *Can. Dep. Agr. Publ.* 1424. 19 p.
- Sampson, D. R. 1970. *Malus* Cameron, Maybride and Prince Charming. *In* R. S. Hebb. *Notes from the Arnold Arboretum Plant Registrations*. *Arnoldia* 30:255-258.
- Spangelo, L. P. S. 1971. Hybrid seedling rootstocks for apple. *Can. Dep. Agr. Publ.* 1431. 4 p.
- Voisey, P. W., Bendelow, V. M., and Miller, H. 1970. Electronic recording mixers for the baking test. *Cereal Sci. Today* 15:341-344.
- Wallen, V. R., and Philpotts, L. E. 1970. Aerial photography for plant disease detection. *Can. Agr.* 15(1):30-31.
- Wallen, V. R., and Philpotts, L. E. 1970. Aerial color photography in the plant sciences. *Proc. Workshop on Aerial Color Photography in the Plant Sci.* 69-70.

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Departures

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VISITING SCIENTIST

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INTRODUCTION

The protection of fruit and vegetable crops from insects, diseases, and nematode pests is emphasized in the research conducted at this station.

Attention was focused in 1970 on the orchard air-blast sprayer as a source of aerial pesticide pollution. Extensive monitoring studies confirmed the need to contain pesticides within the target crop by a combination of modifications in the design of application equipment and of orchards. An engineer has joined the staff to strengthen research on spray application. A collaborative systems approach to research was initiated in cooperation with provincial and university scientists to give some direction to the apple industry.

Evaluation of insect activity and population pressures by the ecologists continues to show potential for decreasing pesticide loads and reducing the cost of protection programs. Because of the positive results obtained with the peach crop, semicommercial trials will be made next season that will use only two insecticide sprays. Research on insect pests of apples was expanded and promises to develop more precise methods for refining the use of pesticides.

An extensive educational program for growers was undertaken in order to minimize losses from bacterial disease in the production of sweet cherries. Peach canker was significantly reduced as a result of fungicide evaluation.

Virus research was concentrated on the development of nuclear stock repositories in efforts to improve the quality of propagating material for major fruit cultivars. Dr. Dias, in response to an invitation by the Commonwealth Scientific and Industrial Research Organization, Australia, successfully diagnosed a major grape-disease problem as being caused by a mycoplasma-like agent. Preliminary treatment of infected plant material with antibiotics showed promise.

Valuable data relating nematode population levels to damage and crop loss for a number of major vegetable crops was compiled in an effort to evaluate and make recommendations for the use of nematicides.

Mr. G. G. Dustan retired after 30 years of service. His outstanding contributions to the fruit industry in all phases of insect control greatly enhanced the image of this station.

G. M. Weaver
Director

PESTICIDES

Application

Assessment of spraying practices. In a spray application experiment with apple trees, both droplet size and leaf coverage decreased slightly as volume decreased from 3.36 to 0.63 kliter/ha (300 to 56 gal/acre). The percentage of volume emitted as droplets of less than 50 microns increased fivefold.

In vineyards, a fivefold reduction in the volume of the spray applied with a hooded hydraulic sprayer gave no loss in control of berry moth and mildews. A new hooded air-assisted applicator with air-shear nozzles was adjusted for maximum performance using chemical residue data, dye coverage data, and droplet-size measurements.

In spray distribution tests in an apple orchard planted 9 × 9 m (30 × 30 ft), 50% of a pesticide (captan-dicofol-phosmet mixture) was deposited on target foliage, 10–15% reached the ground, and the remainder was apparently airborne. Drift from 4× sprays was higher than from dilute sprays applied by air-blast sprayers. Gun application produced the least drift. During air-blast application maximum spray concentration in the air 30 m (100 ft) away reached 0.02 mg/m³, which is considered safe for human health. Little difference in biological efficacy (mite mortality) resulted when 4× or dilute sprays were applied by air-blast or gun.

Screening technique for assessing compatibility among pesticides. Considerable progress was made in the initial screening of materials for compatibility. Young apple

seedling terminals were dipped in suspensions of freshly prepared pesticide combinations. Captan or dodine mixed with propargite or chlorfenamidine hydrochloride and added to one of the organophosphorus compounds azinphos-methyl, phosmet, tetra-chlorvinphos, or phosalone did not injure McIntosh or Red Delicious foliage. However, extensive injury occurred on both varieties when the organophosphorus compounds were mixed with chlorfenamidine plus dodine. Under hot, dry conditions all products used alone or in combinations produced severe leaf spotting on McIntosh.

Chemical Control

Toxicity and persistence of dicofol alone and combined with phosmet. Dicofol (18.5% WP) was applied to apple trees at 6.7 kg/ha (6 lb/acre) and 5.0 kg/ha (4.5 lb/acre) at dilute (2 kg/kliter = 2 lb/100 gal) and 4× concentrations with phosmet and captan in three early sprays. For all treatments, the decline in toxicity of deposits to European red mites was faster than the decline in residues.

Although phosmet is a weak acaricide, the toxicity and persistence of dicofol deposits were greatly increased when combined with phosmet. Toxicity of dicofol applied alone was negligible 14 days after application, whereas the toxicity of the mixture was appreciable 30 days after treatment. However, this additive effect on mite kill occurred only after the deposits had weathered for several days.

Bioassay with mites and gas chromatographic analyses of deposits showed no advantage of low-volume over high-volume application, especially at reduced rates. The reduced-rate low-volume application was least effective.

Soil treatment with aldicarb in new apple plantings. Aldicarb, 10% granular, applied to the soil around newly planted McIntosh apple trees for 3 successive years gave good control of European red mites and reduced the number of aphids and leaf-feeding caterpillars. Effective rates were 11 g (0.4 oz) and 17 g (0.6 oz) of aldicarb per centimeter of trunk diameter when applied twice in June and watered in with 4.5 liters (1 gal) of water per tree. The number of mites increased during August of the third year on all trees.

Resistance of European red mites to acaricides. European red mites from an apple orchard at the Station were found to be resistant in varying degrees to organophosphorus compounds, including parathion and azinphos-methyl, but not to the newer acaricides chlorfenamidine, oxythioquinox, propargite, fentin hydroxide, tetrasul, and formetanate hydrochloride.

In a continued monitoring program, resistance to dicofol was detected in two grower orchards and to tetradifon in two orchards. These two compounds are still effective in most Ontario orchards.

Laboratory tests showed that resistance to dicofol confers an 8- to 10-fold cross-resistance to bromopropylate and to AC 76213 (American Cyanamid). However, no such cross-resistance was detected for chlorfenamidine, tetrasul, fentin hydroxide, and propargite.

Modified spray program for control of peach pests. Two sprays of either azinphos-methyl (50% WP) at 312.5 g/kliter (5 oz/100 gal) or phosmet (50% WP) at 625 g/kliter (10 oz/100 gal), applied about the time of shuck split and later on in the season to protect the ripening fruit, gave as good control of oriental fruit moth, *Grapholitha molesta* (Busck), and peach twig borer, *Anarsia lineatella* Zeller, as twice (the amount currently recommended) these rates.

Control of the carrot rust fly. In a small-plot test in muck soil the currently recommended furrow treatment with diazinon did not give satisfactory control of the first generation of the carrot rust fly, even at double the usual rate. Two unregistered compounds, chlorfenvinphos and carbofuran, appeared promising as furrow treatments.

Evaluation of insecticides and acaricides. Two applications of endosulfan were as effective in controlling tarnished plant bug on strawberry as one DDT spray applied at first bloom; two applications of the DDT analogue methoxychlor were much less effective.

Three sprays of either phosmet or tetra-chlorvinphos gave better control of grape berry moth than azinphos-methyl, and both are much safer to use. Where four sprays were applied, pirimiphos-methyl, phosmet, iodfenphos, and azinphos-methyl gave equally good control of the berry moth.

Evaluation of fungicides for control of brown rot and mildew. Sprays of benomyl,

captafol, thiabendazole, and captan were applied to peach trees 26, 13, and 1 day before harvest. Only benomyl significantly controlled brown rot up to 9 days after harvest. Captan gave the poorest control. Six applications of either EL 273 (Eli Lilly), thiophanate-methyl, or benomyl on the raspberry cv. Trent, or EL 273 or benomyl on the cv. Comet, gave acceptable control of mildew. Neither Dikar (Rohm & Haas) nor dinocap controlled mildew on either cultivar.

Control of apple scab with new fungicides. Two unregistered fungicides, EL 273 (10% WP) and thiophanate-methyl (70% WP), eradicated apple scab as effectively as did phenylmercuric acetate (PMA), 10% solution, 0.3 liter/kliter (0.25 pint/100 gal) after a postinfection interval of 48 hr (11.6 C), and were markedly superior after 72 hr in a single-spray eradication trial. In a protective program both unregistered materials and dodine, 65% WP, 0.25 kg/kliter (0.25 lb/100 gal), gave excellent control of scab on fruit and foliage. Both of these unregistered materials also controlled powdery mildew, and phytotoxicity was not evident after 13 sprays at double these rates.

INSECTS

Ecology and Integrated Control

Distribution of carrot rust fly in Holland Marsh. A study is under way to develop a method of monitoring carrot rust fly populations in the Holland Marsh as a basis for refining the use of insecticides. In unsprayed plots located on different farms throughout the Marsh, the numbers of flies captured on sticky boards correlated reasonably well with the amount of damage assessed at harvest. Flies and damage were most prevalent in plots near the Marsh periphery. Because damage was slight or negligible in most plots in the interior of the Marsh, it may be feasible to reduce the number of sprays in these areas.

Seasonal occurrence of the codling moth. The seasonal occurrence of adult codling moths was monitored in orchards at Vineland and Meaford with the aid of 15-w black light traps and by recording emergence in screen cages. At Vineland, first-generation moths began emerging on May 25 and were most active between June 29 and July 18. The first

adults were taken at Meaford on June 1 and emergence continued to August 21; maximum numbers emerged between July 1 and 10. Second-generation moths developed from 47% and 4% of first-generation larvae at Vineland and Meaford. In Essex County, adults started emerging on May 19, and about 64% of the first-generation larvae gave rise to the partial second generation, adults of which began emerging about mid-July.

NEMATODES

Host-Parasite Relationships

Nematode population densities and crop loss. Five vegetable crops were grown outdoors in microplots consisting of 15.24-cm (6-inch) clay tiles having soil infestations of 0, 300, 900, 2,700, and 8,100 *Meloidogyne hapla* Chitwood nematodes per 454 g of soil. Both the number and weight of marketable lettuce (cv. Pennlake) were reduced by a maximum of 25%, and reductions increased with increasing nematode densities in the soil. This nematode density significantly reduced the yields of cabbage (cv. Market Prize) and cauliflower (cv. Igloo); also cauliflower curd maturity was delayed. With potatoes (cv. Sebago) and onions (cv. Copper Gem), nematode populations were inversely correlated with the number and weight of marketable produce and directly correlated with the number and weight of culls. Commercial losses were 46% and 64% respectively, at nematode densities of 8,100.

Nematodes associated with forages. Six genera and ten species of nematodes are associated with forages in southwestern and central Ontario. Ninety percent of the samples collected contained the root-lesion nematode, *Pratylenchus*; 83% the pin nematode, *Paratylenchus*; 70% the spiral nematode, *Helicotylenchus*; 41% the stunt nematode, *Tylenchorhynchus*; 31% the cyst nematode, *Heterodera*; and 17% the root-knot nematode, *Meloidogyne*. The dominant species were *Pratylenchus minyus* Sher & Allen, *Paratylenchus projectus* Jenkins, *Helicotylenchus digonicus* Perry, *H. canadiensis* Waseem, *Heterodera trifolii* Goffart, and *M. hapla*.

Development of nematodes under forage mixtures. Components of a forage mixture were planted individually in a greenhouse in

a Guelph loam infested with four forage nematodes. *P. projectus* dominated under timothy and trefoil where populations increased from 37 to 3,200 and from 67 to 867, respectively, per 25 g of soil; *H. digonicus* dominated under alfalfa where the population rose from 350 to 633 per 25 g of soil. *P. minyus* initially maintained itself on alfalfa, clover, timothy, and trefoil, and then slowly declined in number. *M. hapla* behaved similarly on the three legumes, but its numbers declined drastically on timothy.

Control

Nematode control in flue-cured tobacco. Fumigation of soils containing moderate to high numbers of the root-lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh., increased yields of flue-cured tobacco by 224–336 kg/ha (200–300 lb/acre). In soils with low numbers of the nematode, however, fumigation failed to produce significant yield increases. The data show that increased yield in fumigated soil is due largely to nematode control. Row fumigation, which costs about \$50/ha (\$20/acre), gave significant nematode control and resulted in yields comparable to plots receiving broadcast fumigants, which cost \$100/ha (\$40/acre).

Fall fumigation of tobacco soils reduced root-lesion nematode populations as effectively as spring fumigation. If fumigation is delayed until 6–8 weeks after application of the ammonium nitrate to the rye cover and green manure crop, soil nitrogen transformations are not inhibited and the quality of tobacco is not affected.

PLANT DISEASES

Fruit Mycology

Epidemiology of apple scab. Under both field and controlled-infection conditions, the upper surface of apple leaves developed almost complete resistance to infection by *Venturia inaequalis* (Cke.) Wint. as the leaves reached full size. The lower leaf surface remained susceptible to infection and lesion development for 4 to 6 weeks after full leaf expansion. These late-season infections were an important source of overwintering inoculum. On heavily infected unsprayed McIntosh trees, new fruit infections occurred

throughout the growing season. Therefore it is important to maintain adequate fungicide coverage to within a few weeks of harvest.

Root rot of cherry. The cause of root rot in sour cherry is being studied in the districts of Niagara and Collingwood and in Lambton County. Rot-inducing organisms enter mainly through lateral roots. Pathogenic bacteria were isolated, but fungi were the principle pathogens. Some 65 culturally distinct fungi have been isolated; varying degrees of pathogenicity have been demonstrated for 11 isolates. A 3-year survey on loss of trees showed an average yearly mortality of 2% to 5%.

Fruit Virology

Prunus stem pitting. This disease was first observed in Ontario in a sour cherry orchard at Vineland in 1968. Diseased sour cherry trees have been found in a number of orchards throughout most of the fruit-growing regions of Ontario. Also, several sweet cherry orchards, two peach orchards, and one plum orchard are known to have infected trees. Diseased trees grow poorly, decline, and eventually die. The etiology of the disease is being studied.

Virus and virus-like diseases of grape. An undescribed virus was isolated from cv. Veeport vines with intense chrome yellow vein banding, stunt, and low productivity. The virus produced chlorotic lesions in *Nicotiana glutinosa* L.; necrotic lesions in *Gomphrena globosa* L., *Chenopodium amaranticolor* Coste & Reyn., and *C. quinoa* L.; and a severe blotching in *Petunia hybrida* Vilm.

Heat treatment at 37.5 C for 64 days followed by shoot-tip culture eliminated abnormalities from the leaves of the cv. Elvira; therefore, the leaf symptoms may be of viral rather than genetic origin. Peach rosette mosaic virus in cv. Concord vines was also eliminated by heat treatment at 37.5 C for 30 days followed by shoot-tip culture.

Vegetable Mycology

Interaction between Fusarium oxysporum f. conglutinans and turnip mosaic virus in Brassica chinensis. *Brassicace chinensis* L. (pak-choi) plants were inoculated simultaneously with *Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyd. & Hans. (F) and turnip mosaic virus (V) and held at 26 C soil

and 22 C air temperatures, 60% relative humidity, and supplied with 14 hr of artificial light (10,764 lux). After 5 weeks of incubation, the mean weight of plants inoculated with F and V was lower than that of plants inoculated with either pathogen alone. Plants inoculated only with F weighed less than plants inoculated only with V. All inoculated plants weighed less than the healthy controls. Foliar disease symptoms on plants infected with both pathogens were more severe than those on plants with F or V alone. Vascular discoloration of the tissues of plants inoculated with F and V was more intense than that of plants inoculated with F alone. No discoloration was observed in vascular tissues of plants inoculated with V alone.

Vegetable Virology

Mode of transmission and control of cucumber necrosis virus. Suspensions of *Olpidium cucurbitacearum* Barr & Dias zoospores and tobacco necrosis virus (TNV) or of *O. brassicae* (Woron.) Dang. and cucumber necrosis virus (CNV) received pH adjustments from 4 to 10; virus was not transmitted. Zoospores of both chytrids were motile at pH 6, 7, and 8, but were nonmotile or disrupted at pH 4, 5, 9, and 10. Transmission occurred with suspensions of *O. cucurbitacearum* and CNV, and with *O. brassicae* and TNV at pH 6, 7, and 8. Some transmission occurred at pH 5, but none at pH 4, 9, or 10. Transmission failures at pH 4, 9, and 10 appeared correlated with loss of motility of zoospores. Virus-free zoospores of *O. cucurbitacearum* released in a purified virus preparation of CNV or TNV containing 0.5% sucrose transmitted CNV but not TNV. Vector specificity

for both viruses does not appear to be related to the pH of the suspension or to the permeability of the zoospore membrane.

Ferbam powder (76% WP) mixed with CNV-infected soil at 0.2 kg/kliter (3.2 oz/100 gal) or a ferbam drench at 0.5 kg/kliter (8 oz/100 gal) controlled *Olpidium* infection, prevented virus transmission, and was not phytotoxic.

Influence of plant population density on the incidence of stylet-borne viruses in pepper. Field experiments suggest that close planting and high-density planting do not increase the incidence of, or losses caused by, stylet-borne viruses. Plant size was inversely proportional to the density of the planting. Based on symptoms, the number of naturally infected plants per unit area did not differ significantly at harvest. However, the percentage of virus-infected plants and the virus disease index per unit area decreased as the plant population increased. Also the number of aphids per plot decreased consistently as plant density increased.

Effect of aphicides on the incidence of stylet-borne viruses in pepper. Seven weekly applications of endosulfan or diazinon and three monthly applications of demeton or dimethoate failed to significantly decrease the number of virus-infected plants in replicated pepper plots that contained each of the cultivars Vinedale, Calwonder, and Long Thick Red at final harvest. Aphids were significantly fewer in plots that had been sprayed with demeton or dimethoate, but they were never completely eliminated. The results suggest that the application of insecticides to the crop alone for virus control is ineffective.

PUBLICATIONS

Research

- Allen, W. R., Davidson, T. R., and Briscoe, M. R. 1970. Properties of a strain of strawberry latent ringspot virus isolated from sweet cherry growing in Ontario. *Phytopathology* 60:1262-1265.
- Chiba, M. 1970. DDT residues in fruit, foliage and soil of a vineyard following a standard insect control program. *Can. J. Plant Sci.* 50:219-227.
- Chiba, M., Yule, W. N., and Morley, H. V. 1970. Suitability of TLC, GLC and bioassay for the determination of aldrin, dieldrin and DDT residues in different soils without cleanup. *Bull. Environ. Contam. Toxicol.* 5:263-270.
- Dias, H. F. 1970. Transmission of cucumber necrosis virus by *Olpidium cucurbitacearum*. *Virology* 40:828-839.
- Dias, H. F. 1970. The relationship between cucumber necrosis virus and its vector *Olpidium cucurbitacearum*. *Virology* 42:204-211.

- Kemp, W. G. 1970. The effect of gamma radiation on carnation mottle virus in crude *Dianthus barbatus* sap. Can. J. Microbiol. 16:1374-1375.
- Hagley, E. A. C. 1970. The distribution and survival of overwintering codling moth larvae in southern Ontario. Proc. Ent. Soc. Ont. 100(1969):40-47.
- Olthof, T. H. A., Townshend, J. L., Potter, J. W., and Cornelisse, A. 1969. Plant-parasitic nematode genera associated with crops in Ontario in 1968. Can. Plant Dis. Surv. 49:54-55.
- Phillips, J. H. H., and Proctor, J. R. 1970. Development of methods for sampling the oriental fruit moth, *Grapholitha molesta* (Lepidoptera: Tortricidae), in an Ontario peach orchard. Can. Entomol. 102:454-471.
- Phillips, J. H. H., and Proctor, J. R. 1970. Parasitism of the oriental fruit moth, *Grapholitha molesta* (Lepidoptera: Tortricidae), in an unsprayed peach orchard on the Niagara peninsula, Ontario. Can. Entomol. 102:1395-1404.
- Putman, W. L. 1970. Life history and behavior of *Balaustium putmani* (Acarina: Erythraeidae). Ann. Entomol. Soc. Amer. 63:76-81.
- Putman, W. L. 1970. Occurrence and transmission of a virus disease of the European red mite, *Panonychus ulmi*. Can. Entomol. 102:305-321.
- Putman, W. L. 1970. Threshold temperatures for the European red mite, *Panonychus ulmi* (Acarina: Tetranychidae). Can. Entomol. 102:422-425.
- Putman, W. L. 1970. Some aspects of sex in the European red mite, *Panonychus ulmi*. Can. Entomol. 102:612-617.
- Putman, W. L. 1970. Some effects of wind on the European red mite, *Panonychus ulmi* (Acarina: Tetranychidae). Can. Entomol. 102:659-667.
- Putman, W. L. 1970. Effects of water and high humidity on the European red mite, *Panonychus ulmi* (Acarina: Tetranychidae). Can. Entomol. 102:955-961.
- Reyes, A. A. 1969. The seasonal occurrence of fungal and bacterial diseases of crucifers in Ontario in 1967 and 1968. Can. Plant Dis. Surv. 49:56-57.
- Stevenson, A. B. 1970. Endosulfan and other insecticides for control of the leaf form of the grape phylloxera in Ontario. J. Econ. Entomol. 63:125-128.
- Stevenson, A. B. 1970. Strains of the grape phylloxera in Ontario with different effects on the foliage of certain grape cultivars. J. Econ. Entomol. 63:135-138.

Miscellaneous

- Allen, W. R. 1970. Bacterial canker of sweet cherry: a costly disease that is receiving little attention. The Grower 19(4):7.
- Dias, H. F. 1970. Grapevine yellow mosaic, p. 220-230. In Virus diseases of small fruit and grapevines. Univ. Calif., Division of Agricultural Sciences, Berkeley, Calif.
- Hewitt, W. B., Dias, H. F., Martelli, G., and Taylor, R. H. 1970. Grape fanleaf virus. C.M.I./A.A.B. Description of Plant Virus No. 28.
- Olthof, T. H. A., Townshend, J. L., Potter, J. W., and Marks, C. F. 1970. Plant parasitic nematodes of economic importance in Ontario. Proc. Entomol. Soc. Ont. 100:8-9.

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INTRODUCTION

The development of thirteen multidisciplinary program teams oriented to the solution of high-priority animal industry problems has been proceeding smoothly. The results of the research are reported under the scientific disciplines for another year while the changeover from single-disciplinary research to multidisciplinary research continues.

Substantial progress has been made in redesigning two major programs concerned with the breeding of dairy cattle and sheep. Both projects involve the development of synthetic strains, which will incorporate genes from breeds of cattle and sheep from overseas.

Basic studies on fatty acid metabolism and on the causes of ketosis have led to applied tests in the barn with ketotic cows. A practical solution to this problem may soon be found. Studies on the energy requirements for pregnant ewes and sows suggest that rather large changes should be made in the feeding standards for these females when they are maintained under intensive confinement.

A computerized data acquisition system has been developed which will permit study of several physiological and behavioral parameters associated with different reproductive states. This experimental approach will complement the biochemical approaches that have been developed to measure quantitatively the changes in the reproductive hormones in the blood of animals throughout the reproductive cycle.

The development of specialized facilities for animal research continues on the A.R.I. Greenbelt Farm. This year a barn designed for intensive studies with sheep was completed. This barn has several controlled-environment rooms (temperature, light, and ventilation); special facilities for digestibility and metabolism trials; a field laboratory for preparation of forage, feces, and urine samples; and many individual animal pens for feeding trials and other intensive experimental work.

R. S. Gowe
Director

BIOCHEMISTRY

A Study of the Metabolism of Ruminant Ketosis and Fatty Acid Metabolism

Antiketogenic metabolites were tested on spontaneous ketotic (SK) cows and feed-restricted ketotic (FRK) cows. Cows were arbitrarily defined as being ketotic when the blood acetoacetate (AcAc) and β -hydroxybutyrate (β -OHB) levels were 5 and 20 mg/100 ml or higher respectively. With FRK cows this condition was achieved when the animals had a negative energy balance between 7.2 and 10.8 Mcal/day. L-Carnitine was infused into these cows by means of a jugular catheter at rates varying from 1 to 14 g/hr for 24 hr. L-Carnitine infusion consistently and significantly decreased the levels of free fatty acids (FFA) in the plasma from the ketotic level of 1 to 2 μ eq/ml, but resulted in large fluctuations of blood AcAc and β -OHB levels. From these findings, it was postulated that the metabolic deficit of ruminant ketosis may be impaired FFA oxidation in muscle resulting from a carnitine deficit.

This impaired oxidation in turn results in increased plasma FFA concentration and hyperketogenesis in liver.

As a part of a continuing investigation on the factors controlling fatty acid metabolism in the liver, the mechanism of fatty acid uptake and transport across rat liver plasma membrane was studied. The results with plasma membrane show that there are receptor proteins on the membrane which strongly bind fatty acid and that the bound fatty acid is activated to the CoA ester, and then incorporated into neutral lipids and phospholipids of the membrane. Enzymes involved in the esterification and de-esterification of fatty acids were identified in purified plasma membrane. By the use of a fatty acid analogue, α -bromopalmitate, it was possible to conclude that specific receptors for the uptake and transport of fatty acids are located on the outer surface of rat liver cells. The results suggest that specific carrier systems involving receptor proteins, or enzymes, or both, might be involved in the transport process.

Etiology of Nutritional Muscular Dystrophy in Farm Animals

To clarify the mechanisms by which Se prevents nutritional muscular dystrophy (NMD), studies were continued on identifying the selenocompounds formed in animals. Purified preparations of skin collagen, tendon gelatin, thymus histones, and ewe colostrum β - and γ -caseins, isolated from animals administered ^{75}Se -selenite, all contained a trace of cystine and incorporated very little ^{75}Se activity. Keratins, such as skin, feathers, and hair, and β -lactoglobulin and α -lactalbumin of ewe colostrum, all contained high levels of cystine and of radioselenium. The data suggest that the cystine content of a protein is an important factor that affects the initial uptake of Se, presumably by selenotrisulfide (P-S-Se-S-P) formation. In time, protein-bound Se appears to be transformed from selenotrisulfides to other forms. Significant amounts of Se were transferred from the ewe to lamb by the immune globulins. Because daily oral administration of cystine to beef calves gave no protection against NMD, the high-cystine content of oat silage proteins is apparently not responsible for its antidystrophic effect. The results contrast with the complete protection against NMD provided by the sulfur amino acids for the chick, but are in agreement with similar observations on the ineffectiveness of cystine and methionine for prevention of myopathy in lambs.

Studies in Bone Mineralization

Changes effected by the hypo- and hypercalcemic states in long bones (tibia, femori) of growing immature chickens were studied. When these states were induced in chickens by varying levels of dietary Ca, the most notable change in bone composition was the continuous decrease of the Mg/Ca ratios from the hypo-Ca state through the normo-Ca to the hyper-Ca states. Both hydroxyproline and hexosamines were highest in hypo-Ca bones and lowest in normo-Ca bones; this change was more prominent in hexosamines than in hydroxyproline. The change is of particular interest because it is evidently in agreement with the electron-microscopic observations on changes in the mucopolysaccharide (MPS) sheaths that surround the canalicular processes in cortical bones. When the hypo-Ca state was induced in chickens by the administration of a hypocalcemic hormone,

calcitonin, the ash level was lower in these than in the normo-Ca bones, as was observed in the hypo-Ca state induced by low-Ca diet. The changes in the mineral constituents of these bones were similar to those observed in the hyper-Ca state induced by high-Ca diet.

Studies on Energy Utilization in Animals

The hormone thyroxine, acting as an electron acceptor, has been shown to selectively promote ATP-energized accumulation of K^+ by mitochondria. By contrast, Na^+ is energetically transported when the conformation of the mitochondrial membrane is altered by removal of Mg^{++} . The findings suggest that an ATP-dependent change in the status of electrical gradients in the membrane can account for mitochondrial transport specificity. An ATP-dependent redistribution of electrons may also be involved in $\text{Na}^+ - \text{K}^+$ exchange at the cell membrane. ^{42}K uptake into single cells (lymphocyte culture) was increased by accompanying exposure to a mitogen. The effect represents an increase in V_{max} without apparent change in K_m . Uptake of ^{42}K was inhibited by the glycoside, ouabain, which is known to selectively inhibit coupled $\text{Na}^+ - \text{K}^+$ transport. Uptake was shown to represent stimulation of the $\text{Na}^+ - \text{K}^+$ transport system and not biosynthesis of new transport protein. Five $\text{Na}^+ + \text{K}^+$ adenosine triphosphatase inhibitors also inhibited DNA and RNA synthesis and formation of mitotic figures, suggesting that functioning of the $\text{Na}^+ + \text{K}^+$ adenosine triphosphatase is essential to cell activation and replication.

Pesticide Residues

Data have indicated that addition of activated charcoal had no effect on uptake or elimination of pesticides, such as chlordane, DDT, lindane, ethion, linuron, and atrazine, from the diet in laying hens. Neither charcoal nor pesticides affected mortality, egg production, egg weight, shell quality, body weight, or feed consumption. Ethion and atrazine could not be detected in eggs, abdominal fat, or tissues. An apparent linuron residue in control eggs was unaltered by addition of linuron to the diet. Lindane and chlordane could not be detected in control eggs, and the levels of 0.05 and 0.15 ppm respectively detected after feeding for 6 weeks returned to control levels 3 weeks after withdrawal of the pesticides. Residues of *o,p'*-DDT at 0.019

ppm and *p,p'*-DDT at 0.072 ppm were detected in control eggs. After DDT was fed for 6 weeks, residues of *p,p'*-DDT reached a maximum of 0.19 ppm, but returned to control levels 3 weeks after withdrawal of the pesticide. Levels of DDT in abdominal fat and tissue are being determined.

GENETICS

Poultry

Genetic resistance to Marek's disease. Although much is known about the resistance of various strains of poultry to Marek's disease (M.D.), less is known about sire family variation and practically nothing is known about inbreeding and resistance to M.D. An experiment was conducted on 20 sire families, selected at random from each of two egg-production strains (04 and 08). After necropsies of all birds that died and all that survived to 78 days, it was found that 11 sire families of 04 had less than 15% M.D. incidence and none had more than 50% incidence, whereas 10 sire families of 08 had less than 15% M.D. incidence and none had more than 50% incidence.

A somewhat shorter but similar experiment of 54 days duration was performed on 23 inbred families derived from an egg-production strain 03. The inbreeding coefficient of each inbred family was approximately 40%. Of the 23 inbred families derived from 04, 18 had less than 15% M.D. incidence and the most susceptible family exhibited 50% M.D. incidence. Of 31 inbred families derived from 03, 4 had less than 15% M.D. incidence and 11 had more than 50% M.D. incidence. Furthermore, after full-sibs of these birds were raised to 147 days of age at La Pocatière, where M.D. is epizootic, it was found that the most resistant families ranked about the same in the "field" test as those in the 54-day experiment where chicks were infected under controlled conditions. These resistant inbred families will eventually be recombined to form strains that should be productive as well as M.D. resistant.

Esterase genotype, growth, and reproductive traits in fowl. Thirteen hundred and ninety-nine meat-type females from a single hatch were classified by electrophoretic techniques for genotype at an aliesterase locus. Three growth-selected lines and three random-bred

control populations were sampled. The control populations were presumed to be in equilibrium after 6 to 12 generations of random breeding. Genotypic frequencies differed between the selected and control lines presumably as a result of the selection. The frequencies of the three alleles (Es^A , Es^B , and Es^C) in the combined populations were 0.285, 0.615, and 0.100. Least-squares analyses revealed a significant interaction between line and genotype for 56-day body weight and egg weight, but not for body weights at 42, 140, 280, or 420 days, age to first egg, 420-day hen-housed or survivor egg production, fertility, or hatchability. Differences between genotypes were significant ($P < 0.05$ or < 0.01) for 56-day weight, age to first egg, survivor egg production, and egg weight. The least-square means for genotype Es^A/Es^C ranked first or second in level of performance for all growth traits and for hen-housed production, percent survivor production, and hatchability. The genotype Es^A/Es^C exceeded the overall mean of the experiment by 27 g (3%) for 56-day body weight and by 15 eggs (11%) for hen-housed egg production.

Incubation period for goslings. Analyses of data on the length of the incubation period for over 8000 goslings from three breeds and their crosses, covering four generations of breeding, indicated significant environmental and genetic effects.

The Pilgrim, Hungarian, and Chinese breeds differed by as much as 8 hr in their incubation period, the Hungarians requiring the shortest time. Crosses of the three breeds had a shorter incubation than the purebreds, indicating heterosis in the goose for this trait. Males hatched an average of 1.6 hr earlier than females. As the hatching season progressed, the length of the incubation period decreased. No evidence was found of any interactions between sex, genotype, and hatch.

The partial regression coefficients of incubation period on preincubation storage length averaged 1.0 hr/day and on egg weight 0.077 hr/g.

For eggs set within a few days of being laid, a reasonable estimate of the time required to allow almost all goslings to hatch would be 30.5 days. The influence of the various genetic and environmental factors could justify some caution, however, in applying this estimate too rigorously.

Comb type and performance. The growth and reproductive performance of over 17,000 individuals of the single, pea, walnut, and rose comb types were compared in 12 generations of the Ottawa and Athens-Canadian meat-type random-bred control strains. Populations with the different comb types differed significantly in 63-day breast angle, in keel and shank lengths, and for all body weights up to and including 147-day body weight. No consistent differences between populations with the four comb types were observed for adult body weight, egg production, or any other associated production trait. The comb type of the birds did not have any effect on the phenotypic variance of any trait. The mean 63-day body weights of the four comb type groups indicated no significant difference between pea and walnut combs or between single and rose combs. Rose and single combs both differed, however, from pea and walnut. This supports the hypothesis that the *P* gene has a slight adverse effect on growth. The 95% confidence interval estimates for the difference in 63-day body weight between single and pea comb males ranged from 1.1 to 2.4% of the population mean.

Dairy Cattle

Effect of size and fatness at freshening on milk yield. Recent studies have shown that the loss in body weight following freshening is much more closely related to yield than is body weight per se. In addition, when freshening weight and age are held constant, increases in wither height are accompanied by decreases in yield; both of these relationships are much less pronounced in second and later lactations. These observations suggest that, among heifers of a given freshening weight, the fattest heifers (those with the smallest wither height) tend to produce the most milk. It appears that stored fat may be used to support milk production, and that selection among bulls based on the yield of their first-lactation daughters may favor those bulls that produce the fattest daughters. The phenotypic and genetic relationships among these traits are being studied further, as they may have important implications in the evaluation of progeny tests.

Age and herd adjustment of milk yield records. Thirty to 40% of the variance in first-lactation milk yield and age at first calving is due to differences between herds. Therefore,

differences between herds have a substantial effect on first-lactation records and could have an important effect on the progeny tests of young bulls.

A procedure for adjusting first-lactation milk yield records for age and herd effects has been evaluated. Differences between herds in average age at first freshening, average age at second and later calvings, and average milk yield in second and later lactations were considered. Because the regression of yield on age after adjustment was smaller than after using other common adjustment procedures, age adjustment was effective. However, the procedure was not effective in adjusting for herd differences because 20% of the variance in adjusted records was associated with herds.

Although effective adjustment for age at first freshening presents no difficulty, effective adjustment for herd differences cannot be achieved as outlined above. Other methods of adjusting milk records for differences between herds are being investigated.

Sheep

Finnish Landrace boosts reproductive performance. Fifteen Finnish Landrace (F), 39 MM line (similar in performance to the Suffolk), and 26 Finnish \times MM (F \times) ewes were exposed to rams at 7-8 months of age. All the F ewes, 81% of the F \times ewes, and only 20% of the MM ewes subsequently lambed. The averages were 2.3, 1.3, and 1.0 lambs respectively, indicating earlier sexual maturity of the F and F \times ewes. The lambs were weaned at 8-16 hr after birth and reared on a milk replacer and grain-concentrate diet. At 100 days of age the lambs from the F, F \times , and MM ewes had an average weight of 22.8, 26.8, and 26.1 kg. At this time the average weight of lamb produced per ewe exposed was 51.6, 21.6, and 7.4 kg for the F, F \times , and MM ewes. In this trial the ewe lamb productivity of the F breed was six times that of the MM, and the F \times ewe lambs were three times as productive as the MM's under intensive rearing conditions. The performance of these ewes at second lambing will be determined in 1971.

NUTRITION

Cattle

Energy-to-protein ratios for calves. Growth rate and proportion of absorbed N retained were increased in calves by addition of energy from butterfat or glucose to a diet of whole milk (2.6% fat). Subsequently, it was determined that young calves could tolerate up to 8.5% glucose added to whole milk, but higher levels (13.5% or 18%) caused severe diarrhea and reduced milk intake, growth rate, and N retention.

Grain-roughage combinations for dairy beef. In a study to evaluate interaction between grain and roughage in diets for Holstein steers, a ration with 40% barley straw gave as rapid growth as all-grain when corn was the cereal constituent, but the ration depressed growth when fed with barley.

Triticale silage for dairy cows. Whole-crop triticale was ensiled at the firm-dough stage and compared with corn silage for efficiency of milk production. Digestibility of triticale silage was lower than that of corn (50.9% vs. 57.8%; $P < 0.05$) and mean intake was less (8.4 vs. 9.7 kg/day). These differences were reflected in a lower milk yield with triticale than with corn silage: 21.6 vs. 25.4 kg/day. Milk composition was unaffected by diet except for a reduction in protein with triticale (3.1% vs. 3.3%). It would appear from these results that triticale is not a substitute for corn where the latter can be grown for ensiling.

Prevention of nutritional muscular dystrophy (NMD). Following the feeding of either first-cut grain silage or rapeseed forage silage, harvested at heading stage and early bloom respectively, to cows in northern Ontario where NMD is common, there was no incidence of the disease in spite of low blood Se levels in the calves. When hay was fed to the cows, the incidence of NMD in calves was high, but could be prevented by implantation of a pellet containing 18 mg Se in the ear. The Se implantation technique, which provides slow release of Se, was tested also with pregnant ewes; only one lamb out of 17 born to ewes implanted in midgestation showed NMD, whereas the incidence was high in the unimplanted group.

Sheep

Energy cost of pregnancy in the ewe. By the use of the slaughter technique, pregnant and nonpregnant ewes were compared for efficiency of energy utilization during gestation. Ewes in late pregnancy utilized more energy than did the nonpregnant ones, but this was largely accounted for by the energy cost of tissue synthesis in fetal growth, with little indication of any increased requirement of the dam. Energy retained in the concepta was only 3% of the net energy expended on maintenance of the ewe and on intrauterine growth.

Artificial rearing of lambs. Some 670 lambs were taken from their dams at 8–16 hr postpartum and fed refrigerated Ewelac (a commercial ewe's milk replacer manufactured by L. E. Pritchitt & Co. Ltd., U.K.) until 35 days of age by means of an automatic pipeline system. Average daily gain of all lambs surviving to 35 days was 0.31 kg; there was no difference in daily gain between singles and twins, but males grew faster than females (0.32 vs. 0.29 kg/day). At 35 days of age, lambs were randomly assigned to 12 dry feeds in a $2 \times 2 \times 3$ factorial experiment: all-concentrate vs. 20% roughage, meal vs. pellets, and protein levels of 12%, 15%, and 18%. Overall mean daily gain to 140 days was 0.2 kg, but there appeared to be some depression on the 12% protein diet, especially up to 100 days of age. No other treatment differences were apparent.

Swine

Fat and glucose metabolism in growing pigs. Utilization of body fat for energy during fasting was measured by continuous sampling of expired air from pigs whose body fat was labeled with ^{14}C -palmitic acid. After the pigs had fasted for 3 to 6 hr, the level of expired $^{14}\text{CO}_2$ per hr was 13% of that expired after 48 to 72 hr fasting, and the average level during the first 12 hr of fast was 18%. Percentage of utilized energy derived from body fat was calculated to be 6.8% during the first 3 to 6 hr fasting and 10.3% during the third day. It appeared from examination of plasma samples that the fasting pig is capable of using fatty acids of either endogenous or exogenous origin for synthesis of blood glucose.

Poultry

Dietary Na and Cl in relation to egg production. Sodium proved to be the first limiting element in egg production, and a supplementary level of 0.1% NaCl was necessary to support maximum feed intake and egg production. The unsupplemented basal diet supported 10% egg production, and the addition of only Na supported 45% egg production. A Cl level equivalent to 0.06% NaCl supported maximum production if Na was adequate. Plasma levels of Na, Cl, and K were unaffected by dietary salt level, but if the basal diet was supplemented only with Na, the amount of Cl in the plasma was depressed. Egg weight was maximal when the supplementary salt level was 0.1% or more; lower levels gave proportionate depressions in egg size. Maximal specific gravity of eggs was attained with 0.05% or 0.1% salt; lower or higher levels of supplementary salt depressed the specific gravity.

Growth restriction of broiler breeding stock. Two methods were tested, singly and in combination, on 2000 pullets of two commercial breeding stocks: quantitative restriction by feeding on alternate days, and the use of a low-protein diet (LP). Body weights at housing, compared with weights on the standard diet (SD) given ad lib., were 75% for LP diet ad lib., 55% for SD restricted, and 44% for LP restricted. Feed consumption per bird from 3 to 21 weeks ranked in the same order: 14.7, 11.9, 8.0, and 6.5 kg. Overall mortality from 0 to 147 days was 6%; it was unaffected by protein level, but appeared to be increased by feed restriction. Subsequent laying performance suggested that a low-protein diet and a less severe system of feed restriction would be the best rearing treatment.

PHYSIOLOGY

Reproduction

Steroid hormones. Levels of blood steroids in the ewe at several stages of single and multiple pregnancies have been determined. Of about 100 steroids detected in the neutral fraction alone, 60 have been identified. Of these, many are major components identified for the first time.

Steroid hormones: progesterone. The progesterone concentration in the peripheral

plasma of cows has been measured sequentially during the estrous cycle (7 cycles), gestation (7 cows), and postpartum (10 cows) by a competitive protein-binding procedure.

The concentration was lowest just before, during, and just after estrus (0.1–0.4 ng/ml), it began to increase on the 4th to 6th day (day of estrus = 1st day), and reached a peak of 3–6 ng/ml on the 11th to 18th day of the cycle. In six of the seven cycles studied the progesterone concentration dropped rapidly over a 24–48 hr period and reached a basal level 24–72 hr before the next observed estrus.

During early pregnancy the plasma progesterone concentration was, in general, similar to the maximum levels found during the luteal phase of the cycle.

Although considerable individual variability existed, all the cows showed a decline in progesterone level over a 60-day period until a relatively low value (1.0–3.5 ng/ml) was reached between 90 and 150 days of gestation. This decline was followed by a variable rise to a level of 4–12 ng/ml. This level was maintained until 35–70 days before parturition, when a gradual steady decline began. On the day before parturition the level of progesterone was <2.0 ng/ml.

After parturition parallel observations were made on the appearance of a discharge of mucus with or without behavioral estrus and on plasma progesterone levels as an indication of the presence of luteal tissue arising perhaps from an ovulation. The level of progesterone remained at <0.5 ng/ml until the first sign of the resumption of cyclic activity occurred. The time at which this occurred was very variable (20 days to >60 days). Although not conclusive, the evidence favors the view that for estrous behavior to occur, estrus must be preceded by luteal activity. The discharge of mucus can occur without previous luteal activity.

Progesterone concentration in the peripheral plasma of the ewe has been measured sequentially during the estrous cycle (4 cycles), gestation (3 ewes), and just before and at parturition (9 ewes).

The concentration was lowest just before, during, and just after estrus (<0.5 ng/ml), it began to increase on the 4th day (day of estrus = 1st day), and reached a peak of 2.0–4.0 ng/ml around the 10th day. There is strong evidence for a dip in the concentration before a second peak is reached on the 14th

to 15th day. The second peak may be higher, the same, or lower than the first peak. The progesterone concentration declined rapidly over a 48-hr period and reached a basal level of <0.5 ng/ml 24–48 hr before the onset of estrus. During the first 80 days of pregnancy the progesterone concentration was similar to the peak luteal level found during the estrous cycle (2.0–4.0 ng/ml). Thereafter a rapid increase in the concentration occurred, and reached a level of 15–20 ng/ml at 100–110 days of gestation. This value was maintained until approximately 3 days before parturition, when the concentration decreased rapidly to about 4–8 ng/ml. After parturition a basal level of <0.5 ng/ml was rapidly reached.

The hormonal requirements for embryonic attachment to the uterine wall and for the successful maintenance of pregnancy have been studied in five sheep ovariectomized 5 days after conception. A constant level of plasma progesterone was maintained with sialastic implants impregnated with progesterone. The progesterone blood levels were continuously monitored. The embryos developed normally, and when the progesterone implants were removed on the 70th day, pregnancy continued normally. The rise in the progesterone level noted in the intact pregnant ewe occurred in the ovariectomized ewes and similar levels were reached. The progesterone in the blood after the 70th day obviously came from an extraovarian source, either from the maternal adrenals or from

the conceptus. It likely came from the conceptus.

Computerized data acquisition system. In order to study changes in certain physiological parameters associated with different reproductive performance, a computerized data acquisition system has been developed in cooperation with the Engineering Research Service to accept, to process, and to store the large volumes of data that can arise from such experiments.

This data acquisition system is flexible and has a large capacity. At present, 64 channels of analogue data, such as body and environmental temperature; cardiovascular functions; and eating, drinking, and sleeping patterns, can be digitized and recorded. Provision has been made to permit the extension of this equipment to 112 channels. Sixteen sense lines are available for recording discrete events, such as the time the lights are switched on and the doors of the room are opened. Sixteen control lines are also available for switching lights on and off, starting motors, operating solenoids, and other functions, at predetermined times. All these functions are under computer control.

Through computer programming the various channels can be monitored at intervals of time ranging from 1 sec to several minutes. The data are stored on magnetic tape, or teleprinter, or both, at specified intervals of time. The information on the magnetic tape can subsequently be processed directly on a large computer for summarization and statistical treatment.

PUBLICATIONS

Research

- Bender, F., Heaney, D. P., and Bowden, A. 1970. The potential of wood as a feed for ruminants. *Forest Prod. J.* 20:36-41.
- Cipera, J. D., Chan, A. S., and Belanger, F. 1970. Evidence for the increased hypocalcemic activity in hypercalcemic chicks. *Proc. Symp. Calcitonin*, p. 320-326.
- Cunningham, H. M. 1970. Biological half-life of caffeine in pigs. *Can. J. Anim. Sci.* 50:49-54.
- Cunningham, H. M. 1970. Equipment for the continuous sampling of expired C-14 from animals in a respiration chamber. *Can. J. Anim. Sci.* 50:753-754.
- Dow, D. S. 1970. Characteristics of thyroxine swelling in skeletal muscle mitochondria: Relationship to valinomycin swelling and swelling in the absence of Mg^{++} . *Bioenergetics* 1:423-444.
- Dow, D. S., Walton, K. G., and Fleischer, S. 1970. Control of mitochondrial swelling by Mg^{++} — The relation of ion transport to structural changes. *Bioenergetics* 1:247-271.
- Erfle, J. D., Fisher, L. J., and Sauer, F. D. 1970. Carnitine and acetylcarnitine in the milk of normal and ketotic cows. *J. Dairy Sci.* 53:486-488.

- Fahmy, M. H., and Hidiroglou, M. 1970. Body weight and gains of calves from purebred and crossbred Shorthorn cows. *Can. J. Anim. Sci.* 50:621-627.
- Fisher, L. J., MacIntosh, A. I., and Carson, R. B. 1970. Effect of *ad libitum* versus restricted intake of concentrate and stage of lactation on the mineral content of cow's milk. *Can. J. Anim. Sci.* 50:121-127.
- Grunder, A. A., Merritt, E. S., and Kristjansson, F. K. 1970. Predictability of age to first egg from serum esterase activity levels. *Poultry Sci.* 49:769-774.
- Heaney, D. P., and Bender, F. 1970. The feeding value of steamed aspen for sheep. *Forest Prod. J.* 20:98-102.
- Hidiroglou, M., Hoffman, I., and Jenkins, K. J. 1970. Selenium distribution and radiotocopherol metabolism in the pregnant ewe and foetal lamb, p. 272-274. *In* C. F. Mills [ed.] Trace element metabolism in animals. E. & S. Livingstone, Edinburgh.
- Hidiroglou, M., Jenkins, K. J., Lessard, J. R., and Borowsky, E. 1970. Effect of feeding cod liver oil on the fate of radiotocopherol in sheep. *Can. J. Physiol. Pharmacol.* 48:751-757.
- Hidiroglou, M., Jenkins, K. J., Lessard, J. R., and Carson, R. B. 1970. Copper and molybdenum status of growing beef cattle in a selenium deficient area of northern Ontario. *Can. J. Anim. Sci.* 50:279-284.
- Hidiroglou, M., Jenkins, K. J., Lessard, J. R., and Carson, R. B. 1970. Metabolism of vitamin E in sheep. *Brit. J. Nutr.* 24:917-928.
- Hunt, J. R. 1970. Fate of ingested sodium bicarbonate in the fowl. *Ann. Biol. Anim. Biochim. Biophys.* 10:111-118.
- Hunt, J. R., and Chancey, H. W. R. 1970. Influence of dietary phosphorus on shell quality. *Brit. Poultry Sci.* 11:259-267.
- Jenkins, K. J., Dickson, R. C., and Hidiroglou, M. 1970. Effects of various selenium compounds on the development of muscular dystrophy and other vitamin E dyscrasias in the chick. *Can. J. Physiol. Pharmacol.* 48:192-196.
- Jenkins, K. J., Dickson, R. C., and Hidiroglou, M. 1970. Intravascular transport of selenium in the chick, p. 336-339. *In* C. F. Mills [ed.] Trace element metabolism in animals. E. & S. Livingstone, Edinburgh.
- Jenkins, K. J., Hidiroglou, M., MacKay, R. R., and Proulx, J. G. 1970. Influence of selenium and linoleic acid on the development of nutritional muscular dystrophy in beef calves, lambs and rabbits. *Can. J. Anim. Sci.* 50:137-146.
- Lee, A. J., and Hickman, C. G. 1970. The effectiveness of an age herd-level adjustment procedure for milk and fat yield. *J. Dairy Sci.* 53:913-922.
- Lessard, J. R., Hidiroglou, M., Carson, R. B., and Wauthy, J. M. 1970. The copper, molybdenum and sulfur contents of forage crops at Kapuskasing, Ontario. *Can. J. Plant Sci.* 50:685-691.
- Lister, E. E., and Fisher, L. J. 1970. The establishment of the toxic level of nitrofurazone for young liquid-fed calves. *J. Dairy Sci.* 53:1490-1495.
- Lister, E. E., and MacKay, R. R. 1970. Effect of medication with antibiotics and mature bovine plasma on mortality, morbidity, rate of growth and serum immunoglobulins of Holstein calves. *Can. J. Anim. Sci.* 50:645-650.
- Lodge, G. A. 1970. Quantitative and qualitative control of proteins in meat animals, p. 141-166. *In* R. A. Lawrie [ed.] Proteins as human food. Butterworths, London.
- Lodge, G. A., and Heaney, D. P. 1970. Energy cost of pregnancy in the ewe, p. 109-112. *In* A. Schürch and C. Wenk [ed.] Energy metabolism of farm animals. Juris Durck, Verlag, Zurich.
- Mahadevan, S., Malaiyandi, M., Erfe, J. D., and Sauer, F. 1970. Metabolism of L-carnitine esters of β -substituted palmitic acid by rat liver mitochondria. *J. Biol. Chem.* 245:3218-3224.
- Merritt, E. S. 1970. Hatching egg storage and post embryonic performance. *Poultry Sci.* 49:316-317.
- Nagai, J., and Kristjansson, F. K. 1970. Litter size and segregation in *Mus musculus* classified for *Transferrin*. *Can. J. Genet. Cytol.* 12:307-315.
- Nevo, A. C., Polge, C., and Frederick, G. 1970. Aerobic and anaerobic metabolism of boar spermatozoa in relation to their motility. *J. Reprod. Fert.* 22:109-118.
- Pigden, W. J., and Heaney, D. P. 1969. Lignocellulose in ruminant nutrition. *Advan. Chem. Ser.* 95:245-261.
- Sarkar, N. K. 1970. The effects of synthetic glucocorticosteroid (triamcinolone diacetate) and dibutyryl adenosine-3',5'-(cyclic) monophosphate on hepatic lipase activities in rats. *FEBS (Fed. Eur. Biochem. Soc.) Letters* 10:301-305.
- Sarkar, N. K. 1970. The changes in glucose production and the activities of aspartate and alanine aminotransferases in chicken livers as a function of age. *Life Sci. Part II Biochem. Gen. Mol. Biol.* 9:667-673.

- Sarkar, N. K. 1970. The variation in the activities of hepatic ribonuclease and ribonuclease inhibitor in chicken livers as a function of age. *Life Sci. Part II Biochem. Gen. Mol. Biol.* 9:675-681.
- Sauer, F., Erfle, J. D., and Binns, M. R. 1970. Turnover rates and intracellular pool size distribution of citrate cycle intermediates in normal, diabetic and ketotic rats estimated by computer analysis from specific activity decay data of ^{14}C -labeled citrate cycle acids. *Eur. J. Biochem.* 17:350-363.
- Voisey, P. W., and Hunt, J. R. 1969. The effect of compression speed on the behaviour of eggshells. *J. Agr. Eng. Res.* 14:40-46.
- Walton, K. G., Kervina, M., Dow, D. S., and Fleischer, S. 1970. Prolonged storage of mitochondria by freezing: Retention of respiratory control and energized swelling. *Bioenergetics* 1:3-8.
- Miscellaneous**
- Fahmy, M. H., and Hidioglou, M. 1970. Reproductive performance of purebred versus crossbred Shorthorn cows. *Canadex* 420.35.
- Forrest, R. J., and Lister, E. E. 1970. Meat production potential of dairy steers and bulls. *Can. Dep. Agr. Publ.* 1426.
- Gowe, R. S. 1970. Long-term selection for egg production in two strains of chickens. *Proc. Annu. Nat. Breeders Roundtable, Kansas City.* p. 64-88.
- Gowe, R. S. 1970. Animal Research Institute staff and program. *Anim. Res. Inst., Can. Dep. Agr.* 28 p.
- Heaney, D. P. 1970. Reliability of feeding value indices for evaluation of forage mixtures and between species comparisons. *Proc. XI Int. Grassland Congr.* p. 757-761.
- Hickman, C. G. 1969. Proposed cattle breeding program. *Canadex* 401.30.
- Hickman, C. G. 1970. Dairy cattle breeding research results. *Ont. Milk Prod.* 45(7):18, 20.
- Hickman, C. G. 1970. Factors affecting sire production proofs. *Proc. OAAB Seminar on cow indexing and sire evaluation systems for dairy cattle.* p. 29-41.
- Lee, A. J. 1970. Genetic differences between studs, regions and countries. *Proc. OAAB Seminar on cow indexing and sire evaluation systems for dairy cattle.* p. 60-61.
- Lee, A. J. 1970. Production record adjustments—challenges and opportunities. *Proc. OAAB Seminar on cow indexing and sire evaluation systems for dairy cattle.* p. 1-4.
- Lister, E. E. 1969. Feeding dairy steers. *Canadex* 420.50.
- Lister, E. E. 1969. Economics of all-concentrated Holstein-Friesian steers. *Canadex* 420.50.
- Lister, E. E., and Jordan, W. A. 1969. Over-fed beef cows. *Canadex* 440.60.
- Logan, V. S. 1969. Animal Research Institute Greenbelt Farm. *Anim. Res. Inst. Publ.* 44 p.
- Merritt, E. S. 1970. Length of incubation period of domestic goose eggs. *XIVth World's Poultry Sci., Madrid.* p. 270-273.
- Nagai, J. 1970. Dairy cattle improvement in Canada (in Japanese). *Anim. Husb.* 24:1550-1556.
- Peters, H. F. 1970. Production systems. *Proc. 2nd Annu. Sheep Conf., Brandon, Man.* 10 p.
- Peters, H. F. 1970. Performance testing of sheep. *Proc. 2nd Annu. Sheep Conf., Brandon, Man.* 12 p.
- Peters, H. F. 1970. Sheep production. *Canadex* 430.
- Robertson, H. A. 1970. A very early pregnancy diagnosis test for livestock. *Canadex* 400.30.

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M. D. SUTTON, B.A., M.A., Ph.D.	Bacteriophage and bacterial diseases

Electron Microscope Center

G. H. HAGGIS, B.Sc., Ph.D.	Electron microscopy
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M. K. POMEROY, B.Sc., M.Sc., Ph.D.	Frost resistance; biochemistry and cytology
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L. N. CHYKOWSKI, B.S.A., M.Sc., Ph.D.	Leafhopper-transmitted viruses
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Y. C. PALIWAL, B.S.A., M.Sc., Ph.D.	Transmission by aphids and microscopic vectors
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Departures

R. H. C. GAMBLE, B.Sc. Transferred to Plant Research Institute, June 1970	Administrative Officer
G. W. SKYRING, B.Sc., Ph.D. Resigned March 1970 <i>Transferred to Ottawa Research Station, April 1970</i>	Microbial selection and numerical taxonomy
P. K. BASU, B.Sc., M.Sc., Ph.D.	Bacterial diseases
W. C. JAMES, B.Sc., Ph.D.	Crop loss assessment
W. L. SEAMAN, B.Sc., Ph.D.	Editor, Canadian Plant Disease Survey; seed-borne diseases
J. T. SLYKHUIS, B.Sc., M.Sc., Ph.D.	Cereal viruses
V. R. WALLEN, B.Sc., M.Sc., Ph.D.	Seed- and soil-borne diseases

VISITING SCIENTIST

I. A. de la ROCHE, B.Sc., M.Sc., Ph.D. National Research Council postdoctorate fellow, seconded by arrangement with the University of Ottawa	Physiological genetics
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INTRODUCTION

The highlights of our research progress during 1970 are recorded in this report. Detailed information on these matters is readily available in the publications listed at the end of the report. The Institute supplies reprints on request.

Exciting new developments include: further evidence implicating changes in the cell membrane as being directly involved in the frost-hardening process, a new procedure for testing the freezing tolerance of seed, advances in the field of cryoprotectants, demonstration that myxin acts by the degradation of the deoxyribonucleic acid template itself in susceptible cells, and the establishment of scopoletin as a unique plant growth regulator.

An extension to the Electron Microscope Center was built and opened in the fall of 1970 to provide a properly integrated laboratory for use by all research scientists who require these facilities, regardless of whether they work locally or outside Ottawa.

A considerable amount of time was spent during the year on a thorough internal review of the Institute's research activities. A very significant redirection of the entire research program resulted. Sections were abolished, disciplinary subdivisions were eliminated, and common interest groups were established around four main programs. Larger and more active research units have emerged with no increase in staff.

The reorganization demanded the utmost in individual flexibility. I want to express my sincere appreciation to the scientific staff for their participation in the discussions and for the cooperative spirit that prevailed.

This report reflects the new internal organization, even though a few of the old programs were being completed during 1970.

R. M. Hochster
Director

AGRICULTURAL MICROBIOLOGY

Comparative and Ontogenetic Studies of Fungal Enzymes and Other Proteins

A comparative study of the isoenzyme patterns in six agaric species of Basidiomycetes demonstrated a multiplicity of isoenzymes ranging from seven major forms in *Coprinus micaceus* Fr. to 10 in *Agaricus hortensis* Cke. Several of these isoenzymes were identical, but several were electrophoretically distinct. A total of 18 different isoenzymes were obtained from among the six species examined. This wide range in molecular forms obtained for this enzyme introduces novel perspectives in the understanding of the structural and functional aspects of the enzyme complex. In addition, the six species had several electrophoretically similar proteins. Many proteins, however, were unique to each of the species studied.

Lysine constituted almost 50% of the total amino acids identified in an isolated sample of a low-molecular-weight (8,000 mol wt) isoenzyme. The sample protein contained 8.25% copper.

Studies with *Fusarium oxysporum*

Schlecht. indicated that the net yields of sterols were reduced by an inhibitor of cholesterol synthesis (ICS) obtained from the mitochondria of starved rats' livers, and by glycerol, 44% and 63% respectively.

An improved technique for staining precipitin (antibody-antigen complex) patterns in gel has been developed using dopa (DL-dihydroxyphenylalanine) as a precipitin specific "stain."

Metabolic Control of Pathogenic Fungi

Mitochondria of fungal pathogens that cause wilt diseases of crop plants have been isolated and specific, biosynthetic enzymes of the mitochondrial membrane are being examined as possible sites of metabolic control of these pathogens. One such enzyme, dihydroorotate-ubiquinone reductase, has been solubilized and purified several hundred fold. This enzyme catalyzes an important step in the synthesis of an essential component of nucleic acid. The purified protein contains flavin mononucleotide as a cofactor and transfers electrons only to quinone. Metabolic antagonists of these two types of

compounds are being investigated as possible control agents for fungi.

Marked differences in the thermal stability of dihydroorotate-ubiquinone reductases isolated from *F. oxysporum* and from *Neurospora* have been observed. The molecular basis of these differences is being investigated. Physical parameters such as temperature may provide additional means of controlling fungal pathogens.

Host-specific Toxins

Work in past years disclosed the basic chemical structures of the host-specific toxins of *Helminthosporium victoriae* Mehan & Murphy, *H. carbonum* Ullstrup, and *Periconia circinata* (Mangin) Sacc. Understanding of some of the finer points of structure as related to changes in attendant toxic properties has been advanced materially by these studies.

A study of the biosynthesis of host-specific toxins showed that this is only subject to general genotypic control and the actual toxin synthesized is subject to variations in the environment. This is one explanation for the remarkable adaptability of pathogens producing host-specific toxins when confronted with new hosts. Chemically inactivated toxin preparations have been found to counteract the toxicity of purified preparations of the host-specific toxins of *H. victoriae* and *P. circinata*. Such a finding may have potential use in treating the diseases produced by these pathogens.

The plant hormone antheridogen has been found to be organ-specific but not species-specific. This provides much needed knowledge about the mechanism of action of specific substances that control plant growth and development.

Taxonomy of Soil Coryneform Bacteria

The electrophoretic properties of eight dehydrogenases of 11 *Arthrobacter*, 3 *Agrobacterium*, and 3 *Rhizobium* cultures were studied. Comparisons of the dehydrogenase electrophoretic patterns were made on the basis of selected data. The overall similarities corresponded, in general, with groupings of these organisms found previously using numerical taxonomic procedures. Although a high degree of affinity between the arthrobacters and the rhizobia-agrobacteria seemed unlikely, the results for glutamic dehydrogenase, dihydroorotate dehydrogenase,

and to some extent those for lactic and malic dehydrogenases suggested that there may be some affinity not previously suspected. It was concluded that although these zymograms are useful for the characterization of microorganisms with known or presumed affinities, application of this technique in bacterial taxonomy is not simple. Also the zymogram technique is not easily applicable to large-scale screening of a number of different enzymes of large collections of cultures. It was thus concluded that results of analyses of original or edited data would be hard to interpret without more precise criteria of dehydrogenase homology.

Myxin and Membrane Synthesis in *Escherichia coli* 15T⁻

When actively growing cells of *Escherichia coli* 15T⁻ were treated with a high concentration of myxin (5 μ g/ml), cell division was inhibited and further growth ceased. After a 45-min exposure to the antibiotic, vacuolated areas appeared as the result of intracellular ramifications of the plasma membrane. The amount of involved membrane suggested continued synthesis of this structure in the presence of myxin (Stevenson, I. L. 1969. *Can. J. Microbiol.* 15:707-711). Radioisotope studies with ¹⁴C-acetate disclosed a greater incorporation of the label in isolated envelope fractions of the cells in the presence of myxin than in normally growing cells. It appears that with 5 μ g/ml myxin, membrane synthesis continues, but other biosynthetic systems responsible for growth and cell division are effectively inhibited.

Phage-typing of *Arthrobacter*

The possibility of developing a phage-typing system for identification and ecological studies of *Arthrobacter* species was investigated. Forty-two *Arthrobacter* phages were isolated from soil samples. The patterns of activity of each phage based on the sensitivity and resistance of 22 strains of *Arthrobacter*, representing 14 species, to both high titer and the routine test dilutions were determined. Twenty-one of the phage isolates were polyvirulent; the remainder were specific for strains of one species. Ten phage isolates selected from the 24 patterns of activity produced by the 42 isolates were selected to identify nine species of *Arthrobacter*. Repeated application of the phage-typ-

ing system indicated that the pattern of activity, and the titer and purity of plaque type of the phages were all unstable in storage. Consequently, the phages were of negligible value in the identification of the *Arthrobacter* species. Further examination of the 42 phage isolates indicated their instability with regard to plaque type, the production of mutants, alteration of lytic activity, and loss of virulence. In storage they declined rapidly in titer and lost their lytic activity. Exposure to chloroform for 4 hr reduced phage titers up to 1×10^2 ; after 5 days a loss of 75% of the titer was demonstrated. None of the named *Arthrobacter* strains used to test the phages were found to be lysogenic.

Strains of *Pseudomonas coronafaciens* (Ch. Elliott) Stevens, the cause of halo blight of oats, from the London, Ont., and Regina, Sask., areas were identified by phage-typing. The isolate from London was extremely virulent and spread rapidly when tested in experimental plots under natural conditions.

ELECTRON MICROSCOPE CENTER

Cryofracture

A variety of mouse tissues, lung, heart, kidney, myelinated nerve, and striated muscle have been examined by the technique of cryofracture. In this technique small pieces of tissue are frozen and fractured, and the fractured surfaces are examined after freeze-drying. At times this type of preparation appears to open up quite large crevices between cells. The outer surfaces of muscle cells, capillaries, myelin sheaths of nerves, and kidney tubule cells can be examined by this means.

The method also enables the inner surface of capillaries and the surfaces of the air spaces of the lung (alveoli, bronchioles) to be examined over larger areas than is possible in the comparable method of examination of frozen sections after drying.

The method has been used for the investigation of the larval gut of the spotted cutworm, *Amathes c-nigrum* (Linnaeus).

FROST HARDINESS AND DORMANCY

Winter Survival of Seed

Variability exists between dormoat strains in primary dormancy and in resistance to freezing stresses, but neither is sufficient to wholly explain the variability in winter survival between strains. Primary dormancy is reversible by gibberellic acid (GA), high O₂ levels, and low temperatures. When germination of seed does not occur after inhibition, a state of secondary dormancy is induced, which is characterized by complete or partial irreversibility by GA. The ability of dormoats to remain dormant in soil until winter is associated with the capacity of the strain for induction of secondary dormancy.

The ability to survive freezing is dependent upon low seed hydration. Seeds in which endosperm hydrolysis proceeds uncoupled from embryo germination imbibe water and are severely damaged by freezing in soil or under test conditions.

No capacity of seeds to harden against freezing in the manner of wheat crown tissue or bark tissue has been found in these strains.

A procedure for testing the freezing tolerance of dormant or nondormant seed samples has been developed.

Frost Hardiness in Response to Nutritional Restriction

Electron-microscopic studies of cytological changes that accompany the autumn development of restricted levels of frost hardiness in black locust bark tissues, which had been starved by isolation from nutrient supplies in late summer, indicated that augmentation of total protoplasm, which has previously been reported to occur during normal hardening, does not occur under these conditions. Starch reserves were depleted earlier in autumn than in normal tissues and the transition from cisterna-like, endoplasmic reticulum in summer to a vesicular form in winter was not as prevalent in cells from isolated tissues as in normal tissues. Lipid bodies increased markedly during autumn in cells from both normal and isolated tissues. Mitochondria appeared not to be as abundant in autumn cells of isolated tissues as in autumn cells of normal tissues, and the transition to more regularly shaped mitochondria during autumn hardening in normal cells was not as pronounced in cells from isolated tissues.

Dictyosomes were observed occasionally in cells from both normal and isolated tissues.

Monovalent Cations and Frost Hardening

It has long been known that monovalent cations increase both the permeability of membranes and the fluidity of protoplasm of plant cells. These qualities are among those that distinguish frost-hardy cells from non-hardened cells. Tests were made of the possible use of high potassium nutrition to induce frost hardiness. When Rideau winter wheat was grown under nonhardening conditions with Hoagland's nutrient solution and the latter was subsequently substituted by an isotonic solution of K_2SO_4 , the tolerance of the plants to freezing was raised significantly. This response was transient; the plants adapted over several days to the new conditions and reverted to the original susceptibility to frost. Temperature curves for stems during freeze tests exhibited one to several freezing points that were neither synchronized nor related to the stem's age or morphology. Synchronization of freezing was induced by a water continuum, wind, or fluctuation of temperature.

The Frost-hardening Reaction

In the current year, analytical studies conducted over an extended period on the broad changes in the polar lipids and phospholipids associated with frost hardening of black locust tree cells have been completed. The results demonstrated, under a wide variety of seasonal and growth-chamber conditions, a close and consistent association of increases in these polar lipids and phospholipids with an increase in frost hardening. These results, along with those of parallel ultrastructural studies performed with the electron microscope in the past few years, clearly and conclusively indicated that changes in the cell membrane must in some way be implicated in the mechanism of frost hardening. It was evident that an intensive and concerted effort was now needed to examine in detail and in depth all lipid and membrane phenomena connected with hardening at an analytical, physicochemical, and ultrastructural level. Such an effort is expected to lead to a new and improved understanding of the basic mechanism of frost hardening in plants.

The Rest Period of *Rhododendron* Flower Buds

The rest period of *Rhododendron* flower buds in culture was found to be the same as that of buds on intact plants. Under natural conditions the frequency distribution of the rest period of individual buds is bimodal in character. This bimodal distribution was also found when the plants were treated with a rest-breaking cold treatment. In culture, the rest period of buds follows the same pattern of development as buds on a plant even to the extent of the bimodal distribution. The absence of a response to nutrient supply, pH, or temperature variations clearly supports the earlier report that the mechanism controlling the rest period lies within each bud and is stable against changes in the environment. This system for studying the rest period is the first one of its kind and gives an excellent opportunity to study the rest period in a controlled system.

Scopoletin

The physical constants of a diphenol extracted from *Rhododendron* flower buds confirmed it as being scopoletin. Biochemical studies showed that unlike monophenols, scopoletin prevents the oxidation of the growth hormone indoleacetic acid by peroxidase. Biological assays of scopoletin showed that by itself, it has no effect on growth. But when assayed in the presence of indoleacetic acid, its effect can be either to promote or inhibit depending on the level of indoleacetic acid present or added to the growing tissue.

HOST-PARASITE RELATIONSHIPS

Mode of Action of Myxin on Bacterial Cells

It was shown previously that DNA was synthesized in T4 bacteriophage-infected 15T *Escherichia coli* cells after exposure to myxin. Now it was necessary to prove that this was T4 DNA and did not represent the release of bacterial DNA synthesis, which is completely blocked by myxin in uninfected cells. This DNA was isolated in a highly purified form using the Denhardt DNA-DNA hybridization technique and was suitably labeled with tritium. These findings support the thesis that myxin inhibition of DNA biosynthesis is not due to the destruction of

the following systems: energy metabolism, any of the deoxynucleoside kinases, RNA polymerase, or protein synthesis in general. Studies involving a brief exposure of normal cells to myxin, accompanied by the inhibition of protein synthesis, have shown that the lethal effect of myxin is not due primarily to the inhibition of DNA synthesis, but to the concomitant destruction of the DNA template itself. Under these conditions a short exposure to myxin in the presence of chloramphenicol appears to activate a DNA-degradative system, which can continue to function when myxin is removed if protein synthesis remains inhibited.

The concentration of myxin required to inhibit DNA synthesis in bacteria can be greatly reduced in the absence of bacterial cell walls. Work with protoplasts showed that even less than $2 \mu\text{g/ml}$ of myxin is sufficient to inhibit DNA synthesis and to degrade intracellular DNA. The concentration required to inhibit the metabolism of strain JG151 of *E. coli*, which does not carry an abortive phage, was found to be further reduced to $1 \mu\text{g/ml}$. This finding indicates that abortive phage induction is not involved in the myxin effect and shows the existence of large differences in sensitivity between strains.

Comparison of myxin effects with those of another DNA-inhibitory antibiotic, nalidixic acid, showed that the two drugs do not act at the same site in the cell.

Work with inhibitors of energy metabolism, sodium azide and 2,4-dinitrophenol, has indicated that myxin-induced degradation is an energy-dependent process.

Wheat Striate Mosaic Virus

The wheat striate mosaic virus (WSMV) was shown to be transmitted by a new vector *Elymana virescens* (F.), but fewer leafhoppers of this species became infective (23%) after an acquisition access period of 3 days than did *Endria inimica* (Say) (90%), a known vector of WSMV. In addition, the minimum incubation period of the virus was much longer in *E. virescens* (15–18 days) than in *E. inimica* (4–6 days). WSMV particles were observed in thin sections of various parts (leaves, sheaths, culms, awns, and roots) of infected wheat plants (*Triticum durum* Desf.). The particles were found in abundance in the cytoplasm and in the nuclei of both parenchyma and phloem cells. Three

types of WSMV particles were recognized: bacilliform ($250 \times 75 \mu\mu$), bullet-shaped ($200 \times 75 \mu\mu$), and long bacilliform ($415 \times 75 \mu\mu$). Such particles were observed also in extracts of infected leaves that had been infiltrated with glutaraldehyde to fix the virus in situ.

An antiserum against WSMV was prepared by using purified preparations of the virus. The titer of the antiserum was 160 and the minimum virus-antigen concentration detected was about $6.25 \mu\text{g/ml}$, as determined by the precipitin-ring test.

Clover Phyllody Disease

The development of disease in aster plants ceased when their roots were soaked for 24 hr in a solution containing 100 ppm of oxytetracycline, either before or after inoculation of plants by infective leafhoppers. Also, an examination of ultrathin sections of roots of infected plants that had been treated with the antibiotic as above showed that the membrane surrounding many *Mycoplasma* cells (the microorganism found associated with the disease) was broken and their ribosomelike structure had disintegrated. Leafhoppers, *Macrostelus fascifrons* (Stal), were unable to acquire clover phyllody agent from infected plants maintained in the antibiotic solution (100 ppm). Also, infective leafhoppers lost their ability to transmit the disease if they were exposed to oxytetracycline by allowing them to feed on plants maintained in the antibiotic solution.

Oxytetracycline was shown, by means of a sensi-disc bioassay technique, to be readily absorbed from solution by aster seedling roots and translocated to stems, petioles, and leaves. Healthy seedlings treated by root immersion for 24 hr in oxytetracycline solution (100 ppm) accumulated a significant amount of antibiotic in their aerial tissues. After the treated seedlings were repotted in natural soil, active antibiotic persisted in the plants for more than 2 weeks. Although the concentration of antibiotic in the aerial tissues gradually declined, a detectable quantity remained 18 days after treatment. It was also significant that healthy leafhoppers that were allowed to feed on aster seedlings maintained in oxytetracycline solution (100 ppm) accumulated active antibiotic in their bodies and the acquired amount was increased by extending the feeding period.

After the transfer of the leafhoppers from

the treated seedlings to healthy untreated plants, active antibiotic remained in their bodies for a period of 7 days after initial feeding. It was concluded that uptake and persistence of oxytetracycline in aster seedlings and in leafhoppers are directly correlated with: (i) prevention of clover phyllody disease in healthy plants either before or after inoculation by infective leafhoppers; (ii) remission of symptoms in diseased plants after antibiotic treatment; and (iii) failure of infective leafhoppers to transmit the disease after feeding on antibiotic-treated plants.

Antibiotics

Single treatments of newly inoculated asters with oxytetracycline HCl, tetracycline HCl, or doxycycline HCl applied at 1,000 ppm as 1-hr root dips, 3-min foliage dips, or foliage sprays resulted in twofold and threefold delays in symptom expression of clover phyllody and aster yellows respectively. Results with a concentration of 100 ppm, although less pronounced, were significant. Concentrations of 10 ppm were ineffective. Considerable phytotoxicity was encountered with the three antibiotics when they were applied as root dips at 1,000 ppm. Foliage applications were generally as effective as the root dips.

Clover Proliferation Disease

Transmission of the causal agent by the normally inefficient male leafhoppers, *M. fascifrons*, could not be increased by injecting the insects with inoculum. When adult male and female leafhoppers were given a 7-day acquisition access feed on infected asters and their alimentary canals were tested for relative causal agent concentration at various intervals, marked differences were found between the sexes. Infectivity was first detected in both males and females at 14 days. In males, infectivity decreased to a low level at 21 days and remained low at 28 days. In females, infectivity increased sharply by day 21 and then decreased by day 28. The increase in the concentration of the causal agent in the alimentary canal suggested that it multiplies in this organ in both male and female leafhoppers but to a lesser extent in males. Results also suggested that tissues of the male leafhopper are less susceptible to infection than are those of the female, which would explain the difference in transmission between the sexes.

Clover Phyllody and Aster Yellows Interactions

Infection of aster plants with the clover phyllody causal agent (CPCA) did not protect the plants against subsequent infection with a celery-infecting strain of aster yellows causal agent (AYCA), but symptom development was delayed. Infection with AYCA prevented subsequent infection with CPCA, and indicated that CPCA and AYCA are related. In some instances, both causal agents were recovered from dually infected plants.

Unidentified Clover Disease

Surveys during the early growing season of 1970 showed that this disease was present in approximately 80% of the clover fields examined in eastern Ontario. Only trace amounts were seen in most fields, but infections of up to 50% were observed in at least two fields. Natural infection has been observed in red, white, alsike, and zigzag clovers. The following plant species have been experimentally infected: strawberry cv. Cavalier, aster, periwinkle, carrot, sweet clover, and petunia.

Tomato Spotted Wilt Virus

A purification procedure for the Canadian isolate of the tomato spotted wilt virus (TSWV) was standardized. An antiserum (ring test end titer: 1/320) against the virus was developed mainly for use in attempts to detect the virus in the vector thrips and their internal organs. The tobacco thrips, *Frankliniella fusca* (Hinds), a vector of TSWV, was collected in 1970 at Renfrew, Delhi, Chatham, and Leamington. These Ontario thrips were found to be a heterogeneous mixture of vector and nonvector types; the vector type varied from 2% to 10% in a population. Ultrathin sections of inoculative *F. fusca*, upon examination in an electron microscope, disclosed spherical viruslike particles (60–80 nm diameter; similar in size to TSWV) throughout the gut tissues. The particles, occurring as large aggregates or as only a few particles in rows surrounded by a membrane, had a distinct 40-nm electron-dense nucleic acid core. The identity of these particles is being investigated.

Mechanism of Transmission of Cereal Viruses by Eriophyid Mites

Wheat streak mosaic virus (WSMV) is transmitted efficiently and in a persistent

manner by the mite *Aceria tulipae* (Keifer). Massive concentrations of the virus occur in the midgut and hindgut of the mites that are fed on infected leaves and then held on virus-free substrates. In an attempt to understand the mechanism of virus transmission by eriophyid mites, two nonvector systems were studied. Ultrathin sections of *A. tulipae* fed on plants infected with Agropyron mosaic virus (a virus morphologically identical and serologically related to WSMV) did not reveal any virus particles anywhere in the mite body, whereas sections of *A. tulipae* fed on plants infected with barley stripe mosaic

virus (BSMV) revealed large accumulations of BSMV particles as multilayered stacks and discrete bundles in the midgut and hindgut. The virus was also detected in the clarified homogenates of mites by serology and negative-contrast electron microscopy. It appears that a mite species may transmit a virus in a persistent manner only if: (i) the ingested virus is retained in sufficient concentration in the alimentary canal and is maintained in an ineffective state for a period of time, and (ii) the virus can complete a circulative cycle in the body of the mite by passing through membranes and reaching the salivary glands for inoculation into a plant.

PUBLICATIONS

Research

- Ahmed, M. E., Sinha, R. C., and Hochster, R. M. 1970. Purification and some morphological characters of wheat striate mosaic virus. *Virology* 41:768-771.
- Basu, P. K. 1970. Temperature, an important factor determining survival of *Corynebacterium michiganense* in soil. *Phytopathology* 60:825-827.
- Chiykowski, L. N. 1970. Notes on the biology of the leafhopper *Aphrodes bicincta* (Homoptera: Cicadellidae) in the Ottawa area. *Can. Entomol.* 102:750-758.
- Chiykowski, L. N., and Sinha, R. C. 1970. Sex and age of *Macrostelus fascifrons* in relation to the transmission of the clover proliferation causal agent. *Ann. Entomol. Soc. Amer.* 63:1614-1617.
- Madhosingh, C. 1970. A low molecular weight tyrosinase isoenzyme. *Life Sci. Part II (Biochem. Gen. Mol. Biol.)* 9:553-559.
- Madhosingh, C. 1970. Tyrosinase isoenzymes in six agaric species of Basidiomycetes. *Can. J. Microbiol.* 16:895-899.
- Miller, R. W. 1970. Estimation of labile sulfide content of cellular components. *Anal. Biochem.* 35:181-192.
- Miller, R. W. 1970. Reactions of superoxide anion, catechols and cytochrome c. *Can. J. Biochem.* 48:935-939.
- Paliwal, Y. C., and Sinha, R. C. 1970. On the mechanism of persistence and distribution of barley yellow dwarf virus in an aphid vector. *Virology* 42:668-680.
- Pomeroy, M. K., Siminovitch, D., and Wightman, F. 1970. Seasonal and biochemical changes in the living bark and needles of red pine (*Pinus resinosa*) in relation to adaptation of freezing. *Can. J. Bot.* 48:953-967.
- Pringle, R. B., and Scheffer, R. P. 1970. Production of amines similar to victoxinine by *Helminthosporium carbonum*. *Phytopathology* 60:565-566.
- Pringle, R. B. 1970. Interaction between antheridogens and fatty acids in fern spore germination. *Plant Physiol.* 45:315-317.
- Pringle, R. B. 1970. Chemical constitution of the host-specific toxin of *Helminthosporium carbonum*. *Plant Physiol.* 46:45-49.
- Rouatt, J. W., Skyring, G. W., Purkayastha, V., and Quadling, C. 1970. Soil bacteria: numerical analysis of electrophoretic protein patterns developed in acrylamide gels. *Can. J. Microbiol.* 16:203-205.
- Schneider, E. F. 1970. The rest period of *Rhododendron* flower buds. II. Studies on the rest period in tissue culture and *in situ*. *J. Exp. Bot.* 21:799-807.
- Sinha, R. C. 1970. *Elymana virescens*—a newly described vector of wheat striate mosaic virus. *Can. Plant Dis. Surv.* 50:118-120.
- Sinha, R. C., and Paliwal, Y. C. 1970. Localization of a Mycoplasma-like organism in tissues of a leafhopper vector carrying clover phyllody agent. *Virology* 40:665-672.
- Skyring, G. W., and Quadling, C. 1970. Soil bacteria: a principal component analysis and guanine-cytosine contents of some *Arthrobacter coryneform* soil isolates and of some named cultures. *Can. J. Microbiol.* 16:95-106.

- Skyring, G. W., Miller, R. W., and Purkayastha, V. 1970. Improved method for the characterization of bacterial dehydrogenases using acrylamide-gel disc-electrophoresis. *Anal. Biochem.* 36:511-520.
- Slykhuis, J. T. 1970. Factors determining the development of wheat spindle streak mosaic caused by a soil-borne virus in Ontario. *Phytopathology* 60:319-331.
- Stevenson, I. L. 1970. The effect of myxin on membrane synthesis in *Escherichia coli*. *Can. J. Microbiol.* 16:1249-1253.
- Sutton, M. D., and Wallen, V. R. 1970. Epidemiological and ecological relations of *Xanthomonas phaseoli* and *X. phaseoli* var. *fuscans* on beans in southwestern Ontario 1961-1968. *Can. J. Bot.* 48:1329-1334.
- Miscellaneous**
- Chiyskowski, L. N. 1970. Additional host plants of strawberry green petal (clover phyllody). *Rep. Comm. Hort. Res., Can. Hort. Council.* p. 2.
- Haggis, G. H. 1970. Cryofracture of biological material. *Proc. 3rd Annual Scan E. M. Symposium.* p. 97.
- Itz, S. 1970. An introduction to the electron microscope. *J. Biol. Photog. Ass.* 38:121-127.
- Schneider, E. F. 1970. The rest period of Azalea 'Redwing'. *Rep. Comm. Hort. Res., Can. Hort. Council.* p. 2.
- Siminovitch, D., Butler, J., Rheaume, B., and Lyall, L. 1970. An improved foam making vehicle for the application of foams for frost protection. *Rep. Comm. Hort. Res., Can. Hort. Council.* p. 3.
- Voisey, P. W., and Andrews, C. J. 1970. A cold hardiness cabinet. *Can. Agr. Eng.* 12(1):55-56.

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H. V. DANKS, B.Sc., Ph.D., 1968-70	Biology of overwintering
R. E. LEECH, B.Sc., M.Sc., Ph.D., 1970-71	Taxonomy of spiders (Araneida)
C. WILKINSON, B.Sc., A.R.C.S., Ph.D., M.I. Biol., 1970-71	Taxonomy and biology of leaf miners (<i>Stigmella</i> , <i>Nepticula</i>)

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INTRODUCTION

The Entomology Research Institute provides a national identification service for Canada on insects, arachnids, and nematodes. To meet this responsibility the Institute carries out extensive research in taxonomy, biosystematics, and faunistics. The Institute is also responsible for developing and curating the Canadian National Collections of Insects, Arachnids, and Nematodes.

During the year the review of the Institute that was started in 1969 was completed, new sections were organized, and the research program was revised. A projection of the Institute's activities through to 1975 was completed.

The Agricultural Entomology Section was transferred to the Ottawa Research Station, because its research activities do not directly relate to the primary functions of the Entomology Research Institute.

W. B. Mountain
Director

THE NATIONAL IDENTIFICATION SERVICE

There was a sharp increase in the use of the National Identification Service during the year. The number of specimens submitted for identification increased by more than twice.

During the year approximately 950 shipments of insects, arachnids, and other arthropods, comprising some 79,500 specimens, were received for identification. The Department of Agriculture submitted 207 shipments (22%) containing 14,280 specimens (17%) and the Department of Fisheries and Forestry submitted 172 shipments (18%) containing 26,790 specimens (33%).

Insect and other arthropod material identified and returned comprised of 71,500 specimens. The accompanying table shows the number of specimens identified, their various sources, and the distribution within the groups.

A total of 232 samples of soil and plants were submitted for extraction and identification of nematodes. Of these, 148 (63%) were from departmental research stations and universities, 68 (29%) from the Plant Protection Division of this department, and 16 (7%) from outside sources. About 6,000 specimens were identified.

Field Collections, Faunal Surveys, and Museum Travel

Field collecting in British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia added approximately 8,000 Coleoptera, 13,500 Diptera,

15,000 Hemiptera, 11,200 Hymenoptera, and 40,000 Acarina to the Collections.

The cutworm moth survey of western North America continued; some 6,000 specimens of Lepidoptera were collected in Montana and Oregon.

K. G. A. Hamilton, a graduate student who is specializing in Cicadellidae at the University of Georgia, conducted leafhopper studies at the Research Station, Summerland, B.C. He collected several thousand specimens of approximately 200 species. This work was undertaken by this Institute in cooperation with the research program at Summerland on virus diseases of cherry and other crops in the Okanagan Valley.

About 50,000 specimens, mostly Coleoptera, were collected in Brazil, Colombia, and Panama, and 7,000 specimens of Lepidoptera were collected in Japan.

Five scientists from the Institute visited the U.S. National Museum, Washington, the Philadelphia Academy of Sciences, and the Museum of Comparative Zoology at Harvard University to examine type specimens. Two lepidopterists visited the British Museum to study Pyralidae and larval Lepidoptera.

Members of the Nematology Section collected 162 soil and plant samples from specific surveys of Canadian agricultural areas. One of our nematologists visited the Osservatorio per le Maletti della Pianta, Pescara, Italy, to arrange for exchange of nematodes, especially the cyst-forming *Heterodera*.

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonaptera	Other insects	Acarina	Other arthropods	Totals
<u>Canada</u>											
Department of Agriculture	903	3,683	173	9,182	1,623	743	-	3,704	1,246	28	21,285
Department of Fisheries											
and Forestry	599	2,741	781	5,806	5,177	1,574	-	323	575	85	17,661
Other federal departments	29	2	1	-	23	3	7	237	15	5	322
Provincial departments	93	586	-	25	52	36	9	576	6	2	1,385
Industry	32	4	-	-	2	10	-	12	-	-	60
Universities	304	3,980	22	242	321	354	62	95	279	-	5,659
Private inquiries	1,492	150	26	16	339	55	-	1,903	22	293	4,296
<u>United States</u>											
Government departments	182	295	-	-	67	456	189	6	219	-	1,414
Universities	3,804	6,040	231	22	969	357	-	14	89	17	11,543
Private inquiries	481	59	22	12	86	353	-	28	-	-	1,041
<u>Other countries</u>											
	580	4,662	3	1,463	28	24	84	-	8	-	6,852
Total	8,499	22,202	1,259	16,768	8,687	3,965	351	6,898	2,459	430	71,518

RESEARCH

Coleoptera and Miscellaneous Orders

Manuals and handbooks. Work began on a handbook of the fleas of Canada, Alaska, and Greenland; a list of species was compiled, a key to genera was prepared, and some of the illustrations were completed. A handbook of the Scolytidae of Canada and Alaska was initiated, and some of the distribution maps were prepared.

Acarina. A study of the genus *Heterotarsonemus*, treating three species (one new) associated with bark beetles, and a review article on the relationships between mites and insects in forest habitats were published. A paper on three new species of ascid mites associated with forest insect pests and a paper on the conifer-feeding eriophyid genus *Nalepella*, including a key to the eight known species, were completed.

Coleoptera. Two papers on bark beetles, one describing a new species of *Dendroctonus* and the other designating a lectotype of *Pseudohylesinus sericeus* (Mann.), were published. Five comprehensive manuscripts were completed and are in press: five new species of *Megapenthes* of the Elateridae, with a key

to the 29 known nearctic species; a revision of the Alleculidae of the West Indies, with 70 species (55 new) in 11 genera (4 new); four new species and five new cases of synonymy of bark beetles from western North America; a revision of the Scolytidae and Platypodidae of Jamaica, including 43 species (26 new) in 29 genera; and a technical bulletin on the Scolytidae and Platypodidae of California, giving the known taxonomic and biological information for 171 species in 44 genera.

Siphonaptera. Three manuscripts, completed and in press, include descriptions of a new genus and species of flea from Tasmania, two new species and three new subspecies from Australia, and three species (two new) from southern Mexico.

Faunistics. A paper on the fauna of Coleoptera (125 species), Odonata (5 species), and Orthoptera (1 species) of Sable Island, N.S., with notes on zoogeographic affinities, was published; most of the species were new records for this island and some were new for Canada. The program of collecting and evaluating fossil insects in Canadian amber continues.

Comparative Morphology

During the year a major biosystematic study was started to elucidate some species complexes in cutworms, using morphological, biochemical, physiological, serological, cytological, and genetic techniques. Several similar, smaller projects on species complexes in tabanids and bumblebees are also under way. The eggs, larvae, and adults of several species are also being examined by these methods and techniques to determine useful taxonomic characters.

A rearing program using artificial food has been developed for 17 species of cutworms. All larvae are being reared individually, and eight of the species have produced their second generation. The electrophoretic patterns and the total protein content of the larval blood of *Amathes c-nigrum* (L.) have been determined; these results will serve as a base for similar determinations in other cutworm species. Examination of the pattern of spines on the cuticular lining of the pyloric region of the hindgut in lepidopterous larvae has shown that a basic pattern exists, but that considerable diversity occurs between species. The pattern in *A. c-nigrum* has been determined and is being compared with that in other cutworm species as a possible taxonomic character. A comparison of the larval hemocytes of five cutworm species has shown a distinct blood cell complex for each species. An examination of the sensillae and armature of the proboscis in many Lepidoptera, including several cutworm species, indicates that the proboscis has possible taxonomic value. The chorionic architecture of the eggs from several species of cutworms that were collected locally was examined by scanning electron microscopy, and the differences between congeneric species appeared to be sufficient for identification purposes.

The external morphology of the eggs from 62 species of lepidopterans representing 60 genera in 16 families were also examined to determine the inter- and intra-familial diversities and relationships of the chorionic architecture. Also, the eggs from 37 species of tachinids were examined for comparative analyses of the phenetic characters. Testes squashes for chromosome studies and spermathecae for morphological examination were obtained from 27 species of adult tabanids. The differences in spermathecal structure suggest that these organs may be of taxonomic value. The hemolymph protein

patterns of the larvae and adults of some species of *Chrysops* and *Tabanus* were more alike than either was like that of *Hybomitra*. The characterization of the karyotype of a colony of *Pyrobombus* (*C.*) *rufocinctus* (Cr.) as five metacentric and one dot chromosomes established a basis for comparison with other taxa of the *rufocinctus* complex; spermathecal structure also appears to be of taxonomic value in bumblebees. Examination of the distribution and innervation of the endocrine organs in three species of Diprionidae has revealed previously undescribed neurohemal organs in each thoracic and abdominal segment.

Work continued on the morphology and evolution of the insect abdomen. Special attention was given to the homologizations of the external genitalia between orders.

Diptera

Handbooks. About 120 drawings, six taxonomic keys, and texts for four families were contributed for the Manual on the Genera of North American Diptera. The project is now about one-fourth finished (target date 1975). Progress was made with handbooks on the genera of Ceratopogonidae, the Nearctic species of the black fly genus *Simulium*, the Canadian Chironomidae, the blowflies of Canada, and the larvae and pupae of flies that live under bark of trees.

Biting flies. A paper on the type specimens of 43 species of black flies described by Baranov was completed. A new species of prairie *Culicoides* was recognized.

Parasites and predators. The eggs and primary larvae of 90 species of Canadian Tachinidae were collected and compared to clarify generic relationships within the family. Twenty species (12 new) of bat flies were described and keyed. The taxonomy of chaemaemyiid predators of adelgids was advanced, and a key to the world species of *Neoleucopis* was prepared. A new sarco-phagid that parasitizes the spruce budworm was described. A paper dealing with 10 lonchaeid predators of bark beetles and weevils was completed.

Other Diptera. A review of world genera of Mydaeinae (15 genera, 5 new) and of the New Guinea species (62 species, 41 new) was completed. Descriptions of 17 species (5 new) of Mongolian Lauxaniidae, keys to 66 world genera and subgenera of dung flies,

and keys to 15 genera and 50 species of Piophilidae were prepared. The immature stages of 50 species of flies were associated with their adult stages by rearing.

Biosystematics. The blood proteins of larvae and adults of several species of horse flies were compared by serological techniques. A review paper on the habits and ecology of Chironomidae was completed, and the life history of an important Arctic species was analyzed.

New structure and functions. A paper on auditory mating responses in primitive flies was completed. Studies on the feeding habits of other primitive flies and moths revealed that adults of many species lick at dried honeydew on leaf surfaces; such a habit may have been important during the early evolution of these insects, antedating the flowering plants. The study showed that flower-visiting in many flies and moths is a secondary adaptation.

Faunistics. The first draft, including half the drawings, of a paper on the chironomids of Char Lake, N.W.T., was completed.

University collaboration. The research projects of Dr. S. Adisoemarto and Miss A. Soponis, postgraduate students at Carleton University, were supervised by Drs. D. M. Wood and D. R. Oliver, respectively. Dr. Adisoemarto has returned to Indonesia. The 4th International Symposium on Chironomidae was held in Ottawa and the proceedings, consisting of 30 papers, have been edited for publication.

Hymenoptera and Hemiptera

During the year, 22 papers were published or are in press. A comprehensive taxonomic treatment of the aphid subfamily Saltusaphidinae (49 species) is a valuable handbook because of its keys and illustrations. Descriptions of the Trogositidae of North America (58 species) were revised for the first time and published in a monograph. The bibliography of a monographic series on bumblebees of the Western Hemisphere was published. New species were described in smaller papers on Encyrtidae, parasitic Cynipoidea, *Bombus*, and Eulophidae. Two new monobasic genera were described in Eulophidae and two in Myrmaridae. The genus *Euderus* (25 species) in the Nearctic region was revised. A striking new subfamily of cynipid wasps of

uncertain affinities from the Orient was described. Parasitic Hymenoptera associated with animal carrion were surveyed. Five new species in the mirid genus *Trigonotylus* were described.

Lepidoptera and Trichoptera

Lepidoptera. A handbook on Canadian species of two tribes of the geometrid subfamily Ennominae was completed. All known stages of the 63 included species were described and illustrated, and maps show their geographic distributions. Many of the species are forest pests.

In the Pyralidae, a revision of the economically important corn borer genus *Ostrinia* was published. Twenty species, many consisting of several subspecies, were recognized. The keys, descriptions, and illustrations may be used to make identifications in this complex group.

A revision of the subfamily Midilinae was published; 45 species and the 7 genera to which they belong were defined.

A multivariate computer analysis of physical and biotic factors affecting the abundance and distribution of species of the cutworm genus *Euxoa* was completed. Temperature, rainfall, plant form, altitude, latitude, and sample size were considered in the analysis. Over 75% of the variance in species density in various habitats can be explained on the basis of the parameters employed. The primary factors governing distribution are apparently those of seasonal temperatures and rainfall.

Trichoptera. Work was started on a handbook of Canadian Trichoptera. There are about 600 species of caddisflies in the Canadian fauna. Descriptions, drawings, and keys were prepared for a section at the beginning of the handbook that deals with about 10% of the species.

Results of a taxonomic study of the large genus *Rhyacophila* were published. The phylogeny and distribution of the genus and other genera in the Rhyacophilidae are described in detail. A total of 157 new species and subspecies are described.

Nematology

Work began on illustrated taxonomic keys for the Hoplolaiminae, the Heteroderidae, and several genera in the Tylenchidae. Similar work began on a key to the world genera of plant-parasitic nematodes.

New information from morphometric studies of the more common species of the genera *Helicotylenchus* and *Rotylenchus* provides a basis for evaluation of presently used criteria for species separation and for classification of the Canadian fauna. A new lesion nematode, *Pratylenchus macrostylus* Wu, was described from British Columbia and Ontario. Several undescribed species of the pin nematode *Paratylenchus* and a ring nematode, *Criconemoides*, were found in surveys of cultivated areas of Ontario.

Paratylenchus projectus Jenkins was the most commonly found of the described species. Examination of cone tops and associated structures of *Heterodera* from exotic and Canadian sources revealed significant differences not previously recorded. This new information will provide the basis for an illustrated key to world species. Topotypes and agar-cultured specimens provided new information for the establishment of a neotype for a saprophytic nematode, *Eucephalobus striatus* (Bastian), and for assessment of the reliability of characters used in the taxonomy of species in this genus. A new genus, *Geraldus* (a saprophytic nematode), was established, diagnoses of the family Chambersiellidae and the genus *Chambersiella* Cobb were emended, and a new subfamily, Macro-laiminae, was created.

Examination of a stylet nematode, *Tylenchorhynchus dubius* (Butschli), by electron microscopy of the head, spear, and associated tissues, including the corpus and isthmus, and of the esophageal glands and the anterior part of the intestine provided new information about the character and transition of the inner lining of the esophagus, the gland ducts, and their orifices. This study provides a better understanding of the digestive processes in plant-parasitic nematodes and a sounder basis for morphological and phylogenetic comparisons within this and other genera.

Canadian and exotic species of *Pratylenchus* and *Meloidogyne hapla* Chitwood are being reared in the greenhouse and on callus plant tissue for biosystematic studies.

THE CANADIAN NATIONAL COLLECTIONS

The Canadian National Collection of Insects has been under the care of the Department since 1917, when the National Museum of Canada transferred the National Collection of Insects to the former Entomological Branch of the Department of Agriculture.

The Canadian National Collection of Insects is now one of the largest and best curated in the world. It contains about 10 million prepared specimens and more than 100,000 separate species.

In 1970 approximately half a million insects were added to the collection.

Acarina

About 40,000 specimens were collected from Alberta and about 8,000 mites were curated.

Coleoptera

About 50,000 beetles were collected from southern Ontario and Quebec, and 106,000 specimens were curated.

Diptera

About 125,000 specimens were curated. The Mesnil Collection of Tachinidae, one of the world's best collections of this family, was purchased. It consists of about 10,000 fully identified specimens, of which about 400 are holotypes, and it contains representatives of about 1,800 species, mostly Eurasian.

Hymenoptera, Hemiptera, and Homoptera

About 38,000 insects in these orders were collected and about 134,000 specimens were curated.

Lepidoptera

About 35,000 specimens (25,000 Noctuidae; 3,000 Geometridae; 2,000 Pyralidae; and 5,000 Microlepidoptera) were curated.

Trichoptera

The Schmid Collection of Himalayan Trichoptera constituting 115,000 specimens and including 275 holotypes and 5,000 allotypes and paratypes was purchased.

Miscellaneous Orders of Insects

The collection of lice, Anoplura and Mallophaga, was arranged in systematic order and about 2,000 slides of accumulated material were identified to genus and species and incorporated into the name collection, which now contains about 250 species. Curation of other miscellaneous orders concentrated on dragonflies, stoneflies, and grasshoppers; approximately 2,000 specimens of these were added to the collection by collecting, exchange, and purchase. The Aradidae in the Canadian National Collection were curated and one new species was described.

The Canadian National Collection of Nematodes is much more recent and smaller in size than the Canadian National Collection of Insects. It was established in 1954. The Collection contains about 150,000 specimens. Plant-parasitic groups are most strongly represented with 187 species, soil-inhabiting forms 105 species, predaceous soil nematodes 68 species, marine forms 197 species, and insect parasites 11 species.

During 1970 approximately 7,000 specimens were curated, and 20,000 were processed in glycerin and stored in vials for future study.

PUBLICATIONS

Research

- Anderson, R. V., and Hooper, D. J. 1970. A neotype for *Cephalobus persegnis* Bastian, 1865, redescription of the species, and observations on variability in taxonomic characters. *Can. J. Zool.* 48:457-469.
- Arnold, J. W. 1970. Haemocytetes of the Pacific beetle cockroach, *Diploptera punctata*. *Can. Entomol.* 102:830-835.
- Baker, A. D., and Sanwal, K. C. 1969. Some notes on nomenclature (Nematoda). *J. Helminthol.* 43:263-266.
- Barron, J. R. 1970. A new species of *Copidosoma* (Hymenoptera: Encyrtidae) parasitizing larvae of *Anacamptis innocuella* (Lepidoptera: Gelechiidae). *Can. Entomol.* 102:1337-1339.
- Barron, J. R. 1970. A new species of *Psyllaephagus* (Hymenoptera: Encyrtidae) parasitizing *Aphalara steironemicola* (Homoptera: Psyllidae) on *Steironema ciliatum*. *Can. Entomol.* 102:1509-1512.
- Boch, R., Shearer, D. A., and Petrasovits, A. 1970. Efficacies of two alarm substances of the honey bee. *J. Insect Physiol.* 16:17-24.
- Bright, D. E. 1970. A note concerning *Pseudohylesinus sericeus* (Coleoptera: Scolytidae). *Can. Entomol.* 102:499-500.
- Byers, J. R., and Wilkes, A. 1970. A rickettsialike microorganism in *Dahlbominus fuscipennis* (Zett.) (Hymenoptera, Eulophidae): observations on its occurrence and ultrastructure. *Can. J. Zool.* 48:959-964.
- Corbet, P. S. 1969. Terrestrial microclimate: amelioration at high latitudes. *Science* (Washington) 166:865-866.
- de Ruelle, R. 1970. A catalogue of types of Coleoptera in the Canadian National Collection of Insects. *Mem. Entomol. Soc. Can. No. 72*:1-134.
- Doutt, R. L., and Yoshimoto, C. M. 1970. Hymenoptera: Chalcidoidea: Mymaridae of South Georgia, in Subantarctic Entomology, particularly of South Georgia and Heard Island. *Pac. Insects Monogr.* 23:i-iv, 1-374.
- Downes, J. A. 1970. The feeding and mating behavior of the specialized Empidinae (Diptera): Observations on four species of *Rhamphomyia* in the High Arctic and a general discussion. *Can. Entomol.* 102:769-791.
- Freeman, T. N. 1970. A new species of *Cameraria* on Bur Oak in Manitoba (Gracillariidae). *J. Lepidopt. Soc.* 24:86-87.
- Furgala, B., and Boch, R. 1970. The effect of Fumidil B, Nosemack and Humatin on *Nosema apis*. *J. Apicult. Res.* 9(2):79-85.
- Gochnauer, T. A. 1970. The possibilities and problems of package bees. *Amer. Bee J.* 110:52-53.
- Gochnauer, T. A., and Hamilton, H. A. 1970. Disinfection of honeybee combs by gamma irradiation. I. American foul brood disease. *J. Apicult. Res.* 9(2):87-94.
- Guppy, J. C., and Harcourt, D. G. 1970. Spatial pattern of the immature stages and general adults of *Phyllophaga* spp. (Coleoptera: Scarabaeidae) in a permanent meadow. *Can. Entomol.* 102:1354-1359.
- Guppy, J. C., and Miller, C. D. F. 1970. Identification of cocoons and last-instar larval remains of some hymenopterous parasitoids of the armyworm, *Pseudaletia unipuncta*, in eastern Ontario. *Can. Entomol.* 102:1320-1337.

- Hamilton, K. G. A. 1970. The genus *Cuerna* (Homoptera: Cicadellidae) in Canada. *Can. Entomol.* 102:425-441.
- Harcourt, D. G. 1970. Crop life tables as a pest management tool. *Can. Entomol.* 102:950-955.
- Hardwick, D. F. 1970. A generic revision of the North American Heliiothidinae (Lepidoptera: Noctuidae). *Mem. Entomol. Soc. Can. No.* 73:1-59.
- Hardwick, D. F. 1970. The biological status of "*Heliothis stombleri*". *Can. Entomol.* 102:339-341.
- Hardwick, D. F. 1970. The genus *Euxoa* (Lepidoptera: Noctuidae) in North America. I. Subgenera *Orosagrotis*, *Longivesica*, *Chorizagrotis*, *Pleonectopoda*, and *Crassivesica*. *Mem. Entomol. Soc. Can. No.* 67:1-175.
- Hardwick, D. F. 1970. The life history of *Eutricopis nexilis* (Noctuidae). *J. Lepidopt. Soc.* 24:151-156.
- Hardwick, D. F. 1970. The life history of *Pyrrhia exprimens* (Noctuidae). *J. Lepidopt. Soc.* 24:234-239.
- Hardwick, D. F. 1970. The life history of *Schinia florida* (Noctuidae). *J. Lepidopt. Soc.* 24:282-287.
- Hinks, C. F. 1970. The neuro-endocrine organs in adult Noctuidae. *Can. J. Zool.* 48:831-835.
- Hopper, B. E. 1970. *Diplolaimelloides brucei* n. sp. (Monhysteridae: Nematoda), prevalent in marsh grass, *Spartina alterniflora* Loisel. *Can. J. Zool.* 48:573-575.
- Hopper, B. E. 1970. Free-living marine nematodes from Biscayne Bay, Florida, III. Eurystominiidae: *Pareurystomina bissonettei* sp. n. from Biscayne Bay and other locations. *Proc. Helminthol. Soc. Wash.* 37(2):175-178.
- Hopper, B. E., Meyers, S. P., and Cefalu, R. 1970. Microsporidian infection of a marine nematode, *Metoncholaimus scissus*. *J. Invertebr. Pathol.* 16:371-377.
- Howden, H. F. 1970. Jamaican *Cyrtinus*, with descriptions of two new species (Coleoptera: Cerambycidae). *Can. Entomol.* 102:1312-1316.
- Howden, H. F. 1970. Jamaican Scarabaeidae: Notes and descriptions (Coleoptera). *Can. Entomol.* 102:1-15.
- Howden, H. F. 1970. The Coleoptera, p. 1-30. *In* Fauna of Sable Island and its zoogeographic affinities. *Nat. Mus. Natur. Sci. Publ. in Zool. Vol.* 4.
- Howden, H. F. 1970. The genus *Paragnorimus*, with descriptions of two new species (Coleoptera: Scarabaeidae). *Can. Entomol.* 102:1385-1389.
- Hudson, A. 1970. Factors affecting egg maturation and oviposition by autogenous *Aedes atropalpus* (Diptera: Culicidae). *Can. Entomol.* 102:939-949.
- Hudson, A. 1970. Notes on the piercing mouthparts of three species of mosquitoes (Diptera: Culicidae) viewed with the scanning electron microscope. *Can. Entomol.* 102:501-509.
- Kelton, L. A. 1970. Four new species of *Trigonotylus* from North America (Heteroptera: Miridae). *Can. Entomol.* 102:334-338.
- Kelton, L. A., and Knight, H. H. 1970. Revision of the genus *Platylygus* Van Duzee, 1915, with descriptions of twenty-six new species. *Can. Entomol.* 102:1429-1460.
- Lindquist, E. E. 1969. Mites and the regulation of bark beetle populations. *Proc. 2nd Int. Congr. Acarol., Sutton Bonington (England), 19th-25th July, 1967. Section VIII, Biological Control. Akad. Kiado, Budapest, p.* 389-399.
- Lindquist, E. E. 1970. Relationships between mites and insects in forest habitats. *Can. Entomol.* 102:978-984.
- Lindquist, E. E. 1970. Review of the genus *Heterotarsonemus* (Acarina: Tarsonemidae). *Can. Entomol.* 102:812-829.
- MacKay, M. R. 1970. Lepidoptera in Cretaceous amber. *Science (Washington)* 167:379-380.
- Martin, J. E. H. 1970. The Odonata and Orthoptera, p. 31-33. *In* Fauna of Sable Island and its zoogeographic affinities. *Nat. Mus. Natur. Sci. Publ. in Zool. Vol.* 4.
- Masner, L. 1970. A new species of *Nixonia* Masner (Scelionidae, Hymenoptera) from Rhodesia. *Proc. Entomol. Soc. Wash.* 72:90-93.
- Matsuda, R. 1970. Morphology and evolution of the insect thorax. *Mem. Entomol. Soc. Can. No.* 76:1-431.
- McAlpine, J. F. 1970. First record of Calypterate flies in the Mesozoic era (Diptera: Calliphoridae). *Can. Entomol.* 102:342-346.
- McAlpine, J. F. 1970. Identities of Lonchaeid flies described by Kertész, with notes on related species (Diptera: Lonchaeidae). *Can. Entomol.* 102:442-453.
- McAlpine, J. F., and Morge, G. 1970. The identity, distribution and biology of *Lonchaea zetterstedti* Becker with notes on related species (Diptera: Lonchaeidae). *Can. Entomol.* 102:1559-1566.

- McGuffin, W. C. 1970. The immature stages of *Scopula ancillata* (Hulst) (Geometridae). J. Lepidopt. Soc. 24:54-55.
- Meyers, S. P., Hopper, B. E., and Cefalu, R. 1970. Ecological investigations of the marine nematode *Metoncholaimus scissus*. Marine Biol. 6:43-47.
- Miller, C. D. 1970. The Nearctic species of *Pnigalio* and *Sympiesis* (Hymenoptera: Eulophidae). Mem. Entomol. Soc. Can. No. 68:1-121.
- Milliron, H. E. 1970. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae). Mem. Entomol. Soc. Can. No. 65:1-52.
- Milliron, H. E. 1970. *Pyrobombus* (P.) *cascadensis*, an undescribed species of bumblebee from the Pacific Northwest, U.S.A. (Hymenoptera: Bombinae). Can. Entomol. 102:382-383.
- Mukerji, M. K., and Guppy, J. C. 1970. A quantitative study of food consumption and growth in *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). Can. Entomol. 102:1179-1188.
- Mukerji, M. K., and Harcourt, D. G. 1970. Spatial pattern of the immature stages of *Hylemya brassicae* on cabbage. Can. Entomol. 102:1216-1222.
- Mulvey, R. H., and Dickerson, O. J. 1970. *Miconchus kansasensis* n. sp. (Mononchidae: Nematoda) from Kansas, United States. Can. J. Zool. 48:231-234.
- Munroe, E. G. 1970. A new genus and three new species of Chrysauginae (Lepidoptera: Pyralidae). Can. Entomol. 102:414-420.
- Munroe, E. G. 1970. New species of *Syllepsis* Poey (Lepidoptera: Pyralidae: Pyraustinae), with a key to known species. J. Lepidopt. Soc. 24:287-291.
- Munroe, E. G. 1970. Revision of the subfamily Midilinae (Lepidoptera: Pyralidae). Mem. Entomol. Soc. Can. No. 74:1-94.
- Munroe, E. G. 1970. Types of Nymphulinae, Scopariinae, Cybalomiinae, Odontiinae, Evergestinae, and Pyraustinae (Lepidoptera: Pyralidae) in the Zoological Institute, Academy of Sciences of the U.S.S.R., Leningrad, with selections of lectotypes. Can. Entomol. 102:1025-1035.
- Munroe, E. G., and Mutuura, A. 1970. Contributions to a study of the Pyraustinae (Lepidoptera: Pyralidae) of Temperate East Asia. IX. Can. Entomol. 102:294-304.
- Munroe, E. G., and Mutuura, A. 1970. Contributions to a study of the Pyraustinae (Lepidoptera: Pyralidae) of Temperate East Asia. X. Can. Entomol. 102:1489-1507.
- Mutuura, A., and Munroe, E. 1970. Taxonomy and distribution of the European corn borer and allied species: Genus *Ostrinia* (Lepidoptera: Pyralidae). Mem. Entomol. Soc. Can. No. 71:1-112.
- Oliver, D. R. 1970. Designation and description of lectotypes of the six Greenland Orthoclaudiinae (Diptera, Chironomidae) described by Lundbeck in 1898. Entomol. Scand. 1:102-108.
- Peterson, B. V. 1970. The identities of three closely related western species of *Prosimulium* (Diptera: Simuliidae). Can. Entomol. 102:118-128.
- Peterson, B. V. 1970. The *Prosimulium* of Canada and Alaska (Diptera: Simuliidae). Mem. Entomol. Soc. Can. No. 69:1-216.
- Peterson, B. V., and Maa, T. C. 1970. A new *Lipoptena* from Chile, with a key to the New World species (Diptera: Hoppoboscidae). Can. Entomol. 102:1117-1122.
- Peterson, B. V., and Maa, T. C. 1970. A new species of *Basilia* (Diptera: Nycteribiidae) from Colombia. Can. Entomol. 102:1519-1523.
- Peterson, B. V., and Maa, T. C. 1970. One new and one previously unrecorded species of *Basilia* (Diptera: Nycteribiidae) from Uruguay. Can. Entomol. 102:1480-1487.
- Richards, W. R. 1970. *Aphalara steironemicola*, a new psyllid collected on *Steironema ciliatum* in Ontario (Homoptera: Aphididae). Can. Entomol. 102:1508-1509.
- Richards, W. R. 1970. A revision of the Palaearctic *Iziphya*, with a key to the world fauna (Homoptera: Aphididae). Can. Entomol. 102:213-225.
- Richards, W. R. 1970. *Iziphya grandipes*, a new aphid from Ontario (Homoptera: Aphididae). Can. Entomol. 102:496-498.
- Richards, W. R. 1970. *Tuberculatus spiculatus*, a new aphid from Mexico (Homoptera: Aphididae). Can. Entomol. 102:107-109.
- Richards, W. R., and Kumar, R. 1970. *Myzcallis aptera*, a new *Berberis* infesting aphid from India. Can. Entomol. 102:116-118.
- Schmid, F. 1970. Considerations sur le male d'*Ornithoptera allottei* Rothschild et sur la phylogenie des Ornithoptères. J. Lepidopt. Soc. 24:88-105.
- Schmid, F. 1970. Le genre *Rhyacophila* et la famille des Rhyacophilidae. Mem. Entomol. Soc. Can. No. 66:1-230.
- Schmid, F. 1970. Quelques Thaumaleides nouvelles ou peu connues (Diptera, Thaumaleidae). Natur. can. 97:499-510.

- Schmid, F. Sur quelques *Apsilochorema orientaux* (Trichoptera: Hydrobiosidae). Tijdschr. Entomol. 7:261-271.
- Schmid, F. 1970. Sur quelques sous espèces d'*Ornithoptera victoriae* Gray (Papilionidae). Natur. can. 97:467-475.
- Shearer, D. A., Boch, R., Morse, R. A., and Laigo, F. M. 1970. Occurrence of 9-oxododec-2-enoic acid in queens of *Apis dorsata*, *Apis cerana*, and *Apis mellifera*. J. Insect Physiol. 16:1437-1441.
- Teskey, H. J. 1970. A review of the genus *Glutops* Burgess (Diptera: Pelecorhynchidae) with descriptions of four new species. Can. Entomol. 102:1171-1179.
- Teskey, H. J. 1970. The immature stages and phyletic position of *Glutops rossi* Pechuman (Diptera: Pelecorhynchidae). Can. Entomol. 102:1130-1135.
- Thomas, J. B., and Bright, D. E. 1970. A new species of *Dendroctonus* (Coleoptera: Scolytidae) from Mexico. Can. Entomol. 102:479-483.
- Timbers, G. E., and Danks, H. V. 1970. A liquid-nitrogen operated chamber for insect super-cooling studies. Can. Entomol. 102:90-94.
- Wu, L. Y. 1970. Genus *Ottolenchus* n. rank and *Ottolenchus sulcus* n. sp. (Tylenchidae: Nematoda). Can. J. Zool. 48:249-251.
- Yoshimoto, C. M. 1970. A new Eulophid parasite (Hymenoptera: Chalcidoidea) from eggs of the nursery pine sawfly *Diprion frutetorum* (Hymenoptera: Tenthredinoidea). Can. Entomol. 102:908-910.
- Yoshimoto, C. M. 1970. A new Ibaliid wasp from North America (Hymenoptera: Cynipoidea, Ibaliidae). Can. Entomol. 102:1196-1198.
- Yoshimoto, C. M. 1970. A new species of *Astichus* Forster (Hymenoptera, Eulophidae) associated with the birch bracket fungus, *Polyporus betulinus*, and woody fungus *Ganoderma applanatum* in Eastern Canada. Can. Entomol. 102:656-659.
- Yoshimoto, C. M. 1970. A new species of *Tetrastichus* (Hymenoptera, Eulophidae) parasitizing pupae of *Sesamia inferens* Walker (Lepidoptera, Noctuidae). Can. Entomol. 102:1607-1609.
- Yoshimoto, C. M. 1970. A new subfamily of Cynipoidea from Nepal (Hymenoptera). Can. Entomol. 102:1583-1585.

Miscellaneous

- Downes, J. A. 1970. Biogeographic field study. Review of *The Kodiak Island Refugium* Karlstrom and Ball [ed.] Science (Washington) 167:1242-1243.
- Munroe, E. G. 1970. Book review. A short history of the browntail moth, by William Curtis. Can. Entomol. 102:640.
- Oliver, D. R. 1970. The 4th International Symposium on Chironomidae. Chironomus 1:63-74.

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INTRODUCTION

In 1970 the Food Research Institute adopted a new internal organization. For administrative purposes and to give each employee a home base, disciplinary sections were established. These sections supply personnel for our programs; teams of research scientists work together to achieve the goals and objectives set by the Institute. Each of our programs is designed to meet one of our objectives.

During the year, the rape team developed an alternative procedure for preparing rapeseed flour. By this new method the hulls are separated from the meats before the extraction steps are performed. Knowledge of the carbohydrates, lipids, phenolics, and proteins of rapeseed was also advanced.

Research conducted by the dairy team produced more information on skim milk lipoproteins, the thermal gelation of milk protein, and the flavor and technology of Cheddar cheese. Nonsterile milk puddings were developed from the product concept stage, through the formulation and consumer acceptance stages, to the final presentation of information to the dairy industry.

In the meat program progress was made in measuring the interconversion of multiple forms of beef myoglobin.

Our special research program was designed to provide assistance to outside agencies, which this year included the Ottawa Research Station, the Production and Marketing Branch, the Canadian International Development Agency, and private industry. Research activities that are nearing completion, and therefore do not merit individual programs, are also described in the section Special Research Program.

R. P. A. Sims
Director

RAPSEED PROGRAM

Rapeseed Flour and Meal

A procedure for producing rapeseed flour for human consumption was developed. Special disks were designed for the attrition mill, and a suitable air-classifier was built to separate the rapeseed hulls from the kernels. The same procedure that was developed previously for producing glucosinolate-free flour and meal was then followed with the hull-free seeds. The resulting rapeseed flour was lower in fiber content than flour prepared by the original procedure. This new flour was compared with soy flour for use in preparing baked goods and meat patties, and was found to be equal to the soy flour in the preparation of several products.

Rapeseed Carbohydrates

Fractionation of coat-free, oil-free, oligosaccharide-free, and essentially protein-free polysaccharides from rapeseeds on DEAE cellulose (borate form) yielded, *inter alia*, a water-eluted fraction, which, based on its

sugar components (glucose:xylose:galactose:arabinose 16:6:3:1), characteristic iodine staining properties (blue stain), $[\alpha]_D$ value (+88°), and infrared spectrum (absorption bands at 895, 965, 755, 945, 1630, and 2900 cm^{-1}), appeared to be analogous to the group of polysaccharides currently designated as seed amyloids.

The rapeseed amyloid was found to be homogenous in the ultracentrifuge. Methylation and periodate oxidation data showed that the molecule had a branched structure with an average unit made up of 25 sugar residues consisting of nine terminal, nonreducing end groups, comprising three residues of D-galactose, five of D-xylose, and one of D-glucose. There were eight residues of D-glucose at which branching (through the 4- and 6-positions) occurred in the polysaccharide. The remaining eight nonterminal residues consisted of two (1→6)-linked D-glucose, one (1→2)-linked D-xylose, and five (1→4)-linked D-glucose residues. Methylation data also showed that arabinose was not an integral part of the amyloid and probably arose from a small proportion of an arabinan or an arabinogalactan contaminant. By analogy with other amyloids and based on its

infrared spectrum and its resistance to the action of amylases, it was assumed that the glycosidic bonds in the polysaccharide were predominantly of the *B*-D-type.

Fractionation of nonamyloid polysaccharides from DEAE cellulose (borate form) was achieved on DEAE cellulose (carbonate form). The latter technique, developed by this Institute, was found to be extremely useful for further fractionation of the complex rapeseed polysaccharide mixture, which after purification on DEAE cellulose (phosphate form), yielded a pure acidic arabinogalactan.

Rapeseed Phenolics

The presence of polymeric phenols in the seed coat of *Brassica campestris* L. cv. Echo has been established, and these may be classed as tannins of a flavonoid nature. The phenolic composition of the kernels is not easily characterized, but more low molecular weight substances were found in that part of the seed than in the coats. Both coats and kernels contain oligomeric and probably monomeric flavan 3,4-diols and other flavonoids.

Gallotannins and ellagitannins were not found in rapeseed extracts. Hydrolysis of extracts and eluates did not reveal the presence of gallic, ellagic, caffeic, isoferulic, and *p*-coumaric acids. A catechinlike substance was found in the kernel extracts that was hard to identify, but it may be the cause of discoloration during the preparation of protein isolates or concentrates from rapeseed meal.

Rapeseed Protein

An improved method for estimating total N in rapeseed products was developed, and a method for determining rapeseed protein in solutions of N-containing denaturants is under study.

In preliminary solubilization experiments, the inclusion of disulfide-reducing agents in the extraction medium was shown to markedly affect the protein molecular weight distribution.

Dehulled hexane-extracted rapeseed flour produced a green color in alkali. When incorporated into alkaline dough or batter, it also turned green. The baked products, however, were tan colored. Acetone extraction of the flour removed the green characteristic.

Alkali solubilization of rapeseed flour produced very dark solutions and subsequently

dark protein isolates. Acetone extraction, alone or with additions of disulfide-reducing agents, before alkali solubilization yielded markedly lighter extracts and gave pale yellow protein isolates. The lightest colored protein isolates were derived from the treatments containing disulfide-reducing agents. The protein isolates contained no detectable isothiocyanates, and 0.01 mg/g or less of goitrin.

Lipids of Yellow Sarson

Seed grown in Saskatchewan was investigated. It contained 40% lipid, most of which was triglyceride. The following distribution of erucic acid among the lipids was found: nonpolar lipids of the free (hexane-extractable) lipid and the bound (chloroform-methanol-extractable) lipid were high in erucic acid (40%); the polar bound lipid was low in erucic acid (6%) and the polar free lipid was intermediate (30%). The polar components of the bound lipid were similar to those found in other *Brassica* species, whereas the polar free lipid was different; its main components were phosphatidyl choline and phosphatidyl ethanolamine.

DAIRY PROGRAM

Cheddar Cheese Flavor

Volatile flavor components. In flavor research extreme care must be taken to avoid losses of components due to absorption in the gas-liquid chromatography (GLC) column and to minimize the effects of tailing on column resolution. Columns packed with a silylated support, coated with OV101 or OV225, showed minimum absorption of components essential to Cheddar cheese aroma. They were tested by trapping the total GLC effluent, and the aroma of the effluent was confirmed as similar to that of the original cheese distillate.

Silylation of cheese distillates or fractions trapped from GLC effluents reduced the tailing of polar compounds and improved the resolution. Trapped fractions were silylated in the trap in a closed system. For reference, GLC and mass spectral data were obtained on 40 trimethylsilyl derivatives.

Fruity flavor defect. This most common and serious flavor defect in Canadian Cheddar cheese is evident as subtly different, but

closely related, aromas. To identify the components responsible for this defect, a computer program was designed to pinpoint GLC peaks related to fruitiness. Techniques were also developed for analyzing many different types of cheese aromas with the use of modified headspace sampling and GLC.

Bitter and astringent flavor defects. Isolation of astringent peptides from Cheddar cheese is accomplished by extraction with chloroform-methanol (2:1) followed by the addition of water to create two phases. The interface between these layers contained insoluble material, which, when it was collected, revealed properties similar to the astringent material dissolved in the aqueous methanolic phase.

Astringent peptides, after preservation by freeze-drying, required treatment at acid pH to restore the astringent flavor.

Control of Bacteriophage

Four cows vaccinated in the udder with phage vaccine developed high phage-neutralizing titer in their milk. In two cows, the titer decreased rapidly, but in the other two it persisted. However, these latter two cows showed symptoms of mastitis and their milk yield declined. Because of the results, these vaccination experiments were discontinued.

Cultures of lactic streptococci were successfully treated with spermine and homologous phage races to produce phage-resistant strains. It was necessary to modify Erskine's procedure and to incubate the phage and spermine with the culture for 30 min, then transfer 1% to fresh media and incubate overnight at 22 C.

Milk-coagulating Enzymes

A mixture of rennet and hog pepsin is the chief enzyme preparation used to make Cheddar cheese in Canada. By the use of the established techniques of Linklater and of Shovers and Kornowski, the pepsin content of rennet was found to be significant (5-15%). Determination of rates of inactivation at pH 7 to 8 of commercial rennet and of rennin indicated the presence of an enzyme or enzymes (probably bovine pepsin) that was more easily denatured than rennin but was more stable than hog pepsin. Preliminary results with pH inactivation suggested that commercial rennet samples contained substantially lower amounts of rennin than

were indicated by the older tests. A small cheesemaking trial of four comparisons indicated no major differences in texture and flavor between cheeses made with rennet preparations containing low and high levels of rennin.

Lipoproteins in Skim Milk

The defects of sediment, poor quality, and slow acid production in making cottage cheese were shown previously to be affected by homogenization-labile components in skim milk, possibly lipoproteins. Lipoproteins were thereby isolated from skim milk by preparative ultracentrifugation in sodium bromide solutions. Three lipoproteins were observed in the analytical ultracentrifuge in the high-density class with the major component sedimenting at 8.5 S. Two lipoproteins were also observed in the low-density class.

Thermal Gelation of Milk

The gelation of suspensions of skim milk powder was studied under a wide range of conditions. During gel preparation, the addition of small amounts of commercial shortenings was necessary to prevent excessive foaming. Because gel firmness is one of the most important characteristics, factors affecting firmness were studied in detail by using a penetrometric method devised for this purpose. The measurements were made at a constant temperature to allow for modest temperature dependence of gel firmness. Firmness decreased as total solids decreased, at gelation temperatures above or below 100 C, and when oxidizing agents or Ca-binding compounds were present; moderate reducing agents increased gel firmness.

Milk Puddings

Formulations for nonsterile milk puddings were developed for a wide range of flavors. Small taste panels of 20 people showed a high level of acceptability. A larger consumer panel of 213 housewives, conducted by a company of consultants, also indicated good acceptability.

Commercially available puddings were found to vary widely in their physical characteristics of viscosity and firmness. To tailor the locally made puddings to meet consumer requirements, factors found to influence viscosity, firmness, "spoonability," and physical

stability were studied. Type and concentration of starch, type and concentration of stabilizers, and temperatures and times of cooking were shown to be important.

SPECIAL RESEARCH PROGRAM

Potatoes

Carbohydrate constituents. In continuing studies of composition in relation to processing quality, the cold-water-soluble fractions of Netteed Gem potatoes grown in four eastern and four western locations were examined. Fractionation on carboxymethyl cellulose gave two fractions: the major fraction was eluted by water, the minor by sodium chloride solution. The former was further fractionated on DEAE-cellulose to give a water fraction, and a major and a minor fraction were eluted by borate and by sodium chloride respectively. The water fraction appeared to be mainly a neutral galactan, though some glucose contamination remained. The borate and salt fractions appeared to be acidic arabinogalactans. Partial separation from material absorbing at 280 μ was achieved. The salt fraction eluted from carboxymethyl cellulose, surprisingly, was found to contain small amounts of polysaccharide, apparently mainly araban. Pronase digestion of this material produced, in low yield, fractions containing mainly arabinose and small amounts of galactose, glucose, and a uronic acid.

A general requirement in analyzing pectin-containing foodstuffs is the determination of methyl ester content. A new, simple method applicable to small amounts of material has been developed. Following saponification, methyl esters may be determined directly without distillation. The method may be used to monitor directly pectin methyl esterase activity.

Efficiency of maleic hydrazide. The requirement for applying large amounts of maleic hydrazide (MH) to potato vines for adequate sprout control prompted an investigation of the possible reasons. Analysis of vines and tubers revealed some counteracting forces. In tubers containing the usual MH complement (25-35 ppm), the MH was evenly distributed throughout. Most of the MH was not located at the growth site and

therefore it was ineffective. Inhibition appeared to depend on higher deposits at the buds. When field application was increased, the proportion in the skin of the tuber increased.

Analyses of material after high applications revealed the formation of an analogue of MH in the leaves. The occurrence of the analogue appeared to reduce the supply of MH available to the tuber. This derivative was separated from MH by paper chromatography and was tentatively identified as a glucoside. A compound that seemed to be identical with this derivative was isolated from treated bean leaves.

Frozen Storage of Tomatoes

The suitability for freezing seven varieties of tomatoes grown by the Ottawa Research Station was examined. Loss of color and textural changes were observed during storage of fruit frozen with liquid N and stored at -5 F and -50 F.

Lycopene and β -carotene contents were determined periodically during storage. No noticeable change in either compound was detected at -50 F. At -5 F the lycopene content was significantly lower after 1 month and remained at about the same level for the duration of the storage period. The β -carotene content did not change significantly.

Two lines of the tomatoes were rated as promising for preservation by freezing on the basis of color stability during storage and texture after thawing.

Apples

Inheritance of chemical constituents. The type of inheritance involved in relation to chemical composition of apples is not well understood. It would be of value to know whether, for selected constituents, the type is additive, with predictable results, and therefore a highly desirable type; dominant, which, though requiring examination of large populations, is still quite useful; or apistatic, which has no definite pattern.

In cooperation with the Ottawa Research Station, leaf samples were collected from a large number of year-old seedlings of crosses between scab-resistant selections and cultivars. The total phenolic content was determined, and two-dimensional chromatograms were run to separate the phenols. No evidence of a consistent pattern was found in any of the phenol data. However, inspection

of the chromatograms showed that the five cultivars used in the crosses had a fairly high content of a phenol tentatively identified as (-)-epicatechin, whereas the four scab-resistant selections and the seedlings showed little or none.

Scab resistance. Malus floribunda Sieb. and some of its crosses show considerable resistance to the scab organism, *Venturia inaequalis* (Cke.) Wint. This apple species contains in addition to phloridzin, which is the principal phenolic compound in the leaves of the cultivars, a closely related compound, sieboldin. A quantity of this compound was isolated from the leaves of *M. sieboldii* Rehd. and tested in vitro on *Venturia* spores. Respiration and growth of the spores in vitro were slightly increased, indicating that sieboldin does not seem to be involved in scab resistance.

Byssoschlamys nivea

The stimulation of respiration of ascospores of *B. nivea*, a heat-resistant spoilage organism of canned fruits and vegetables, by acetate ion and heat shock was confirmed. Absence of acetate resulted in very low levels of respiration and germination, regardless of heat shock treatments. Cu ion at 0.01 M concentration reduced respiration to a negligible level. Earlier indications of stimulatory effects by certain other cations were not substantiated. Examination of 12 species for cellulolytic activity by the use of viscosimetric techniques showed little activity in most strains. Slight activity was shown by two strains. All 12 isolates had extensive pectolytic activity.

The Multiple Myoglobins of Beef Muscle

Further research was undertaken to determine the significance of the multiple occurrence of myoglobin to meat color quality and to physiological function. Sampling muscles before or after the onset of rigor mortis and preventing glycolytic pH decrease did not appear to affect relative distribution of the three myoglobin fractions, previously reported in this study.

Electrophoretic resolution of the three isomers was improved by adapting the technique of isoelectric focusing to acrylamide cylinders. Quantitation of resolved fractions was improved by using spectrophotometric scanning rather than densitometry. The gels

were scanned in quartz tubes and without staining.

Eating Quality of Large White Turkeys

In cooperation with the University of Guelph, a study was made of the eating quality of large white turkeys, as influenced by age and sex. Toms were killed at 17, 19, 21, 22, 23, 25, and 27 weeks and hens at 14, 16, 17, 18, 19, 21, and 24 weeks of age. Comparisons were made among ages within sexes, and across sexes at selected ages. In all, 136 birds were used.

Flavor, tenderness, and juiciness were evaluated using the paired comparisons method by an experienced sensory evaluation panel. Tenderness was also determined using a modified Warner-Bratzler shearing device.

Flavor and tenderness ratings in both the males and females decreased during the age periods immediately preceding the appearance of secondary sex characteristics. These changes in eating quality closely paralleled the changes in feed conversion, fleshing, and finish in the same birds. There was no appreciable difference in eating quality between sexes except that 27-week-old males were juicier than 24-week-old females. The panel results showed a positive correlation among the three sensory characteristics that were assessed.

Mayonnaise Formulation

At the request of a Canadian exporter to Japan, the manufacture of mayonnaise containing rapeseed oil was examined to obtain maximum physical and chemical stability. The variations in components included different types of vinegar, egg products, and oil. Oil from the seed of *Brassica campestris* L. (Echo variety for moderate erucic acid content, and Oro for zero erucic acid content) was used, and corn oil was the control.

A formula and manufacturing procedure was developed for a rapeseed oil mayonnaise that was quite acceptable to a taste panel and was a better consistency than Canadian and Japanese brands tested. After 3 months of storage at 55 F, all laboratory samples maintained a stable emulsion.

Protein-enriched Noodles

At the request of the Canadian International Development Agency a wheat-based noodle product with added nonfat milk powder was developed to provide a food aid item of superior nutritive value and good eating quality. Three types of flour (spring wheat,

durum, and durum clears) were used singly or blended. Taste panels compared the noodles with control batches of plain noodles made with the same equipment. No major changes in processing were needed to produce a very acceptable noodle with up to 15% added dry milk, provided the flour was made from durum wheat. Samples were supplied to CIDA.

PUBLICATIONS

Research

- Elliott, J. A., and Emmons, D. B. 1970. The detection of rennin in cheese with the passive indirect hemagglutination test. XVIII Int. Dairy Congr. 1E:296.
- Emmons, D. B. 1970. Inactivation of pepsin in hard water. J. Dairy Sci. 53:1177-1182.
- Emmons, D. B., and Beckett, D. C. 1970. Control of pH during cutting and cooking in manufacturing Cottage cheese. XVIII Int. Dairy Congr. 1E:335.
- Emmons, D. B., Petrasovits, A., Gillan, R. H., and Bain, J. M. 1970. Cheddar cheese made with rennet and pepsin. XVIII Int. Dairy Congr. 1E:294.
- Fejer, S. O., Johnston, F. B., Spangelo, L. P. S., and Hammill, Madeleine M. 1970. Ascorbic acid in red raspberry fruit and leaves. Can. J. Plant Sci. 50:457-461.
- Johnston, F. B., Kenkars, E., and Nunes, A. C. 1970. Starch and dry matter content of Netted Gem in relation to French-fry texture. Amer. Potato J. 47(3):87-93.
- Kalab, M. 1970. Factors affecting the Ellman determination of sulfhydryl groups in skim milk powder and gels. J. Dairy Sci. 53:711-718.
- Larmond, Elizabeth, Moran, E. T., Jr., and Kim, C. I. 1970. Eating quality of two basic breeds of broiler chickens and their crosses. Can. Inst. Food Technol. J. 3:63-65.
- McGugan, W. A., and Howsam, Shirly G. 1970. Techniques for the isolation and identification of Cheddar cheese volatiles. XVIII Int. Dairy Congr. 1E:300.
- McKillican, Mary E., and Larose, J. A. G. 1970. Residual lipids of hexane-extracted rapeseed meal. J. Amer. Oil Chem. Soc. 47:256-258.
- Moran, E. T., Jr., Orr, H. L., and Larmond, Elizabeth. 1970. Dressing, grading and meat yields with broiler chicken breed. Food Technol. J. 24(1):73-78.
- Moran, E. T., Jr., Orr, H. L., and Larmond, Elizabeth. 1970. Production efficiency, grades and yields with the large white turkey as related to sex and age. Poultry Sci. 49:475-493.
- Poapst, P. A., Durkee, A. B., and Johnston, F. B. 1970. Root-differentiating properties of some glycosides and polycyclic phenolic compounds found in apple and pear fruits. J. Hort. Sci. 45:69-74.
- Poapst, P. A., and Genier, C. 1970. A storage disorder in Kennebec potatoes caused by high concentrations of maleic hydrazide. Can. J. Plant Sci. 50:591-593.
- Poapst, P. A., Genier, C., and Schnitzer, M. 1970. Effect of soil fulvic acid on stem elongation in peas. Plant Soil 32:367-372.
- Siddiqui, I. R. 1970. The sugars of honey, p. 285-309. In R. S. Tipson and D. Horton [ed.] Advances in carbohydrate chemistry and biochemistry. Vol. 25. Academic Press, New York.
- Tape, N. W. 1970. Application of microwave energy in food manufacture. Can. Inst. Food Technol. J. 3:39-43.
- Tape, N. W., Sabry, Z. I., and Eapen, K. E. 1970. Production of rapeseed flour for human consumption. Can. Inst. Food Technol. J. 3:78-81.
- Wood, P. J., Siddiqui, I. R., Vandermeer, J. W., and Gochnauer, T. A. 1970. Carbohydrates of *Nosema apis* spores. Carbohydr. Res. 15:154-158.

Miscellaneous

- Aref, M. M. 1970. Low temperature preservation of foods. Can. Food Ind. 41(12):39-41.
- Emmons, D. B., Larmond, Elizabeth, and Beckett, D. C. 1970. Milk-based puddings and custards could open profitable new markets for dairies. Modern Dairy 49(3):17-21.

Kenkars, E., and Tape, N. W. 1970. Method of manufacturing French-fries. Can. Pat. 853,636 Oct. 17 Canadian Patents and Development.

Sims, R. P. A. 1970. Gambling on goodness. Can. Food Ind. 41(6):50-52.

Tape, N. W. 1970. Princess or urchain. Agr. Inst. Rev. 25(3):15-17.

Tape, N. W. 1970. Rapeseed—Canada's soybean. Can. Food Ind. 41(5):45-49.

Tape, N. W. 1970. The dehydration of foods and some new methods of drying. Can. Food Ind. 41(8):29-31.

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A. N. BURDETT, B.Sc., Ph.D. Resigned August 1970	Floriculture
C. FRANKTON, B.Sc., Ph.D. Retired November 1970	Chenopodiaceae, Cardueae, weeds

VISITING SCIENTIST

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INTRODUCTION

Our Agrometeorology staff has developed competence in the use of computer techniques for interpreting data and preparing maps for publication. A network for gathering data on soil moisture, now in operation, is expected to be useful in many aspects of agricultural research.

The taxonomic methods developed for Hyphomycetes were extended to all groups of fungi, and to the algae, mosses, and ferns in a series of stimulating and provocative papers by Dr. S. Hughes. This will undoubtedly stimulate research in biosystematics and phylogeny of many plant groups.

A new weed, wild garlic (*Allium vineale*), was discovered in southern Ontario. Since wild garlic is a serious weed in Australia, parts of Europe, and the United States, weed-control specialists will be interested in knowing that it has now spread to Canada.

Dr. B. R. Baum participated in the Departmental oat-collecting expedition to the Middle East during the spring and early summer months. A seed collection of more than 2,000 accessions of wild and cultivated oats was made and herbarium specimens were collected from 600 sites. Both collections are being utilized in Dr. Baum's monographic studies and in the breeding and cytogenetic studies of other Research Branch workers on the genus *Avena*.

Our intensive efforts to determine the cause of premature wilting of cut roses has been rewarded by the discovery of both the cause and the means of prevention of this important problem.

Dr. J. W. Groves died May 6, 1970. His distinguished career as a mycologist in the Department was recognized at home and abroad.

Dr. C. Frankton retired in November. In addition to making outstanding contributions to Canadian botany, he achieved a career marked by characteristic service to others.

Allan Chan
Director

AGROMETEOROLOGY

Instrumentation

The sampling system and associated instrumentation for flux measurements of CO₂ and other gases by the eddy correlation technique have been perfected. This technique has been used to measure short-term net photosynthesis and evapotranspiration of corn. The results may well lead to improved crop-weather models.

Computer Techniques

A promising and possibly unique cartographic procedure for lettering and drawing geographic details, by use of the Grebber flat-bed plotter, onto reduced computer maps plotted by the SYMAP program has been completed, and now provides effective maps suitable for publication. A soil moisture data-gathering network is now operational and computerized listings of the verified data will be distributed regularly, in spring and fall, soon after the samples have been taken.

Model Development

A biomathematical model that provides quantitative information concerning the effects of three environmental parameters on the daily growth or production of economic crops has been developed and successfully tested. An estimator that uses standard climatic data to record monthly soil temperatures at six depths is nearing completion. Barley biometeorological time scale equations together with similar techniques as proposed by G. W. Robertson, of this Institute, have been developed to assess climatic resources for maturing this crop throughout Canada, particularly on the Great Plains.

Applications

Some 17 maps dealing with moisture patterns and frost dates across Canada on a 1:2 million scale suitable for country-wide comparisons have been completed. One of these maps shows a climatic moisture index that expresses May-to-September rainfall as a percentage of potential crop-water demand. This index has been used, with other criteria,

for soil classification purposes in the Soil Climatic Map of Canada prepared by the Soil Research Institute. The Section continues to provide information, advice, and documentation on both a national and international level, and assists in the coordination of climatic programs for the Canada Land Inventory. Staff members again contributed to position papers dealing with two topics, freezing temperatures and farm weather services, which were prepared for the Canada Committee on Agricultural Meteorology.

MYCOLOGY

Taxonomic Research

Phycomycetes. Studies on the morphology and physiology of soil and other chytridiaceous fungi have been directed to the finding of new and usable criteria for their classification and identification in culture. One new species of *Phlyctochytrium* and two varieties of a *Rhizophydium* species have been described. Studies on the transmission of wheat spindle streak mosaic virus, performed in cooperation with the Ottawa Research Station, have shown that the zoosporic fungus *Polymyxa graminis* Led. is the likely vector.

Basidiomycetes: rusts and smuts. Studies of 22 Eurasian and 21 North American rusts of Cardueae were published. New study methods disclosed many new taxa and made it possible to assess the potential of such rusts for biological control. A paper on methods of study of the rust fungi was completed. A study of the 13 species of *Gymnosporangium* found in Western Canada, and parasitic on Cupressaceae and Rosaceae, has been completed. The study supports earlier work with "eastern" species by showing that the aecial development period is a useful one for distinguishing rust species that are morphologically alike. Attention has been drawn to *G. haraeaeum*, which is occasionally brought into Canada on junipers from Japan.

Basidiomycetes: Hymenomycetes. The third part of a series, titled "The Genus *Merulius*" was published. The microscopic features of type specimens for 21 species proposed by Peck and Schweinitz were presented, in some instances for the first time. Recently completed manuscripts dealing with an additional 52 names proposed in *Merulius* are to be published as the final parts, IV and V, of

this series. Comparative studies of cultures of species of *Merulius* and *Phlebia* have been completed, and detailed descriptions have been prepared from the types of 30 species of *Coniophora*. In addition, because of our field work, and the contributions of other workers, a large bank of *Coniophora* cultures has been assembled for critical study of the cultural characters of these species. Studies have been made on herbarium material of *Papulaspora*, *Melanospora*, and *Burgoa* collections and dried cultures and on about 40 isolates in culture. Growth characteristics have been recorded and photographed; development of various kinds of bulbils and sclerotia has also been observed. A quick test has been discovered for distinguishing the poisonous mushroom *Lepiota molybdites* (G. Meyer ex. Fr.) Sacc. from similar but edible mushrooms in the *L. brunnea-rhacodes* group. Ammoniacal Congo red stains all spores of the latter group, but leaves the mature spores of *L. molybdites* largely unstained.

Ascomycetes: Discomycetes. A fungus isolated from the mycorrhiza of *Picea mariana* was grown in culture on various media, under controlled temperature and light. In this environment the isolate produced mature apothecia with four-spored asci, and it has been described as a new species of *Martininia*. Approximately 100 specimens of discomycetes in the DAOM herbarium collected in northern Canada since 1954 have been critically examined. They include specimens from 11 families, 31 genera, and 52 species.

Ascomycetes: Pyrenomycetes. "Black mildews" of the families Asterinaceae and Meliolaceae, which occur on conifers in Canada, were investigated and described. The fungi concerned are *Appendiculella pinicola* (Dearn.) Pirozynski & Shoemaker on members of the Pinaceae, *Asteridiella pitya* (Sacc.) Mansf. on *Taxus*, and *Maurodothina farrae* Pirozynski & Shoemaker on *Abies*. Ascus initiation and development in the pyrenomycete *Platyspora pentamera* (Karst.) Wehm. and results from a light and electron microscope study of *Venturia inaequalis* (Cooke) Wint. in Thüm. (causing scab of apples) have been described. The examination, identification, and illustration of some Pleosporaceae on brome has been completed, and revision of the *Ophiobolus* species in Canada is nearly complete.

Fungi Imperfecti. The ontogeny of conidia is important in the taxonomy of Fungi Imperfecti and is one of the primary characters used in the delimitation of form genera. A consideration of the methods whereby gemmae develop in bryophytes and pteridophytes reveals a remarkable parallel with those of conidia in Fungi. This has necessitated a review of current ideas on conidium development and a reevaluation of the stress laid upon certain features in this process. Spore ontogeny in Uredinales was considered in the light of those methods of conidium development in other Fungi. Accordingly, pycnospores are phialoconidia, aeciospores are meristem arthroconidia, and urediniospores are sympodioconidia. Teliospores are produced either as terminal chlamydospore-like cells, or develop successively as sympodioconidia or meristem arthroconidia. It is concluded that teliospore ontogeny should play a greater part in the circumscription of genera. *Seimatosporium ledi* Pirozynski & Shoemaker, which causes leaf spot of *Ledum groenlandicum* in Canada, was described and compared with related species parasitic on leaves of *Ledum* spp. and cultivated rhododendrons in North America. An interesting coelomycete found on twigs of *Abies* in British Columbia was described as *Comatospora suttonii* Pirozynski & Shoemaker gen. et sp. nov. and compared with related European and North American fungi. Several species of *Circinotrichum* (including *C. papakurae* sp. nov.) and *Gyrothrix* (including *G. verticillata* (Goidanich) comb. nov.) collected in New Zealand were described.

ORNAMENTAL PLANTS

Winterhardiness

Biotelemetry. Biotelemetric studies with roses and evergreens showed that the electric resistance (impedance) of roots and shoots increased as the seasons advanced from late summer to autumn and winter. Previous studies showed that such changes in impedance indicated cold hardening capacity of tissues. Increases in the impedance of roots were not as great as in shoots and the impedance of roots and shoots of evergreens was consistently higher than those of roses. Simultaneous readings of temperatures of air, soil, and plants indicated interrelation of these temperatures.

Turf Grass

Characteristics of Kentucky bluegrass cultivars. Growth characteristics of four Kentucky bluegrass cultivars were obtained from greenhouse experiments. Stem length, number of nodes per tiller, internodal length, and lengths of upper leaf sheath and leaf blade were significantly different for varieties. Nugget and Fylking, strains of northern latitudes, were taller, and had shorter leaf sheaths and upper leaf blades than Merion and Windsor, strains of more southern latitudes. Nugget and Fylking produced many side shoots, which grew almost as long as the initial tiller, whereas Merion and Windsor produced few or sometimes no side shoots. The presence of cataphylls on the side shoots indicated that the shoots were true rhizomes and not tillers.

Rose Breeding

Insect resistance in seedlings of Rosa rugosa. One group of seedlings grown from seeds of *R. rugosa* collected in Abaskiri, on the Japanese island of Hokkaido, showed high resistance to aphids and mites. Another seedling, from open-pollination seed of the *R. rugosa* hybrid Blanc Double de Coubert, which had been grown beside other roses that were heavily infested with aphids and sawfly, showed no infestation. The sawfly was identified as *Ardis brunniventris* Hartig.

Keeping Quality of Cut Flowers

Protein breakdown in cut flowers. The protein breakdown in cut flowers was determined by acrylamide gel electrophoresis. With aging, the amount of protein decreased and the units appeared to be smaller. Kinetin treatment tended to maintain the integrity of leaf proteins.

Extending life of cut roses. Just before he left the Institute Dr. Burdett found that premature wilting of cut roses coincided with deposition of an unidentified material that plugged the conducting vessels in the stems. His work was continued by Dr. Parups and Dr. Chan and a formulation consisting of several chemicals was found to be much more effective than commercial preservatives. By the end of 1971 a patent for this formulation will be sought.

Evaluation and Introduction of Ornamental Plants

Evaluation of 750 woody plants, 540 herbaceous perennials, 454 bulbous, cormous, and tuberous plants, 495 garden annuals and related plants, and 46 outdoor chrysanthemums were made in 1970.

The annuals selected for intensive testing were cultivars of 375 *Petunia*, 20 *Phlox drummondii*, and 28 *Ageratum*. Compared with those observed in 1966-67, all showed improved form and color.

In cooperation with the Canadian Nursery Trades Association and the Canadian Ornamental Plant Foundation, eight new ornamental plants that have originated at the Plant Research Institute are being propagated for introduction under 'Project 73' to celebrate the 50th Anniversary of the Canadian Nursery Trades Association.

VASCULAR PLANT TAXONOMY

Taxonomic Studies

Work on the development of a classification and information system for oat (*Avena*) cultivars on a world-wide scale is continuing with the processing by computer techniques of macro- and micro-morphological data derived from 5,000 samples of oat cultivars and strains grown in Ottawa. In the course of the micro-morphological studies, hydathodal pores on grass lodicules were discovered for the first time. The collection and organization of data for a register of pedigrees of oat cultivars is nearing completion, and records of more than 3,000 cultivars are now included in the system. The "phylogenetic" information derived from the pedigrees has been compared with existing systems of oat classification and with the one being developed, but in no case is there a close match. For this reason and because of the nature of the various genealogies, it is concluded that there must be two independent goals: the classification and identification of cultivars on the one hand and the elaboration of phylogenies on the other.

Systematic studies of the thistle subtribe Cardueae (family Compositae) were completed with the study of the genus *Saussurea*. A monograph on the Cardueae of Canada is in advanced stage of preparation.

Biosystematic studies on wind-pollinated

families are continuing with revisions of the *Atriplex subspicata* and *A. nuttallii* (Chenopodiaceae) complexes. In *A. subspicata* Rydb. the somatic chromosome numbers of both 36 and 54 have been recorded. *Atriplex aptera* A. Nels. ($2n = 36$) was shown to be closely related to *A. nuttallii* Wats. ($2n = 18$). Attention has been drawn to the wide distribution of the recently recognized weed species *A. oblongifolia* Waldst. & Kit. in southern British Columbia and Alberta, and to its possible spread to other areas of Western Canada.

Cytotaxonomic studies were carried out on *Draba glabella* and its close allies in Canada and Alaska, and valuable taxonomic data were obtained from scanning electron microscope examinations of pollen grains and basal leaf hairs.

A new yellow-flowered species of *Draba*, *D. kananaskis* G. A. Mulligan ($n = 32$), was described from the Kananaskis Range in southwestern Alberta. This new species may be endemic in an area unglaciated during the Wisconsin.

A study of the breeding behavior of members of the genus *Draba* shows that *D. oligosperma* is apomictic over most of its range but that some plants occurring within a small area in Montana are probably sexual. Canadian material of 15 other species of *Draba* was shown to be self-compatible and usually automatically selfed. Evidence has been presented to indicate that outcrossing occasionally occurs in these species, and moreover, that some outcrossing due to self-incompatibility exists in species occurring farther south in North America.

A biosystematic study of *Cannabis* (marijuana, hemp) was begun because of the increasing demand for basic knowledge of the biology of this drug and fiber plant. Over 200 seed stocks have been obtained from around the world, and plants from these are being examined morphologically, physiologically, and chemically in cooperation with the Pharmaceutical Chemistry Division of the Department of National Health and Welfare.

The taxonomic revision of the wild clover species of North America is continuing and work is now completed on the *Trifolium eriocephalum* complex. This work has led to the description of two new subspecies and a detailed account of the geographical distribution of the taxa of the complex. Studies are

continuing on the remaining species of *Trifolium* in the section *Lupinaster*.

Floristic Studies

In pursuance of items on the International Biological Program (CCIBP-CT), six sites in the District of Mackenzie were evaluated for possible preservation. Much valuable material was gathered, and it is being used in the preparation of the *Flora of the Continental Northwest Territories*. Continuing studies on detailing the distributional ranges of Canadian species now concentrate on *Euphorbia*, *Spiranthes*, and the plants of British Columbia. Work on an illustrated brochure of 50 spring wild flowers of the National Capital Region is almost completed.

Weeds

In annual, biennial, and caespitose-perennial weeds, self-fertilization and in a few instances agamospermy were found to be factors that help to make them successful as weeds. On the other hand, perennial weeds that can persist and spread in disturbed habitats by their powers of vegetative reproduction were found to be self-incompatible. A plant received at the Plant Research Institute for identification in September 1970 provided a first report of wild garlic, *Allium vineale* L., occurring as a weed in Canada. The plant was collected on a farm 4 to 5 miles west of St. Catherines, Ont. Long recognized as a serious weed of wheat and forage fields in the United States and elsewhere, it is apparently common and spreading in the area of this collection and has since been identified in material sent for identification from Fisherville, Ont., about 35 miles southwest of St. Catherines.

Palynology

Detailed pollen-grain micro-morphology has been studied, by the use of the light and the scanning electron microscope, on very

many species of the genera *Trifolium*, *Dalea* (Leguminosae), *Clarkia* (Onagraceae), and *Tamarix* (Tamaricaceae). The data obtained have been valuable in the solution of taxonomic problems in the groups concerned and in throwing new light on possible evolutionary relationships.

A revision of the booklet *Canadian havens from hay fever* was produced. This includes up-to-date information on air-borne ragweed (*Ambrosia*) pollen densities at more than 220 stations in Canada. Approximately 1,000 permanent slides were added to the pollen identification collection.

Ecophysiology

An ecological investigation of peat bogs was carried out, and despite contrary indications in the literature it was found that the water relations of bog plants are similar to those of plants growing outside of bogs. The low levels of nitrogen and phosphorus found in the leaves of many bog species may reflect adaptation to the very infertile substrate.

Herbarium, Index Seminum, and Plant Identification

The vascular plant collection contains 575,572 mounted herbarium specimens, an increase of 5,431 during the past year. Loans of 3,760 specimens were made to cooperating institutions in North America and Europe, and 2,196 specimens were sent out under the exchange program.

Over 6,500 packets of seeds of native and adventive plants were sent to more than 300 research centers through the Index Seminum program, and in return approximately 6,500 samples were received for Canadian scientists and agriculturists.

As a service to scientific and governmental agencies and to the general public, approximately 2,500 plant identifications were made by the research staff of the Taxonomy Section during the year.

PUBLICATIONS

Research

Arnold, R. H. 1970. A canker and foliage disease of yellow birch. II. Artificial infection studies with *Diaporthe alleghaniensis*. Can. J. Bot. 48:1525-1540.

Barr, D. J. S. 1970. *Phlyctochytrium arcticum* n. sp. (Chytridiales): morphology and physiology. Can. J. Bot. 48:2279-2283.

- Barr, D. J. S. 1970. *Hyphochytrium catenoides*: a morphological and physiological study of North American isolates. *Mycologia* 62:492-503.
- Barr, D. J. S. 1970. *Phlyctochytrium reinboldtae* Persiel (Chytridiales): morphology and physiology. *Can. J. Bot.* 48:479-484.
- Barr, D. J. S. 1970. Two varieties of *Rhizophydium sphaerocarpum* (Chytridiales). *Can. J. Bot.* 48:1067-1071.
- Barr, D. J. S., and Slykhuis, J. T. 1970. Zoosporic fungi associated with wheat spindle streak mosaic in Ontario. *Can. Plant Dis. Surv.* 49:112-113.
- Bassett, I. J., and Crompton, C. W. 1970. In A. Löve, IOPB chromosome number reports XXVII. *Taxon* 19:437-442.
- Baum, B. R. 1970. The problem of classifying cultivars with special emphasis on oat (*Avena*) cultivars. *Can. J. Bot.* 48:1373-1381.
- Baum, B. R. 1970. The type of the genus *Medicago* (Leguminosae). *Taxon*. 19:80-84.
- Baum, B. R., Bassett, I. J., and Crompton, C. W. 1970. Pollen morphology and its relationships to taxonomy and distribution of *Tamarix* series *Vaginantes*. *Oesterr. Bot. Z.* 118:182-188.
- Baum, B. R., and Findlay, J. N. 1970. Hydathodal pores in lodicules of *Avena* (Gramineae). *Can. J. Bot.* 48:2360.
- Baum, B. R., and Thompson, B. K. 1970. Registers with pedigree charts for cultivars: their importance, their contents, and their preparation by computer. *Taxon* 19:762-768.
- Burdett, A. N. 1970. The cause of bent neck in roses. *J. Amer. Soc. Hort. Sci.* 95:427-431.
- Corlett, M. 1970. Ascocarp development of two species of sooty molds. *Can. J. Bot.* 48:991-995.
- Corlett, M. 1970. Surface structure of urediniospores of *Puccinia coronata* f. sp. *avenae*. *Can. J. Bot.* 48:2159-2169.
- Frankton, C., and Bassett, I. J. 1970. The genus *Atriplex* (Chenopodiaceae) in Canada. II. Four native western annuals: *A. argentea*, *A. truncata*, *A. powellii*, and *A. dioica*. *Can. J. Bot.* 48:981-989.
- Ginns, J. H. 1970. Taxonomy of *Plicatura nivea* (Aphylliphorales). *Can. J. Bot.* 48:1039-1043.
- Ginns, J. H. 1970. The genus *Merulius* III. Species of *Merulius* and *Phlebia* proposed by Schweinitz and Peck. *Mycologia* 62:238-255.
- Hughes, S. J. 1970. New Zealand Fungi 14. *Antennaria*, *Antennularia*, *Antennatula*, *Hyphosoma*, *Hormisciella*, and *Capnobotrys* gen. nov. *N.Z. J. Bot.* 8:153-209.
- Hughes, S. J. 1970. Ontogeny of spore forms in Uredinales. *Can. J. Bot.* 48:2147-2157.
- Mosquin, T. 1970. Chromosome numbers and a proposal for classification in *Sisyrrinchium* (Iridaceae). *Madrono* 20:269-275.
- Mosquin, T. 1970. The reproductive biology of *Calypso bulbosa* (Orchidaceae). *Can. Field Natur.* 84:291-296.
- Mulligan, G. A. 1970. A new species of *Draba* in the Kananaskis Range of southwestern Alberta. *Can. J. Bot.* 48:1897-1898.
- Mulligan, G. A. 1970. Cytotaxonomic studies on *Draba glabella* and its close allies in Canada and Alaska. *Can. J. Bot.* 48:1431-1437.
- Mulligan, G. A., and Baum, B. R. 1970. In A. Löve, IOPB chromosome number reports XXVIII. *Taxon* 19:608-610.
- Mulligan, G. A., and Findlay, J. N. 1970. Reproductive systems and colonization in Canadian weeds. *Can. J. Bot.* 48:859-860.
- Mulligan, G. A., and Findlay, J. N. 1970. Sexual reproduction and agamospermy in the genus *Draba*. *Can. J. Bot.* 48:269-270.
- Mulligan, G. A., and Porsild, A. E. 1970. In A. Löve, IOPB chromosome number reports XXV. *Taxon* 19:102-113.
- Ornduff, R., and Mosquin, T. 1970. Variation in the spectral qualities of flowers in the *Nymphoides indica* complex (Menyanthaceae) and its possible adaptive significance. *Can. J. Bot.* 48:603-605.
- Parmelee, J. A., and Hiratsuka, Y. 1970. *Phaeoseptoria contortae* sp. nov. on *Pinus contorta* from Alberta. *Can. J. Bot.* 48:1002-1004.
- Paruþs, E. V. 1970. Effect of morphactin on the gravimorphism and the uptake, translocation and spatial distribution of indol-3-acetic acid in plant tissues in relation to light and gravity. *Physiol. Plant.* 23:1176-1186.
- Pirozynski, K. A., and Patil, S. D. 1970. Some setose Hyphomycetes of leaf litter in south India. *Can. J. Bot.* 48:567-581.
- Pirozynski, K. A., and Shoemaker, R. A. 1970. Seimatosporium leaf spot of *Ledum* and *Rhododendron*. *Can. J. Bot.* 48:2199-2203.
- Pirozynski, K. A., and Shoemaker, R. A. 1970. Some Asterinaceae and Meliolaceae on conifers in Canada. *Can. J. Bot.* 48:1321-1328.

- Savile, D. B. O. 1970. Autoecious *Puccinia* species attacking Cardueae in North America. *Can. J. Bot.* 48:1567-1584.
- Savile, D. B. O. 1970. Some Eurasian *Puccinia* species attacking Cardueae. *Can. J. Bot.* 48:1553-1566.
- Shoemaker, R. A., and Smith, J. D. 1970. *Melanospora sphaerodermoides* on seed of *Agrostis palustris*. *Can. J. Bot.* 48:1657-1658.
- Sly, W. K. 1970. A climatic moisture index for land and soil classification in Canada. *Can. J. Soil Sci.* 50:291-301.
- Svejda, F. 1970. Further observations on the relationship between winterhardiness in roses and the electric impedance of uninjured tissues. *Can. J. Plant Sci.* 50:493-497.
- Weresub, L. K. 1970. Automatic tautonyms: Zoology vs. Botanical Code. *Taxon* 19:787-788.
- Wilner, J., and Brach, E. J. 1970. Comparison of radio telemetry with another electric method for testing winter injury of outdoor plants. *Can. J. Plant Sci.* 50:1-8.
- Miscellaneous**
- Baier, W. 1970. Potential role of weather modification in Canadian agriculture, p. 93-115. *In* J. Maybank and W. Baier [ed.] *Weather modification: a survey of the present status with respect to agriculture*. Research Branch, Can. Dep. Agr.
- Baier, W. 1970. Effects of hypothesized daily rainfall augmentations on estimated seasonal irrigation requirements, p. 117-123. *In* J. Maybank and W. Baier [ed.] *Weather modification: a survey of the present status with respect to agriculture*. Research Branch, Can. Dep. Agr.
- Baier, W., Edey, S. N., and Hore, F. R. 1970. Risk analysis of climatic data. *Erda* 8:2-4.
- Baier, W., and Edey, S. N. 1970. Grass minimum temperatures. *Greenhouse-Garden-Grass* 9(2):3-6.
- Baier, W. 1969. Agrometeorological research and extension in Western Germany. *Greenhouse-Garden-Grass* 8(4):16-17.
- Baier, W. 1970. Meteorology in agricultural planning. *Can. Agr.* 16(4):30-32.
- Bassett, I. J., and Frankton, C. 1970. Canadian havens from hay fever 1970. Canadian Government Travel Bureau (Dep. Ind., Trade Com.), Ottawa. 28 p.
- Buckley, A. R. 1970. Reblooming iris varieties may help boost perennial sales. *Can. Nurseryman* 7(7):17,34.
- Buckley, A. R. 1970. Sell the little known hydrangeas. *Can. Nurseryman* 7(8):31,38.
- Buckley, A. R. 1970. Permanent plants for the shade. *Can. Nurseryman* 7(9):20-21.
- Buckley, A. R. 1970. Astilbes. *Horticulture* 48(7):38-39.
- Buckley, A. R. 1970. Episcia, a colorful house plant. *The Prairie Garden* 27:88-89.
- Buckley, A. R. 1970. Winter protection of perennials. *The Prairie Garden* 27:33-34.
- Buckley, A. R. 1970. Plants of the Holy Land. *Can. Nurseryman* 7(10):14,23.
- Cody, W. J. 1970. Index Seminum 1971. Botanical Garden and Arboretum, Plant Res. Inst., Can. Dep. Agr. 24 p.
- Cody, W. J. 1970. *Paronychia fastigiata* (Caryophyllaceae), forked chickweed, new to Ontario. *Can. Field Natur.* 84:58-59.
- Cole, T. J. 1970. Some North American rock plants. *Amer. Rock Garden Soc. Bull.* 28(2):41-46.
- Cole, T. J., and Sherck, L. C. 1970. Woody plant source list. *Plant Res. Inst., Can. Dep. Agr.* Ottawa.
- Cordukes, W. E. 1970. Turfgrass tolerance to road salt. *The Golf Superintendent*, May:44-48.
- Corlett, M. 1970. Probing the secrets of the apple scab fungus. *Can. Agr.* 15(2):24-25.
- Dore, W. E. 1970. A wild ground-bean (*Amphicarpa*) for the garden. *Greenhouse-Garden-Grass* 9(2):7-11.
- Dore, W. E. 1970. The Saunders collection. *Greenhouse-Garden-Grass* 9(1):10-20.
- Dore, W. E. 1970. The wild Canada onion. *Herbarist* 36:34-38.
- Frankton, C., and Mulligan, G. A. 1970. Weeds of Canada. *Can. Dep. Agr. Publ.* 948. 217 p.
- Gillett, J. M. 1970. What is citron? *Greenhouse-Garden-Grass* 9(2):1-2.
- Ginns, J. H., and Driver, C. H. 1970. The mycobiota of slash pine stumps and its influences on the occurrence of annosus root rot. *Fonds de recherche forestières de l'Université Laval* 13:11-18.
- Moore, R. J. 1969. How weedy thistles came to Canada. *Greenhouse-Garden-Grass* 8(4):1-2.
- Moore, R. J. 1970. History of the Mycology and Taxonomy sections. *Greenhouse-Garden-Grass* 9(1):7-9.
- Mulligan, G. A. 1970. Wild garlic, *Allium vineale*, a new weed in Canada. *Greenhouse-Garden-Grass* 9(2):12.

- Ouellet, C. E. 1970. Climatic factors and plant winter survival. *Can. Agr.* 15(2):3-5.
- Ouellet, C. E. 1970. Zones de rusticité et choix des arbres et arbustes d'ornement. *Agriculture* 38(1):25-29.
- Savile, D. B. O. 1969 (1970). The meaning of "Pleomorphism." *Mycologia* 61:1161-1162.
- Savile, D. B. O. 1969 (1970). Biology in the North. *Sci. Affairs* 4(3):69-71.
- Savile, D. B. O. 1970. James Walton Groves. *Proc. Roy. Soc. Canada* 8(Ser.4):73-77.
- Svejda, F. 1970. La selection des rosiers rustiques et remontants adaptés au climat Canadien. *Mon Jardin et Ma Maison*, Lyon, France, livraison de juillet.
- Svejda, F. 1970. Martin Frobisher, a new hybrid rugosa. *Can. Rose Annual*:59-71.
- Williams, G. D. V. 1970. Effects on weather-based prairie wheat production estimates of increasing precipitation amounts by ten and thirty percent, p. 124-133. *In* J. Maybank and W. Baier [ed.] *Weather modification: a survey of the present status with respect to agriculture*. Research Branch, Can. Dep. Agr.
- Williams, G. D. V., and MacKay, K. H. 1970. Tables of daily degree-days above or below any base temperature. *Can. Dep. Agr. Publ.* 1409. 37 p.

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Ontario Soil Survey (Guelph)

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Cartography

J. G. ROBERTS	Chief cartographer
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Departures

B. H. CAMERON, B.Sc., M.Sc. Appointment terminated April 1, 1970	Party leader—Edmonton
E. J. EVANS, B.Sc., M.Sc., Ph.D. Resigned April 30, 1970	Soil fertility
B. J. FINN, B.S.A., M.Sc., Ph.D. Retired May 27, 1970	Soil fertility
R. E. WICKLUND, B.S.A., M.Sc., Ph.D. Retired July 31, 1970	Head of Unit—Guelph

Transferred to Research Station, Fredericton, April 1, 1970

D. B. CANN, B.Sc. (Agr.), M.Sc., Ph.D.	Soil classification and correlation
J. I. MACDOUGALL, B.Sc., B.Sc. (Agr.)	Head of Unit—Truro
J. L. NOWLAND, B.A., M.Sc.	Party leader—Truro

VISITING SCIENTISTS

P. B. HOYT, B.Sc., M.S., Ph.D. Postdoctorate transfer of work	Chemistry of organic matter and aluminum
S. U. KHAN, B.Sc., M.Sc., Ph.D. In-service transfer of work	Humic acid chemistry
K. MATSUDA, B.Sc., M.Sc., Ph.D. Japanese Government fellow	Humic acid chemistry
S. SRINILTA, B.S.A., M.S., Ph.D. (Thailand) National Research Council postdoctorate fellow	Soil physics

INTRODUCTION

This is a report of the work done in the Soil Research Institute in 1970.

The main concerns of the Institute were investigations of the chemical, physical, and biological processes and reactions that control the availability and supply of nutrients and moisture in soils. This year, increased attention was given to waste disposal problems, to possible fertilizer pollution, and to the reactions of some toxic trace metals in soils.

The taxonomic and interpretive classification of soils continued and studies on remote sensing were initiated. The cooperative soil survey programs in Ontario and Alberta continued, but the administration of the Nova Scotia Survey group was transferred to the Research Station, Fredericton, N.B. The Cartography Section prepared and published Soil Survey maps as well as printed and computerized maps for the Agriculture, Forestry, and Wildlife sectors of the Canada Land Inventory.

J. S. Clark
Director

SOIL PHYSICAL CHEMISTRY

Forms of $\text{Al}(\text{OH})_3$

When base was added to a dilute solution of AlCl_3 , two distinct, initial solid phases were formed. One apparently formed by the precipitation of mononuclear Al cations and the other by the precipitation of polynuclear cations. Near neutrality and at 25 C, the initial solid phase formed from the mononuclear cations was converted to gibbsite, whereas that from the polynuclear cations was not.

The initial solid phases formed almost instantaneously, whereas the formation of the polynuclear hydroxyaluminum cations took several hours. At pH values less than 5.0, the polynuclear cations were more stable than the solid phases, so the initial solid phases tended to dissolve to form polynuclear cations. However, once the initial solid phases were formed, they were transformed to other less soluble solid phases so that some solid phase always persisted in the system. Preliminary studies showed that temperatures markedly affected the rates of the reactions in the transformations of Al. Studies on the formation of hydroxyaluminum solid phases at temperatures found in soils are under way.

Effects of Chloride and Sulfate on the Formation of Hydroxyaluminum Compounds

When montmorillonite-Al salt systems containing both SO_4 and Cl were neutralized basaluminite was formed faster than in salt systems containing only SO_4 anions. The time

required to reach a constant ionic product, $(\text{Al})(\text{OH})^{2.5}(\text{SO}_4)^{0.25}$ was greater in the mixed anion preparations than with SO_4 alone. Unusually large interlayer spacings occurred when both Cl and SO_4 were present and the interlayer spacing was markedly affected by relative humidity. The basal spacings were 25 Å with glycerol, 22 Å in moist air, and 20 Å in dry air. In systems containing only SO_4 , the hydroxyaluminum interlayer material disappeared when basaluminite was formed. In the mixed anion preparations, the interlayer material persisted for some time after basaluminite was formed.

At 25 C, when base was added to solutions of AlCl_3 , $\text{Al}(\text{NO}_3)_3$, or $\text{Al}(\text{ClO}_4)_3$ at concentrations of less than 3×10^{-2} N, the respective anions were incorporated into the initial solid phases that precipitated. However, the final product that formed was $\text{Al}(\text{OH})_3$. When the Cl concentration was 0.6 N, and the Al salt solutions were 80% neutralized, a crystalline aluminum hydroxy-chloride, $\text{Al}(\text{OH})_{2.5} \cdot x\text{H}_2\text{O}$, was formed. In the comparable nitrate systems a poorly crystallized hydroxyaluminum nitrate precipitated, but gibbsite crystallized after 9.5 months. The incorporation of anions in the solid phases decreased the rate of $\text{Al}(\text{OH})_3$ crystallization.

Interlayer Hydroxyaluminum Phosphates

The amorphous interlayer aluminum hydroxy-phosphate formed when AlCl_3 and H_3PO_4 were neutralized in the presence of montmorillonite (Report for 1968) remained stable for 3 years at 25 C. No discrete crystalline PO_4 was formed. However, the interlayer

hydroxyaluminum phosphate slowly became better oriented as shown by sharper, more symmetrical X-ray diffraction patterns. By increasing the reaction temperature to 99 C, crystalline variscite was produced within a few days and some poorly crystallized variscite was obtained after heating at 50 C for several months. The interlayer hydroxyaluminum phosphate evidently can persist as a relatively stable phase for long periods at moderate temperatures.

SOIL ORGANIC CHEMISTRY

Isolation and Identification of Compounds Extracted From Fulvic Acid

Exhaustive methylation of fulvic acid increased its solubility in benzene, thereby allowing separation by column and thin-layer chromatography and by gas chromatography. The relatively pure components obtained were identified by their chromatograph retention times and their mass- and infra-red spectra. Twenty-one ethers and esters of phenolic and benzene carboxylic acids have been identified. Many of the identified compounds were similar to those obtained by alkaline KMnO_4 oxidation of fulvic acid. The improved extractability of the fulvic acid components after methylation suggests that the phenolic and benzene carboxylic acids were hydrogen bonded to form a polymeric structure of an unknown configuration.

Small amounts of alkanes, fatty acids, and dialkyl phthalates were also identified in the extracts. The alkanes and fatty acids ranged from C14 to C36 and accounted for 0.16% and 0.10%, respectively, of ash-free dry weight of the fulvic acid. The dialkyl phthalates consisted of bis(2-ethylhexyl)-, dibutyl-, dichlohexyl-, and benzyl-butyl phthalates and made up 0.03% of the fulvic acid. These lyophobic compounds were incorporated into the structure of fulvic acid, which is lyophilic, suggesting that the acid may facilitate the mobilization and transfer of lyophobic compounds in soils.

Further Studies on Phenolic Compounds in Soils

The phenolic constituents of five soils from Eastern Canada and two Chernozemic soils from Western Canada were investigated. The phenolic compounds were extracted by

hot acid and alkaline hydrolysis. The ether-soluble materials in the hydrolysates were identified by thin-layer and gas chromatography. The five Podzolic soils contained small amounts of *p*-hydroxybenzoic acid, vanillic acid, syringic acid, ferulic acid, *p*-coumaric acid, *o*-protocatechuic acid, and alkylated phenols such as dimethyl phenol. In one of the soils, two substituted resorcinols were detected. The Chernozemic surface horizons did not contain detectable amounts of either syringic or alpha resorcylic acid, but they did contain vanillic and protocatechuic acids. Significant amounts of ferulic acid were present in the Orthic Black soil, suggesting that the complement of phenolic compounds may indicate difference between Ah horizons of soils.

Organic Phosphorus in Soils and Lake Sediments

The extraction and recovery of 40% to 100% of the organic P in four soils from the Ottawa area by the ultrasonic-acetylacetone extraction procedure supported earlier work that showed there were marked differences in the extractability of organic P from soils. After gel filtration, about 50% of the extracted organic P was recovered in a high molecular-weight fraction. Alkaline hydrolysis converted 30% to 50% of the P in these fractions to inorganic form. Inositol phosphates comprised up to 15% of the organic P in these soils and attempts to isolate and identify nucleic acids were unsuccessful.

The total organic P in three Solonchic soils from Alberta decreased from 67% in the Ah horizons to 5% in the C horizons. About 70% of the total organic P in the Ah horizons was extracted with NaOH. Inositol penta- and hexa-phosphates comprised about 12% of the total organic P extracted with NaOH, and lower inositol phosphate esters and other unidentified organic P compounds made up more than 20%.

The total P content of 19 Luvisolic and 1 Podzolic soil from the Beaverlodge area of Alberta changed from 31 mg to 93 mg P/100 g soil with a mean value of 53 mg/100 g. From 20% to 61% (mean 35%) of the total P was organic and the C:N:organic P ratios were 117:9:1.

Analysis of samples of lake sediments showed that the total P was higher (53 to 526 mg P/100 g) in these sediments than in the soils from the Beaverlodge area, but only 5%

of the total was organic P. The C:N:organic P ratios were 300:24:1 in the sediments.

SOIL BIOCHEMISTRY

Soil and Soil-water Pollution From Animal Wastes

Monitoring of tile-drain effluents, wells, and piezometer located near manure piles and on land that receives heavy applications of liquid manure was continued at the Ottawa farm of the Research Branch.

As reported in 1969, heavy applications of manures did not increase the NH_4 , K, P, or Ca + Mg content of the waters in a small stream that passes through the farm. However, the $\text{NO}_3\text{-N}$ content increased from 0.1 ppm before manure application to 2 to 4 ppm after. The NO_3 content of the tile drains increased from April to May but decreased in June, apparently because N was utilized by crops. The nitrate content of the drain effluents did not seem to be related to fertilizer or manure applications.

Relatively high NH_4 and NO_3 concentrations were found at depths of 60, 120, and 270 cm in soil near manure piles. The NH_4 and NO_3 content of water in a piezometer 167 m from the piles and in nearby wells was low, indicating that the lateral movement of N was slight. Denitrification may have reduced N contamination of ground waters.

Mn Oxidizing Organisms

When a preparation of peat extract containing MnSO_4 was inoculated with particles from Mn pans of Newfoundland soils, a deposit with a high Mn content was formed slowly. A strain of *Cephalosporum* fungus was isolated from both the pans and the deposit formed in the laboratory. The fungus produced a black deposit when cultured on a MnSO_4 -agar medium at pH 4.1 and at 4 C. The black deposits contained about 75% Mn but were amorphous to X rays.

Enzymatic Degradation of Fulvic Acid

Degradation of Podzol Bh fulvic acid by a cell-free preparation and a controlled replacement culture of the white rot fungus *Poria subacida* (Pk.) Sacc. produced between 10% and 25% 1,4-benzoquinone and 2 methyl, 4-naphthaquinone. The ratio of the

two quinones was 1.5:1 respectively. The quinones were identified using thin-layer chromatography, ultraviolet spectroscopy, and gas chromatography. Adequate controls eliminated the possibility that the quinones were secondary fungal metabolites. These studies indicate that significant amounts of quinolic components are present in the original structure of the fulvic acid.

MINERALOGY

Amorphous Materials in Soils

Physical and chemical analytical techniques indicated that organic components and amorphous iron oxides were intimately mixed with amorphous aluminosilicates in soils to form an amorphous material with properties like those of allophane. When samples were heated to high temperatures, the displacements of the infrared absorption bands specifically indicated the presence of these amorphous materials in soils.

Rates of K Exchange in Soil Clays

The rates of K exchange of untreated and peroxide-treated clays from five Podzol soils of increasing degrees of weathering were determined with the use of sodium tetraphenyl boron. The amounts of K fixed and not extracted by NH_4 were also measured. The Ae horizons of the soils contained mainly interstratified mica-vermiculite-montmorillonite and the C horizons mostly mica. The rates of K exchange were inversely related to the degrees of weathering of the Ae horizon clays. Except for the clay from the most highly weathered Ae horizon, the K exchange rate of the interstratified mica from the Ae was greater than for the less-weathered micaceous clay from the C. The many hydrated edges and layers, which increased the exposed exchange sites, seemed to account for the different exchange rates.

Removal of organic matter from the Ae horizon clays increased the rates of K exchange and the amounts of K fixed, suggesting that organic matter blocked exchange sites.

Structural Disorder in Clay Minerals

Electron diffraction patterns of several microcrystalline muscovites and pyrophyllites showed evidence of microcrystalline disorder. The electron diffraction patterns and single crystal X-ray studies indicated that the disorder effects were produced by nonuniform displacements of oxygen atoms in the oxygen plane rather than by Si-Al substitution.

Fourier analysis methods showed that the broadening of 001 reflections of several microcrystalline muscovites was also caused by disorder arising from variable interlayer spacing. The single crystal C dimension varied from one unit cell to another.

SOIL FERTILITY

Potassium

Continuing work on soil clays of varying mineralogy showed differences in their content of solution, and exchangeable and non-exchangeable forms of native K. The amounts of exchangeable K ($1\text{ N NH}_4\text{OAc}$) correlated significantly with activity ratios (AR^k) estimated from equilibration experiments and with the amounts of non-exchangeable K removed by plants. The latter were correlated with the amounts of non-exchangeable K released upon leaching with 0.1 N BaCl_2 or 0.01 N HCl . A montmorillonitic clay, two others with vermiculite-mica mixed layers, and a chloritic intergrade released the highest amounts of native non-exchangeable K. Two clays containing a mixture of vermiculite and montmorillonite, and another of well-ordered muscovite released the lowest amounts.

Plants and particularly leaching of the clays with 0.1 N BaCl_2 removed appreciable amounts of fertilizer K fixed against extraction with $1\text{ N NH}_4\text{OAc}$. Most of the clays, regardless of their mineralogical differences, gave an initial rapid release of fixed fertilizer K, followed by a slower rate of release upon further leaching.

A field experiment on a sandy clay loam where K fertilizer (1248 kg K/ha) was mixed with the plough layer in the fall of 1963 and allowed to react without cropping in 1964 showed that 89% of the added K was fixed against extraction with $1\text{ N NH}_4\text{OAc}$. Subsequent crops of oats, rye, barley, and alfalfa

grown from 1965 to 1970 removed 758 kg K/ha , compared with 602 kg/ha from control plots. The residual effect of the K treatment in 1963 was reflected in both the yield and concentration of K in the alfalfa crop in 1970. In a pot test with soil collected in the fall of 1969, the residual K fertilizer increased the K uptake of oats by 60% and of alfalfa by 36% over that obtained with the control soil. Despite this residual effect, however, the recovery of the added K by crops in 1965-1970 was only 11.6%. Also, the heavy K application had no marked long-term effect on exchangeable K in the soil. The amount at the end of the 1970 season (0.16 meq/100 g) was identical with that found initially in the control soil.

Soybean Yield and Soil Temperature

The yield of soybeans without fertilizer was 269 kg/ha and 2188 kg/ha when the temperature 20 cm deep was maintained at 10.3 C and at 31.6 C , respectively. Yield differences between the high and low temperature treatments decreased when fertilizer was applied. Soil temperature had little effect on oil quality but it reduced the iodine number of the extracted oil and the protein content of the bean.

Wheat Growth and Soil Temperature

Differential soil temperature treatments were applied to plots of Manitou and Mexican QK113 wheat in plots without fertilizer and in plots with 89 kg/ha of N, P, and K. The temperature treatments were begun July 3, 1970, at the third-leaf stage, whereas the previous year temperature treatments were started at emergence. In 1970 growth and yield for the two varieties were about the same with the three soil temperatures and two fertilizer treatments used. The uptake of P by the two wheat varieties did not increase with increasing soil temperature as it did with soybeans.

Metal - Organic Matter Complexes

The iron content of metal - organic matter complex was negatively correlated with the intensity of the fluorescence peaks. The lower the molecular weight, the higher the value of the fluorescence band and the lower the degree of metal substitution of metal - organic matter complex. Gel filtration and the fractionation of the humic compounds are the

best ways to obtain preparations for spectrofluorometric analysis.

PHYSICS

Moisture Distribution in Rewetted Soils

Earlier work showed that moisture distributions in rewetted soils could be predicted by the independent domain theory, provided that reduced conductivities and a narrow range of boundary conditions were used. The latter involved drying the soil to prescribed limits and restricting the infiltration depth and rate so that the soil did not become completely saturated. In 1970 two depths of initial wetting and several depths and rates of rewetting were used. In general, water that was added with a constant flux below the infiltration capacity distributed faster than water that was ponded at the surface. Agreement between measured and computed moisture distributions was obtained for infiltration by using higher conductivities for constant flux than for ponded infiltration. However, the shapes of the redistribution moisture profiles differed and it appeared that the scanning curves must vary because of the different depths and rates of infiltration. The revised version of the independent domain theory was programmed to predict the infiltration and redistribution profiles. Computation showed that the permissible corrections to the theoretical prediction would not produce agreement with measurement of all depths. The data also showed that deviations from theory caused by the pore blockage on drying increased with initial water content and depth in the soil.

Evaporation of Soil Moisture

Studies on the evaporation of moisture from soil that were started last year were continued. Evaporation was computed on the basis of an isothermal model, with the use of temperature and humidity as boundary conditions. The results agreed with experimental evaporation rates and soil-moisture distributions better than the previously used conditions of flux and moisture content. Some reduction in previously measured values of conductivity near the soil surface was necessary to obtain agreement with experimental loss. The method introduced last year of computing backwards to obtain combined

liquid and vapor conductivity in thin layers near the surface from evaporation fluxes required further development. The surface-moisture contents were so sensitive to small differences in evaporative flux that estimates of conductivity were inaccurate for moisture contents above the wilting percentage.

SOIL CLASSIFICATION AND GENESIS

The soil classification and genesis programs were continued, both in the Institute and in cooperation with provincial organizations. A preliminary soil map of Canada and a legend were prepared and correlated within the North American section of the FAO/UNESCO soil map of the world. A preliminary soil climate map of Canada was also prepared. The map and legend were approved at the October 1970 meeting of the Soil Survey Committee of Canada. The soil and climatic maps and legends are being revised for publication.

Soil studies were made in the Fort Smith, Fort Simpson, and Keele River areas in the Northwest Territories and the Yukon and on Devon Island to assist International Biological Program Studies in the Arctic. Assistance was given to the Canadian Wildlife Service on soil studies in the McConnell River area of Hudson Bay, in Banff National Park, and on Southampton Island.

The Institute began a project on remote sensing, and a member of the Institute was appointed to the Interdepartmental Committee on Remote and Airborne Sensing to help coordinate the agricultural remote sensing program. A system of ground truth sites for a coordinated national program of remote sensing was established for summer 1971.

Soil Genesis

Luviosolic soils developed on calcareous tills in central Alberta, southern Ontario, and Nova Scotia were studied. Clay skins were most strongly developed in the well-structured Alberta soil, but the amounts of oriented and presumably translocated clay were greater in some of the eastern soils. Base saturation values were high in some Gray Luvisols from Alberta and low in the sola of Gray Luvisols from Nova Scotia. It was suggested that if a new "Dystric" subgroup was introduced to classify Gray Luvisolic soils

with low base saturation, the Brunisolic subgroups of Luvisolic soils could be eliminated. The Ah horizons of Gray Brown Luvisols contained more coarse organic fractions and uncoated sand grains than the Ahe horizons of the Dark Gray Luvisols. The ratios of humic to fulvic acid were lower in the Gray Brown Luvisols than in the Dark Gray Luvisols.

Two of five Gleysolic soils with prominently mottled B horizon satisfied the present criteria for the Fera subgroups of the Gleysolic order. It is suggested that more emphasis be placed on the morphological properties in the classification criteria for the Gleysolic order. Goethite occurred in all of the prominently mottled B horizons.

Studies of mineral-organic surface horizons (Ah) of several classes of soils have shown that much of the organic matter may be present in the silt-sized separates as well as in clay. Neither the distribution of the organic matter in the various size fractions nor the ratio of humic to fulvic acid in the fractions formed the basis for improving diagnostic criteria for separating different kinds of Ah horizons.

Ontario Soil Survey, University of Guelph, Guelph

Field surveys for the projects in Halton, Waterloo, Peterborough, and Northumberland counties were completed and soil maps for these areas are in various stages of preparation. In Brant County 12,500 ha were surveyed at a detailed scale. The pedologic and

engineering characteristics of the soils of the county were determined in cooperation with the Civil Engineering Department of the University of Waterloo and the Ontario Department of Highways.

Alberta Soil Survey, University of Alberta, Edmonton

Approximately 710,000 ha were surveyed at reconnaissance scale in map sheet 73L. Soil capability maps were prepared for 6,820,000 ha.

CARTOGRAPHY

During the year the Cartography Section prepared and published 11 Soil Survey maps and 2 Soil Capability maps for inclusion in Soil Survey publications. The use of photomosaics as base maps for Soil Survey publications was introduced this year and 30 of the required 39 page-size photo Soil Survey maps were prepared for publication of the Soil Survey of Waterloo County, Ont.

There were 61 capability maps published for the Canada Land Inventory. The cartography for an additional 77 maps was completed; these are either awaiting printing or translation of the corresponding general area descriptions. About 800 detailed computer Land Capability maps were prepared for the Canada Land Inventory Geo-Information System. In addition, 23 miscellaneous black-and-white and multicolored maps were prepared and published for other institutes and divisions in the Department and for the Canada Land Inventory.

PUBLICATIONS

Research

Brydon, J. E., and Day, J. H. 1970. Use of the Fieldes and Perrott NaF test to distinguish the B horizons of podzols in the field. *Can. J. Soil Sci.* 50:35-41.

Clark, J. S. 1970. Distribution constant for exchange of calcium and manganese in Wyoming bentonite. *Can. J. Soil Sci.* 50:85-86.

Day, J. H. 1970. The classification of organic soils in Canada. *Int. Peat Congr.* 80-84.

Gamble, D. S., Schnitzer, M., and Hoffman, I. 1970. Cu^{+2} -fulvic acid chelation equilibrium in 0.1 M KCl at 25° C. *Can. J. Chem.* 48:3197-3204.

Halstead, R. L., and Anderson, G. 1970. Chromatographic fractionation of organic phosphates from alkali, acid and aqueous acetylacetone extracts of soils. *Can. J. Soil Sci.* 50:111-119.

Ivarson, K. C., Sowden, F. J., and Mack, A. R. 1970. Amino-acid composition of rhizosphere as affected by soil temperature, fertility and growth stage. *Can. J. Soil Sci.* 50:183-189.

Ivarson, K. C., and Sowden, F. J. 1970. Effect of frost action and storage of soil at freezing temperatures on the free amino acids, free sugars and respiratory activity of soil. *Can. J. Soil Sci.* 50:191-198.

- Kodama, H. Discussion, comment and reply in the 1969 Int. Clay Conf. Proc. 1969 Int. Clay Conf. 2:64-193.
- Kodama, H., and Schnitzer, M. 1970. Kinetics and mechanism of the thermal decomposition of fulvic acid. *Soil Sci.* 109:265-271.
- Levesque, M. 1970. Contribution de l'acide fulvique et des complexes fulvo-métalliques à la nutrition minérale des plantes. *Can. J. Soil Sci.* 50:385-395.
- Mack, A. R., and Finn, B. J. 1970. Differential response of timothy clonal lines and varieties (*Phleum pratense* L.) to soil temperature, moisture and fertility. *Can. J. Plant Sci.* 50:295-305.
- Mathur, S. P. 1970. Degradation of soil humus by the fairy ring mushroom. *Plant Soil* 33:717-720.
- McKeague, J. A., and Brydon, J. E. 1970. Mineralogical properties of ten reddish brown soils from the Atlantic Provinces in relation to parent materials and pedogenesis. *Can. J. Soil Sci.* 50:47-55.
- Morita, H. 1970. Polyphenols in the extractives of an organic soil. *Third Int. Peat Congr.* 28-31.
- Morita, H., and Hillis, W. E. 1969. Polyphenols in the leaves of Eucalyptus, Renantherin and Macrantherin. *Aust. J. Chem.* 22:1471-1476.
- Ogner, G., and Schnitzer, M. 1970. Humic substances: fulvic acids - dialkyl phthalates complexes and their role in pollution. *Science (Washington)* 170:317-318.
- Ogner, G., and Schnitzer, M. 1970. The occurrence of alkanes in fulvic acid, a soil humic fraction. *Geochim. et Cosmochim.* 34:921-928.
- Poapst, P. A., Genier, C., and Schnitzer, M. 1970. Effect of a soil fulvic acid on stem elongation in peas. *Plant Soil* 32:367-372.
- Ross, G. J. 1969. Acid dissolution of chlorites: Release of magnesium, iron and aluminum and mode of acid attack. *Clays and Clay Minerals* 17:347-354.
- Ross, G. J., and Kodama, H. 1970. Differential release of potassium from interstratified mica clay minerals as related to probable differences in their mica layer components. *Clays and Clay Minerals* 18:151-156.
- Schnitzer, M. 1970. Characteristics of organic matter extracted from Podzol B horizons. *Can. J. Soil Sci.* 50:199-204.
- Schnitzer, M., and Desjardins, J. G. 1969. The alkaline permanganate oxidation of methylated and of untreated fulvic acid. *Soil Sci. Soc. Amer. Proc.* 34:77-79.
- Schnitzer, M., and Hansen, E. H. 1970. Organometallic interactions in soils: 8. An evaluation of methods for determination of stability constants of metal-fulvic acid complexes. *Soil Sci.* 109:333-340.
- Schnitzer, M., and Ogner, G. 1970. The occurrence of fatty acids in fulvic acid, a soil humic fraction. *Israel J. Chem.* 8:505-512.
- Singh, S. S., and Brydon, J. E. 1970. Activity of aluminum hydroxy sulfate and the stability of hydroxy aluminum interlayers in montmorillonite. *Can. J. Soil Sci.* 50:219-225.
- Sowden, F. J. 1970. The extraction of nitrogen-containing organic matter fractions from soil. *Can. J. Soil Sci.* 50:227-232.
- Sowden, F. J. 1970. The action of proteolytic enzymes on soil organic matter. *Can. J. Soil Sci.* 50:233-241.
- Staple, W. J. 1970. Predicting moisture distributions in rewetted soils. *Soil Sci. Soc. Amer. Proc.* 34:387-392.
- Topp, G. C. 1970. Instrumentation and observation techniques. *Proc. 7th Can. Hydrol. Symp.* 21-36.
- Topp, G. C. 1970. Soil water content from gamma ray attenuation: A comparison of ionization chamber and scintillation detectors. *Can. J. Soil Sci.* 50:439-447.
- Turner, R. C., and Ross, G. J. 1970. Conditions in solution during the formation of gibbsite in dilute Al salt solutions: 4. Effect of Cl concentration and temperatures and a proposed mechanism for gibbsite formation. *Can. J. Chem.* 48:723-729.
- Webber, M. D., and Racz, G. J. 1970. Soluble complexes in the systems dicalcium phosphate dihydrate (CaHPO₄·2H₂O) or dimagnesium phosphate trihydrate (MgHPO₄·3H₂O) equilibrated with salt solutions. *Can. J. Soil Sci.* 50:243-253.

Miscellaneous

- Day, J. H. Classification of organic soils in Canada. *Tech. Mem. 99, Muskeg Subcomm., Ass. Comm. Geotech. Res., Nat. Res. Council, November 1970.*
- Shields, J. A., and Clayton, J. S. 1970. Soil capability for agriculture. *Shellbrook Map Sheet Area, 73G.*
- Shields, J. A., Stonehouse, H. B., and Clayton, J. S. 1970. Soil capability for agriculture. *North Battleford Map Sheet Area, 73C.*

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Development of synthetic diets for
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INTRODUCTION

The function of the Research Institute, Belleville, Ont., is to discover and develop ways of reducing damage caused by pests, and to do this with the least possible use of persistent pesticides. The method followed is to identify and understand the components of a pest's ecology, behavior, and physiology that can be manipulated in selective control programs. Processes receiving particular attention toward this end are fecundity, mortality or stress imposed by biotic agents and physical or chemical factors, host selection and food preference, and stimuli that cause aggregation of pests.

During 1970 a significant step was made toward the continuing goal of propagating parasites artificially to serve the needs of inundation programs: an ichneumonid parasitoid was raised from egg to adult on a synthetic, chemically defined medium; this was the first time that anyone has succeeded in rearing a hymenopterous insect in this way. The results of a 3-year study have shown that no compounds used routinely to protect synthetic diets for insects from microbial contamination do so without having detrimental effects on the growth rate, size, or survival of the insect; in this study the compounds that produced the least damaging effects were identified. A pheromone that attracts and at high concentrations can drown ovipositing mosquitoes was isolated and purified. The first severe infestation in North America of the European sweetclover casebearer, *Coleophora frischella*, was detected and evaluated at Belleville.

In collaboration with the Department of Fisheries and Forestry, the text was completed of a book reviewing biological control programs in Canada during the decade 1959-68. The first such review was published in 1962.

In addition to its research function, the Institute also provides a service as the national center for information on biological control agents, and for their import, quarantine, and dispatch. It has performed this service since its establishment at Belleville in 1929 (not 1919 as printed in the 1969 report). The Institute also provides liaison with the Commonwealth Institute of Biological Control to sponsor surveys and research needed by Canada in foreign countries.

This is the eighth report, and the fifth annual report, to be published from the Institute.

Philip S. Corbet
Director

REPRODUCTIVE PHYSIOLOGY AND BEHAVIOR

Ovary Development and Antimetabolites

In the larviparous fly *Pseudosarcophaga affinis*, hemolymph proteins accumulate at the beginning of oocyte growth and are rapidly removed from the blood during yolk deposition. When adults are given a diet supplemented with ethionine, the removal of certain hemolymph protein fractions is selectively inhibited, whereas their synthesis is unaffected. A diet deficient in methionine, however, inhibits the synthesis of these fractions.

Fecundity of Biting Flies

Field studies designed to establish base lines for fecundity of the snowmelt mosquito *Aedes trichurus* have determined the viability

of laid eggs. Nearly all of more than 1,000 batches of eggs laid in individual cages comprised unembryonated as well as embryonated eggs. Therefore insemination, a characteristic of nearly all wild-caught females, does not ensure that all eggs laid will hatch. Of 12,080 eggs deposited about 42% were unable to hatch.

Egg-laying Behavior of Mealworms

In the laboratory, adults of the mealworm *Tenebrio molitor* are usually found in groups on or near the surface of whole wheat flour, where mating apparently occurs; females move down into the flour to oviposit. Although females reared at high densities descend to a greater depth than do females reared at low densities, both groups lay most (75%) of their eggs in the same layer of flour only a few centimeters beneath the surface.

PHYSICAL AND CHEMICAL CONTROLS

Antitanning Agents

A search for selective chemicals that interfere with or prevent puparium formation in muscid flies has centered on the biosynthesis of γ -glutamyl-phenylalanine in larvae of the house fly, *Musca domestica*. Biosynthesis of this unusual, genus-specific compound is mediated by γ -glutamyl transpeptidase, which catalyzes the transfer of the γ -glutamyl moiety of reduced glutathione (GSH) to free phenylalanine. The ability of this enzyme to transfer glutamyl moieties to analogues of phenylalanine is being studied in order to select possible antitanning agents that will affect the accumulative phase of the tanning reaction in the face fly, *Musca autumnalis*; the house fly, *M. domestica*; and the stable fly, *Stomoxys calcitrans*.

Though the aromatic decarboxylase inhibitor α -MDH prevents normal tanning (i.e., hardening and darkening) of the insect cuticle, bilaterally symmetrical black-spotting but not hardening of fly puparia (*Musca domestica* and *Sarcophaga bullata*) occurs a few hours after treatment of white, newly formed puparia with this antitanning agent. This patterned darkening begins at sites on the puparium that have structural contact (via tracheae and muscles) with the metamorphosing tissues. Metamorphosis is inhibited in α -MDH-treated material and the resulting adults are imperfectly differentiated.

Autocidal Control of Mosquitoes

The feasibility of applying the sterile-male technique to mosquitoes that have already been localized by other means continues to be examined in the field and laboratory.

An egg-associated pheromone that attracts ovipositing females has been isolated from *Culex tarsalis* and purified chromatographically. The pheromone possesses surfactant properties and when high concentrations are used mosquitoes drown as they attempt to oviposit on the water surface. For the bioassay of compounds possessing high surfactancy, filter paper wetted with a mixture of such substances and water provides a suitable oviposition substrate for mosquitoes that lay eggs in rafts. *Culex pipiens* and *Aedes aegypti* do not respond to the *C. tarsalis* pheromone.

Aggregation of larvae. Attempts were continued to aggregate mosquito larvae with d-c electric fields. Voltages of 800 and 1,600 (higher than was used before) attracted 70–80% of the larvae and about 80% of the pupae of *Aedes aegypti* to the cathode. In similar tests the behavior of available native species differed markedly from that of *Aedes aegypti* and was more variable.

Chemosterilization of males. When females of *Culex pipiens* were exposed first to untreated males and then to chemosterilized males (tepa applied topically to adults), their fecundity was not reduced. When females were exposed first to chemosterilized males and then to untreated males, their fecundity was reduced, but only half as much as expected, suggesting that chemosterilized males do not render females unreceptive as effectively as do untreated males.

Mortality of males within 5 days of treatment (tepa applied as a tarsal contact to adults) was six times greater for males treated at emergence than for those treated when 1 day old; but no differences in sterility or competitiveness could be detected between survivors of each treatment group. Immersion of pupae for 4 hr in buffered solutions of thiotepa sterilized the males but not the females. In large cages, males sterilized in this way were fully competitive with untreated males, but only if their emergence into the cage had preceded by 1 day that of the untreated males.

Ant Control by Pheromones

In large laboratory formicaria, a mixture of *n*-undecane and formic acid was used to attract and trap all the workers of carpenter ants, *Camponotus* spp., within 24 hr. Attempts to apply this method in the field have failed. The two chemicals previously reported to be in the Dufour's glands were identified as 1-tridecene and 1-pentadecene.

Aphids

Application of menazon at up to 0.17 kg/ha (6 oz/acre) on plots of the corn variety Pride 5 reduced the incidence of large populations of the corn leaf aphid, *Rhopalosiphum maidis*, from about 11% to 3%. The pea aphid, *Acyrtosiphon pisum*, was attracted by extracts of *Juniperus virginiana*.

Work continued on chemicals that, by attracting ovipositing coccinellids, would help

to reduce aphid numbers in chosen situations. A method was developed for large-scale preparation of the oviposition attractant from the wood of *Juniperus virginiana*; the extract retained its activity in a water formulation suitable for spraying on plants. Females of the coccinellid *Coleomegilla maculata lengi* were attracted for oviposition by extracts of several plants, a synthetic polymer, and some readily available phenolic compounds.

Silica as an Insecticide and a Repellent

Formulations containing water, silica, a sticker, and one or more additives including organic chemicals, fatty acids, and oils were used in the greenhouse to reduce feeding damage caused by the Colorado potato beetle, *Leptinotarsa decemlineata*; these materials reduced damage by acting as both repellents and insecticides. Formulations with one additive reduced damage and increased yield in field tests. High concentrations of silica injured young plants and reduced yield. The effects of artificial defoliation on yield varied with the variety of potato and the time and degree of defoliation.

When timothy grass was sprayed with various wet formulations of silica, oviposition by the European skipper butterfly, *Thymelicus lineola*, in cages was reduced to about 1/5 to 1/12 that on untreated plants.

PARASITES

Mirid Parasites

Population levels of adults of three species of the mirid genus *Slaterocoris* breeding on *Solidago canadensis* declined from 1968 to 1970, but apparently not as a direct result of braconid parasitism, because the abundance of two (undescribed) species of *Leiophron* remained about the same.

Braconid parasitism contributes little to the control of mirids on orchard crops. None of the *Atractotomus mali* or *Deraeocoris fasceolus* examined on pears from Summerland, B.C., were parasitized; nor were mirids of a small complex on apples in the Belleville district. Four primary endoparasites attack *Lygus lineolaris*, the most injurious mirid on apples in Ontario and Quebec, but they do not suppress populations enough to prevent economic damage. An undescribed species of

the braconid genus *Euphoriana* is an important parasite at Belleville of *Trigonotylus coelestialum*, the holarctic mirid pest of cereals.

Twelve new species in the braconid, euphorine genera *Euphoriella*, *Leiophron*, *Euphoriana*, and *Holdawayella* were described.

Parasites of the Alfalfa Weevil

Six species of parasites of the alfalfa weevil, *Hypera postica*, imported from the United States and Sweden, were released in 11 counties of southern Ontario. Two of these species were recovered, in small numbers, from most of the fields sampled, apparently as a result of a natural spread from New York State and Quebec. Characters to distinguish three species of *Microctonus* that are parasitic on *Hypera postica* were found.

Parasite-Host Interactions

Laboratory experiments with three hymenopterous species, *Nasonia vitripennis*, *Muscidifurax zaraptor*, and *Spalangia cameroni*, that parasitize fly pupae showed that females of both *M. zaraptor* and *S. cameroni* lay their eggs in unparasitized fly pupae in preference to parasitized ones. However, females of the two species differed in their reactions to parasitized hosts: *M. zaraptor* laid more often in pupae attacked by *S. cameroni* than in those parasitized by either *N. vitripennis* or *M. zaraptor*, whereas *S. cameroni* discriminated little between hosts attacked by each of the three parasite species. These behavioral differences between females of *M. zaraptor* and *S. cameroni* are directly related to the probabilities of survival of their larvae: those of *M. zaraptor* often mature on hosts attacked by *S. cameroni* and infrequently on pupae attacked by *N. vitripennis* or *M. zaraptor*, whereas larvae of *S. cameroni* seldom mature on hosts previously attacked by any of the three species.

Associative learning was found to enable the polyphagous parasite *Itopectis conquisitor* to concentrate on the host species that it encountered most frequently; this ability increased its searching efficiency. Females of the oligophagous parasite *Nemeritis canescens* are also capable of associative learning, but this capability is less developed than in *I. conquisitor*.

Studies continued on the chemical factor in host hemolymph that induces oviposition by *I. conquisitor*. Females readily oviposited in a

synthetic mixture of 17 common L-amino acids. A mixture of L-serine and either L-arginine or L-lysine and L-alanine also induced oviposition but less strongly. The response was pH-dependent and was inhibited to varying degrees by the presence of Na^+ , K^+ , Ca^{++} , Mg^{++} , and PO_4^{--} ions.

PATHOGENS

Cutworms on Tobacco

Field trials in 1969 at Delhi, Ont., showed that nuclear virus sprays on the rye cover crop controlled damage to tobacco seedlings by the cutworm *Euxoa messoria*. Figures for yield, grade, and dollar value per acre (unavailable for the 1969 report) confirmed the conclusions based only on damage to seedlings: virus combined with a sublethal dose of DDT equal to 1/40 of the recommended full application or followed by one or two sprays of a special strain of *Bacillus thuringiensis* produced dollar-value returns as good as those obtained by full application of DDT.

Similar field trials in 1970 in a heavy cutworm infestation at Delhi, Ont., showed that damage to tobacco seedlings was approximately halved when the rye cover crop was sprayed with the recommended application of the insecticide Dursban (Dow Chemical of Canada Ltd.) or with various combinations of nuclear virus and Dursban, and nuclear virus followed by Thuricide (a commercial preparation of *Bacillus thuringiensis*; International Minerals & Chemical Corporation). For example, nuclear virus at 1/5 of the 1969 dose plus 1/10 of the full dose of Dursban protected seedlings as well as did the full dose of Dursban. Dursban gave somewhat better control in plots with a very heavy density of cutworms and somewhat poorer control in those with a lighter density than did virus sprays. This suggests that an overall reduction of cutworm density in the tobacco area would facilitate virus control of cutworms in crop fields. Granulosis virus protected tobacco seedlings almost as well as did nuclear virus. Thuricide was less effective than was the special strain of *B. thuringiensis* used in 1969.

A study of collections of cutworm larvae from trap plants of tobacco set in rye fields increased the knowledge on natural survival

and causes of mortality. About 35% of third-instar larvae survived to pupation; insect parasitism, microsporidial infection of the fat body, and bacterial septicemia caused most of the mortality; fungus infection was rare and natural virus infection did not occur. Trap plants sprayed with either nuclear polyhedrosis or granulosis virus resulted in infection in a large proportion of cutworm larvae and indicated that this method might be economically used to introduce virus infection into cutworm populations in the tobacco area of Ontario.

POPULATION ANALYSES

Regulatory Effects of Predators

A technique was developed for assessing the ability of the predatory mite *Typhlodromus fallacis* to reduce densities of greenhouse populations of the mite *Tetranychus urticae*. The effectiveness of *T. fallacis* as a mortality factor was not affected significantly by differential dispersion of predator and prey populations. Densities of *T. urticae* on alfalfa were reduced (compared with levels in previous years) because of competition with the newly arrived alfalfa weevil, *Hypera postica*.

A study continued of the role of spiders and other predators in regulating grassland pests. Five years' sampling of arthropods in a meadow by quick-trap and vacuum sampler yielded 2,142–3,366 individuals/m² annually. Leaf- or sap-feeders (predominantly leafhoppers and thrips) comprised 16–24%, entomophagous forms (75% predators, 25% parasitoid Hymenoptera) 2–9%, and other forms (largely Collembola and mites) 66–78%. Spiders (53/m²) comprised about 43% of total predators, the commonest species being *Erigone autumnalis* (13/m²) and *Ceraticelus emertoni* (11/m²), both of which are web-builders that are less than 2 mm long when mature. These and seven other small species together averaged 39/m², or 74% of all spiders. The rest of the spider population comprised about 140 species, none of which exceeded 2/m² in mean density.

In unsprayed orchards pupae and exposed larvae of the apple maggot, *Rhagoletis pomonella*, were destroyed by European earwigs, *Forficula auricularia*, and pupae by sowbugs, *Porcellio laevis*. Adult apple maggots resemble the adult male of the jumping spider

Paraphidippus marginatus; their appearance and avoiding responses apparently protect them from predators.

Behavioral Control

The feasibility of localizing orchard populations of the apple maggot in order to increase their accessibility for control continues to be examined. Modified trees possessing one or more of three characteristics attracted 4-12 times as many adult apple maggots as did adjacent commercial-type trees; the effectiveness of such trap-trees changed as the fruit matured. The presence of a trap-tree did not increase the number of adults attracted to adjacent commercial trees.

INSECT-PLANT RELATIONS

Biological Control of Weeds

Studies continued on the control of noxious weeds by liberating, after they had been screened, weed-feeding insects from abroad.

Carduus nutans and *C. acanthoides*. Numbers of the weevil, *Rhinocyllus conicus*, on *C. nutans* in Saskatchewan doubled and establishment can be assumed. Some breeding occurred among *R. conicus* liberated against *C. acanthoides* in Ontario, but establishment is not certain.

Centaurea maculosa and *C. diffusa*. The gall-forming trypetid *Urophora affinis* was released against both weeds in British Columbia. Fifty larvae per m² were recovered on the former and 3/m² on the latter.

Cirsium arvense. Two unsuccessful releases were made of the beetle *Altica carduorum*, and no more are planned. A colony of the weevil, *Ceutorhynchus litura*, in Ontario increased by about 40%, compared with the level in 1969, to cover an area of about 4,000 m².

Euphorbia cyparissias. At Braeside, Ont., this weed has increased about threefold since 1955 and now occurs over about 777 ha (30 sq miles). The European spurge hawkmoth, *Celerio euphorbiae*, reached a density of 0.4 larva/m² near the release site, but 14 larvae/m² are needed to strip the weed. Small releases were made of the spurge root borer, *Chamaesphexia empiformis*.

Hypericum perforatum. The beetle *Chrysolina hyperici* overwintered in Ontario, where adult survival was 19%, and in Nova Scotia. Survival of the beetle *C. quadrigemina* in Ontario was 6%; the stock from British Columbia survived about twice as well as did that from California. The species has become adapted to cold winters during the 11 years since its first introduction to British Columbia from California. The aphid *Aphis chloris* was obtained for screening.

Linaria vulgaris. The moth *Calophasia lunula* increased to a density of 0.7 larva/m² at Belleville, Ont.; a further 10-fold increase is needed to defoliate the weed in the release area.

Senecio jacobaea. In Nova Scotia defoliation by larvae of the moth *Hypocrita jacobaeae* kills the weed, and the density of *S. jacobaea* at the release site is declining. In British Columbia, however, many defoliated plants regenerate and produce stunted flower stalks the following year without a decline in the number of plants. Climate causes these differences. Releases of the anthomyiid fly *Hylemya seneciella* in British Columbia and Nova Scotia were unsuccessful.

Silene cucubalus. Screening tests for the host specificity of the leaf-feeding beetle *Cassida hemisphaerica* were begun.

NUTRITION

Effects of Antimicrobials in Insect Diets

Experiments to determine the proper use of antimicrobial compounds in artificial diets for insects were concluded.

All of 21 compounds tested in diets on axenically reared larvae of the fly *Pseudosarcophaga affinis* had detrimental effects on rate of development, size, or survival of the insect. The magnitude of the effects depended on the concentration and kind of the antimicrobial. The eight compounds that caused the least impairment were Aerosporin, mycitradin sulfate, penicillin G potassium, potassium sorbate, sodium benzoate, sodium propionate, streptomycin sulfate, and Tetracycline.

Contamination of the artificial diet of *P.*

affinis by bacteria, yeast, and molds was detrimental to the insect by prolonging its development, causing mortality of larvae, and reducing adult emergence. These effects appeared to result from alteration of the consistency and food value of the diet and not from visible infection of larvae. Aerosporin completely suppressed the growth of yeast, and mycfradin sulfate, streptomycin sulfate, and Tetracyclin completely suppressed the growth of bacteria at concentrations that were innocuous for the insect. But these antibiotics and the mold inhibitors potassium sorbate, sodium benzoate, and sodium propionate failed to suppress growth of molds at dietary levels that did not in themselves cause insect mortality. At lower concentrations that inhibited but did not completely suppress microbial growth, none of the antimicrobials prevented the microbial contaminants from impairing insect development and survival.

Food Selection and Nutrition

Larvae of *P. affinis* select the diet that is superior for larval growth rate and survival. A certain nutrient balance (2.25% amino acids and 0.5% glucose) that was nutritionally superior was selected in preference to lesser (0.75%) or greater (6.0%) levels of amino acids. Certain levels (2.0% and 4.0%) resulted in equal rates of growth and choice; other levels (0.75% and 5.5%) resulted in equal growth rates but unequal choice.

Artificial Propagation

A chemically defined synthetic diet was developed for the hymenopterous endoparasite *Itopectis conquisitor*. On this diet about 80% of the newly hatched larvae became adults, which produced a normal generation in the natural host.

Methods were developed for propagating two predators of the mite *Tetranychus urticae* on alternate species of prey.

INSECT IMPORTS AND EXPORTS

Six agricultural and six weed projects of the Department of Agriculture and seven projects of the Department of Fisheries and Forestry were provided with information, or living insects from abroad, or both. About 121,000 living insects were imported from ten foreign countries and 27,500 beneficial insects were shipped to five Canadian provinces for use against the insects *Choristoneura fumiferana*, *Coleophora laricella*, *Hypera postica*, *Neodiprion sertifer*, *Pieris rapae*, *Psylla pyricola*, *Rhyacionia buoliana*, and *Tipula paludosa*; and the plants *Carduus acanthoides*, *Centaurea maculosa*, *Cirsium arvense*, *Euphorbia cyparissias*, *Hypericum perforatum*, and *Senecio jacobaea*. Shipments to four foreign countries totaled 680 specimens.

SCIENTIFIC NAMES OF ANIMALS AND PLANTS

This list contains the full scientific name of each species mentioned in the text and, where appropriate, the equivalent common name.

<i>Acyrtosiphon pisum</i> (Harris)	pea aphid
<i>Aedes aegypti</i> (Linnaeus)	yellow-fever mosquito
<i>Aedes trichurus</i> (Dyar)	mosquito
<i>Altica carduorum</i> (Guérin-Méneville)	beetle
<i>Aphis chloris</i> Koch	aphid
<i>Atractotomus mali</i> (Meyer-Dür)	plant bug
<i>Bacillus thuringiensis</i> Berliner	bacterium
<i>Calophasia lunula</i> (Hufnagel)	moth
<i>Carduus acanthoides</i> Linnaeus	plumeless thistle
<i>Carduus nutans</i> Linnaeus	nodding thistle
<i>Cassida hemisphaerica</i> Herbst	tortoise beetle
<i>Celerio euphorbiae</i> (Linnaeus)	European spurge hawkmoth
<i>Centaurea diffusa</i> Lameere	diffuse knapweed

<i>Centaurea maculosa</i> Lameere	spotted knapweed
<i>Ceraticelus emertoni</i> (O. Pickard-Cambridge)	dwarf spider
<i>Ceutorhynchus litura</i> (Fabricius)	weevil
<i>Chamaesphacia empiformis</i> Esper	spurge root borer
<i>Choristoneura fumiferana</i> (Clemens)	spruce budworm
<i>Chrysolina hyperici</i> (Foerster)	beetle
<i>Chrysolina quadrigemina</i> (Suffrian)	beetle
<i>Cirsium arvense</i> (Linnaeus) Scopoli	Canada thistle
<i>Coleomegilla maculata lengi</i> Timberlake	ladybird beetle
<i>Coleophora frischella</i> Linnaeus	European sweetclover casebearer
<i>Coleophora laricella</i> (Hübner)	larch casebearer
<i>Culex pipiens</i> Linnaeus	mosquito
<i>Culex tarsalis</i> Coquillett	mosquito
<i>Deraeocoris fasceolus</i> Knight	plant bug
<i>Erigone autumnalis</i> Emerton	dwarf spider
<i>Euphorbia cyparissias</i> Linnaeus	cypress spurge
<i>Euxoa messoria</i> (Harris)	dark-sided cutworm
<i>Forficula auricularia</i> Linnaeus	European earwig
<i>Hylemya seneciella</i> Meade	anthomyiid fly
<i>Hypera postica</i> (Gyllenhal)	alfalfa weevil
<i>Hypericum perforatum</i> Linnaeus	St. John's-wort
<i>Hypocrita jacobaeae</i> (Linnaeus)	European cinnabar moth
<i>Itopectis conquisitor</i> (Say)	parasitic wasp
<i>Juniperus virginiana</i> Linnaeus	eastern red cedar
<i>Leptinotarsa decemlineata</i> (Say)	Colorado potato beetle
<i>Linaria vulgaris</i> Miller	toadflax
<i>Lygus lineolaris</i> (Palisot de Beauvois)	tarnished plant bug
<i>Musca autumnalis</i> De Geer	face fly
<i>Musca domestica</i> Linnaeus	house fly
<i>Muscidifurax zaraptor</i> Kogan and Legner	parasitic wasp
<i>Nasonia vitripennis</i> (Walker)	parasitic wasp
<i>Nemeritis canescens</i> Gravenhorst	parasitic wasp
<i>Neodiprion sertifer</i> (Geoffroy)	European pine sawfly
<i>Paraphidippus marginatus</i> (Walckenaer)	jumping spider
<i>Pieris rapae</i> (Linnaeus)	imported cabbageworm
<i>Porcellio laevis</i> Koch	sowbug
<i>Pseudosarcophaga affinis</i> auct. nec Fallén	parasitic fly
<i>Psylla pyricola</i> Foerster	pear psylla
<i>Rhagoletis pomonella</i> (Walsh)	apple maggot
<i>Rhinocyllus conicus</i> (Froelich)	weevil
<i>Rhopalosiphum maidis</i> (Fitch)	corn leaf aphid
<i>Rhyacionia buoliana</i> (Schiffermueller)	European pine shoot moth
<i>Sarcophaga bullata</i> Parker	flesh fly
<i>Senecio jacobaea</i> Linnaeus	tansy ragwort
<i>Silene cucubalus</i> Wibel	bladder campion
<i>Solidago canadensis</i> Linnaeus	Canada goldenrod
<i>Spalangia cameroni</i> Perkins	parasitic wasp
<i>Stomoxys calcitrans</i> (Linnaeus)	stable fly
<i>Tenebrio molitor</i> Linnaeus	yellow mealworm
<i>Tetranychus urticae</i> Koch	two-spotted spider mite
<i>Thymelicus lineola</i> (Ochsenheimer)	European skipper butterfly
<i>Tipula paludosa</i> Meigen	European marsh crane fly

Trigonotylus coelestialium (Kirkaldy)
Typhlodromus fallacis (Garman)
Urophora affinis Frauenfeld

plant bug
predatory mite
gall fly

PUBLICATIONS

Research

- Bodnaryk, R. P. 1970. Biosynthesis of gamma-L-glutamyl-L-phenylalanine by the larva of the housefly *Musca domestica*. *J. Insect Physiol.* 16:919-929.
- Bodnaryk, R. P. 1970. Chemical taxonomy: an application to the genus *Sarcophaga* (Diptera: Sarcophagidae). *Can. Entomol.* 102:349-353.
- Bodnaryk, R. P. 1970. Effect of dopa-decarboxylase inhibition on the metabolism of β -alanyl-L-tyrosine during puparium formation in the fleshfly *Sarcophaga bullata* Parker. *Comp. Biochem. Physiol.* 35:221-227.
- Bodnaryk, R. P. 1970. Levels of free glutamic acid, phenylalanine, and γ -glutamyl-L-phenylalanine during pupal sclerotization in the housefly, *Musca domestica* L. *Comp. Biochem. Physiol.* 35:499-502.
- Bronskill, J. F. 1970. Permanent whole-mount preparation of lepidopterous genitalia for complete visibility of the female sex pheromone gland. *Ann. Entomol. Soc. Amer.* 63:898-900.
- Bucher, G. E., and Cheng, H. H. 1970. Use of trap plants for attracting cutworm larvae. *Can. Entomol.* 102:797-798.
- Bucher, G. E., and Luthy, P. 1970. Flagellation of DD136 bacteria. *J. Invertebr. Pathol.* 15:292-294.
- Burnett, T. 1970. Effect of simulated natural temperatures on an acarine predator-prey population. *Physiol. Zool.* 43:155-165.
- Burnett, T. 1970. Effect of temperature on a greenhouse acarine predator-prey population. *Can. J. Zool.* 48:555-562.
- Capek, M. 1970. A new classification of the Braconidae (Hymenoptera) based on the cephalic structures of the final instar larva and biological evidence. *Can. Entomol.* 102:846-875.
- Chutter, F. M. 1970. A preliminary study of factors influencing the number of oocytes present in newly emerged blackflies (Diptera: Simuliidae) in Ontario. *Can. J. Zool.* 48:1389-1400.
- Corbet, P. S. 1970. The use of parasitic water-mites for age-grading female mosquitoes. *Mosquito News* 30:436-438.
- Dondale, C. D., and Legendre, R. 1970. Mise en évidence de phénomènes de diapause hivernale chez l'Araignée paléarctique *Pisaura mirabilis* (Clerck, 1758) (Pisauridae). *C. R. Acad. Sci. (Paris)* 270:2483-2485.
- Dondale, C. D., Redner, J. H., Farrell, E., Semple, R. B., and Turnbull, A. L. 1970. Wandering of hunting spiders in a meadow. *Bull. Mus. Nat. Hist. Natur. Paris* 41:61-64.
- Harris, P., and Piper, G. L. 1970. Ragweed (*Ambrosia* spp.: Compositae): its North American insects and the possibilities for its biological control. *Commonw. Inst. Biol. Contr. Tech. Bull.* 13:117-140.
- Hegdekar, B. M. 1970. Amino acid analogues as inhibitors of insect reproduction. *J. Econ. Entomol.* 63:1950-1956.
- House, H. L. 1970. Choice of food by larvae of the fly, *Agria affinis*, related to dietary proportions of nutrients. *J. Insect Physiol.* 16:2041-2050.
- House, H. L. 1970. Effects of different proportions of nutrients on insects. *Entomol. Exp. Appl.* 12(1969):651-669.
- James, H. G. 1970. Immature stages of five diving beetles (Coleoptera: Dytiscidae), notes on their habits and life history, and a key to aquatic beetles of vernal woodland pools in southern Ontario. *Proc. Entomol. Soc. Ont.* 100(1969):52-97.
- James, H. G., Wishart, G., Bellamy, R. E., Maw, M., and Belton, P. 1970. An annotated list of mosquitoes of southeastern Ontario. *Proc. Entomol. Soc. Ont.* 100(1969):200-230.
- Loan, C. C. 1970. *Coleophora frischella* L. (Lepidoptera: Coleophoridae): a new pest of sweet clover in Canada with an assessment of damage at Belleville, Ontario. *Phytoprotection* 51:91-97.
- Loan, C. C. 1970. *Euphoriana* Gahan: a re-definition with new name combinations and a new Canadian species (Hymenoptera: Braconidae, Euphorinae). *Proc. Entomol. Soc. Wash.* 72:437-442.
- Loan, C. C. 1970. Two new parasites of the tarnished plant bug in Ontario: *Leiophron pseudopallipes* and *Euphoriana lygivora* (Hymenoptera: Braconidae, Euphorinae). *Proc. Entomol. Soc. Ont.* 100(1969):188-195.

Maw, M. G. 1970. Capric acid as a larvicide and an oviposition stimulant for mosquitoes. *Nature* (London) 227:1154-1155.

Peschken, D., Friesen, H. A., Tonks, N. V., and Banham, F. L. 1970. Releases of *Altica carduorum* (Chrysomelidae: Coleoptera) against the weed Canada thistle (*Cirsium arvense*) in Canada. *Can. Entomol.* 102:264-271.

Riordan, D. F., and Peschken, D. P. 1970. A method for obtaining P³²-labelled eggs of the flea beetle *Altica carduorum* (Coleoptera: Chrysomelidae). *Can. Entomol.* 102:1613-1616.

Singh, P. 1970. Host-plant nutrition and composition: effects on agricultural pests. *Inform. Bull.* 6, Research Institute, Can. Dep. Agr., Belleville, Ont., 102 p.

Singh, P., and House, H. L. 1970. Antimicrobial agents: their detrimental effects on size of an insect, *Agria affinis*. *Can. Entomol.* 102:1340-1344.

Singh, P., and House, H. L. 1970. Antimicrobials: 'safe' levels in a synthetic diet of an insect, *Agria affinis*. *J. Insect Physiol.* 16:1769-1782.

Singh, P., and House, H. L. 1970. Effects of streptomycin and potassium sorbate levels in relation to nutrient levels on the larvae of *Agria affinis*. *J. Econ. Entomol.* 63:449-454.

Wylie, H. G. 1970. Oviposition restraint of *Nasonia vitripennis* (Hymenoptera: Pteromalidae) on hosts parasitized by other hymenopterous species. *Can. Entomol.* 102:886-894.

Yazgan, S., and House, H. L. 1970. An hymenopterous insect, the parasitoid *Itoplectis conquisitor*, reared axenically on a chemically-defined synthetic diet. *Can. Entomol.* 102:1304-1306.

Miscellaneous

Bronskill, J. F. 1970. Fine-mesh stainless steel gauze containers for fluid processing of very small free-floating specimens. *Stain Technol.* 45:87-89.

Bucher, G. E. 1970. Control of cutworms in tobacco by virus diseases. *The Lighter* 40(2):14-19.

Bucher, G. E. 1970. Cutworms in tobacco: control by virus diseases. *Can. Agr.* 15(4):37-39.

Burnett, T. 1970. Pest control. Revised. *Encycl. Brit.* 1970:727-732.

Corbet, P. S. 1970. Alternatives to chemical control, p. 34-47. *In* Ont. Dep. Health and Ont. Dep. Agr. Food, Air-blast equipment and pesticide use in Ontario—a symposium.

Corbet, P. S. 1970. Biological control of weeds. *Sci. Affairs* 4:68-69.

Corbet, P. S. 1970. Pest management: objectives and prospects on a global scale, p. 191-204. *In* R. L. Rabb and F. E. Guthrie [ed.] *Concepts of pest management*. North Carolina State University, Raleigh.

Nicholls, C. F. 1970. Some entomological equipment. *Inform. Bull.* 2 (2nd ed.), Research Institute, Can. Dep. Agr., Belleville, Ont., 118 p.

Wilkinson, A. T. S., Harris, P., Neary, M. E., and Thompson, L. S. 1970. Control of stinking willie with the cinnabar moth. *Can. Agr.* 15:9-11.

Williamson, G. D. 1970. A summary of parasite and predator shipments made in Canada in 1969, including tables of insect liberations made against noxious weeds and the shipment of beneficial insects to foreign countries. *Can. Dep. Agr. Liberation Bull.* 33, 9 p.

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Departure

H. A. U. MONRO, B.S.A., M.Sc., Ph.D. Died June 1970	Fumigation
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VISITING SCIENTISTS

P. I. M. CHABEDA, B.Sc., M.As. Canadian International Development Agency fellow	Pesticide residue analysis
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Biophysics

Biochemistry: toxicology

Fumigation

Plant pathology: fungicides

INTRODUCTION

The highlights of the Institute's research activities for 1970 are summarized here. Research continued on the mode of action of toxicants (fungicides, herbicides, and insecticides) and biologically active material such as toxins associated with plant pathogens, insect attractants, and phytoalexins. The search for these materials, their characterization, and their utilization requires a multidisciplinary approach. This program has been increased at the Institute and with other establishments in the Branch and elsewhere. The current pressure to replace the persistent pesticides has made the search for alternatives even more important. However, the need to determine any deleterious side effects and to improve efficiency is equally critical. Pollution studies were started to determine the extent of insecticide residue runoff in two representative areas.

The passing of Dr. H. A. U. Monro, one of the original staff members of the Institute, was mourned by all of us.

E. Y. Spencer
Director

BACTERIOLOGY

Structure and Composition of the Insecticidal Parasporal Body of *Bacillus thuringiensis*

Factors that affect the dispersion of the parasporal body are being studied by means of fractionation and bioassay.

BIOPHYSICS

The Physical-Chemical Properties and Functioning of the Cytoplasmic Membrane

In an analysis of membrane composition, during the study of selective transport, a method was developed for total solubilization of the model erythrocyte membrane. Studies are now being directed to an explanation of fungicidal selectivity.

FUMIGATION

Cumulative Toxicity of Phosphine to Insects

Sublethal doses of phosphine have been found to produce injury to insects that is cumulative when repeated treatments are made. With *Sitophilus granarius* (L.), repeated low dosages were apparently more effective than a single treatment at a higher concentration. In an attempt to explain this behavior the mechanism of phosphine toxicity in insects is under investigation. The first

step is an examination of the reaction with cytochrome oxidase.

Fumigant Control of the European Red Mite

In cooperation with the research stations at Vineland Station and Summerland, ethylene dibromide is being investigated to establish conditions for the elimination of viable diapausing eggs of the European red mite from apples without injuring the fruit.

INSECT PHYSIOLOGY AND TOXICOLOGY

Electrophysiological Studies on Insect Visceral Muscle

Studies on the properties of the insect gut muscle were continued to gain further basic knowledge before analyzing the mode of action of insecticides. The normal patterns of the electrical and mechanical responses of the longitudinal muscle fiber were examined.

Pharmacologically Active Substances in Insects

In the search for alternative insect toxicants, the new neurotransmitter substance has now been purified 25 million times. At this stage of purity it has been possible to eliminate candidates such as glutamate. Sufficient material is now available for chemical analysis.

Mode of Action of Photoperiod in Determining Growth and Development in Insects

A study of the effect of photoperiod on blood-borne sodium and potassium ions and its relationship to the termination of diapause was completed. It was much easier to terminate diapause photoperiodically in field borers than in the laboratory-reared ones, and this correlates with the lower sodium levels in the latter. The physiological changes will continue to be followed by light- and electron-microscopic examination of sections. These results and techniques will be used to predict the emergence of the corn borer in various localities and thus result in more precise timing of application of suitable short-lived insecticides.

Pathways of Glucose Metabolism in Insects

To systematize the study of possible target sites particularly of organochlorine insecticides, a multienzyme system was chosen which consisted of pathways involved in glucose metabolism. A radiorespirometric method was developed by which the inhibitor effect could be localized, and it was used in an examination of DDT and lindane activity. The results indicated that the target site could include interference with oxidative phosphorylation.

Mechanism of Oxidative Phosphorylation

During a study of the way that organochlorine insecticides interfere with the synthesis of ATP by the mitochondria, the effect of DDT, lindane, and dieldrin on the membrane was examined by measuring the changes in ionic gradients. The results indicated that a number of factors affecting ion transport have yet to be clarified in order to show relevance to mode of action in insects.

Biochemistry of Insecticide Resistance

Some insecticides are inducers of enzymes that detoxify other insecticides, whereas others may detoxify by selection of genes for specific enzymes. To clarify the mechanisms involved, the effect of the inhibitors actinomycin and puromycin on DDT stimulation of leucine incorporation into insect microsomal protein has been examined.

Carbohydrate Metabolism

As part of a program to uncover potential targets for insect control, the regulation of polysaccharide synthesis and breakdown is being investigated. The main-flight energy source, glycogen, has been assayed by a new microtechnique and a cofactor on which glycogen synthetase is dependent has been isolated. After the mechanism of activation of phosphorylase has been determined, emphasis will be directed toward the biosynthesis of chitin in insects.

Acetylcholinesterase

Because of the importance of acetylcholinesterase as the target for organophosphorus and carbamate insecticides, an intensive kinetic study has been made to determine differences in the reaction of enzymes from vertebrate and invertebrate sources. The fly head enzyme was found to differ from the vertebrate source in that the enzyme-substrate complex is involved in the former as a rate-determining step and cations are readily bound, whereas this is not true of the latter.

Work is continuing on a study of the differential detoxification of the geometrical isomers of several dimethyl phosphate insecticides through transmethylation.

Isolation and Identification of Insect-feeding Stimulants and Attractants

In a collaborative study with the Research Station, Winnipeg, Man., the spread in activities of synthetic triglycerides, as well as differences in response elicited by various fractions of the natural mixture from the storage fungus *Nigrospora sphaerica* (Sacc.) Mason, suggested a broadly based structure-activity relationship.

From a cooperative project with the Research Institute, Belleville, Ont., the constituents of *Juniperus virginiana* (L.) extract that attract ovipositing coccinellids were shown to be very similar chemically to phlobaphenes. A number of common phenols are also active, indicating a general response to phenolic substances. In another collaborative project initial results indicated that the substance that stimulates oviposition of the mosquito *Culex tarsalis* Coquillett is a diglyceride containing at least one esterified hydroxy fatty acid.

FUNGAL PHYSIOLOGY AND TOXICOLOGY

Systemic Fungicides

The effects of eight systemic fungicides applied to Herta barley seed infected with *Helminthosporium sativum* Pamm., King & Bakke at various stages in seedling development were compared. Some were phytotoxic, others favored recovery of a saprophyte, and still others controlled infection of coleoptile and seedling leaves. To test the theory that fungicides are active due to selective accumulation by the fungus, two susceptible fungi were found to take up 200 times the concentration of thiabendazole as that in an external solution. Four of the systemic fungicides varied in their effect on root pressure, transpiration, and amino acid transport of topped tomato plants.

Mode of Action of a Fungal Toxin and an Antifungal Agent

Preliminary evidence confirms the production of a toxic material in barley leaves infected with spores of *H. sativum*. Its identity with the toxin, helminthosporal, isolated from the fungus grown on artificial media is being checked. The biochemical studies on the mode of action of helminthosporal and related activities of some other dialdehydes and barbiturates are now largely completed.

The biological significance of the antifungal substance hordatine, isolated from barley, has been examined further. In addition to its inhibitory activity on germinating spores, it has had a strong inhibitory effect on respiration of the mycelium of *Monilinia fructicola* (Wint.) Honey.

Physiology of Plant-pathogenic Psychrophilic Fungi

To aid in elucidating the source of hydrogen cyanide produced by a low-temperature basidiomycete, appropriate radioactive-labeled compounds were synthesized. It was shown that isoleucine is not a precursor of hydrogen cyanide and that a number of dipeptides, especially alanyl-glycine and glycyl-glycine, promote hydrogen cyanide production even more efficiently than glycine. A hypothetical pathway has now been proposed.

Miscellaneous Plant and Fungal Metabolites

The determination of the stereochemistry of unique pigments from *Alternaria solani* (Ell. & Martin) Jones & Grout, a pathogen of solanaceous plants, is nearing completion. One pigment has been found to be active against gram-positive bacteria and another is closely related in structure to the antibiotic bostrycin.

Studies with green peppers inoculated with a pathogenic fungus have indicated the production of a weak antifungal diffusate that is not a phytoalexin and is nonspecific in origin.

PLANT PHYSIOLOGY AND TOXICOLOGY

Metabolic Root Pressure and Uptake of Triazine Herbicides

Investigations with detopped tomato plants indicated that solute translocation stops well above the wilting point. Urea-treated plants extracted moisture from drier soils than the controls. Evidence suggests that under optimum conditions of soil moisture and temperature the concentration of atrazine in the stump exudate from detopped tomato plants is representative of its concentration in the transpiration stream of intact plants.

Control of Enzyme Synthesis in Plants by Synthetic Growth Regulators

At least two distinct groups of indoleacetic acid oxidases were found, which differed in electrophoretic mobility as well as in their response to growth regulators. The fast-migrating component was associated with a rapid rate of plant growth, higher water content, and large cells. The slower-moving component was promoted by 2,4-D, 2,4,5-T, picloram, and high concentrations of indoleacetic acid and was accompanied by growth retardation.

Isolation of Auxin Reactive Proteins

Attempts are being made to design specific affinity adsorbents in order to be able to isolate from crude extracts specific proteins that may mediate the primary action of natural and synthetic growth regulators. Initially

the auxin group has been selected and suitable derivatives of 2,4-D and amiben (chloramben) have been coupled to Sepharose in preparation of the affinity column. Preliminary work has resulted in the isolation of macromolecular protein factors, which differ between peas and corn.

Interaction of Soil Microorganisms with Herbicides

The long- and short-term influence of herbicides on the microorganisms of Fox sandy loam is being investigated. The response of bacteria and molds to paraquat, atrazine, simazine, diuron, and linuron was moderate, whereas that of actinomycetes was pronounced. Some favored cellulolytic bacteria, and all were detrimental to the urease-positive bacteria. The study of the effects on other specific soil bacteria is in progress.

Insecticide Behavior in Soil

As an integral part of this study nine soil insect species of economic importance were maintained and cultures of the black cutworm and the European corn borer were established. A mass rearing technique for the red-backed cutworm was developed and a strong culture of this serious economic pest is being established.

In the search for replacements for DDT several promising materials were found. Although most are of short to moderate duration in soil, some are as persistent as DDT. Because there might be undesirable ecological damage from the persistent ones, a more detailed study is under way.

Following the primary and secondary screening, several promising materials have emerged from the final microplot tests, showing excellent potential for the control of the red-backed cutworm, which attacks vegetable crops. Similar results have been obtained in this program from which several new insecticides have been registered for the control of cabbage insects.

In the recently established insecticide ecology program the effect of some soil insecticides on nontarget soil invertebrates, such as Collembola and earthworms, is in progress. Also, a study was started to determine the importance of predatory carabid beetles in suppressing soil insect populations and optimum conditions for their development. Some significant side effects were noted.

The 5-year survey on the accumulation of organochlorine insecticides in agricultural soils sampled in southwestern Ontario was completed. Meantime, techniques of extraction, clean-up, and analysis by gas-liquid chromatography were devised for several of the more promising organophosphorus and carbamate insecticides. The persistence of these materials in soils and their uptake by earthworms are being studied.

The new program on soil-insecticide interaction is now under way. Infrared absorption spectra are being used to examine the complex of fensulfothion (Dasanit) and montmorillonite clay saturated with different cations at varying moisture contents. Preliminary results indicated an increased stabilization of the sulfone on adsorption.

Effect of Insecticides and Nematocides on Soil Microbial Activities

Significant inhibitory effects on molds, bacteria, and nitrifiers in most cases were exhibited by six nematocides being used or showing promise, but the microbes subsequently recovered to the control levels. The oxygen consumption varied depending on the specific material and concentration. In a joint program with the research stations at Delhi and Vineland Station, Ont., the effects of some organophosphorus and carbamate insecticides and some fumigants on the nitrifying microbes in tobacco soil were examined. Tests on samples taken in June indicated that fumigants applied in the fall and spring had decreased the nitrifiers in most plots by that time.

In studies on the utilization of carbon by microbes, some cultures isolated were able to utilize lindane as the carbon source for energy and growth.

Water Pollution by Pesticides

To assess the possible contribution of agriculture to the pollution of waters with pesticides, two pilot areas were established for sampling water, bottom mud, and fish. The first drains almost solely tobacco farms in its upper reaches, and tobacco, corn, and mixed farms in its lower area. The second drains a muckland area used for growing a variety of vegetable crops. Preliminary results from the 6-month summer sampling indicate fractional parts per million total DDT in the water and fractional to unit parts per million in the bottom muds.

PUBLICATIONS

Research

- Bond, E. J., Butler, W. H., De Matteis, F., and Barnes, J. M. 1969. Effects of carbon disulphide on the liver of rats. *Brit. J. Ind. Med.* 26:335-337.
- Bond, E. J., Robinson, J. R., and Buckland, C. T. 1969. The toxic action of phosphine. Absorption and symptoms of poisoning in insects. *J. Stored Prod. Res.* 5:289-298.
- Bowman, B. T., Adams, R. S., Jr., and Fenton, S. W. 1970. Effect of water upon malathion adsorption onto five montmorillonite systems. *J. Agr. Food Chem.* 18:723-727.
- Chefurka, W., Horie, Y., and Robinson, J. R. 1970. Contribution of the pentose cycle to glucose metabolism by insects. *Comp. Biochem. Physiol.* 37:143-165.
- Chefurka, W., Yapo, A., and Nisman, B. 1970. *In vitro* synthesis of β -galactosidase by membrane fractions of *Escherichia coli*. *Can. J. Biochem.* 48:893-907.
- Dumas, T. 1969. Microdetermination of phosphine in air by gas chromatography. *J. Agr. Food Chem.* 17:1164-1165.
- Ela, R., Chefurka, W., and Robinson, J. R. 1970. *In vivo* glucose metabolism in normal and poisoned *Periplaneta americana*. *J. Insect Physiol.* 16:2137-2156.
- Harris, C. R. 1970. Laboratory evaluation of candidate materials as potential soil insecticides. III. *J. Econ. Entomol.* 63:782-787.
- Harris, C. R., and Gore, F. 1970. Laboratory tests on the contact toxicity of some insecticides to adults of the cabbage flea beetle *Phyllotreta cruciferae*. *J. Econ. Entomol.* 63:1025-1026.
- Harris, C. R., and Hitchon, J. L. 1970. Laboratory evaluation of candidate materials as potential soil insecticides. II. *J. Econ. Entomol.* 63:2-7.
- Harris, C. R., and Sans, W. W. 1970. Vertical distribution of residues of organochlorine insecticides in soils collected from 6 farms in southwestern Ontario. *Proc. Entomol. Soc. Ont.* 100:156-164.
- Harris, C. R., and Svec, H. J. 1970. Laboratory studies on the toxicity of technical formulations of some insecticides to cabbage loopers. *J. Econ. Entomol.* 63:666-667.
- Harris, C. R., and Svec, H. J. 1970. Laboratory tests on the toxicity of some insecticides to the cabbage aphid. *J. Econ. Entomol.* 63:665-666.
- Harris, C. R., and Svec, H. J. 1970. Toxicological studies on cutworms. VI. Laboratory studies on the toxicity of several experimental insecticides to dark-sided cutworms as soil treatments and stomach poisons. *J. Econ. Entomol.* 63:605-609.
- Hellenbrand, K., and Krupka, R. M. 1970. Kinetic studies on the mechanism of insect acetylcholinesterase. *Biochemistry* 9:4665-4672.
- Miller, D. M. 1970. Total solubilization of erythrocyte membranes by nonionic detergents. *Biochem. Biophys. Res. Commun.* 40:716-722.
- Monro, H. A. U., Olsen, O. A., and Buckland, C. T. 1970. Methyl bromide and ethylene oxide fumigation on *Synchytrium endobioticum*. *Can. J. Plant Sci.* 50:649-658.
- Nagai, T. 1970. Insect visceral muscle. Response of the proctodeal muscles to mechanical stretch. *J. Insect Physiol.* 16:437-448.
- Richardson, L. T. 1970. Effects of atrazine on growth response of soil fungi. *Can. J. Plant Sci.* 50:594-596.
- Robinson, J. R., and Bond, E. J. 1970. The toxic action of phosphine—Studies with $^{32}\text{P}\text{H}_3$; terminal residues in biological materials. *J. Stored Prod. Res.* 6:133-146.
- Roslycky, E. B. 1970. Radiobacterophage neutralization anomaly in relation to cations. *Can. J. Microbiol.* 16:527-533.
- Starratt, A. N. 1970. Structure of an artifact formed during isolation of *Penicillium gladioli* metabolites. *Can. J. Chem.* 48:2940-2942.
- Stoessl, A., and Unwin, C. H. 1970. The antifungal factors in barley. V. Antifungal activity of the hordatines. *Can. J. Bot.* 48:465-470.
- Stoessl, A., and Venis, M. A. 1970. Determination of submicrogram levels of indole-3-acetic acid: A new, highly specific method. *Anal. Biochem.* 34:344-351.
- Thorn, G. D., and Richardson, L. T. 1970. The effects of various fungicides in soil on water and amino acid transport in tomato plants. *Can. J. Bot.* 48:2033-2037.
- Tu, C. M. 1970. Effect of four organophosphorus insecticides on microbial activities in soil. *Appl. Microbiol.* 19:479-484.
- White, G. A. 1970. Barbiturate-induced α -amylase synthesis in barley endosperm. *Can. J. Bot.* 48:1981-1988.

Miscellaneous

- Harris, C. R. 1970. Persistence and behaviour of soil insecticides, p. 58-64. Proc. Int. Symposium on Pesticides in the Soil, Feb. 25-27, 1970. Michigan State Univ., East Lansing, Mich.
- Harris, C. R. 1970. Insecticide pollution and soil organisms. Proc. Entomol. Soc. Ont. 100:14-29.
- Harris, C. R., and Svec, H. J. 1970. Laboratory studies on the contact toxicity of some insecticides to honeybees. Proc. Entomol. Soc. Ont. 100:165-167.
- Stoessl, A. 1970. Antifungal compounds produced by higher plants, p. 143-180. *In* C. Steelink and V. C. Runeckles [ed.] Recent advances in phytochemistry, Vol. 3.

Analytical Chemistry Research Service Ottawa, Ontario

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Pesticide Residues

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H. V. MORLEY, B.Sc., Ph.D.	Organochlorines
R. PURKAYASTHA, B.Sc., M.Sc., Ph.D.	Herbicides

Departures

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I. HOFFMAN, B.Sc., M.A., Ph.D., F.C.I.C. Transferred to Environmental Secretariat, National Research Council	Director

INTRODUCTION

The Analytical Chemistry Research Service has continued to provide a wide range of analytical services both in a practical way by analyzing some 45,250 biological samples during the year and in analytical research by providing specialized advice and direct assistance to research scientists in the Branch, especially in the development of analytical methods. In this way a significant contribution has been made toward solving agricultural problems at many establishments across the country.

The acquisition of nuclear magnetic resonance equipment has added a new dimension to the work of the Service. Furthermore, additional steps have been and are being taken in the development of a central instrumentation center on behalf of the Research Branch at Ottawa.

Early in the year Mr. R. B. Carson, the Director, retired, and was replaced by Dr. I. Hoffman, who in turn resigned to take up a post at the National Research Council at Ottawa. I was named Acting Director in October, though I continue to be Director, Cell Biology Research Institute.

R. M. Hochster
Acting Director

INORGANIC CHEMISTRY

Survey for Atmospheric Contamination Following Forest Spraying with Fenitrothion

In cooperation with the departments of Fisheries & Forestry and National Health & Welfare, a project was undertaken in connection with the first large-scale forest use of fenitrothion to control the spruce budworm in New Brunswick. The main purpose was to monitor for pesticide contamination in urban centers at the perimeter of the area sprayed by aircraft.

A total-phosphorus procedure was chosen to ensure the determination not only of the parent compound but also of any possible breakdown products. Fenitrothion as both vapor and particulate matter was trapped by drawing air at 12 liters/min through a column of florasil linked in series with a bubbler containing dimethyl formamide. The analytical procedure developed for these samples included stripping with dichloromethane and digestion with nitric-perchloric acids. The color complex formed with ammonium molybdate and amino-naphthol-sulphonic acid was read at a wavelength of 760 μ .

Brief increases in phosphorus concentrations showed that the population in the urban centers was exposed to some very low levels of fenitrothion during the spraying operations. There was more phosphorus in the

vapor form than in the particulate state. Although this off-target environmental contamination was detectable, the total daily intake was judged to be well below any level hazardous to human health, even if all the excess phosphorus found was present as fenitrothion.

Joint Canadian - United States Feed Composition Project

Results were reported for Ca, Cl, Co, Cu, Fe, Mg, Mn, P, K, Se, Na, S, Zn, protein, fat, fiber, ash, N.F.E., lignin, and energy in 55 samples of graded grain. These analyses of pea beans, yellow soybeans, flax, white peas, white oats, barley, rye, corn, winter wheat, and buckwheat from Eastern Canada added to the authoritative data reported in 1968 for samples of Western Canadian grain.

Results published in this joint project are now used widely in compounding animal diets and in nutritional studies.

ORGANIC CHEMISTRY

Pheromones of the Honey Bee

Although drones do not distinguish between an extract of queens and an equivalent amount of synthetic queen substance, swarming worker bees do make a distinction, which indicates the presence of synergists.

The chemical structural requirements necessary for an alarm reaction in worker bees have been postulated.

Some of the components of pollen have been identified.

Chemotaxonomy

A genetic study on varieties of oats being conducted in cooperation with Dr. T. Rajhathy, of the Ottawa Research Station, which makes use of thin-layer chromatography of the phenolic fraction extracted from leaves, has been extended to several other varieties. The principal aim of the research is to try to determine the genetic history of *Avena*. This work has been extended to include gas chromatography of the trimethylsilyl derivatives of the leaf extracts.

PHYSICAL CHEMISTRY

Acid Dissociation of Cu^{++} Chelation Equilibria of Fulvic Acid

The important chemical features of fulvic acid as a weak acid polyelectrolyte of low molecular weight have been deduced from evidence in the literature, as has the nature of the site-bound bidentate copper chelate formed by fulvic acid. It was found to be of the same type as the Cu^{++} -salicylic acid chelate. These conclusions are further supported by new experimental work.

The weak acid polyelectrolyte problem has been reformulated to achieve greater mathematical simplicity, thermodynamic rigor, and chemical usefulness. This was done by describing the experimentally observed acid dissociation and metal ion chelation equilibria as weighted averages of the individual reaction groups or sites. It was postulated for this purpose that the individual carboxyl groups are chemically similar but not identical. A similar theoretical approach may apply to other polyelectrolytes of agricultural interest, for example: the pectins.

Three new types of experimental result have now been published for a particular sample of fulvic acid.

- (a) Potentiometric and conductometric titrations have been used in combination to determine the types of carboxyl groups, and their numbers per gram of fulvic acid.
- (b) The acid dissociation equilibrium of each

of two types of carboxyl groups has been measured as a function of the degree of ionization. This was done potentiometrically.

- (c) The Cu^{++} chelation equilibrium was measured as a function of the degree of ionization at the bidentate chelation sites, by means of the cation-exchange method.

It is apparent from this work that specific ion electrodes and narrower molecular weight fractions should be used for future measurements.

PESTICIDE RESIDUES

Analyses for Residues

In soil. A comparison and evaluation of three gas chromatographs equipped with electron-capture detectors, tritium, and Ni^{63} , and operated in the pulse and D.C. mode has been completed. It was shown that anomalous results may be obtained in the analysis of soil extracts in the absence of cleanup, even under "normal" operating conditions.

The second check sample program for pesticide residues in soils carried out by the Canadian Committee on Pesticide Use in Agriculture was concluded and the results combined with those of the first year for a statistical evaluation.

In plant material. Two-dimensional, thin-layer chromatographic, fluorometric analysis has demonstrated marked varietal differences in coumestan content in field and in greenhouse specimens of the same variety.

In animal tissue. Analysis of beef fat from cattle treated (back-drench) with DDT for control of the horn fly has established that the tolerance of 7 ppm can be met under prescribed conditions.

Analysis of eggs has shown that incorporation of 1% activated charcoal into chicken diets fortified with low levels of pesticides does not significantly influence the level of lindane, chlordane, or DDT in the eggs.

In poultry. A sensitive thin-layer chromatographic method has been developed for the simultaneous detection of atrazine and linuron in eggs and chicken tissue. The method has been adapted also to a variety of samples such as water, soil, corn, blood, and milk. The sensitivity of the method varied between 0.05 and 0.5 ppm.

A colorimetric method has been worked out for determining linuron residues in eggs and other tissue. The recovery of linuron after extraction and cleanup was more than 80% at the 0.04–2.0 ppm level. No significant residues of linuron were detected in eggs and in tissues of chickens fed a diet containing the pesticide.

The ultraviolet (UV) method for the determination of atrazine has been adapted for the analysis of atrazine residues in eggs and tissue. The recovery of atrazine after extraction and cleanup was 80% at the 0.1 ppm level. No detectable residues of atrazine could be found in eggs or tissue of pesticide-fed chickens.

Chromatography of Herbicides

Thin-layer chromatography of urea and triazine herbicides. The detection limits of 10 N-containing herbicides separated on silica gel layer and on alumina layer have been determined. So far, eight detection techniques have been studied.

Gas chromatography of N-containing herbicides. The gas chromatographic behavior of atrazine and linuron has been studied by using five different stationary phases. The development of methods for residue analysis is in progress, with emphasis on cleanup procedures for electron-capture detection.

Organophosphorus Residues

A gas-liquid chromatographic, thermionic method for determining crufomate was developed and used to estimate the amount of pesticide in the venous blood of cattle treated with crufomate 25E formulation. The selectivity of the thermionic detector enabled crude extracts of blood to be used, thus eliminating the cleanup step. The results obtained by this method for crufomate were comparable with those determined by the bioassay technique. This is interpreted as indicating that crufomate does not form stable toxic metabolites in animal blood.

Parameters affecting the operation of the thermionic detectors (CsBr) in the Pye model 134 and 154 gas chromatographs were evaluated. The best operating conditions, as determined by the best precision of results, were found to be on the positive slope of the detector response/hydrogen flow curve. The sensitivity to most organophosphorus pesticides was 1×10^{-11} to 2.5×10^{-10} and to atrazine was 1×10^{-9} . Only at high-temperature program rates (16 C/min) did the precision of the retention time and peak height data equal that for isothermal conditions. Considerable operator time was needed to maintain maximum sensitivity over an 8-week period with the same CsBr annulus.

Chickens on a feed diet containing a low level of pesticide (0.5 ppm) produced eggs that were free from ethion at the 0.05-ppm level.

PUBLICATIONS

Research

- Boch, R., Shearer, D. A., and Petrasovits, A. 1970. Efficacies of two alarm substances of the honey bee. *J. Insect Physiol.* 16:17-24.
- Chiba, M., Yule, W. M., and Morley, H. V. 1970. Suitability of thin-layer chromatography, gas chromatography and bioassay for the determination of aldrin, dieldrin and DDT residues in different soils without cleanup. *Bull. Environ. Contam. Toxicol.* 5:263-270.
- Gamble, D. S. 1970. Titration curves of fulvic acid: the analytical chemistry of a weak acid polyelectrolyte. *Can. J. Chem.* 48:2662-2669.
- Gamble, D. S., Schnitzer, M., and Hoffman, I. 1970. Cu^{2+} -fulvic acid chelation equilibrium in 0.1 M KCl at 25.0°C. *Can. J. Chem.* 48:3197-3204.
- Greenhalgh, R., Heggie, R. M., and Weinberger, M. A. 1970. Effect of the structure of phosphorylating agents on their reaction with ethanolamine, an ambient nucleophile. *Can. J. Chem.* 48:1351-1357.
- Haufe, W. O., and Morley, H. V. 1970. Residues in cattle treated with DDT for control of horn flies on pasture. *Bull. Environ. Contam. Toxicol.* 5:389-396.
- Shearer, D. A., Boch, R., Morse, R. A., and Laigo, F. M. 1970. Occurrence of 9-oxodec-trans-2-enoic acid in queens of *Apis dorsata*, *Apis*

- cerana*, and *Apis mellifera*. *J. Insect Physiol.* 16:1437-1441.
- Shearer, D. A., and Morris, G. F. 1970. Microdetermination of fluorine in organic compounds with a fluoride ion electrode following an oxygen flask combustion. *Microchem. J.* 15:199-204.
- Weinberger, M. A., Greenhalgh, R., and Lutley, P. M. 1970. Mechanism of the reaction of sarin with methanol in the presence of amines. *Can. J. Chem.* 48:1358-1361.

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INTRODUCTION

Research and development activities in the past have been primarily related to productivity. Recently the concern about man and his environment has begun to affect the design of farm equipment, farm structures, animal and crop waste management systems, and pesticide application systems. The systems engineering and analysis concepts that are developing will also place different parameters and criteria on research and development requirements. A systems engineer was taken on staff to work in this area.

Engineering research and development projects were carried out at or for 24 federal establishments, 8 in the Ottawa area and 16 in other parts of Canada. Engineering research for the agricultural scientist calls for specialized equipment that reduces technical labor and for instrumentation and control systems that permit precise research and improved data collection and analysis. Five plot machines were made to facilitate field research. A temperature-controlled system for further research in coldhardiness of plants was developed as well as an electronic system for measuring size, area, and volume of agricultural products. A new instrument has been devised for measuring the texture of agricultural products and foods, which is important in the determination of quality standards.

Systems engineering projects in forage harvesting and storage and in confinement housing for swine were developed. Studies of methods of animal waste disposal and odor control were carried out and subsurface drainage practices were implemented.

A special issue of ERDA lists the current agricultural engineering research and development projects in Canada. A compilation has been made of Canadian manpower and facility resources in this field at universities and federal and provincial establishments.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

Specialists in this section cooperated with federal and provincial government agencies, universities, and industry by serving on advisory and code committees, and by providing a consultation service within the specialized areas of Field Crop Mechanization, Water Resources, Livestock Housing Systems, Storage Structures, and Systems Engineering.

Developmental Research Program

A forage project was started in cooperation with the Research Station, Melfort, Sask., and farm machinery manufacturers, to investigate hay harvesting, handling, and storage systems for the area. Beef-feeding trials are being used to evaluate the product of each forage system.

An investigation was begun of the potential of tape planting of lettuce seed in organic soils. The Research Station, St. Jean, Que., cooperated in this work and used taped seed provided by an interested company.

Research was conducted into structural components and insulation for animal production and crop storage buildings and to

evaluate the diaphragm shear strength of cladding materials used in farm building construction. Computer programs are being developed for the design of clear-span lumber roof trusses. Sprayed-on polyurethane foam insulation was exposed to high vapor pressure gradients typical of farm animal and storage buildings. Tests showed an excessive moisture accumulation within the insulation when it was sealed with vapor-tight cladding such as galvanized steel at the cold surface and exposed to high water vapor pressures at the opposite unprotected surfaces.

Canada Farm Building Plan Service

Draftsmen and engineers at the Canada Farm Building Plan Service (C.F.B.P.S.) Design Center, cooperating with provincial subcommittees, completed 49 drawing sheets giving details of construction for swine buildings, prepared three drawing sheets for dairy structures, and worked with the Information Division to prepare 50 beef drawing sheets in French.

The format of the C.F.B.P.S. Catalogues

of Plans was changed from 6 × 9-inch bulletin style to 8½ × 11-inch loose-leaf leaflets. This change was made to facilitate the rapid introduction of new plans reflecting the latest farm building technology and research results.

Other Advisory and Consulting Services

Eight technical presentations were made to provincial extension specialists, farm producer associations, technical advisors of utilities, professional associations, and Research Branch work-planning conferences. Specialists participated in three radio and television interviews. Thirteen articles were contributed to departmental periodicals such as ERDA and Soil Horizons, and three of these articles were reprinted by Canadex.

Using construction techniques and components developed for the C.F.B.P.S., five main buildings were planned and engineered for the 1970-71 winter and spring construction at research stations and experimental farms in Eastern Canada. This was an emergency construction program carried on in cooperation with the Architectural and Engineering Section of the Research Branch.

A dairy barn at the Animal Research Institute Greenbelt Farm was instrumented to compare a "porous ceiling" fresh air inlet ventilation system with a conventional "slot intake" ventilation system.

In cooperation with a subcommittee of provincial extension engineers, integrated building systems were developed for life-cycle confinement housing for cold-climate swine production. A technical bulletin on swine-housing management was drafted to outline these systems and to include balanced housing, design, pens and hardware, building arrangements, construction practices, ventilation and heating, and waste handling.

Storage, agitation, and removal of liquid dairy and sheep manure were evaluated in cooperation with the Animal Research Institute. An acceptably odor-free, rapid, plow-down system for land disposal of liquid animal and poultry manure was devised. Commercial equipment for injecting liquid manure into cropland is under investigation.

An under-floor oxidation ditch is being evaluated for aerobic partial treatment of swine waste at Abbotsford, B.C., in cooperation with the British Columbia Department of Agriculture and the University of British Columbia. Cooperative research with the Soil

Research Institute and the Animal Research Institute is being expanded to evaluate the pollution potential from stored manure, land applications of liquid manure, and commercial fertilizers.

Subsurface drainage experiments were established in cooperation with the Research Station, Harrow, Ont., to study the nutrient content of the drainage water, to evaluate the performance of new plastic drainage tubing, and to assess the effect of various drain depths and spacings.

RESEARCH SERVICE

Assistance in solving technical problems was provided to other government agencies, universities, and industry. Seminars and short courses were presented at universities. The workshop completed 120 fabrication orders.

Equipment for Mechanization of Field and Laboratory Experiments

A forage harvester was modified to remove tobacco plants from test plots to maintain uniform soil fertility. To compress tobacco leaf test samples for shredding, a press was made to compress a rectangular block of leaves uniformly.

The efficiency of oil extraction from seeds was improved by the development and use of a cell to simultaneously press six test samples without cross contamination.

A four-row variable space furrow opener was developed for systematic planting of corn. A four-row weeder was manufactured for weed control in cereal test plots. An Oregon plot thresher was modified to thresh experimental forage crops. A two-row cereal plot harvester was completed and placed in commercial production. Vacuum pickups were made to count and dispense 25 or 100 rape seeds accurately.

A 622 dm³ controlled-temperature cabinet was constructed for use in the study of plant coldhardiness. The temperature was automatically programmed in 0.5 C increments over +4 C to -20 C with spatial and temporal variations less than ±0.5 C by using mechanical refrigeration. When cooling was supplemented by spraying liquid nitrogen into the cabinet to reach -65 C, variations increased to ±1.5 C.

A system was developed for controlling moisture content of nitrogen in X-ray diffraction measurements over the range 100 to

1,800 ppm with an accuracy of better than 10% at flows of 140 liters/hr. A light-activated switch was introduced to conserve battery power in insect traps during daylight.

Instrumentation

An electronic system was designed and built to record the weight of lysimeters. Changes of 0 to 25 kg in 250 kg were measured with an accuracy of ± 0.1 kg and a resolution of 0.05 kg.

A livestock caliper was developed to measure whither height in cattle and to minimize costs of commercial reproduction. Accurate scales were prepared for the "Consumer Cost Calculator" sold by the Queen's Printer.

A bilingual lectern prompter was made to assist speakers presenting papers. Instructions are unobtrusively presented by a visual display in French or English.

A technique was worked out for differentiating between dead and viable larvae of the alfalfa leaf-cutter bee, *Megachile rotundata* F., by measuring the specific dielectric constant of the larvae as they passed between parallel brass plates.

Instruments were developed to measure egg albumen height within 0.1 mm. An electronic circuit automatically detects when a probe touches the albumen and registers the position on a digital display.

An electronic planimeter was developed to measure leaf area by using an oscilloscope as a flying spot scanner. The accuracy of measurement was 0.5% for areas greater than 10 cm², but for areas smaller than 5 cm² it was 10%.

An instrument was made to automatically record the maximum and minimum in any variable that can be converted to an electric signal. Present applications are for temperatures over the range 0 to 50 C with an accuracy of 0.5%, pH from 7 to 14 with an accuracy of 1%, and radiant energy from 0 to 2 cal cm⁻² min⁻¹. The data are displayed continuously and automatically recorded on punched tape at intervals from 60 sec to 24 hr. An electronic integrator was developed to automatically record any electric signal and print the accumulated result at 5-sec intervals such as temperature (0 to 100 C) and weight (0 to 500 g) with an accuracy of 0.25% in meteorological measurements.

An electronic system has been devised for measuring the size, area, and volume of agricultural products in three dimensions as they

pass by a detector on a moving belt. Accuracy is limited to 2% for linear dimensions and 4% for area by the accuracy and linearity of the television camera used. An automatic digital data acquisition system was designed for monitoring physiological and environmental parameters in animal research at 100 channels per second.

Processing and Quality Measurement

Techniques have been worked out for measuring the toughness of cooked soybeans and baked beans to evaluate breeding material, the firmness of heat-induced milk gels, the consistency of reconstituted instant potatoes, and the toughness of meat. Serious inaccuracies have been found in instruments used to grade pea tenderness in Ontario. Seven mechanical techniques were highly correlated and the instrument design selected can be based on practical considerations. A viscometer was developed to test a variety of foods where viscosity is developed by mechanical mixing. A new instrument has been developed for measuring the texture of agricultural products and foods. Based on a new test cell, the instrument can be made to suit one particular product or to have operational flexibility to test many products.

An air classifier was made to separate the hulls and meal of crushed rapeseed in 4.5-kg batches.

A semiautomatic instrument was devised to estimate shell strength by measuring the deformation of eggshells under nondestructive loads. The digital result is more precise than that of existing instruments and operator errors and fatigue have been reduced.

Experiments have shown that the puncture test is a reliable objective technique to select crack-resistant fruit in breeding new tomato varieties.

A prototype machine for coring apples has been tested and indicates that orientation by floatation is not sufficiently precise to improve production efficiency over mechanical orientation.

Differential thermal analysis has been used to determine if paraffin is present in excess of 1% in beeswax.

TECHNICAL AND SCIENTIFIC INFORMATION

Through the exchange of information with agricultural engineering establishments outside of Canada and by better integration with other information services, the Technical and Scientific Information Section has been able to give greater assistance to agricultural engineers and research scientists using its services.

The engineering periodical ERDA has kept agricultural engineers aware of worldwide developments and practices. It has provided an account of Canadian developments through progress reports of research projects and a record of important developments in the field of Canadian agricultural engineering research.

PUBLICATIONS

Research

- Bakal, A., Timbers, G., and Hayakawa, K. 1970. Solution of the equation involved in the transient heat conduction for foods approximated by an infinite slab. *Food Technol.* 3:76-77.
- Bolton, E. F., Aylesworth, J. W., and Hore, F. R. 1970. Nutrient losses through tile drains under three cropping systems and two fertility levels on a Brookston clay soil. *Can. J. Soil Sci.* 50:275-279.
- Brach, E. J. 1970. Remote sensing—A powerful research tool in agriculture. *J. Can. Soc. Agr. Eng.* 12:80-89.
- Brach, E. J., and Poirier, P. 1970. Electronic identification of dead larvae of the alfalfa leaf-cutter bee. *Can. Entomol.* 102:1300-1303.
- Brach, E. J., Reid, W. S., and McAdam, W. E. 1970. A continuous integrating spectrophotometer. *Trans. Inst. Electrical Electronic Eng.* IM-19:92-101.
- Brach, E. J., St. Amour, G. F., and Mason, W. J. 1970. A three channel integrating photometer. *J. Can. Soc. Agr. Eng.* 12:52-54.
- Buckley, D. J., and Hunsaker, W. G. 1970. Acquisition of computer compatible data in agricultural research. *J. Can. Soc. Agr. Eng.* 12:90-91.
- Buckley, D. J., and Stewart, W. W. A. 1970. A light-activated switch for controlling battery-operated light traps. *Can. Entomol.* 102:911-912.
- Feldman, M., and Domier, K. W. 1970. Wheel traffic effects on soil compaction and growth of wheat. *J. Can. Soc. Agr. Eng.* 12:8-11.
- Hergert, G. B. 1970. A vacuum-blower plot harvester. *Can. J. Plant Sci.* 50:359-361.
- Hergert, G. B. 1970. A light weight planter for population and cultivar studies with corn and soybeans. *Can. J. Plant Sci.* 50:610-611.
- Hergert, G. B., and Dyck, F. B. 1970. A four-way divider for plot seeders. *Can. J. Plant Sci.* 50:513-515.
- Hore, F. R., and Sojak, M. 1970. Specifications for corrugated plastic drainage tubing. *J. Can. Soc. Agr. Eng.* 12:103-106.
- Hore, F. R. 1970. Disposal of animal wastes. *Proc. Environmental Management for the Public Health Inspector. Inst. Public Affairs. Dalhousie Univ. Sept.* p. 41-52.
- Timbers, G. E., and Danks, H. V. 1970. A liquid-nitrogen operated chamber for insect supercooling studies. *Can. Entomol.* 102:90-94.
- Turnbull, J. E., and Todd, D. M. 1970. The effect of nailing patterns on the tensile strength of plywood gussets. *J. Can. Soc. Agr. Eng.* 12:42-44.
- Voisey, P. W. 1970. Test cells for objective textural measurements. *J. Can. Inst. Food Technol.* 3:93-102.
- Voisey, P. W., and Andrews, C. J. 1970. A coldhardiness cabinet. *J. Can. Soc. Agr. Eng.* 12:55-56.
- Voisey, P. W., Bendelow, V. M., and Miller, H. 1970. Electronic recording mixers for the baking test. *Cereal Sci. Today* 15(10):341-344.
- Voisey, P. W., and deMan, J. M. 1970. A recording food grinder. *J. Can. Inst. Food Technol.* 3:14-18.
- Voisey, P. W., and deMan, J. M. 1970. An electronic recording viscometer for food products. *J. Can. Inst. Food Technol.* 3:130-135.
- Voisey, P. W., and Foster, W. F. 1970. A non-destructive eggshell strength tester. *Can. J. Anim. Sci.* 50:390-396.
- Voisey, P. W., and James, P. E. 1970. Factors affecting the performance of the beta backscatter eggshell measurement. *Can. Agr. Eng.* 12:48-51.

- Voisey, P. W., Lyall, L. H., and Kloek, M. 1970. Tomato skin strength—Its measurement and relation to cracking. *J. Amer. Soc. Hort. Sci.* 95:485-488.
- Voisey, P. W., and Miller, H. 1970. The Ottawa electronic recording dough mixer. 7. Factors affecting performance and the use of digital recording techniques. *Cereal Chem.* 47:207-219.
- Voisey, P. W., and Walker, E. K. 1970. Apparatus for the measurement of tobacco filling value and cigarette firmness. *Tobacco Sci.* 14:40-43.
- Wilner, J., and Brach, E. J. 1970. Comparison of radio telemetry with another electric method for testing winter injury of outdoor plants. *Can. J. Plant Sci.* 50:1-8.
- Engineering Research Service. 1970. Current agricultural engineering research and development projects in Canada—1970. ERDA Suppl. 3, Eng. Res. Service.
- Hergert, G. B. 1970. A tobacco leaf thresher. Eng. Res. Service Engineering Specifications 6911.
- Sowden, F. J., and Hore, F. R. 1970. Discussion paper on "Groundwater quality near a live-stock rearing area" by R. W. Gilham and L. R. Webber. Proc. 22nd Can. Soil Mechanics Conf., Queens Univ. Civil Eng. Res. Rep. No. 67. August.
- Timbers, G. E., and Caron, J. 1970. Controlled temperature cabinet for winterhardiness studies. Eng. Res. Service Engineering Specifications 6802.
- Voisey, P. W. 1970. Summary of projects and publications to 1969. Eng. Res. Service Engineering Specifications 7000.

Miscellaneous

Engineering Research Service. 1970. ERDA Issues No. 8-11, 1970. Eng. Res. Service.

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Systems and programming
Design of experiments, multivariate
techniques
Analysis coordinator

INTRODUCTION

In 1970, the Statistical Research Service provided advice and assistance on statistical problems largely concerned with the design and analysis of experiments and surveys together with the interpretation of results.

Emphasis is placed on cooperation with other scientists in the Research Branch. The work covered included classification and discriminatory problems, subjective assessments, and bioassay. Assistance was also given to the Production and Marketing Branch in quality control problems and in assessing food quality for marketing recommendations. Advice was given to scientists in universities and other organizations. Plans were made for a study by the World Health Organization on the identification of chromosome aberrations. The Statistical Research Service was actively involved in various aspects of the assessment of crop losses caused by diseases. Several techniques for assessing disease incidence, and the relationship between it and crop loss were examined.

Improvements were made in our library of computer programs to include the analysis of data from a wide variety of balanced and unbalanced experimental designs, with provision for transformations, covariance, and estimation of missing values. The bioassay programs can analyze data from a wide range of experimental conditions. Other programs include aspects of quantitative genetics, numerical taxonomy, discriminatory and other multivariate procedures. The general tabulating program was made more flexible.

The library of mathematical subroutines and functions was augmented by work on generalized inverses, patterned matrices, optimization, pseudorandom number generators, and quadratic functions.

P. Robinson
Director

Statistical Ecology and Population Dynamics

Two problems were investigated during the year: the migration between two localities by one species, and the interaction between two coexisting species. In the discrete formulations adopted, if it is assumed that migration is proportional to the numbers at the origin and the destination, the relationships between the two populations are analogous to those between two coexisting species in the sense that the biological attributes of each species may change according to the numbers of the other. Models for both processes were obtained and the stability conditions sought.

Advisory work on statistical ecology included discussions on a faunistic study of the insects of apple orchards, work programs of the pear psylla, sampling procedures for nematodes under an assumed negative binomial distribution, predator-prey studies, and studies relating the environment to the abundance of adult *Euxoa* spp.

Subjective Assessments

Collaborative work with the Food Research Institute and with various divisions of the Production and Marketing Branch involved the design and analysis of experiments and surveys and the testing of different statistical models. A program (S049) was developed for the analysis of results from factorial paired-comparison trials without ties.

The effect of age on the eating quality of turkeys was studied in order to make marketing recommendations. The relationship between subjective and objective measurements of meat tenderness, which was also investigated, led to a better interpretation of observed differences among the objective measurements, and provided a basis for probabilistic prediction of panel responses from objective measurements.

An evaluation of the cooking characteristics of different types of frozen eggs resulted in recommendations to the industry. A survey was designed for assessing inspection methods for grading skim milk powder, and the results were analyzed.

A study was designed for assessing consumer preference of different methods of cooking pork roasts. A survey on interlaboratory differences in determining protein content was designed.

Data on the relative attraction effect on drones of natural and synthetic pheromones of queen bees were analyzed.

Bioassay

Hundreds of bioassays are now statistically assessed each year. The capability for analysis and modeling was increased by the completion of computer programs S043, S104, S105, and S106 (see Annual Report for 1969). These programs were applied in collaborative studies of the following complex assays.

In a study of the concentration-time factor in the granary weevil, *Sitophilus granarius* (L.), treated with methyl bromide, various regression models were fitted to the quantal mortality data and to the quantitative uptake data. The average concentration of fumigant applied to the insects (estimated by integrating under the concentration-time curve) was found to be a better explanatory variable than the initial concentration. The general quantal regression program (S104) was valuable not only in fitting models sequentially by maximum likelihood, but also in permitting the inclusion of design parameters. The incomplete block design that was used would otherwise have been extremely difficult to analyze: the resulting elimination of the day-to-day variation gave a significant reduction in heterogeneity.

Analysis of a large series of assays on several insecticides, by the use of the time-response program (S105) for mortality observations made successively on the same insects, permitted a comprehensive and informative summary, which describes the results in terms of time as well as dose.

The program (S106) to analyze quantal assay results for a mixture of two populations having different susceptibilities was successfully applied to the effects of acaricides and fungicides on mites. The analysis provides an estimate of the proportion of the more resistant individuals under test, and has application in genetical studies of resistance, and in assays involving approximately constant but unknown proportions of individuals of different sexes.

Numerical Taxonomy and Discrimination

One of the difficulties in clustering large numbers of individuals (more than 200) is in the computer storage of the pair-wise similarities. To overcome this problem various procedures were considered during the year. One successful method is to find a set of dissimilar reference individuals and to group the remaining individuals with the reference individual to which it is most similar. When the reference individuals are processed, they provide a framework for the clusters. A total of 5,000 individuals have been processed by this method, but 40,000 would be possible. Other approaches to this problem are under consideration.

After the individuals have been clustered, new individuals have to be identified. When discrete characters are invariant within a cluster, a key can be produced. Construction of a key may take a great deal of time and effort; the finding of a minimal set of characters and the minimization of the number of decisions to make when using the key are both desirable. Therefore, a computer program is being incorporated into our library to aid this process.

Where characters can exist in different states within the same cluster (e.g., infraspecific clusters), a simple key is difficult to construct and even more difficult to use. Methods that include a Bayes decision rule, for aiding the identification procedure, are being investigated, especially in connection with data on *Avena*.

During the year, most of our work on discrimination was in connection with studies on *Avena*. For this work, there was a need to choose a subset of characters that are useful for identifying the different populations. A version of the discriminant analysis program ranks the characters in descending order of their discriminatory power by means of a method analogous to a forward stepwise regression.

Two other discrimination studies were made: one on polar bears (in association with the Canadian Wildlife Service), and the other on mud-inhabiting nematodes whose environment is being changed by industrial activity.

With the use of the single linkage method of clustering, several sets of data were processed; these included data on the Umbelliferae, cultivated *Avena*, certain faunistic relationships, and strains of pathogenic bacteria.

Crop Disease Loss Assessment

A number of experiments and preliminary surveys on potato diseases were carried out in potato-growing areas of Canada. The experience gained and the data collected will be used to improve the design of future surveys.

Other projects included a cereal common root rot disease survey, winter wheat foliage disease survey in Ontario, wheat and oats uniformity trials to determine optimum plot size for the disease study, epidemiology of stemphylium leaf spot of red clover, a study on chemical control of septoria disease of oats, and surveys on foliage diseases of alfalfa, white rust of rape, and seedling diseases of sugar beets.

General Statistical Programs

The Statistical Research Service has a comprehensive set of computer programs for bioassay problems. The theoretical advances that have been incorporated into the programs will be published in 1971. A program is needed to analyze data from experiments testing mixtures of poisons. This program will be written in 1971.

The general survey and tabulating program (GENTAB), which was extended and renamed OPTAB (S008), accepts data in any reasonable form on cards, drum, or tape and tabulates them into multiway tables specified by the user. These tables can be totals, counts, maxima, or minima. Any desired mathematical operation may then be made on corresponding elements of a pair of tables (or on the elements of one table) by using the table functions available in OPTAB. The two tables in such a pair do not need to be the same size provided that the smaller table corresponds to one of the (multiway) margins of the larger table. Subtables of a table can be defined as tables, so that percentages relative to any of the margins of a table may be calculated. Tables may be printed either singly or in groups with corresponding elements alongside each other. OPTAB is a program system, embedded in FORTRAN, that uses subroutines and functions already compiled or available from the manufacturer.

Breeding and Quantitative Genetics

A computer program (S054) was written for calculating the coefficients of common parentage for all pairs of individuals in a

pedigree, and for calculating the inbreeding coefficient for each individual.

Two least squares programs (S056 and S057) for analyzing unbalanced data were added to the program library.

Some confusion exists in the literature regarding different measures of stability in variety trials. The different methods proposed may be simplified into three basic aspects of stability, and the measure (or measures) used should depend on the objectives of the investigation.

The system for a register of oat cultivars was expanded to handle data from 2,600 different cultivars and 1,000 unnamed crosses.

Mathematical Procedures

The increasing need for series of pseudorandom numbers (numbers generated by computer to approximate random samples from a specified probability distribution) led to the development of a package of routines (M015) to test for randomness. Theoretical aspects were studied, and a test commonly applied to the frequencies of runs up and down was corrected by incorporating the variance-covariance matrix. The mixed congruential generator available to us from the computer manufacturer was found to have serious deficiencies. Other types of generator were examined, and we now have developed procedures to give pseudorandom numbers that appear to be satisfactory for our purposes.

An important requirement for the analysis of data from unbalanced designs is an efficient procedure for inverting certain matrices. Properties of patterned matrices were examined and an efficient (in terms of time and storage requirements) algorithm (M005) was developed for inverting certain types of such matrices.

Work on comparisons of automatic minimization routines was completed, and the most suitable procedure for a particular requirement may be selected from the package available. For example, the Fletcher and Powell variable step procedure (with modification) is satisfactory for likelihood functions with up to 35 variables arising in probit analysis of quantal assays, while Nelder and Mead's routine proved helpful in fitting data to a model of a biochemical system.

A program (S039) was written to facilitate

the description and analysis of quadratic functions of up to 30 variables.

A computer program (S027) is being developed for obtaining fiducial intervals for the power of a *t*-test.

PUBLICATIONS

Research

Boch, R., Shearer, D. A., and Petrasovits, A. 1970. Efficacies of two alarm substances of the honey bee. *J. Insect Physiol.* 16:17-24.

Sauer, F., Erfle, J. D., and Binns, M. R. 1970. Turnover rates and intracellular pool size distribution of citrate cycle intermediates in normal diabetic and fat-fed rats estimated by computer analysis from specific activity decay data of C¹⁴-labelled citrate cycleacids. *Eur. J. Biochem.* 17:350-363.

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INTRODUCTION

This report describes the progress in long-term experiments and the main research findings in 1970. The research at Brandon emphasizes animal breeding and physiology; plant breeding, physiology, and management; and soils-agronomy research on fertility, cultural practice, crop rotation, and weed control.

Dr. E. E. Swierstra, a physiologist in animal reproduction, was granted a postdoctoral transfer for one year to do further work on reproduction in the male, in the Department of Physiology and Biophysics at Colorado State University, Fort Collins, Colo. Mr. L. D. Bailey, a specialist in soil fertility, continued on educational leave.

Highlights for the year included progress in the evaluation of performance in crossbred calves sired by recently introduced bulls of European breeds of cattle and the outstanding performance of corn grown under favorable conditions of management and weed control in western Manitoba.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Evaluation of foreign breeds. Eight imported heifers, released from quarantine in April, were added to the Limousin herd. Along with the natural increase, these brought the purebred herd to 13 females and 9 males. The four females from the original importation produced calves. The average birth and adjusted weaning weights for three male calves were 36.4 and 266.4 kg (80.3 and 587.0 lb). The one female weighed 34.0 kg (75.0 lb) at birth and 249.9 kg (551.0 lb) at weaning.

In December the six mature bulls averaged 865.0 kg (1,907 lb) at an average age of 34 months. The original four cows averaged 503.5 kg (1,110 lb) at 34 months of age and the eight heifers averaged 450.9 kg (994 lb) at 23 months.

Semen production by Limousin bulls. The six Limousin bulls were evaluated over a 3-week period of semen collection (on a 48-hr collection schedule) when they averaged 21, 25, and 33 months of age. All showed good sex drive and were relatively docile for 3 years of age, but one bull was rather aggressive and required the use of a bull staff for handling. Semen production and sperm counts tended to increase with age: semen volume from 2.2 to 3.7 to 4.0 ml/ejaculate; motility from 67% to 70% to 79%; sperm per ejaculate from 3.94 to 5.16 to 7.66 $\times 10^9$; and motile sperm per ejaculate from 2.77 to 3.82 to 6.04 $\times 10^9$. The average number of

sperm $\times 10^6$ per ml of ejaculate decreased from 1,688 to 1,350 from 21 to 25 months of age, but increased substantially to 1,958 at 33 months.

Ease of calving with Limousin and Simmental sires. Using artificial insemination, Limousin and Simmental bulls were mated to cows of the Hereford, Aberdeen Angus, and Shorthorn breeds in seven herds. There were approximately 215 cows mated to each breed of sire, with equal representation in each herd. There were no abnormal calving problems associated with using sires of these breeds on mature cows. Averaged over breeds of dam, there were 3% and 6% difficult calvings when Limousin and Simmental sires were used. The length of gestation was 285 and 286 days for the Limousin- and Simmental-sired calves.

Among 2-year-old Shorthorn heifers bearing their first calves, there were 11% difficult calvings with the Limousin sires and 43% with the Simmental sires. Based on small numbers, the gestation period for the Limousin-sired calves was 291 days compared with 282 days for the Simmental-sired calves.

Prewaning growth in crossbred calves. Averaged over breeds of dam, birth weights of calves sired by Limousin and Simmental bulls were 36.3 and 39.0 kg (80 and 86 lb). At weaning, calves from Simmental sires averaged 11.4 kg (25 lb) heavier than Limousin-sired calves (217.3 vs. 205.9 kg, or 479 vs. 454 lb).

Response to selection. Ten years of selection in Shorthorns, based on weight at 1 year of age, has resulted in a genetic improvement of 40.4 kg and an environmental improvement of 31.8 kg in yearling weight. Correlated responses have resulted in genetic and environmental increases in weaning weight (6.4 and 2.7 kg) and in birth weight (1.8 and 1.4 kg).

Meat quality. Comparing paternal half-sibs, bulls had significantly leaner carcasses than steers. Steaks from these bulls had significantly higher shear values (required more force to shear a 25-cm core of cooked meat) and lower marbling scores. Steaks from steer carcasses were preferred by a taste panel, which scored them significantly higher for tenderness, juiciness, and flavor.

In taste panel evaluation of roasts from the semitendinosus muscle, steers were preferred over bulls, but differences in shear value and in scores for tenderness, juiciness, and flavor were not significant.

Swine

Response to selection. Selection for average daily gain has improved the trait by 0.06 ± 0.01 kg in seven generations. A correlated response in feed efficiency was observed in the reduction of feed required per kilogram of gain by 2.52 ± 5.25 kg over the period. No significant changes occurred in litter size, weaning weight, and backfat thickness as a result of selection for daily gain.

Evaluation of selection programs for growth rate and feed efficiency. In a hypothetical population, three selection techniques were studied: (a) selection for growth rate; (b) selection for feed efficiency; and (c) primary selection for feed efficiency with secondary selection for growth rate. Selection for growth rate produced the most genetic progress in growth rate, and selection for feed efficiency was the most satisfactory method of improving feed efficiency. However, for simultaneous improvement in both traits, selection for growth rate alone or feed efficiency alone was more effective than primary selection for feed efficiency with secondary selection for growth rate.

Effect of low ambient temperature on sperm production. A study of the effect of normal winter temperatures, from -18 C to -35 C, on sperm production of young boars showed that low temperatures did not interfere with

testicular development, sperm production, or semen quality. Daily sperm production was significantly greater for boars subjected to low ambient temperatures (18.6×10^9 vs. 16.5×10^9 for boars housed in a heated piggery), but this difference was due to a significant difference in testes size (419 vs. 365 g). Daily sperm production per gram of testes was the same in both groups.

Development of the reproductive tract in Yorkshire gilts. In studies of the female reproductive tract in pigs, it was observed that from birth to 70 days of age there was a steady growth of the tract, closely associated with age and normal increase in body weight. There were rapid changes in organ size between 70 and 126 days of age. The weight of the ovaries increased from 0.3 to 5.7 g; the number of Graafian follicles (1–3 mm) from 2 to 230 and (4–6 mm) from 0.2 to 4.8; the weight of the Fallopian tubes from 0.2 to 1.4 g, and the length from 13.0 to 29.2 cm; the weight of the uterus from 3.1 to 33.8 g, and the length from 28.8 to 56.6 cm. Further rapid changes occurred between 126 days of age and puberty, but the most dramatic changes were in the number of larger Graafian follicles, the length of the Fallopian tubes, and the weight (77.1 to 180.2 g) and length (84.1 to 112.4 cm) of the uterus.

Poultry

The effect of environment on selection. The sixth cycle of selection, under full and restricted feeding, for hen-day rate of egg production has been completed. The trait is still responding to selection; birds selected under full-feeding are producing more but smaller eggs. The hen-day rate of egg production to 273 days improved 1% in the full-feed strain and 2% in the restricted strain. Maturity, as indicated by age at first egg, is being accelerated in the restricted strain and retarded in the full-fed strain.

Heterotic effects on egg production. When strains of Leghorns were crossed, there was evidence of heterosis for egg production per hen housed, rate of lay, mortality, and returns over feed costs. Egg weight, age at first egg, and body weight were not affected by strain crossing. Reciprocal strain crosses performed better than the parental strains for some production characteristics, especially returns over feed cost. There were indications

of a genotype \times environment interaction for some traits, but none were significant.

PLANT SCIENCE

Cereal Crops

Malting barley. Progress has been made in developing breeding lines that combine the desirable alpha amylase content of Conquest and the N content of Paragon. The most advanced lines were in the extensive evaluation tests in 1970.

Selection for hull adherence, which has been a problem in malting barley, has been successful, but yield has been a limiting factor. Evaluation of progenies from hybrids of the two highest-yielding, best-quality, and tightest-hulled varieties has advanced to the F₃ and F₄ generations.

Several early maturing, semidwarf lines have equaled Conquest in yield, but are deficient in one or two malting quality characteristics. These have been crossed with high-quality Brandon lines to correct these deficiencies.

Feed barley. Three selections from the most advanced lines were extensively tested in comparison with standard varieties and other advanced breeding lines. All yielded better than Conquest, and one, a Keystone \times Dickson cross, ranked first or second in four of seven tests.

In newer material, crosses of Bonanza \times Dickson have excellent yield potential and 11 of 23 selections outyielded the best parent (Bonanza). Another selection from a Dickson \times Husky backcross yielded excellently and had outstanding agronomic characteristics.

Unicum barley has been promising and a composite-cross bulk population of unicum varieties has been established.

Forage Crops

Bromegrass response to residual fertilizer N. The residual effect of fertilizer N on bromegrass at 168 and 252 kg/ha increased dry matter production 5.3 units per unit of applied N. The combined increases in production for the year of application and the year of residual increase were 26.3 and 22.4 units of dry matter per unit of N applied at 168 and 252 kg/ha.

Corn management for maximum production. Studies in corn production indicated that with seeding as soon as the seedbed can be prepared, good weed control through the use of herbicides and possibly cultural treatment, adequate plant populations, and liberal use of fertilizer, corn can be a very important crop for silage and grain. Grain yields up to 822.7 kg/ha (80 bu/ac) were harvested.

SOILS AND AGRONOMY

Soils

Type of fertilizer and time of application. Four types of N fertilizers, anhydrous ammonia, ammonium nitrate, urea, and solution (28% N) applied in the fall and spring at rates to supply 56 kg of N/ha for barley production, demonstrated an interaction between type of fertilizer and time of application. Silage yields of barley grown on Assiniboine clay indicated that for the types containing ammonia (anhydrous ammonia and ammonium nitrate) fall application produced equal or better results than spring application (9,950 and 9,770 kg/ha vs. 9,540 and 8,990 kg/ha). When urea and solution N were used, production from fall application was less than from spring application (7,740 and 8,690 kg/ha vs. 9,870 and 9,690 kg/ha). Thus, time of application must be considered to achieve the maximum response from the various types of fertilizer.

Solution N for wheat production. When fertilizer solution (28% N) supplying 22, 44, 66, and 88 kg of N/ha was applied to Manitou wheat at the two-leaf stage, yields increased by 40% to 80% compared with untreated checks, which yielded 1,650 kg/ha. The N content of the grain, which was 2.07% on the untreated plots, was increased by as much as 0.66%. Similar results were obtained when treatments were applied at the four-leaf stage of growth. The response to treatment was greater at both postemergence stages of growth than similar rates applied before emergence of the crop. Adequate P was provided for all plots by applying 112 kg/ha of ammonium phosphate with the seed.

Salinity on poorly drained soil. In 1961, eight rotations were established on poorly

drained alluvium soil for the Pasquia drainage project at The Pas, Man. Salinity levels ranged between 0.3 and 28.6 mmhos/cm over the experimental area. During the 8 years of study the best yields were obtained from rotations containing clover or alfalfa (5,380 kg/ha of alfalfa per year, compared with 1,850 kg/ha of wheat when grown continuously). There was no difference between legumes and grain crops in decreasing the level of salinity. The salinity levels of subsoil remained almost constant throughout the period (3 ± 1 mmhos/cm). Groundwater remained saline (5.2 mmhos/cm) and, although there was seasonal fluctuation, the water table was maintained at 200 ± 50 cm. It appears that soil salinity cannot be reduced without lowering the water table by providing drainage, but productivity of the area can be increased by utilizing more legume crops.

Weed Control

Weed control in corn. Sutan (Stauffer Chemical Co.) at 3.36 kg/ha gave good control of green foxtail and increased yields of corn by 92% compared with untreated plots, which yielded 3,808 kg/ha of dry matter. Broad-leaved weeds are not affected by Sutan, and where these weeds and green foxtail were controlled by hand weeding yields were 9,766 kg/ha. A mixture of Sutan and atrazine had similar effects on yield but a different reaction on weed control. The mixture provided fair control of green foxtail and

good control of broad-leaved weeds. The herbicides were applied as sprays before planting and incorporated immediately with a rototiller.

Antagonism of TCA and auxin herbicides in wheat. In root absorption studies in the greenhouse, 2,4-D applied at 10^{-6} , 10^{-5} , and 10^{-4} M decreased the uptake of labeled TCA in wheat seedlings by 85%, 74%, and 59%. MCPA at the same concentrations decreased the uptake of TCA by 82%, 58%, and 43%. These decreases in rate of TCA uptake and translocation were detectable as early as 1 hr after application to the roots. The differential uptake between TCA alone and TCA plus 2,4-D was not affected by the pH of the medium when tested at pH values of 5.0, 5.5, 6.0, and 7.0. Using the techniques of prefeeding either roots or foliage with 2,4-D and of kinetic studies with the Lineweaver-Burk method of plotting, it was found that the inhibition of TCA uptake and translocation by 2,4-D was typical noncompetitive inhibition occurring at the cell level.

Herbicide mixtures for weed control in wheat. In field and greenhouse tests, mixtures of 2,4-D amine at 0.56 kg/ha with TCA at 0.56, 0.84, and 1.12 kg/ha reduced the damaging effect of TCA on wheat and improved control of green foxtail. The mixture of 2,4-D and TCA (both at 0.56 kg/ha) increased the yield of wheat by 6% and decreased green foxtail seeds by 84%, compared with TCA alone. MCPA amine was less effective than 2,4-D in such mixtures in field tests.

PUBLICATIONS

Research

- Chow, P. N. P. 1970. Absorption and dissipation of TCA by wheat and oats. *Weed Sci.* 18:492-496.
- Donaldson, L. E., Hamilton, R. I., Little, D. A., and Lambourne, L. J. 1970. Reduced birth-weights and enlarged thyroid glands in calves born to dams which had eaten *Leucaena leucocephala*. XIth Int. Grassland Congr. Australia. p. 780-782.
- Gross, A. T. H. 1970. Evaluation of bromegrass when grown in pure stand and in mixture with alfalfa. *Can. J. Plant Sci.* 50:463-468.
- Hamilton, R. I., Lambourne, L. J., Roe, R., and Minson, D. J. 1970. Quality of tropical grasses for milk production. XIth Int. Grassland Congr., Australia. p. 860-864.
- Johnston, W. H. 1970. Bonanza, a new six-rowed malting barley. *Can. J. Plant Sci.* 50:608-609.
- Rahnefeld, G. W. 1970. Relative merit of three swine selection programs for the simultaneous improvement of growth rate and feed efficiency. *Can. J. Anim. Sci.* 50:663-670.
- Rahnefeld, G. W., and Swierstra, E. E. 1970. Influence of the sire on litter size in swine. *Can. J. Anim. Sci.* 50:671-675.

- Spratt, E. D., and Gasser, J. K. R. 1970. The effect of ammonium sulphate treated with nitrification inhibitor, and calcium nitrate on growth and N-uptake of spring wheat, ryegrass and kale. *J. Agr. Sci., Comb.* 74:111-117.
- Spratt, E. D., and Gasser, J. K. R. 1970. Effect of ammonium and nitrate forms of nitrogen and restricted water supply on growth and nitrogen uptake of wheat. *Can. J. Soil Sci.* 50:263-273.
- Spratt, E. D., and Gasser, J. K. R. 1970. Effects of fertilizer nitrogen and water supply on distribution of dry matter and nitrogen between different parts of wheat. *Can. J. Plant. Sci.* 50:613-625.
- Swierstra, E. E. 1970. The effect of low ambient temperatures on sperm production, epididymal sperm reserves, and semen characteristics of boars. *Biol. Reprod.* 2:23-28.
- Swierstra, E. E. 1970. Effect of environmental temperatures on semen composition and conception rates, p. 8-11. *In Symp. Proc., Effect of disease and stress on reproductive efficiency in swine.* Ames, Iowa. Extension Serv., Coll. Agr., Univ. Nebraska.
- Miscellaneous**
- Dryden, R. D. 1970. The effect of nitrogen fertilizer on yield and nitrogen content of wheat. *Proc. Man. Soil Sci. Soc., Man. Dep. Agr.*, p. 102-106.
- Geiger, J. E. 1970. Colony development of honey bees. *Amer. Bee J.* 110(10):386,391.
- Gross, A. T. H. 1970. Effect of age of stand of bromegrass on response to "N" fertilizer. *Proc. 16th Annu. Meet. Can. Soc. Agron.*, p. 79-81.
- Gross, A. T. H. 1970. Bromegrass in Manitoba. *Man. Dep. Agr. Publ.* 446. Revised. 4 p.
- Hamilton, R. I. 1970. Pastures that beat us. *Can. J. Agr. Econ.* 18:95-99.
- Hamilton, R. I. 1970. Corn production on the prairies. *Proc. Gen. Council Meeting Grains Council, Winnipeg*, p. 38-57.
- Spratt, E. D., Gorby, B. J., and Ferguson, W. S. 1970. The effect of cropping systems on productivity and salinity on a poorly drained alluvium soil. *Proc. Man. Soil Sci. Soc., Man. Dep. Agr.*, p. 34-40.
- Rahnefeld, G. W. 1970. Backfat thickness and body weight in swine selection. *Can. Dep. Agr. Publ.* 1383. 15 p.

Research Station Morden, Manitoba

PROFESSIONAL STAFF

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Special Crops Section

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E. D. P. WHELAN, B.S.A., M.S.A., Ph.D.	Sweet corn and cucumber breeding

Ornamentals and Fruit Section

W. A. CUMMING, B.S.A.	Head of Section; Ornamentals
W. G. RONALD, B.S.A., M.Sc.	Ornamentals breeding

Departures

J. M. MOLNAR, B.S.A., M.Sc. Transferred to Plant Research Institute, Ottawa, Dec. 1, 1970	Crop management
H. A. QUAMME, B.S.A., M.Sc. Transferred to Research Station, Harrow, Ont., Oct. 1, 1970	Fruit breeding

VISITING SCIENTIST

A. V. VRANCEANU, Dr. Agr.
Food and Agriculture Organization Fellow

Sunflower breeding

INTRODUCTION

This report summarizes the more important findings in research in special crops and horticulture at the Research Station at Morden, Man., in 1970. There was some shift in program during the year. More attention was given to special crops and less to the breeding of fruit and tomatoes. Investigations of new crops, including any species with even remote commercial potential in Canada, began and are destined for expansion.

One new cultivar of soybeans and one of field peas were licensed. Discovery of a mechanism for restoring pollen fertility in sunflowers and a new disease of this crop were other highlights. The high caliber of the ornamentals program was recognized in the granting to W. A. Cumming of a Merit Award of the Public Service of Canada and the Dawson Jackson Medal of the Massachusetts Horticultural Association. These awards are firsts for a horticulturist and a Canadian respectively.

Eric D. Putt
Director

SPECIAL CROPS

Buckwheat

Breeding. In the past 4 years of testing, a high-yielding buckwheat selection, CD 7274, of Russian origin has outyielded Tokyo by 20% or more. From reports on samples sent to Japan, it has satisfactory seed size and good kernel color and flavor. It will be licensed in 1971. A very promising large-seeded selection with excellent seed set is being increased in the winter of 1970-71 to hasten further evaluation in 1971.

A number of abnormalities have been recorded in buckwheat. These include variegated leaves, four- to five-winged pericarp, tricotyledony, and fasciation. Study showed that leaf variegation is inherited, but other abnormalities are considered to be primarily effects of environment.

Row spacing, seeding rate, and seeding date. Results of 3-year studies on row spacing and seeding rates confirmed our initial findings that row spacing greater than 15 cm and seeding rates greater than 28 kg/ha do not increase yields. Two-year data from experiments on date of seeding indicate that buckwheat planted in the middle of June produces high yields in Manitoba.

Weed control. Encouraging results were obtained from work carried out to determine conditions for the safe and effective use of dalapon to control green foxtail in buckwheat. Up to the three-leaf stage, the crop was treated with dalapon at rates as high as

1.26 kg/ha, in a spray volume of 112 liters/ha, without reduction in yield. At the four-leaf stage of growth there was some reduction in yield of the buckwheat, which may have been caused partly by mechanical damage during spraying.

Field Peas

Breeding. The breeding program for field peas formerly at the Ottawa Research Station was transferred to Morden, which is now the only establishment of the Department working on this crop. A new high-yielding variety was named Trapper and released to growers as a replacement for Chancellor. Trapper is also well suited for animal feed due to its high protein content and small seed size. In cooperative tests, a selection, MP 706, from the cross Century × Stral has consistently outyielded the check variety Century and also has had a better cooking quality.

Quality. A rapid method for testing cooking quality of peas was developed. The method makes possible the testing of a large number of samples in a rather short time. A preliminary determination of the protein content of peas from different sites on the same plant showed no significant differences between sites, but differences between individual plants within a variety were highly significant.

Disease. In 1970, disease surveys showed that *Ascochyta pinodes* L.K. Jones is the single most serious pathogen of field peas in

Manitoba. Also, seed source affects the prevalence and severity of the two diseases, *Ascochyta* blight and bacterial blight.

In a limited test, some fungicidal treatments of pea seed resulted in increased stand, but seed treated with benomyl (Benlate; DuPont) produced lower plant stands than untreated seed. Zineb (Niagara) failed to protect foliage against *Ascochyta* blight, but spraying weekly from time of pod formation to maturity improved seed size.

Flax

Breeding. Two years evaluation of 756 random lines from two crosses in the modified pedigree method showed transgressive segregation for yield. Selection was based only on yield performance of lines produced by the advancement of generations at random to virtual homozygosity. This method appears to be superior to the conventional pedigree method for the improvement of yield.

Regional tests indicated that four high-yielding introductions matured too late, or had other undesirable characteristics, preventing their use for commercial production. These introductions have been incorporated in the breeding program as a valuable source of germ plasm to broaden the genetic base.

Oilseed quality. Early swathing and drying of late-planted flax increased the proportion of linolenic acid in the oil and therefore raised the iodine number and the drying quality. *Fusarium* wilt in flax reduced yield and hastened maturity. In addition, it raised the level of oleic acid in the seed and lowered the level of linolenic acid, which reduced quality. Genotypes with the following range in fatty acid composition have been selected: 9% to 51% oleic, 3% to 20% linoleic, and 30% to 73% linolenic acid.

Sunflowers

Fertility restorers. Male fertility restorers for the French cytoplasmic male sterility that was mentioned in our 1969 report were found in several collections of wild *Helianthus annuus* L. and *H. petiolaris* Nutt. Work elsewhere showed that one Morden inbred line of cultivated type also contained male fertility restorers. The restoration ability is dominant and appears to be simply inherited although several factors may be involved in some cases. It is, however, easily transferred

and is consistently expressed in both the field and glasshouse. Because the cytoplasmic male sterility was also consistently expressed, we now have a reliable and practical tool to fully utilize hybrid vigor commercially.

Oilseed quality. When sunflower plantings are delayed, the oleic acid content of the seed oil decreases and linoleic acid increases. In other oilseed crops degree of saturation usually varies inversely with temperatures during seed development and maturation. Because the late plantings matured in cooler temperatures, the behavior of sunflowers appears to be consistent with other crops. The ratio of saturated to unsaturated acids was relatively constant in all plantings.

Specific genotypes that have been selected and inbred contain the following range in fatty acid composition: 8% to 26% saturated, 12% to 66% oleic, and 25% to 80% linoleic acid.

Disease. A serious disease of inbred CM 144 mentioned in our 1968 report has now been shown to be due to *Phialophora* sp. The fungus is systemic. The disease is characterized by a general and uniform yellowing of the plant, but by less necrosis than in *Verticillium* wilt. It has been found in commercial sunflowers near Gretna, Man.

Severe *Pythium* root rot occurred in experimental plots. This is the first field record in Canada.

Corn

Breeding. In 1971 this station plans to release to the seed trade the parental inbred lines required for the production of several new high-yielding corn hybrids. In tests, several new experimental hybrids exceeded Morden 67 by 30% to 50% in grain yield and were of equal maturity. They were also superior in stalk strength and plant appearance.

Population study. The 1970 tests identified three inbreds that tolerated the stress of high populations. They yielded more than twice as much grain at 215,000 plants/ha than at 54,000 plants/ha. One hybrid developed from these inbreds produced 60% more grain at the high than at the low population. It yielded 133 q/ha (211 bu/acre). Many inbreds gave their best yields at the medium population of 108,000 plants/ha; others did so at 54,000 plants/ha. The tolerance exhibited by hybrids to population stress tended to

be similar to that of their parental inbreds, but there were exceptions.

Soybeans

Breeding. About 300 bu of Select and Foundation seed of the new soybean variety Morsoy were distributed to seed growers. In eight tests in Canada and the U.S.A., CM 119 gave the highest average yield and showed resistance to *Phytophthora* root rot.

Results in 1970 confirmed findings of 1969 that yields in rows of soybean test plots were not affected seriously by gaps in the stand unless the gaps were longer than 50 cm. Similarly, when plant population was reduced from 200 to 100 per 6-m row, the yield was not seriously reduced.

ORNAMENTALS

Breeding and Selection

A semidwarf white-flowered *Monarda* hybrid, named Miniota in 1970, will be released to the Canadian Ornamental Plant Foundation in the spring of 1971. This diploid cultivar was selected from an F₃ population of *M. didyma* L. × *M. fistulosa* L. Plants grow to a height of 45 cm and the foliage is disease-resistant. Flower heads are 9 cm in diameter. The white color is accentuated by a small tip of lilac (72C R.H.S. color chart) on the lower lip of each flower.

Promising selections made in 1970 included triploid *Monarda* hybrids in colors of purple, red, and deep pink, and having strong stems and long season of bloom; and specimens of black ash, *Fraxinus nigra* Marsh., in a mature stand, which are seedless and disease resistant, and retain their leaves 2 weeks longer than other seedlings of this species. The black ash specimens have been vegetatively propagated and planted at Morden for closer observation and study.

Propagation

Populus tremula L. 'Erecta', a hardy disease-resistant replacement for *P. nigra* L. var. *italica* (Muenchh.) Koehne, has not found wide acceptance because it is hard to propagate. A rapid propagation method being tested involves budding or grafting to easily rooted *Populus* clones. Of seven clones tested, *Populus* hybrid Brooks #6 appears to be the most suitable. This rootstock produced

rapid growth and has proved compatible in 2 years of testing.

Seeds of *Fraxinus nigra* and *Crataegus arnoldiana* Sarg. exhibit dormancy, which delays germination until the second year after planting. Seed stratification for 3 months at 27 C followed by 4 months at 3 C resulted in germination within 30 days from planting, of 78% in *F. nigra*, and 67% in *C. arnoldiana*.

Tests for 2 years have shown that applying CO₂ with the mist in outdoor mist frames gives slightly better root initiation and root quality in cuttings of plants that are easy to root. The application of CO₂ to cuttings of plants that are hard to root did not increase their rooting ability. We have concluded that, considering the cost of installation plus gas, the addition of CO₂ to the mist in outdoor mist frames is not commercially practical.

Taxonomy

Collections of 670 taxa were added to the herbarium and more than 400 duplicates were exchanged. Our first Index Seminum offered 280 collections. We plan to update and release this list annually.

A chemical mutant and the normal form of the widespread native *Monarda fistulosa*, which are morphologically indistinguishable, were found to share the same habitat throughout the sand hill area between Austin and Douglas, Man. The oil chemistry of the two forms is markedly different. On a fresh-weight basis, the mutant produced almost 1% oil, 75% of which was geraniol. The normal form produced 0.5% oil, of which 37% was thymol and 32% an unidentified oil.

Arboretum

One hundred and fifty-two new accessions were planted in the arboretum in 1970. Accessions of woody plant materials, received during the year, in the form of plants, cuttings, scions, and seeds totaled 643. Propagation of species and cultivars of *Salix* scattered throughout the arboretum has been completed and 108 taxa have been planted in a new generic block reserved for *Salix*. Land is being prepared for six additional generic blocks, and species and cultivars of *Acer*, *Cornus*, *Fraxinus*, *Sorbus*, *Tilia*, and *Viburnum* are being repropagated.

A summary of hardiness and zonation trials conducted over a 5-year period at six locations in the three prairie provinces has been prepared. This summary of 350 woody

plant taxa will be published in the 1971 *Proceedings of the Western Canadian Society for Horticulture*. Mimeographed copies are available from the Research Station.

VEGETABLES

Potato Storage

Tuber maturity and other characteristics of potato varieties largely determine chip color. The relationship between chip color and other traits changes from year to year owing to environmental variability. The usual beneficial effect of preconditioning on chip color may also change. In general, the most consistent results from preconditioning were obtained when tubers were held at 21 C for 8 weeks and stored at 7 C. In the most adverse seasons only potatoes comparable in chipping quality with the selected seedling F5889 gave good chip color when preconditioned tubers were chipped immediately after removal from storage at 7 C.

The estimation of chip color has required much less time since the filter paper disc technique was developed at this station. In research on chip color or in breeding programs for chipping quality, large numbers of tests can be made quickly with this method. Moreover, the tubers are not destroyed. The Morden Chip Color Chart developed recently complements this technique for numerical evaluation of chip color. The quality-control agencies of large potato processors are adapting the method for their use.

Carrot and Parsnip Root Discoloration

Tissue just below the root surface of carrots and parsnips did not discolor when first exposed to oxygen after the surface was damaged. However, as suberization progressed at 21 C, the tissue became increasingly susceptible to oxidative browning, reaching a peak about 1 week after injury.

When ruptured tissue was subjected to suberization, total phenols, chlorogenic acid, and polyphenol oxidase increased. After 24 hr the quantity of the three compounds in the internal tissue was equal to that in the root surface tissue. This increase continued rapidly until 96 hr, when the quantity present was 10 times the initial amount. Accordingly, ruptured carrot and parsnip root tissue when suberized was more susceptible to oxidative

browning than intact tissue at the surface of the root. These results stress the need for extreme caution to prevent bruising these vegetables and reduction of marketing quality.

Dill Oil Quality

The quality of oil from dill, *Anethum graveolens* L., obtained by steam distillation of the entire plant except the roots, rated high because it contained over 45% carvone. In the cultivar Mammoth Long Island, the most carvone occurred when the plants and seed umbels developed an amber color as maturity approached. Also, the greatest amount of carvone occurred in the fraction obtained from 30 to 45 min of steam distillation. Other compounds, namely α -pinene, α -phellodrene, and α -limonene, were also separated from dill oil by gas chromatography.

Cucumbers

Radiation-induced mutations. The M₂ and M₃ progeny from cucumber seed exposed to large doses of gamma radiation produced three mutations affecting chlorophyll content of the cotyledons and two affecting cotyledon and plant size. Also, two mutations producing male sterility and another resulting in a glabrous character have been discovered. The inheritance of these mutants is being investigated. Initial meiotic and pollen-fertility studies lead to the tentative identification of a paracentric inversion and four reciprocal translocation mutants.

Cold germination tests. Tests at 14 C and 20 C showed that a temperature of 14 C was more suitable than 20 C for screening the ability of cucumber seed to germinate under cool conditions. The rate of germination and of initial growth were consistent and significantly correlated only at 14 C for the 76 cultivars. The stearic acid content of the seed was highly correlated with the ability of the seed to germinate and with initial radicle elongation under cool conditions. Seed high in stearic acid took longer to germinate and had slower radicle elongation than seed low in stearic acid. The content of palmitic, oleic, and linoleic acids in seed was not significantly correlated with germination or radicle elongation. Seed ranged in weight from 1.85 to 5.40 g/100 seeds. This great variation was

not significantly correlated with any other factor investigated.

Heading in Cole Crops

When sown at a higher rate than the standard cultivars, the green sprouting broccoli Harvester greatly outyielded the standards. A

once-over cut of Harvester yielded 10% less than cutting plants individually as heads matured. The spray application of N-dimethylaminosuccinamic acid to Brussels sprouts in early August at a rate between 2,000 and 3,000 ppm was as effective as manual removal of the terminal bud in stimulating early maturity and uniform sprout size.

PUBLICATIONS

Research

- Ali-Khan, S. T., and Chubey, B. B. 1970. A rapid method for testing cooking quality of field peas. *Can. J. Plant Sci.* 50:207-208.
- Ali-Khan, S. T., and Kenaschuk, E. O. 1970. Trapper field peas. *Can. J. Plant Sci.* 50:508.
- Chubey, B. B., and Nylund, R. E. 1970. The effect of maturity and environment on phenolic compounds and oxidative browning in carrots. *J. Amer. Soc. Hort. Sci.* 95:393-395.
- Cumming, W. A. 1970. Kelsey Rosybloom crabapple. *Can. J. Plant Sci.* 50:203-204.
- Dorrell, D. G. 1970. Distribution of fatty acids within the seed of flax. *Can. J. Plant Sci.* 50:71-75.
- Giesbrecht, J., and Putt, E. D. 1970. Morsoy, a new soybean cultivar. *Can. J. Plant Sci.* 50:509-510.
- Walkof, C. 1970. Chip color of the developing potato tuber. *Amer. Potato J.* 47:43-48.
- Walkof, C. 1970. Preconditioning potatoes for processing. *Proc. 18th Int. Hort. Congr. (Tel Aviv)*, p. 160.
- Whelan, E. D. P. 1970. Effect of gamma radiation on seedling emergence of *Cucumis sativus*. *Can. J. Plant Sci.* 50:606-607.

Miscellaneous

- Ali-Khan, S. T. 1970. Buckwheat improvement. *Can. Agr.* 15(1):28-29.

- Ali-Khan, S. T. 1970. Low seeding rate proves effective for buckwheat. *Man. Coop.* 27(31):33.
- Chubey, B. B. 1969. A quick color test for the potato industry. *Chip Potato Seminar, Univ. Manitoba*, p. 50-51.
- Chubey, B. B. 1970. Prevention of carrot and parsnip browning. *Proc. 17th Annu. Conv. Veg. Growers' Ass. Man.* p. 48-50.
- Chubey, B. B. 1970. Quality vegetables from the home garden. *The Prairie Garden* 27:110.
- Cumming, W. A. 1970. Cuthbert Grant rose. *Can. Nurseryman*, April, p. 14.
- Enns, H., Dorrell, D. G., Hoes, J. A., and Chubb, W. O. 1970. Sunflower research—A progress report. *Proc. 4th Int. Sunflower Conf., Memphis, Tenn.* p. 162.
- Ronald, W. G. 1970. A short description of leaf characters useful in plant identification. *The Prairie Garden* 27:116-118.
- Ronald, W. G. 1970. Index seminum. *Research Station, Morden, Man.* 11 p.
- Walkof, C. 1969. The importance of tuber maturity and storage temperature to the chipping potential of potatoes. *Old Dutch Chip Potato Seminar, Univ. Manitoba*, p. 44-49.
- Zimmer, R. C. 1970. Birth pangs of a new potato. *The Prairie Garden* 27:114-115.
- Zimmer, R. C. 1970. Rhizoctonia on potato in Manitoba in 1969. *Tech. Sci. Papers. Proc. 17th Annu. Meet. Veg. Growers' Ass. Man.* p. 58-61.

Research Station Winnipeg, Manitoba

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R. H. CUNNINGHAM	Administrative Officer

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K. D. OLIVER, B.A., B.L.S.	Librarian
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Cereal Rusts Section

R. ROHRINGER, Dr. sc. agr.	Head of Section; Physiology
R. J. BAKER, B.S.A., M.Sc., Ph.D.	Population genetics
A. B. CAMPBELL, B.S.A., M.Sc., Ph.D.	Common wheat breeding and genetics
E. M. CZARNECKI, B.S.A.	Common wheat breeding
P. L. DYCK, B.S.A., M.Sc., Ph.D.	Wheat genetics
G. FLEISCHMANN, B.A., M.A., Ph.D.	Crown rust
G. J. GREEN, B.S.A., M.Sc., Ph.D.	Wheat stem rust
E. R. KERBER, B.S.A., M.Sc., Ph.D.	Wheat cytogenetics
W. K. KIM, B.S., M.S., Ph.D.	Biochemistry of parasitism
D. LEISLE, B.S.A., M.Sc., Ph.D.	Durum wheat breeding and genetics
J. W. MARTENS, B.Sc., Ph.D.	Oat stem rust
R. I. H. MCKENZIE, ¹ B.S.A., M.Sc., Ph.D.	Oat breeding and genetics
D. J. SAMBORSKI, B.S.A., M.Sc., Ph.D.	Leaf rust of wheat; physiology

¹On transfer of work to the International Atomic Energy Agency, Seibersdorf, Vienna, Austria, August 1970 to August 1971.

Crop Protection Section

A. J. MCGINNIS, B.Sc., M.S., Ph.D.	Head of Section; Insect biochemistry
W. R. ALLEN, B.Sc., M.Sc., Ph.D.	Toxicology
P. S. BARKER, I.A., M.Sc., Ph.D.	Insect and mite control
B. BERCK, B.S.A., M.Sc., F.C.I.C.	Fumigant chemistry
S. R. LOSCHIAVO, B.Sc., M.Sc., Ph.D.	Grain insect biology
J. T. MILLS, B.Sc., Ph.D., D.I.C., F.L.S.	Ecology of seed-borne diseases
W. ROMANOW, B.S.A., M.Sc.	Grasshopper surveys
R. N. SINHA, B.Sc., Ph.D.	Mite and insect ecology
L. B. SMITH, B.Sc., M.S.A., Ph.D.	Population dynamics
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F. L. WATTERS, ² B.Sc., M.Sc., Ph.D.	Insect biology and control

Cereal Diseases Section

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A. W. CHIKO, B.Sc., M.S., Ph.D.	Viruses
C. C. GILL, B.Sc., Ph.D.	Viruses
W. A. F. HAGBORG, B.S.A., Ph.D.	Bacterial diseases; antibiotics
D. R. METCALFE, B.S.A., M.Sc., Ph.D.	Two-rowed barley breeding and genetics
J. J. NIELSEN, Dr. sc. agr.	Smuts
P. L. THOMAS, B.S.A., M.Sc., Ph.D.	Microbial genetics
P. H. WESTDAL, B.Sc., M.Sc., Ph.D.	Virus vectors

Pedology Section

R. E. SMITH, B.S.A., M.Sc.	Head of Section; Soil genesis, classification, and cartography
G. J. BEKE, B.S.A., M.Sc., Ph.D.	Soil genesis, classification, and interpretive studies
W. MICHALYNA, B.S.A., M.Sc.	Soil genesis, classification, and soil chemistry
C. TARNOCAI, B.S.F., M.S.	Classification, ecology, and soil chemistry

Departure

O. W. GRUSSENDORF, Dr. rer. nat.
Resigned January 31, 1970

Residue chemistry

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National Research Council postdoctorate fellow

R. A. FULLERTON, Ph.D.

Plant pathology

Graduate students

M. DOLINSKI, B.S.A.

Entomology

F. G. KOSMOLAK, B.Sc.(hon.)

Plant biochemistry

R. NOWAK, B.Sc., M.Sc.

Plant biochemistry

T. C. PAUL, B.Sc.

Ecology

M. QUINONES, B.Sc., M.Sc.

Plant pathology

G. ROWLAND, B.Sc.(hon.)

Cytogenetics

²On leave of absence to Food & Agriculture Organization of the United Nations, Rome, Italy, October 1, 1970, to September 30, 1971.

³On leave of absence to Plant Breeding Station, Njoro, Kenya, East Africa, December 1, 1970, to December 31, 1971.

⁴On leave of absence to Plant Breeding Station, Njoro, Kenya, East Africa, December 1, 1969, to June 30, 1971.

INTRODUCTION

Significant progress was achieved toward the objectives of the Station in 1970. A successful oat-collecting trip to Middle Eastern countries, carried out by members of our staff, provided badly needed sources of resistance to stem and crown rust of oats. A number of the genes that were obtained will be immediately utilized in the breeding programs.

Studies on the interrelationships of the flora and fauna in grain bulk ecosystems provided significant information for the control of organisms in stored grain. Of more importance, however, was the development of techniques of analysis for the meaningful interpretation of such data involving interactions in the total ecosystem. These techniques are now being applied to research projects on the soil-grain production and storage ecosystems. The results and recommendations arising from these studies are being introduced into the industry through workshops, extension meetings, and formal presentations.

During the year, the Research Station actively continued to support Canada's foreign aid programs. Besides providing specialized training in Winnipeg, Dr. K. W. Buchannon and Dr. W. C. McDonald were assigned for 1 year to the wheat research program in Njoro, Kenya, a project sponsored by Canadian International Development Agency.

A. E. Hannah
Director

BREEDING, GENETICS, AND CYTOGENETICS

Plant Breeding Methods

Quality data derived from 5 years of tests on hard red spring wheat were used to determine the repeatability of the various measurements of quality and their interrelationships. Nitrogen content and remix loaf volume were found to be the most reliable measurements and gave the most consistent ranking of cultivars each year. A nonlinear relationship between loaf volume and gluten strength was established and may be the cause of low correlations between baking methods.

Good predictions of loaf volume were possible when nitrogen content was considered as a measure of protein content, farinograph dough development time as a measure of protein quality, and gassing power as an indication of abnormal enzymatic activity. Prediction tests, which emphasize these three measurements, give a good initial indication of overall quality of hard red spring wheat lines.

A study of prediction tests for quality indicated that all tests, except N content, showed significant differences among replicates as well as among cultivars. Replicate differences are due to the effects of the milling process and should be considered in screening plant breeders lines.

The recurrent selection program for yield in wheat progressed through the first cycle of selection, and was followed by a third cycle of intermating.

Stomatal number on the upper surface of the flag leaf of wheat was found to differ among random lines of a cross between Manitou and Thatcher.

The confused flour beetle was used as a bioassay organism to test the feeding value of cereals. Differences were detected in rate of larval development when fed on various species and cultivars. The results from tests with insects correlated satisfactorily with those conducted on poultry. However, variability was encountered in results between some tests. It was not possible to determine whether the variability was due to the insect strain or the particular grain ration. Further tests are needed to determine the value of such bioassays for use as a plant breeding tool.

Barley Breeding and Genetics

The genes for resistance to loose smut carried by the cultivars Jet (C.I. 967) and Milton (C.I. 4966) were found to be independent of the genes in C.I. 5791 and Algerian (C.I. 1179) that govern resistance to net blotch and powdery mildew. The Jet gene was found to be linked (recombination value of $39.4 \pm 4.9\%$) with a single dominant gene located in C.I. 4439 governing resistance to

septoria leaf blotch. Genetic stocks possessing these various combinations of disease-resistance genes were sent to the Small Grains Collection, USDA, Beltsville, Md., for increase and distribution.

Work continued on developing a genetic base in the two-row breeding program. Resistance to stem rust and net blotch, derived from hybrids developed at Winnipeg, was combined with lines of superior agronomic type and higher yield potential obtained from Sweden and Czechoslovakia. Advanced-generation hybrids of this material will undergo yield trials in 1971.

In the six-row barley-breeding program, large hybrid populations involving various crosses have been screened to combine into one genotype resistance to stem rust, septoria leaf blotch, and net blotch. One selection, 67-154-4, yielded well in the Cooperative Test and showed wide adaptability. It combines malting quality with good straw strength and resistance to loose smut, stem rust, and net blotch.

Feed-type lines with potential high yield and high amylose content were advanced to yield trials. Amylose is being used as an indicator of nutritive value of barley strains.

Oat Breeding and Genetics

Exceptionally promising material was selected from a four-way cross that combines excellent resistance to stem and crown rust. Many of the F_4 lines were vigorous, short, and strong-strawed. The most uniform lines were harvested in bulk and are being increased in California for yield-testing in 1971.

The fat content of the oat seed is used as one measure of energy. Lines relatively high in fat were isolated and these were crossed with those of acceptable agronomic characteristics. Two thousand lines from these crosses are being analyzed to determine the heritability of fat content.

Common Wheat Breeding

Manitou, a cultivar released from Winnipeg in 1965, is the predominant cultivar grown in the Canadian Prairie Provinces, particularly in the eastern prairies, where rusts are prevalent. Neepawa, licensed in 1969, is increasing in acreage, but has not reached its full potential. However, both varieties have less than the desirable level of resistance to leaf rust. Both the backcross and

pedigree methods are being used to improve this and other characteristics of these varieties.

All commercial Canadian bread wheat cultivars have a long-day photoperiodic response, and consequently are not adapted to many of the wheat-growing areas of the world where short-day conditions prevail. Cultivars developed in Mexico by the Rockefeller Foundation (CIMMYT) have day-neutral photoperiodic response and this characteristic has been backcrossed into a Manitou background. This genotype, tested at 18 locations in Western Canada, yielded significantly less than Manitou, but was shorter, more resistant to lodging, and earlier maturing. Further tests are needed to determine the full range of effects of this gene in long-day environments.

Durum Wheat Breeding

Three high-yielding hybrid lines were advanced to the Cooperative Durum Wheat Test. Over a wide area of testing in 1970, they continued to show a yield advantage of approximately 10% over Stewart 63.

Two aspects of the breeding program are being emphasized at present: the selection of semidwarf lines, and solid-stemmed selections for sawfly resistance. Approximately 150 of the most promising semidwarf selections, derived from a double cross, will be yield-tested in 1971. Solid-stemmed selections were evaluated for quality, and will be tested in a sawfly nursery in 1971.

A study of methods for yield evaluation showed that hill plots give enough information for selection purposes.

Cytogenetics of Wheat

The "monosomic method" was again used to study the association of genes and chromosomes in two synthetic hexaploid wheats ($2n=42=AABBDD$). The synthetics were produced by combining Tetra Canthatch ($2n=28=AABB$) with each of two strains of *Aegilops squarrosa* L. ($2n=14=DD$). All characters analyzed in this study were derived from the *A. squarrosa* parent. A gene conferring resistance to several races of leaf rust, differing from other known resistance genes, and another one controlling brown glume color were found to be located on chromosome 1D. A second gene conferring resistance to leaf rust in the adult-plant stage, differing from the genes carried by Frontana

and Exchange, is located on chromosome 2D. Chromosome 2D also carries a gene for nonwaxy foliage and probably the gene that determines glume tenacity or threshability.

The synthetic hexaploids are nonfree-threshing despite the presence of the Q factor in the AABB component. This fact is of phylogenetic significance, because it suggests that the free-threshing character of common wheat arose as a mutation subsequent to its incorporation into the hexaploid form.

Preliminary evidence indicates that the gene that controls purple coleoptile color is located on chromosome 7D.

An active program is under way to transfer resistance to stem and leaf rust from the synthetic amphiploid *A. speltoides* × *Triticum monococcum* ($2n=28=AASS$) to common hexaploid wheat.

Genetics of Wheat

Thirty-four European wheat cultivars were grouped according to their reactions to a series of North American races of stem rust. These were then crossed with cultivars or lines with known genes for resistance to stem rust. A number of unidentified genes for resistance to stem rust were found in addition to the previously known genes *Sr5*, *Sr8*, and *Sr11*. One of the cultivars, Etoile de Choisy, has a gene for moderate resistance to all the races used. Studies to determine the specific chromosome on which this gene is located are continuing.

The *Lr3* locus is a complex locus with a number of alleles for leaf rust resistance. The basic *Lr3* allele that confers resistance to races 1, 9, and 11 was found in the cultivars Democrat and Sinvalocho. Backcross lines of *Lr3* were developed in the cultivars Thatcher and Prelude. In the Thatcher background, this gene was resistant to some hybrid rust cultures to which it was susceptible when in a Prelude background. This varietal difference appeared to be due to a single gene. Two different *Lr3* alleles were found, one each from the cultivars Bage and Klein Aniversario. Also, these two cultivars appeared to have one or more additional genes closely linked to the *Lr3* alleles.

Two genes, *Lr14a* from Selkirk and *Lr14b* from Maria Escobar and Bowie, conferring a similar mesothetic reaction to different races of leaf rust, were backcrossed into the cultivar Thatcher. Although the two genes are

considered to be alleles, they have been recombined into a single line.

CEREAL RUSTS

Stem Rust of Wheat

In 1970, wheat stem rust was widely distributed in Western Canada and in larger amounts than have been present for several years. There was little rust damage to commercial crops because the main cultivars, Manitou and Selkirk and the recently licensed cultivar Neepawa, are highly resistant. Pitic 62, grown on a limited acreage in the rust area, developed moderate infections late in the season but losses were slight.

There were changes in the relative prevalence of the main races (C18, C33, and C35) but the most interesting feature of the 1970 race survey was the discovery of six new races. The rust organism continues to show a great capacity for change despite its low prevalence in recent years.

The most dangerous race found in recent years is C35. In greenhouse tests it was virulent on the cultivar Pitic 62 and on seedlings of Manitou and Neepawa. In 1970, Pitic 62 was severely infected (90%), Manitou was moderately infected (30–60%), and Neepawa had about half as much rust as Manitou (10–30%) in a field nursery heavily infected with race C35. There was no stem rust on Manitou in farm fields. Apparently, it has adequate resistance under most conditions encountered in Western Canada. Favorable conditions for rust development probably account for much of the rust on Manitou in the nursery, and when conditions in farm fields are similar to those in the nursery, a light rust attack on Manitou is possible. Other races have been found that, like C35, have moderate virulence on Thatcher derivatives such as Manitou and Neepawa. If the trend toward increased virulence on Thatcher derivatives continues, problems will be encountered with stem rust resistance in present commercial cultivars. Sources of resistance to these races are available and are being utilized in the breeding program.

Leaf Rust of Wheat

The survey in 1970 of leaf rust races shows the effect of resistant cultivars on virulence combinations in the leaf rust population. In

1966, 100% of the isolates were virulent on *Lr14* (Renown and Selkirk), 90% were virulent on *Lr10* (Lee and Selkirk), and 50% were virulent on *Lr16* (Selkirk). Since 1966 Manitou, which carries gene *Lr13*, has largely replaced Selkirk in commercial wheat production. In 1970, 100% of the isolates were virulent on *Lr14*, but percentage virulence declined on *Lr10* (50% of the isolates) and *Lr16* (6% of the isolates). Cultures that are virulent on Manitou have appeared and are increasing in prevalence.

Most of the breeding for resistance to leaf rust in North America has been carried out with genotypes obtained from South America. In an attempt to find more divergent sources of resistance, an evaluation of entries in the World Wheat Collection has been made in the past 2 years. Collections from China gave excellent resistance to leaf rust. Comparisons with known genes that confer resistance to a wide range of leaf rust races indicate that these are truly different genes.

Stem Rust of Oats

In 1970, oat stem rust infections were moderate in the Red River Valley and in eastern and central Manitoba. Losses to the oat crop caused by stem and crown rust were estimated at over 10 million bushels. Several significant changes in the physiologic race distribution, the first in several years, were detected in the 1970 survey. Virulence on *pg9* resistance, occurring only in trace amounts in 1966 and not found since, occurred in 17% of all isolates identified. Also, the most promising source of resistance, *pg13*, which has been effective against all field collections to date, was found to be ineffective against one culture (C16) from Nova Scotia and two (C1) from Manitoba. Both of these genes are important components of promising multi-gene resistant lines produced in the breeding program. However, these changes present no immediate threat, because other components of the multigene lines confer effective resistance to the races in question. Races C10, C20, and C23 comprised 67%, 17%, and 11% of all isolates from Western Canada. Race C10 is virulent on all commercial varieties grown in Canada. Races C3 and C5, once widely distributed, have nearly disappeared. In Eastern Canada races C9 and C10 were most common.

More than 1,500 collections of wild *Avena*

species were obtained by a joint Ottawa-Winnipeg expedition to Iran, Israel, Lebanon, Syria, Iraq, Turkey, Algeria, and Tunisia. This material is being evaluated, particularly for rust resistance, and is expected to provide many more sources of resistance to stem rust and crown rust.

A recessive gene for stem rust resistance, *pg13*, obtained from a North African collection of *Avena sterilis* L., was found to confer effective resistance to all field races in Western Canada.

Crown Rust of Oats

The most damaging epidemic of crown rust in the last decade occurred in commercial oat fields in Manitoba in 1970; it exceeded in intensity the previous year's epidemic, which caused losses estimated at about \$2 million.

The crown rust fungus also reached a peak in virulence on the differential oat cultivars throughout Western Canada in 1970. More than 90% of the isolates identified were virulent on these cultivars, so this standard set of differentials became useless.

The crown rust resistance genes isolated from *A. sterilis* and backcrossed into single lines of Pendek provided excellent resistance to the isolates of the pathogen that attacked the standard differential cultivars. *Pc38* and *Pc39*, in particular, were resistant to nearly every isolate of the pathogen tested in 1970.

At Winnipeg, tests in nurseries heavily infested with crown rust showed that singly or combined the *Pc38* and *Pc39* genes afforded excellent resistance to the pathogen. Field selections were made with the objective of incorporating these genes into acceptable agronomic types.

A scheme for the regional deployment of crown rust resistance genes was agreed upon at the National Oat Conference held in 1970 at Raleigh, North Carolina. This plan will provide material that should, if used, impede the development of new virulent races of the pathogen by reducing the contiguous areas of host plants with similar single sources of resistance.

Physiology of Parasitism

Shikimate metabolites. Rust-infected wheat leaves with the temperature-sensitive resistance gene *Sr6* contain 2-hydroxyputrescine amides of ferulic acid and *p*-coumaric

acid when the plants exhibit a resistant reaction during growth at 20 C or less. When maintained at temperatures above 20 C, these plants exhibit a susceptible reaction and contain little or none of these amides, but contain a blue-fluorescing unknown compound. It probably contains a ferulic acid moiety. The reciprocal relationship and the probable ferulic acid content suggest that the unknown may be related to the amides biogenetically. The unknown was isolated in milligram amounts for structural studies.

Biogenetic origin of the 2-hydroxyputrescine moiety of N-(p-coumaroyl)- and N-(feruloyl)-2-hydroxyputrescine. Gamma-hydroxyarginine was isolated from seeds of wild vetch. It is a possible precursor of 2-hydroxyputrescine. If its identity can be confirmed by NMR (by Dr. Stoessl, Research Institute, London, Ont.), it will be used in feeding experiments with rust-infected wheat leaves.

Folate content of undifferentiated and differentiated stem rust uredosporelings. The total folate content of undifferentiated sporelings (which develop germ tubes only) and differentiated sporelings (which develop germ tubes and infection structures) was determined after 24 hr of germination by the use of *Lactobacillus casei* as the assay organism. The folate content of differentiated sporelings was lower than that of undifferentiated sporelings. This was due mainly to declining levels of methylated folates. The former contained more formylated folates than the latter. The ascorbate-insoluble residue was assayed for folate content after treatment with conjugase, or after treatment with pronase or trypsin followed by conjugase. No folate was detected after these enzyme treatments, thereby indicating that germinated rust spores do not contain folates bound to the insoluble residue that remains after extraction with ascorbate.

Polyamines in uredospores. Spores were examined for their polyamine content, because in earlier studies 2-hydroxyputrescine had been detected in resistant-reacting rust-infected wheat leaves. Nongerminated uredospores contained spermidine and an unidentified polyamine. Spermidine content rose after germination, but only if the sporelings produced infection structures. After acid hydrolysis, the unknown polyamine yielded a ninhydrin-reactive compound with

electrophoretic mobilities similar to those of citrulline. It is possible that spermidine has a regulatory function in the RNA and protein syntheses of differentiating sporelings.

Extraction and bioassay of lipid components of uredospores. Uredospores of wheat stem rust contained a sterol, stigmast-7-enol, that was also found in flax rust uredospores. During germination of wheat stem rust uredospores the concentration of stigmast-7-enol decreased while that of a minor sterol component (tentatively identified as cholesterol) increased. This change was more pronounced in differentiated sporelings than in undifferentiated sporelings. Lipid fractions eluted with methanol from silicic acid columns contained two phospholipids (possibly identical with phosphatidylcholine and phosphatidylethanol amine) and two unidentified glycolipids. Bioassay of these fractions indicated the presence of a phytotoxic component in extracts from germinated spores but not in those from ungerminated spores. No evidence was obtained for a *Sr6* gene specific component in these extracts.

*Search for *Sr6* gene specific spore components in other fractions.* Methods were developed for extraction, fractionation, and bioassay of polypeptides and glycoproteins from undifferentiated and differentiated sporelings with the use of gel filtration and high-voltage thin-layer isoelectric focusing. An extensive study using these methods will be started soon. Similar methods for the analysis of polynucleotides are still in the process of development.

Chemical Control

Cost benefit analyses, based on data from tests conducted over 4 years on systemic chemicals for the control of rust of wheat, indicated that a satisfactory fungicide for widespread use would have to be either superior in effectiveness to Plantvax 75 W at \$4.40/kg (\$2.00/lb) or equally effective and less expensive.

Four organic chemicals and 14 antibiotics were screened by using bioassay techniques and were found to be either inactive or too low in systemic activity to be suitable for the control of rust of wheat.

CEREAL DISEASES

Smuts

Cultures of *Ustilago hordei* (Pers.) Lagerh. or *U. nigra* Tapke inhibit growth of *U. nuda* (Jens.) Rostr. when grown together, and in severe cases produce lysis of the hyphae. Only on selected media, and with some lines of the species involved, is there no interference between them. This phenomenon might have been responsible for failure of the attempts to cross *U. hordei* and *U. nigra* with *U. nuda*.

The inositol starvation technique for isolating biochemical mutants was modified for use with *U. hordei*. Initial application of this method produced more than 100 mutants. The pigment production exhibited by some of these supposed double mutants will increase their usefulness in genetic studies and in the development of virulent test lines.

Crosses of lines of *U. hordei* segregated for virulence on the barley cultivar Excelsior; one gene for virulence is involved.

The selfings of and crosses between the Canadian races Nd 1, 2, 3, and 4 of *U. nuda* were successful; infection on host plants ranged from 17% to 96%. For the first time, combinations of monokaryotic haplonts were used as inoculum.

The selfings of and crosses between Canadian race T1, 2, 4, and 5 of *U. tritici* (Pers.) Rostr. were successful. Infection ranged from 28% to 90%. Sets of differentials were inoculated with spores of the selfings to obtain, for the first time, the virulence pattern of homozygous cultures of each race.

One of the races is moderately virulent on some lines of Triticale, and has low virulence on rye. Of 32 cultivars of spring rye inoculated with a mixture of races, 20 cultivars were infected from 2% to 18%.

Of the 144 cultivars of spring wheat known to be either immune or highly resistant to Canadian races, and inoculated with a spore collection from Denmark and Sweden, 22 showed infection up to 62%. Therefore, this collection contains at least one gene for virulence not found in Canada.

Barley Yellow Dwarf

Late-seeded barley in the Red River Valley became heavily infested with the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), which produced infection when allowed to feed singly on test oat seedlings. Twenty-five

percent of the test plants became infected. The virus transmitted was the mild, *R. maidis*-specific strain of barley yellow dwarf virus (BYDV). In some barley fields 100% of the plants were infected with the virus. The combination of virus and the effect of aphid feeding were largely responsible for the serious yield reduction and poor seed quality of grain from these fields.

A severe epidemic of BYDV occurred in large acreages of late-seeded cereals in New Brunswick. The virulent, nonspecific strain of BYDV was isolated from each of nine samples of cereals received from Fredericton.

Studies were made on the effect of inoculating oats with paired combinations of certain isolates of BYDV. A synergistic response resulted in plants inoculated with an *R. padi*-specific isolate and either a *Macrosiphum avena*-specific or a nonspecific isolate. However, interference occurred between the *M. avenae*-specific and the nonspecific isolates.

Two isolates of BYDV, specific for *Schizaphis graminum* (Rondani), were transmitted more efficiently by young nymphs of this aphid than by wingless adults. Persistence of the virus in the aphid was low for one isolate.

Oat Necrotic Mottle

The final steps were developed for a method of purifying oat necrotic mottle virus. Silver nitrate was used as a means of clarifying infectious plant juices. Components of the plant in which the virus was propagated could not be detected serologically in the final concentrated preparation of virus. Dimensions of the flexuous, rod-shaped virus particles were determined under an electron microscope.

Aster Yellows and Blue Dwarf of Oats

In 1970 incidence of aster yellows (AY) and blue dwarf of oats (OBDV) in barley and oats was, in general, high in the Prairie Provinces, and coincided with an extremely large population of the leafhopper vector. Losses in yield caused by these two viruses varied greatly across the prairies, and in some areas ranged to 16% for AY on barley. The method for assessing loss due to OBDV has not yet been perfected, but incidence of infection by OBDV was generally higher than that of AY, particularly in oats, and there were indications of substantial yield losses.

Strains of AY virulent on wheat, first isolated in 1966, were present in 1970, but there was no indication of increased prevalence of these strains nor was there a high incidence of AY noted in wheat.

Of approximately 2,000 cultivars of barley from the World Barley Collection that were screened for reaction to AY, no lines were found to be resistant or tolerant.

Barley Stripe Mosaic

An extensive survey of barley in July 1970 showed barley stripe mosaic to be distributed throughout the range of two-row barley in Manitoba but of only sporadic occurrence in six-row barley. In two- and six-row barley cultivars, 22% and 4%, respectively, of the fields sampled were infected. Symptoms of stripe mosaic in some two-row barley fields were extremely mild and occasionally evidence of symptomless infection was obtained. There was, however, no evidence of widespread masked infection, and the virus was isolated only from fields manifesting symptoms of the disease. The incidence of the disease in infected barley fields varied from a trace to about 50%.

An attempt to symptomatically differentiate field-collected virus isolates by using five barley cultivars did not yield promising results. Initially field-collected virus isolates induced a wide range of symptoms in Black Hullless barley, but subsequent selection and transfer of such isolates resulted in generally increased symptom stabilization. Four distinct virus isolates have been obtained, and the major biological and physical properties of these isolates are being investigated.

Foliage Diseases

Lines from the barley breeding programs were screened for reaction to net blotch, scald, and septoria leaf blotch.

The production of conidia and ascospores of *Pyrenophora tritici-repentis* (Died.) Drechsl. was found to be affected by light quality and length of exposure. Near ultraviolet light was required for conidiophore formation, and the absence of light at 290-540 nm was required for conidial formation. No conidiophores nor conidia formed in continuous dark; only conidiophores formed in continuous light, and both formed under 12 hr of alternating light and dark periods. Perithecia and ascospores formed at wavelengths

of above 540 nm in continuous light and in 12 hr of alternating light and dark periods.

Bacteria

C.T. 615, a selection of bread wheat, was found to be highly resistant to bacterial black chaff under conditions of artificial epidemics in 1969 and 1970 and is being used as a source of resistance in the breeding program. When inoculated under field test conditions, two lines of barley, B.T. 314 and B.T. 808, were exceptionally susceptible to bacterial blight.

Seed Treatment

Certificates of registration for mercurial products bearing label claims for the treatment of cereal seed, wheat, oats, barley, and rye were canceled December 1, 1970. Since 1966, however, and in cooperation with industry, emphasis has been placed on the testing of nonmercurials for seed treatment. Polyram (Niagara Chemicals) and Vitavax (UniRoyal Ltd.) were first tested for efficacy in 1967. Nearly all 66 formulations tested in 1970 had been included in earlier trials. Consequently, fungicides in the form of dusts, wettable powders, and suspensions that control some or all cereal smuts are available. Moreover, some of these products control loose smut of wheat and barley.

In cooperation with Dr. C. A. R. Dennis, Occupational Health Officer, Regina, 100 samples of "heated" grain in different stages of deterioration were examined for microorganisms and for their possible implication in farmer's lung disease. The most abundant spore producers found were *Aspergillus fumigatus* Fres., *A. nidulans* (Eidam) Wint., *A. flavus* Lk., and *Penicillium viridicatum* Westling (the last two fungi can produce toxins) and other *Penicillium* spp.

The effects of eight fungicide formulations on the microflora of 10 lots of naturally infested barley seed were investigated after 7 days incubation. Reactions of individual fungi to treatment with a specific fungicide were independent of seed lot. Panogen Px (NOR-AM Agricultural Products Ltd.), SWF 790 (Green Cross Products), and Polyram 80 (Niagara Chemicals) were nonselective in action, as shown by inhibition of all fungi except those established internally in the seed. Vitavax, G696 (UniRoyal Ltd.), and Hexa (Interprovincial-Co-operatives Ltd.) were selective in action to the microflora.

Hoe 2874 (Canada Hoechst Ltd.) controlled all fungi except *Streptomyces* spp., which are known to be antagonistic to *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur. Hoe 2874 may therefore be useful for controlling common root rot of cereals.

Conidia of *C. sativus* from untreated seed are straight, curved, or occasionally triradial, and are multicellular and produce bipolar germ tubes. Aseptate conidia of different sizes also occur. A narrow channel or plate occurs at the position of invagination between outer and inner layers of endospore walls. Multiradial conidia with reduced lumina occur after treatment with Panogen Px, Polyram 80, and Dithane M45 (Rohm & Haas Co. of Canada Ltd.) and produce lateral or bipolar germ tubes. Brown bands coincident with the channel or plate occur in conidia exposed to Res-Q (Green Cross Products), Polyram 80, Dithane M45, and SWF 790 treatments. Evidence suggests that fungicides enter the conidia via terminal germination areas rather than the conidiophore.

FIELD CROP INSECTS

Soil Ecology

Organisms. As part of a long-range study of cultivated soil ecosystems in Western Canada a preliminary survey of abiotic, microfloral, and microfaunal components was undertaken. A collembolan, *Hypogastrura tullbergi* (Schäffer), was chosen for interaction studies with soil microfloral components in the laboratory. The insect was exposed at 9 ± 1 C and $80 \pm 3\%$ relative humidity and 15 ± 1 C and $75 \pm 2\%$ relative humidity to 43 species of soil fungi and actinomycetes cultured on potato-dextrose-agar slants. *Alternaria alternata* (Fries) Keissler, *Cladosporium cladosporioides* (Fres.) De Vries, *Bipolaris tetramera* (McKinney) Shoem., and *Sporotrichum carnis* Brooks and Hansofd. were the species on which most feeding and reproduction occurred. These species formed a mycelial mat with low spore production, but they permitted free movement of the insects. Feeding, and particularly multiplication, was greater at 15 ± 1 C than at 9 ± 1 C.

Insecticides

The bioactivities of several insecticides were compared in a sandy loam soil and a clay soil by using bioassays with the onion maggot, *Hylemya antiqua* (Meigen). The clay soil deactivated carbofuran (Furadan; Niagara Chemicals) and fensulfothion (Dasanit; Chemagro Ltd.) to a greater extent than trichloronat (Bayer 37289; Chemagro Ltd.) and fonofos (Dyfonate; Stauffer Chemical Co.). In sandy loam soil LC₅₀ values were lower for each insecticide.

Effective crop protection from sugar-beet root maggot damage was obtained when the following insecticides were applied to the seed furrow at 1.12 or 1.40 kg of actual toxicant/ha (1.0 or 1.25 lb/acre). Carbofuran, trichloronat, fonofos diazinon, phorate (Thimet; Cyanamid of Canada Ltd.), and aldicarb (Temik; Union Carbide Canada Ltd.) each increased the yield of sugar beets by 8.98 to 11.90 metric tons/ha 4.0 to 5.3 tons/acre).

Several insecticides sprayed on microplots of sugar beets gave practical plant protection against laboratory-reared, fourth to sixth instar, red-backed cutworms when used as follows: toxaphene at 2.24 kg/ha (2 lb/acre); Dursban (Dow Chemical Canada Ltd.) at 0.56 kg/ha (0.5 lb/acre) acted more rapidly and gave effective protection; Cyolane (Cyanamid of Canada), N-2596 (Stauffer Chemical Co.), and carbofuran at the same rate were ineffective.

Grasshopper Surveys

Grasshopper populations in Manitoba during 1970 were low and unchanged from 1969. Egg hatch was delayed during the last 2 weeks of June by unfavorable weather. Because of lush plant growth throughout, crop damage was negligible and control chemicals were not needed.

INSECTS AND MITES IN STORED PRODUCTS

Surveys

Farm-stored grain. A survey of 2,509 managers of grain elevators revealed that during 1967-68, 1968-69, and 1969-70, respectively, the number of cases of hot spots in farm-stored grain reported by farmers were (percentages of elevator points containing

infestation are given in parenthesis) 715 (6.2%), 17,748 (45.5%), and 7,077 (27.8%), and the number of cases of arthropod infestations were 797 (5.6%), 7,746 (29.0%), and 4,534 (17.5%).

During September and October, surveys to determine the extent and severity of insect and mite infestations in farm-stored grain were conducted in Manitoba, Saskatchewan, and Alberta. Many of the grain bulks examined were infested with the rusty grain beetle; fungus beetles and mites were also present. Because of limited wheat sales, temporary storages were in common use and considerable out-of-condition grain was noted. It was of interest that rusty grain beetles were found in temporary storages in farmers fields as well as in grain harvested in 1970. The stored-grain insect trap used in these surveys permitted detection of populations that would otherwise have been missed.

Ecology

Chemical control of insects. Emphasis has been on field and semifield scale tests to investigate the effectiveness of fumigants against the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), the granary weevil, *Sitophilus granarius* (Linnaeus), and mites. It has been established that the hydrogen phosphide fumigant, Phostoxin, does not kill the eggs of the rusty grain beetle under conditions of small-field scale tests. These tests were repeated at different temperatures. Ethylene dibromide at 1 ml/36.37 liters (1 ml/bu), and combinations of ethylene dibromide and ethylene dichloride are more effective than hydrogen phosphide against eggs and adults of the rusty grain beetle.

Insect detection. Traps used to detect insects in stored grain became rusted after continued use, particularly in moist grain, and some beetles escaped. A modified, and more economical, version developed this year utilizes a glass collection chamber that is escape-proof. This is a precise and sensitive model and will be a valuable tool in ecological studies.

Natural components that affect insect behavior. Triglycerides isolated from wheat germ were shown to induce aggregation of the confused flour beetle. The structures of a number of these triglycerides were established and 38 triglycerides, some of which

occur naturally in wheat germ, were synthesized. Beetles responded most strongly to triglycerides that contained one or two residues of palmitic acid and one of either oleic, linoleic, or linolenic acid. Saturated triglycerides induce a minimal aggregation response. Triglycerides isolated from the fungus *Nigrospora sphaerica* (Sacc.) Mason were also shown to induce aggregation. The beetles were not induced to feed by triglycerides, but a carbohydrate fraction extracted from wheat germ was a potent stimulant. This fraction was composed primarily of sucrose, glucose, and fructose. Model mixtures of these sugars also induced the beetles to feed.

Beetle biology. The squarenosed fungus beetle, *Lathridius minutus* (Linnaeus), can complete its life cycle in 4 weeks at 20 C and 9 weeks at 10 C on a culture medium of decayed wheat. Of the species of fungus isolated from decayed wheat, only *Penicillium crustosum* Thom. and *Penicillium* sp. favored the development of larvae.

In laboratory studies, spontaneous heating in wheat occurred when the moisture content was more than 20% and when water was added at regular intervals. The heating achieved by these methods was not affected by the presence of populations of the rusty grain beetle, *C. ferrugineus*.

The respiration of 1- to 4-week-old adults of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus), was measured manometrically and found to vary from 2.7 microliters/insect per hr at 30 C to 0.9 microliters/insect per hr at 15 C.

Interrelations of abiotic and biotic variables in grain bulk ecosystems. The impact of insect infestation on certain biotic and abiotic variables of three bulk-wheat ecosystems was studied by measuring these variables at monthly intervals during 1969-70. One ecosystem was infested with *C. ferrugineus* and *O. surinamensis*, the second with *S. granarius* and *Tribolium castaneum* (Herbst), and the third ecosystem was insect-free. Variables considered were temperature, moisture, germination, grain weight, dust weight, microorganisms and insects, fat acidity, and uric acid. Principal component and canonical correlation analyses were used for determining interrelations. The first principal component, which is a measure of aging of grain and fungal successions, explained 41-58% of total variability.

Changes were most pronounced in the second ecosystem, in which new pathways involving *Streptomyces* and bacteria were added and the deterioration of the grain was accelerated. Bacterial growth encouraged by the metabolic moisture from the insects seemed to reduce the uric acid content, perhaps by using this chemical in bacterial metabolism.

Multiplication of storage insects on different cultivars of cereals. The rate of multiplication of *Cryptolestes turcicus* (Grouvelle), *O. surinamensis*, *Sitophilus oryzae* (L.), and *S. zeamais* (Mots.) on 35 cultivars of cereals grown in Manitoba was determined. The rate of population increase was greater on the cultivars of oats and barley than on the wheats. All insects except *C. turcicus* multiplied on oats and certain other cultivars of cereals. *S. oryzae* multiplied best on whole kernels of Manitou wheat, Montcalm barley, and Dorval oats. *O. surinamensis* multiplied best on crushed oat cultivars.

Bioassay for nutritive value of cereals. The usefulness of the confused flour beetle as an assay organism for assessing the nutritive value of cereal cultivars was further examined. Nine rations, eight involving cereals, were tested simultaneously with chicks and beetles. The correlation coefficient between average daily gain of the chicks and average length of larval period of the beetles (the two criteria chosen to measure nutritive value) was -0.91 ($P < 0.01$). In this study the cereal varieties were each supplemented with a micronutrient mixture of minerals and vitamins because the birds failed to grow on the cereal alone. It appears that some cereal varieties are more deficient than others in the micronutrients available, as judged by the beetle assay. For example, when micronutrients were added to Betzes barley the average larval period was only 0.9 day less than on Betzes barley alone. In contrast, results from a similar study with Manitou wheat showed that supplementation decreased the average larval period by 5.2 days.

Determination of atmospheric gases in stored grain. Methods were developed and tested for sampling and measuring by gas chromatography (GC) the major and minor components in the atmosphere of stored grain. Twenty-four different GC columns were used interchangeably to develop better

resolution and sharpness of responses. Resolution of 51 gases and vapors was tested on various columns; comparative peak heights, peak shapes, and peak areas were a function of operating conditions. Comparison of the GC method with the Scholander volumetric method for CO₂ in air showed that the values were comparable, but the GC method was simpler, faster, and more sensitive, and required a smaller sample. Small-bore columns were useful for determination of CO₂, O₂, and N₂ in simulated microenvironmental systems applicable to insect, mold, mite, and bacterial populations in stored grain.

PEDOLOGY

Classification and Mapping

Reconnaissance surveys were completed for 17,504,890 ha in the Grand Rapids map sheet area, 63G; the west quarter of Norway House, 63H; the west quarter of Cross Lake, 63I; and Wekusko Lake, 63J. Cooperative studies on the soil capability for agricultural purposes in conjunction with the provincial Canada Land Inventory group were completed for these map sheets.

Soil Characterization and Genesis

Work is continuing on effects of soil moisture regimes on Fe, Mn, Al, and P chemistry in Chernozemic soils. These components of soils are being correlated with redox potential, groundwater status, and soil morphology. The characterization of these constituents will include mineralogical analysis by thin section and electron microprobe techniques.

Characterization and genesis of frozen (Cryic) organic soils in Manitoba is continuing. The physical, chemical, and morphological properties of these soils in the Cranberry Portage area of central Manitoba were determined. Permafrost occurred under elevated, densely wooded peat mounds (palsas) and extended into underlying clay. Doming is largely due to ice accumulation in the clay and peat. The thickness of the active layer is related to vegetation and cumulative depth of snow. The moisture content of the peat in the active layer varies from 30% in the fall to approximately 60% in the winter; that of the permanently frozen core remains constant at

over 90%. The material was moderately decomposed sedge peat in the lower portion of the profile and moderately decomposed forest peat in the middle and upper portions of the profile. Studies are continuing on the migration of water to the frozen-unfrozen interface in these soils.

Data bank. Preliminary work related to the development of a provincial soil survey data bank was initiated, and a preliminary format was prepared. These data permit rapid storage, retrieval, and updating of survey data accumulated since the start of the program and will be used for statistical and land capability analyses.

Hydrology

Flow patterns and the chemistry of groundwater in the Whitewater Lake Basin are being studied in cooperation with the Department of Earth Sciences, University of Manitoba. These factors will be correlated with the distribution and development of genetic soil types in the basin. Field studies have determined the basic groundwater flow patterns and related distribution of soil types in the basin. In the discharge portion of the basin associated soils are predominantly carbonated saline Rego Blacks and carbonated saline Rego Humic Gleysols. The recharge portion of the basin is characterized by Orthic and Eluviated Chernozemic soils.

PUBLICATIONS

Research

- Allen, W. R., and Askew, W. L. 1970. A simple technique for mass-rearing the onion maggot (Diptera: Anthomyiidae) on an artificial diet. *Can. Entomol.* 102:1554-1558.
- Allen, W. R., Askew, W. L., and Klassen, M. 1969. Effect of insecticides and application procedures on phytotoxicity to sugar-beet seedlings and control of the sugar-beet root maggot. *Manitoba Entomol.* 3:70-78.
- Baker, R. J., and Leisle, D. 1970. Comparison of hill and rod row plots in common and durum wheats. *Crop Sci.* 10:581-583.
- Barker, P. S. 1969. Toxicity of lindane-treated surfaces to *Tyrophagus putrescentiae* (Schränk) (Acarina: Acaridae). *Manitoba Entomol.* 3:79-80.
- Barker, P. S. 1970. Susceptibility of eggs and young adults of *Cryptolestes ferrugineus* and *C. turcicus* to chloropicrin. *J. Econ. Entomol.* 63:940-943.
- Bartos, P., Green, G. J., and Dyck, P. L. 1970. Reactions to stem rust and genetics of stem rust resistance in European wheat varieties. *Can. J. Bot.* 48:1439-1443.
- Berck, B., and Gunther, F. A. 1970. Rapid determination of sorption affinity of phosphine by fumigation within a gas chromatographic column. *J. Agr. Food Chem.* 18:148-153.
- Berck, B., Westlake, W. E., and Gunther, F. A. 1970. Microdetermination of phosphine by gas-liquid chromatography with microcoulometric, thermionic and flame photometric detection. *J. Agr. Food Chem.* 18:143-147.
- Bowman, M. S., and Rohringer, R. 1970. Formate metabolism and betaine formation in healthy and rust-infected wheat. *Can. J. Bot.* 48:803-811.
- Campbell, A. B., and Johnson, K. R. 1970. Neepawa hard red spring wheat. *Can. J. Plant Sci.* 50:752-753.
- Cherewick, W. J., and McKenzie, R. I. H. 1969. Inheritance of resistance to loose smut and covered smut in the oat varieties Black Mesdag, Camas, and Rodney. *Can. J. Genet. Cytol.* 11:919-923.
- Dyck, P. L., and Green, G. J. 1970. Genetics of stem rust resistance in the wheat cultivar Red Bobs. *Can. J. Plant Sci.* 50:229-232.
- Dyck, P. L., and Kerber, E. R. 1970. Inheritance in hexaploid wheat of adult-plant leaf rust resistance derived from *Aegilops squarrosa*. *Can. J. Genet. Cytol.* 12:175-180.
- Fleischmann, G. 1969. Crown rust of oats in Canada in 1969. *Can. Plant Dis. Surv.* 49:91-94.
- Gill, C. C. 1970. Aphid nymphs transmit an isolate of barley yellow dwarf virus more efficiently than do adults. *Phytopathology* 60:1747-1752.
- Gill, C. C. 1970. Epidemiology of barley yellow dwarf in Manitoba and effect of the virus on yield of cereals. *Phytopathology* 60:1826-1830.
- Green, G. J. 1969. Air-borne rust inoculum over Western Canada in 1969. *Can. Plant Dis. Surv.* 49:78-79.

- Green, G. J. 1969. Stem rust of wheat, barley and rye in Canada in 1969. *Can. Plant Dis. Surv.* 49:83-87.
- Green, G. J., Martens, J. W., and Ribeiro, O. 1970. Epidemiology and specialization of wheat and oat stem rusts in Kenya in 1968. *Phytopathology* 60:309-314.
- Grussendorf, O. W., McGinnis, A. J., and Solomon, J. 1970. Rapid sample preparation for gas-liquid chromatography of pesticide residues by ball-grinding extraction, freeze-out, and semimicro column cleanup. *J. Ass. Offic. Anal. Chem.* 53:1048-1054.
- Hagborg, W. A. F. 1970. A device for injecting solutions and suspensions into thin leaves of plants. *Can. J. Bot.* 48:1135-1136.
- Hagborg, W. A. F. 1970. Carboxanilido systemic chemicals in the control of leaf and stem rusts of wheat. *Can. J. Plant Sci.* 50:631-641.
- Hannah, A. E. 1969. The agricultural resource in the prairie provinces. *Manitoba Entomol.* 3:13-19.
- Husband, R. W., and Sinha, R. N. 1970. A new genus and species of mite (Acarina: Podapolipidae) associated with the cockroach *Nauphoeta cinera*. *Ann. Entomol. Soc. Amer.* 63:1148-1152.
- Husband, R. W., and Sinha, R. N. 1970. A revision of the genus *Locustacarus* with a key to genera of the family Podapolipidae (Acarina). *Ann. Entomol. Soc. Amer.* 63:1152-1162.
- Jackson, A. O., Samborski, D. J., and Rohringer, R. 1970. Metabolism of alicyclic acids and phenylpropanoids by uredospores of wheat stem rust and wheat leaf rust. *Can. J. Bot.* 48:1085-1091.
- Jackson, A. O., Samborski, D. J., Rohringer, R., and Kim, W. K. 1970. Folate derivatives in ungerminated and germinated uredospores of wheat stem rust. *Can. J. Bot.* 48:1617-1623.
- James, W. C., Gill, C. C., and Halstead, B. E. 1969. Prevalence of barley yellow dwarf virus in winter wheat in Southwestern Ontario, 1969. *Can. Plant Dis. Surv.* 49:98-104.
- Kim, W. K. 1970. Effect of excision and benzimidazole treatment on folate content of wheat leaves and wheat leaf chloroplasts. *Can. J. Biochem.* 48:1091-1095.
- Leisle, D. 1970. Hercules, a new durum wheat. *Can. J. Plant Sci.* 50:118-119.
- Loschiavo, S. R. 1970. 4'(3,3-dimethyl-1-triazeno) Acetanilide to protect packaged cereals against stored products insects. *Food Technol.* 23:181-185.
- Loschiavo, S. R., and Smith, L. B. 1970. Distribution of the merchant grain beetle, *Oryzaephilus mercator* (Silvanidae: Coleoptera) in Canada. *Can. Entomol.* 102:1041-1047.
- Martens, J. W. 1969. Stem rust of oats in Canada in 1969. *Can. Plant Dis. Surv.* 49:88-90.
- Martens, J. W., McKenzie, R. I. H., and Green, G. J. 1970. Gene-for-gene relationships in the *Avena: Puccinia graminis* host-parasite system in Canada. *Can. J. Bot.* 48:969-975.
- Martens, J. W., Ravagnan, G., and McDonald, W. C. 1970. Diseases of sunflowers in Kenya. *East Afr. Agr. Forest. J.* April.
- McDonald, W. C., Martens, J. W., Green, G. J., Samborski, D. J., Fleischmann, G., and Gill, C. C. 1970. Losses from cereal diseases and value of disease resistance in Manitoba in 1969. *Can. Plant Dis. Surv.* 49:114-121.
- McGinnis, A. J. 1969. Resource management in retrospect: an epilogue. *Manitoba Entomol.* 3:56-57.
- McGinnis, A. J., and Kasting, R. 1969. Use of glutamic acid-U-C¹⁴ to determine nutritionally essential amino acids. *Entomol. Exp. Appl.* 12:467-468.
- McKenzie, R. I. H., Martens, J. W., and Rajhathy, T. 1970. Inheritance of oat stem rust resistance in a Tunisian strain of *Avena sterilis*. *Can. J. Genet. Cytol.* 12:501-505.
- Metcalfe, D. R., Buchannon, K. W., McDonald, W. C., and Reinbergs, E. 1970. Relationships between the "Jet" and "Milton" genes for resistance to loose smut and genes for resistance to other barley diseases. *Can. J. Plant Sci.* 50:423-427.
- Mills, J. T. 1970. Morphology of conidia of *Cochliobolus sativus* from untreated and fungicide-treated barley seed. *Can. J. Bot.* 48:541-546.
- Mills, J. T., and Wallace, H. A. H. 1970. Differential action of fungicides upon fungi occurring on barley seed. *Can. J. Plant Sci.* 50:129-136.
- Pesek, J., and Baker, R. J. 1970. An application of index selection to the improvement of self-pollinated species. *Can. J. Plant Sci.* 50:267-276.
- Samborski, D. J. 1969. Leaf rust of wheat in Canada in 1969. *Can. Plant Dis. Surv.* 48:80-82.
- Samborski, D. J., and Rohringer, R. 1970. Abnormal metabolites of wheat: occurrence, isolation and biogenesis of 2-hydroxyputrescine amides. *Phytochemistry* 9:1939-1945.
- Shipton, W. A., and McDonald, W. C. 1970. Production of fertile perithecia of *Pyrenophora avenae* in culture. *Trans. Brit. Mycol. Soc.* 55:329-332.

- Shipton, W. A., and McDonald, W. C. 1970. The electrophoretic patterns of proteins extracted from spores and mycelium of two *Drechslera* species. *Can. J. Bot.* 48:1000-1002.
- Sinha, R. N., Bronswijk, J. E. M. H. van, and Wallace, H. A. H. 1970. House dust allergy, mites and their fungal associations. *Can. Med. Ass. J.* 103:300-301.
- Sinha, R. N., and Lee, P. J. 1970. Maximum likelihood factor analysis of natural arthropod infestations in stored grain bulks. *Res. Pop. Ecol. (Kyoto)* 12:51-60.
- Smith, L. B. 1969. Possible effects of changes in the environment on grasshopper populations. *Manitoba Entomol.* 3:51-55.
- Smith, L. B. 1970. Effects of cold-acclimation on supercooling and survival of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) (Coleoptera: Cucujidae), at subzero temperatures. *Can. J. Zool.* 48:853-858.
- Wallace, H. A. H. 1969. Cooperative seed treatment trials—1969. *Can. Plant Dis. Surv.* 49:49-53.
- Watters, F. L. 1970. Toxicity to the confused flour beetle of Malathion and Bromophos on concrete floors. *J. Econ. Entomol.* 63:1000-1001.
- Miscellaneous**
- Berck, B. 1969. Measurement of phosphine by GLC and microcoulometric, thermionic and flame photometric detection, and its separation from sulfur-containing gases. *Proc. 4th Seminar on Pestic. Residue Anal. (W. Can.), Winnipeg* 4:69-76.
- Berck, B. 1969. Report on the 4th Seminar on Pesticide Residue Analysis (W. Canada). *Pestic. Progr.* 7:169-173. (Also published in *Can. Inst. Food Technol. J.* 2:48-49 and *Chem. Can.* 21:23-24.)
- Berck, B. 1970. Differentiation by GLC of physically bound from chemically bound residues of gaseous pesticides (fumigants) applied to cereal products and soils. *Proc. 5th Seminar on Pestic. Residue Anal. (W. Can.), Vancouver* 5:24-30.
- Berck, B. 1970. The fastest fumigation in the West. *Can. Agr.* 15(3):18-19.
- Fleischmann, G., and Martens, J. W. 1970. Wild oats from the Middle East: A source of genes for rust resistance. *Cereal News* 15:2-4.
- Green, G. J. 1970. The rusts—always a threat. *Manitoba Coop.* 27(31):24.
- McGinnis, A. J., Sinha, R. N., and Loschiavo, S. R. 1970. Insects, mites and molds may cause grain spoilage. *Manitoba Coop.* 27(31):37-38.
- Mills, J. T., and Wallace, H. A. H. 1970. Addition of penetration agents to fungicides for control of barley seedling blight. *Fungicide and Nematocide Tests* 25:107.
- Sinha, R. N. 1970. Feeding of *Tribolium confusum* on world species of *Fusarium* and *Gibberella zeae*. *Tribolium Inform. Bull.* 13:83-84.
- Sinha, R. N., and Mather, H. J. 1970. Grain storage. *Seedtime and Harvest*, No. 81: March. 2 p.
- Tarnocai, C. 1970. Glacial history, surface deposits, soils and vegetation of the Wekusko Lake, Cross Lake, Norway House and Grand Rapids map sheet areas. *Proc. 14th Annu. Man. Soil Sci. Meet.*, Dec. 9-10, 1970.
- Wallace, H. A. H., and Mills, J. T. 1970. Addition of penetration agents to fungicides for control of common bunt of wheat and covered smuts of oats and barley. *Fungicide and Nematocide Tests* 25:132.
- Wallace, H. A. H., and Mills, J. T. 1970. Effects of seed treatment on the viability of tough and damp cereal and flax seed. *Rep. Annu. Conf. of Man. Agron.*
- Wallace, H. A. H., and Mills, J. T. 1970. Germination of tough and damp grain. *Canadex Inform. Leaflet*. May.

Experimental Farm Indian Head, Saskatchewan

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INTRODUCTION

This report outlines the significant results of the research program at the Experimental Farm at Indian Head for 1970. None of the research is reported in detail. Significant results on long-term projects are mentioned. Results of our testing program are incorporated in the information on which practical recommendations are made for the guidance of farmers in Saskatchewan for cereal crops, forage crops, fertilizers, weed control, and rotations.

The Experimental Farm at Indian Head increases and distributes Breeder, Select, and Foundation seed of cereals, oilseed crops, and forage crops in cooperation with the Research Station at Regina. Pedigree seed of the following was produced in 1970: Random oats, DT 317 durum wheat, IB-6-5 two-row barley, Magna bromegrass, Summit 62 crested wheatgrass, Parkway crested wheatgrass, Yukon sweetclover, Bronowski rape, and Sawki Russian wild ryegrass. Breeder seed of Echo rape was distributed to 16 growers. Foundation Magna bromegrass was distributed to several growers and four seed companies and Foundation Summit 62 crested wheatgrass to one grower and one Research Institute.

J. Roe Foster
Director

FIELD HUSBANDRY

Rotations and Soil Fertility

For the past 13 years plots have been sown continuously to wheat. They yielded 22.8 q/ha in 1970 and averaged 15.6 q/ha for the 13-year period. When the fertility requirements of the crop were met and weeds controlled, continuous wheat outyielded wheat in the 2-year rotation by 3.2 q/ha, based on the total acreage under cultivation. Wheat, barley, and flax were rotated to avoid problems caused by the continuous use of the same crop. For the past 3 years, wheat averaged 26.5 q/ha, barley 26.4 q/ha, and flax 10.1 q/ha. In another rotation, a brome-alfalfa mixture was left down for 3 years, then broken and summerfallowed. The wheat averaged 24.3 q/ha on summerfallow and 14.6 q/ha on stubble. These yields were as high as in other rotations where 22 kg/ha of N was applied with the stubble crops.

Rates of Seeding

Rates of seeding wheat on fallow were compared at eight locations in southeastern Saskatchewan. The rates ranged from 0.34 to 2.02 kg/ha. In 1969 and 1970 at Fleming and in 1969 at Arcola, the optimum rate was 1.68 kg/ha. At the other locations the optimum rate was 0.67 to 1.01 kg/ha. Wheat sown at the light rate matured about 1 week later. Most weed growth was controlled with chemicals, but weeds were more troublesome in the plots sown at the light rate.

Fertilizers

Various combinations of N and P were applied to established stands of brome-alfalfa mixtures at four locations in southeastern Saskatchewan. The soils, classed as Rye-son loams and Oxbow loams, were very low in $\text{NO}_3\text{-N}$ and available P. At one location fertilizers did not increase yields in either 1969 or 1970. At the other locations a consistent economic increase resulted with a 2:1 ratio of N and P. Rates of 22.4 kg/ha of N and 9.8 kg/ha of P produced the most economic return. The average increase with this rate was 0.76 ton/ha.

Rates of N, P, and S in various combinations were applied to an established stand of alfalfa on a Gray Wooded soil. The soil was low in $\text{NO}_3\text{-N}$ and very low in available P. N and P did not increase yields, but S produced a consistent response. Yields were increased by 0.67 ton/ha with 15.7 kg/ha of S. Heavier rates of S did not have additional value.

For the past 24 years, P at 4.2 to 21.1 kg/ha has been applied to test plots on the Experimental Farm. The available P in the soil has increased, particularly where the highest rates were used. The soil test was high in 1970 in plots where 21.1 kg/ha had been applied, but yields were increased by only 3.5 q/ha, slightly less than the longtime average of 4.9 q/ha.

Manure has been applied at 13, 20, and 26 tons/ha once every third year to Indian Head heavy clay soil. Available N and P have

increased in all plots. Over the 24-year period, wheat sown on the summerfallow plots that received manure at 20 tons/ha averaged 27.9 q/ha, and the wheat sown on stubble averaged 15.8 q/ha. The check plots averaged 25.3 q/ha and 14.2 q/ha. The increases have been much higher in the last few years. Additional N is required for maximum production of stubble crops.

N alone, and in combination with P, was applied with wheat sown on stubble. The soil tested low in N. In 1970 yields increased progressively as the rate of N was increased from 0 to 67 kg/ha. P had little effect on yields. In 1970, N applied in the fall was slightly more effective than N applied in the spring, but over several years differences have been slight. Various rates of N and P in solution were applied to wheat sown on stubble. This fertilizer compared favorably with granular forms. When N was applied on the surface at 33.6 kg/ha, yields of flax sown on stubble were increased by 5.8 q/ha this year and by an average of 2.9 q/ha during the past 8 years. Even with N at 22.4 kg/ha, maximum yields of flax were obtained when the N was applied on the surface rather than with the seed.

PLANT SCIENCE

Cereals

Cooperative evaluations of Breeders' material, varieties, and lines were made in headquarters and regional tests. Regional tests of varieties were conducted on seven project farms in southeastern Saskatchewan. These regions provide the main crop hazards of drought, frost, and rust. The spring was very late and seeding was delayed by 3 weeks, but moisture conditions were good and yields excellent. Dry weather in late July and August hastened maturity.

Rust was not a serious factor, except at Yorkton and Langenburg where a moderate infection was present on oats and susceptible durum wheats (Pelissier). Stem and leaf rust was generally widespread, but it started too late to reduce yields. The durum wheats, Stewart 63, Ramsey, and Hercules had similar yields. The new line under test, DT 317, yielded about 13% more than Hercules, which yielded 22.9 q/ha (34 bu/acre). Hercules yielded well this year, but it usually yields 10% to 15% lower than Stewart 63.

Fraser was the highest-yielding oat at 32.2 q/ha (84.5 bu/acre), followed by Kelsey, which yielded 0.64 q/ha (1.7 bu/acre) less. The malting and feed barleys yielded similarly; Paragon was the highest at 36.6 q/ha (68 bu/acre) and Galt, Jubilee, and Bonanza yielded slightly less. S 6621, a new line, was the highest yielder of the two-row group at 35 q/ha (65 bu/acre), with Fergus 0.54 q/ha (1 bu/acre) less. There was little difference in yield of flax varieties, with Redwood 65 yielding 13.2 q/ha (21.1 bu/acre). Linott, an early variety that is being retested, yielded slightly more than the other early variety Noralta. The following increase of Select seed of new varieties was made: Random (OT716) oats, 15 ha; durum wheat DT 317, 6.6 ha; and barley IB-6-3, 6 ha.

Neepawa was the highest yielder of the hard red spring wheats at 24.1 q/ha (35.8 bu/acre), about 5% more than Manitou. The nonbread wheat Pitic 62 yielded only 11% more than Neepawa and was heavily affected by sawfly at two locations.

Forage Crops

The spring was cold and backward, but fall rains and snow provided adequate surface reserve moisture. Perennial crops grew well and an above-average hay crop was obtained. Evaluation of Breeders' lines, material, varieties, and introductions continued in cooperative and standard tests.

Management practices. Cutting Beaver and Rambler alfalfa at the 25% bloom stage produced more dry matter than cutting at the 10% or full bloom stage. Clipping afterwards, at various dates in the fall, had no effect on winter survival during 1969 and 1970. Alfalfa and grass in alternate rows or alfalfa mixed with grass in the row produced equal dry matter yields. Clipping Russian wild ryegrass very short after seed harvest had no effect on seed yield the following year.

Seeding Rambler and Beaver alfalfa at 1.1, 2.2, and 3.4 kg/ha (1, 2, 3 lb/acre) with five species of grass had no effect on dry matter yield. The use of grass and alfalfa mixtures in the rotation significantly increased by 51.1 q/ha (7.6 bu/acre) the yield of wheat on stubble in 1970. Fertilizer (N and P) accentuated the increase. Fallow yields were not influenced. Grass alone in the rotation had no effect on the wheat yield.

Plant breeding. Two forage-type oat lines selected at Indian Head were the top yielders of dry matter in a cooperative test grown at seven widely separated locations in Canada. These lines are also promising in yield of seed at several locations. Crosses involving three of the best forage oat lines with genes from *Avena strigosa* and *A. sterilis* were made at Winnipeg in 1969 and 1970. Selection within this material will start in 1971 at Indian Head. Eleven Russian wild ryegrass plants free from leaf spot were cloned and established in an isolated block for further evaluation. Selection within Breeder seed of Echo oilseed rape has isolated some very high yielding lines that have a higher oil content than Echo. They are being analyzed for erucic acid.

The following pedigree seed was distributed in 1970: Echo rape Breeder seed 55.4 kg (122 lb) to 16 growers, nine in Saskatchewan, six in Alberta, and one in Manitoba; Summit 62 crested wheatgrass Foundation seed 90.8 kg (200 lb), Breeder seed 24.2 kg (50 lb) to the Research Station, Saskatoon; Magna bromegrass Foundation seed 933 kg (2055 lb) to several seed growers and four seed companies. The following pedigree seed was produced in 1970: Magna bromegrass 393 kg (865 lb); Summit 62 crested wheatgrass Breeder seed 295 kg (650 lb); Parkway crested wheatgrass Breeder seed 2270 kg (5000 lb); Bronowski rape 393.2 q (1732 bu); Yukon sweetclover Foundation seed 5448 kg (12,000 lb); Sawki Russian wild ryegrass Breeder seed 399 kg (878 lb). Two low glucosinolate rape lines, 569-914 and 569-923 (Saskatoon), produced 556 kg (1224 lb) and 626 kg (1378 lb) respectively.

SOILS—HORTICULTURAL CROPS

Soil Fertility

Effect of fertilizer placement on potato yields. Side-band application of ammonium phosphate (11-48-0) and ammonium nitrate (34-0-0) at rates of 74 kg/ha of P and 167 kg/ha of N, applied at spring planting, produced a total potato yield of 346 q/ha with a

marketable tuber yield of 82.3%. Ammonium nitrate applied as a side-band at early bud stage of the potato, instead of at spring planting, produced a total yield of 361 q/ha with a marketable tuber yield of 83.0%. However, ammonium nitrate applied as a side-band on the soil surface at early bud stage produced a total yield of 382 q/ha with a marketable tuber yield of 84.8%. When applied as a side-band at the late flower stage, ammonium nitrate produced a much lower yield and marketable tuber percentage. All treatments were hilled and irrigated after the early bud and late flower fertilizer treatments.

Effect of crop rotation on potato yields. In an experiment conducted for the past 3 years, a 3-year rotation of potatoes, wheat, and summerfallow produced a total potato yield of 281 q/ha. A 3-year rotation of potatoes, sweet clover, hay, and break produced a slightly lower yield of 272 q/ha. A total yield of 222 q/ha was produced by a 2-year rotation of potatoes and wheat.

Effect of N and P fertilizers on specific gravity and yield of potatoes. Data collected for 6 years indicate that the application of P alone produced high specific gravity values ranging from 1.078 to 1.079. Increasing the rate of N by 56, 112, 168, and 224 kg/ha alone or in combination with 0, 25, 50, 75, and 100 kg/ha of P, respectively, produced a consistent decline in specific gravity values. The lowest specific gravity value, 1.072, occurred when 224 kg/ha of N was combined with 100 kg/ha of P.

Yields recorded for a similar period indicate that the application of P alone generally reduced yields when compared with the check yield. N alone reduced yields when applied at rates higher than 112 kg/ha. High rates of N and P produced higher total yields, but the yield of marketable tubers when 112 kg/ha of N was applied with 50 kg/ha of P was not much less than the yield produced by the high rates.

PUBLICATIONS

Research

- Emmond, G. S. 1970. Comparative effect of pure chemical fertilizer vs mixed fertilizer on yield and specific gravity of potatoes. *Can. J. Soil Sci.* 50:255-256.
- Knowles, R. P., Cooke, D. A., and Buglass, E. 1970. Breeding for seed yield and seed quality in smooth brome grass (*Bromus inermis* Leyss). *Crop Sci.* 5:539-542.

Research Station Melfort, Saskatchewan

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INTRODUCTION

The Research Station, Melfort, specializes in forage production and utilization research and has active research programs in crop and soil management and animal nutrition. Research on forage harvesting and storage systems was initiated in cooperation with the Engineering Research Service in Ottawa.

Early in 1970, Melrose sainfoin was licensed for sale. Progress has been made in improving the efficiency of forage utilization by steers and lambs, and agronomic studies at the Station and at other sites continue to yield information for improving the efficiency of crop production.

The growing season in 1970 was excellent: between April 1 and August 31, 27.7 cm of precipitation and 141 days without a killing frost. This report summarizes the results of research during the past year. More detailed information of interest to farmers and extension workers is published in our annual Research Highlights, available without charge from the Station.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Breeding and Evaluation

Sainfoin. The Melrose variety, licensed in 1970, averaged 3,890 kg of dry matter (DM)/ha and 740 kg of seed/ha over the last few years. In 1970, 2,000 kg of Breeder seed/1.5 ha was produced. The Eski variety averaged 2,490 kg of DM/ha and 432 kg of seed/ha. In the same tests Ladak alfalfa produced 4,705 kg of DM/ha.

Alfalfa. Over the last 3 years seed yields of Rambler averaged 395 kg/ha, Beaver and Ladak 322 kg, and Roamer 245 kg.

Sweetclover. For Yukon, Arctic, Polara, and Erector varieties 3-year average dry matter yields were 6,350, 6,330, 5,970, and 5,620 kg/ha, and 4-year average seed yields were 700, 620, 450, and 490.

Bromegrass. The best producing varieties were Magna, Saratoga, and Carleton, which averaged 4,200, 4,200, and 4,000 kg of DM/ha over the last 3 years. Seed yields of Carleton and Magna averaged 415 and 382 kg/ha.

Production Management

Weed control in sainfoin. Tests have shown that MCPB at 1.68 kg/ha applied at the two-leaf stage gave good control of broad-leaved weeds. Chloramben at 1.12 kg/ha or trifluralin at 1.40 kg/ha incorporated in the soil before planting gave excellent weed control with little or no damage to sainfoin. Perhaps

because of better than normal growing conditions in the spring of 1970, sainfoin reacted more severely to herbicides. Damage was excessive when 2,4-D was applied at 0.35 kg or more per ha and when 2,4-DB was applied at 1.12 kg or more per ha. Application of 2,4-DB at 0.7 to 1.12 kg/ha gave fair to good control of broad-leaved weeds with some damage to sainfoin.

Response of bromegrass-alfalfa pasture to N fertilizer. Nitrogen fertilizer applied for the first time in the spring of the fourth year of grazing at 0, 45, 90, 135, and 180 kg N/ha gave yields of 4.03, 5.02, 5.46, 5.73, and 5.69 tons of forage DM/ha, respectively. When steers were fed barley on pasture, mean dry matter yields were slightly higher than when steers were not given any supplemental feeding on pasture.

Fertilizing forage for hay production. Application of 29 kg N and 56 kg P/ha at the time of seeding doubled the yields of grasses and legumes grown on newly broken land in the Saskatchewan River Delta area. Highest yielding grasses were bromegrass 5,008 kg/ha, meadow foxtail 4,903 kg/ha, timothy 4,627 kg/ha, and meadow fescue 4,421 kg/ha. The highest producing legume was alsike clover, 3,871 kg/ha.

When oats and Italian ryegrass, grown for hay, were fertilized with 23-23-0 at 0, 336, 672, and 1,008 kg/ha, DM yields were similar for both crops and averaged 1,593, 3,607, 5,668, and 8,026 kg/ha. The estimated level of fertilizer at which yields would justify

fertilizer cost was 120 kg/ha. Ryegrass produced 30% more protein/ha than did oats.

Utilizing Pastures

Management of steers on pasture. For the fourth consecutive year four systems of managing steers on bromegrass-alfalfa pasture were compared. In 1970, fertilizer (90 kg N/ha) was applied for the first time. The four systems compared were (i) maintaining a low stocking rate and feeding back surplus pasture preserved as silage (control); (ii) maintaining a high stocking rate throughout the season and supplementing pasture herbage with oat soilage; (iii) maintaining a stocking rate as in (ii), but supplementing pasture with rolled barley; and (iv) "put and take" stocking. The results of the four systems, in order (4-year averages in parentheses), follow. Yields of dry matter: 5,675 (3,964), including surplus harvested as silage; 5,625 (4,073); 5,679 (4,071); and 5,236 (3,583) kg/ha. Consumption of dry matter: 4,719 (3,258), including silage fed; 4,765 (3,492), plus 763 (1,248) kg oat soilage; 4,901 (3,426), plus 640 (1,229) kg of rolled barley; and 4,346 (3,127) kg/ha. Average stocking rate: 3.01 (2.42); 3.85 (3.41); 3.73 (3.48); and 3.93 (2.64) steers/ha. Average daily gain: 1.03 (1.10); 0.97 (1.07); 1.10 (1.28); and 0.87 (1.05) kg/day. Gain/ha of pasture: 346 (287); 364 (394); 372 (485); and 294 (283) kg.

Crested wheatgrass vs. Russian wild ryegrass for pasture. For the fourth consecutive summer, Russian wild ryegrass (RWR) and Fairway crested wheatgrass (CWG) were compared under a "put and take" grazing system with yearling steers. In 1970 (4-year averages in parentheses), both species supported a 99-day grazing period (83 CWG, 94 RWR). While the stocking rate was lower on CWG than on RWR, 3.9 vs. 4.2 steers/ha, average daily gain was higher, 0.85 vs. 0.69 kg/head, and gain/ha was higher, 324 kg vs. 287 kg. Dry matter yield on CWG was 4,110 kg/ha (3,153) and on RWR was 4,381 (3,675) kg/ha.

Oat varieties compared as pasture. Duplicate quarter-acre pastures were sown with four oat varieties and grazed by growing lambs. Average daily gain (g), lamb days/ha, DM production (kg/ha), DM consumption (kg/ha), and lamb gain/ha (kg) by variety were: Fraser, 172, 3,192, 5,195, 3,236, 556;

Harmon, 186, 3,123, 6,025, 3,592, 586; Kelsey, 145, 2,758, 5,055, 2,873, 400; OA-121-3, 159, 3,049, 5,481, 3,294, 482. Waste of pasture DM ranged from 38% to 43%.

Utilization of Harvested Forages

Processing hay for wintering calves. Sweetclover (11.3% CP), marsh (9.5% CP), and timothy-alfalfa (13.5% CP) hays were self-fed in the long, chopped, ground (5.08-cm screen), and finely ground (1.27-cm screen) forms to wintering Charolais × Angus steer calves. The different kinds of hays were fed consecutively in 7-week periods. The labor, time, and fuel required to process the hays were recorded. Average daily gain and DM intakes of steers fed sweetclover in the four forms were 0.41, 0.59, 0.69, 0.81 and 5.1, 6.1, 7.0, and 7.7 kg. The corresponding figures for marsh hay were 0.32, 0.44, 0.47, 0.56 and 5.0, 6.1, 6.4, and 6.8 kg; and for timothy-alfalfa 0.85, 1.07, 1.03, 1.12 and 9.6, 9.7, 10.1, and 10.1 kg. With one exception, the value of the liveweight gain, less feed and processing costs, increased as particle size of the forage was reduced. Feeding the three forages in the finely ground rather than the long form increased the net value of the gains by 124%, 70%, and 50%, respectively.

Forage quality, fineness of grind, and initial level in wheat-based rations. Good-quality (bromegrass-alfalfa) and poor-quality (marsh hay and wheat straw) roughages were ground through either a 1.27-cm or 2.54-cm hammermill screen and incorporated into starting rations for beef cattle at levels of 40%, 60%, or 80% (by weight). Dry rolled wheat, a mineral vitamin A supplement, and an antibiotic made up the remainder of each ration. The wheat content of all rations was increased to 90% during the first 8 weeks of the feeding period. Each ration was self-fed to six steers, whose average initial weights were 345 kg.

Average daily gain (kg), daily DM consumption (kg), feed efficiency, and dressing percentage for 40% roughage were 1.43, 10.1, 7.0, 57.0; 60% roughage, 1.29, 10.0, 7.8, 56.7; 80% roughage, 1.32, 10.6, 8.1, 57.2; good-quality roughage, 1.38, 10.3, 7.5, 57.5; poor-quality roughage, 1.31, 10.2, 7.8, 56.5; fine grind, 1.36, 10.3, 7.6, 56.9; coarse grind, 1.33, 10.1, 7.7, 57.0.

High-roughage starter rations for feedlot

steers. The Melfort method (M), which starts steers on a 70% ground-hay ration and changes to a 10% roughage ration over a 6-week period, was compared with the Lethbridge method (L), which puts steers on a high-energy ration over a 9-day period. A 90% wheat (W) and a 90% barley (B) finishing ration were compared under each method. After 104 days of testing, half the steers (Charolais × Angus) on each treatment were marketed.

Each LB steer marketed 134 kg of roughage, gained 1.54 kg/day, consumed 11.0 kg of feed daily, dressed out at 58.1%, and returned \$16.91 over feeder, feed, and feed processing costs. The comparable figures for each LW steer were 132, 1.52, 10.9, 58.1%, and \$13.42; for each MB steer 291, 1.52, 12.0, 58.5%, and \$17.32; and for each MW steer 293, 1.64, 12.1, 57.7%, and \$20.52. One liver was condemned (LB treatment) and some minor abnormalities of the rumen lining noted. All except one steer were graded Choice or Good.

The remaining 16 steers were fed for another 49 days, half of them on a high-energy ration and the rest on a low-energy ration. At slaughter, livers from two steers were condemned. Both steers had previously been on the LW treatment and were continued on the high-energy ration.

Utilizing alfalfa hay in lamb-finishing rations. The level of ground, good-quality alfalfa hay (18% CP), supplementation with 5% tallow or 5% rapeseed oil, and feeding in the ground or pelleted forms were variables studied using self-fed, growing, finishing lambs.

When the level of alfalfa was increased from 10% to 30%, 50%, or 70%, the gain on ground rations was increased by 38%, 49%, and 48%, respectively, and on pelleted rations by 15%, 4%, and 19%, respectively. T.D.N./kg of liveweight gain averaged 3.84, 3.36, 3.47, and 3.27 kg at the 10%, 30%, 50%, and 70% levels of alfalfa, respectively. Contrary to previous findings, dressing percentages and carcass grades were improved as the roughage level increased to 70%.

Pelleting increased the rate of gain by 17% and improved feed efficiency by 9%, with the most beneficial effect occurring on the 90% alfalfa ration with no added fat and the least beneficial effect on the 70% alfalfa ration with added tallow. Pelleting improved carcass grades slightly.

Adding tallow had little effect on animal performance, but resulted in slightly higher dressing percentages and carcass grades. The use of rapeseed oil did not improve performance. Digestible organic matter (DOM) content of the rations, whether determined in vitro or in vivo, were of little value in predicting liveweight gains. However, in vitro (OM) determinations closely paralleled in vivo values, and the relationship between intake of DOM and animal gain was the same whether in vivo or in vitro values were used.

Dehydrated alfalfa silage. Individually fed 44-kg lambs were offered (a) pelleted dehydrated alfalfa, (b) pelleted, dehydrated alfalfa silage, or (c) a choice of (a) and (b). The alfalfa in both products was harvested from the same field on the same date. The average DM intakes were (a) 103.8, (b) 69.8, and (c) 104.0 g/kg W^{0.75}. Dry matter digestibility was similar, 60.9%, 60.9%, and 59.8%, respectively, but organic matter digestibility was higher for lambs fed dehydrated alfalfa silage (65.4%) than for either ration (a) (60.4%) or ration (c) (61.6%) because of the higher mineral content of the feces of lambs fed pelleted silage.

CROP PRODUCTION

Breeding and Evaluation

Oats. Work is progressing on the development of a superior variety of oats, capable of resisting lodging on heavily fertilized land. Advanced lines from a four-way cross including Rodney, Pendek, and Lodi ripened 2–3 days earlier than Pendek and equaled it in yield and straw strength. Kernel plumpness equaled that of Rodney, but the percentage of hull was generally below that of Rodney.

Special Crops

Corn. Several varieties of field corn, seeded May 15 at about 150,000 seeds/ha in rows spaced 60 cm apart and fertilized with a side-dressing of 45 kg N/ha and 12 kg P/ha mixed with the seed, were harvested on September 1 (dough stage, 40% DM). Yields of DM ranged from 16.6 metric tons/ha for Trojan to 22.4 metric tons/ha for Morden 88.

Soybeans. The variety Fiskeby, sown on

June 3 and matured on September 14, produced 1,323 kg/ha.

Buckwheat. Commercial buckwheat produced 2,189 kg/ha. Pollinating with leafcutter bees did not appear to improve the yield.

Canarygrass, *Phalaris canariensis* L. This crop matured in 103 days in 1970. The plants were over 92 cm high, and erect or nearly erect at harvest. Seed yields were 1,233–1,681 kg/ha.

Broad beans, *Vicia faba* L. This crop required 115 days to mature in 1970. The sturdy plants were 71–81 cm high, averaged 11 pods/stalk, and produced 3,363 kg/ha. The seed analyzed 26.4% crude protein and has potential as a supplement for livestock feeds.

Lentils. This crop resembles vetch and rarely grows higher than 38 cm. The seed ripens 3–5 days later than field peas. The yield is 807–1,681 kg/ha and the seed can be harvested by conventional equipment. The seed is used mainly for soups.

Crop Management

Soil N levels and crop response. The exchangeable ammonium-N plus nitrate-N, measured to a depth of 60 cm in 18 stubble fields during 1967, 1968, and 1969 in Black, Gray-Black, and Gray Wooded soils, was inversely related by regression analyses to the maximum yield increase of Conquest barley ($R^2 = 63.8\%$) obtained from the application of N fertilizer (when P was applied at a standard level of 20 kg/ha). Sodium bicarbonate extractable P was a significant variable in the multiple regression analyses, increasing the R^2 value to 74.6%. Nitrate-N alone also was significantly related to yield increase from N fertilizer ($R^2 = 63.0\%$). Including NaHCO_3 extractable P in the analyses did not improve the relationship ($R^2 = 63.6\%$).

Exchangeable ammonium-N values ranged from 3.7 to 24.1 $\mu\text{g N}/4\text{ g}$ of soil. Nitrate-N values were 4.9 to 75.2 $\mu\text{g N}/4\text{ g}$ of soil. Although there were significant amounts of exchangeable ammonium-N in the soils, the value of exchangeable ammonium as an availability index for soil N is questionable.

The mean protein percentage of the grain from the plots at each location was significantly associated with N soil tests. Increased

yield from N fertilization resulted in a decrease in percentage P of the grain.

Influence of crust strength of Gray Wooded soils on emergence of rape and barley. Twelve Gray Wooded soils from northern Saskatchewan were selected and tested in the greenhouse to determine if crust strength could be related to plant emergence on different soil types varying in texture and organic matter content. Six days after seeding, emergence of Target rape, *Brassica napus* L., grown in rows was highly related to independent modulus of rupture measurements of soil crust strength. Similarly, penetrometer readings of unconfined compressive soil strength were significantly related to the number of rape seedlings emerging. Seven days after seeding Conquest barley, *Hordeum vulgare* L., in rows, emergence was very highly related to modulus of rupture measurements of crust strength and to penetrometer readings.

Burning and fall tillage of stubble. An 8-year study on the effect of fall tillage and burning of stubble, compared with no fall tillage or burning, revealed that none of the treatments that were tested significantly increased yield, weight/bu, or protein content of the following crop of spring wheat. Plowing and burning plus cultivating significantly reduced crop yields. Several tillage machines, moldboard plow, discer, wide level-disc harrow, heavy-duty cultivator equipped with sweep shovels alone, and heavy-duty cultivator equipped with spike shovels and combined with a packer, were compared. The burning treatments were carried out on fields with a high level of wheat stubble (1,217–5,232 kg/ha, averaging 2,691 kg/ha) each year. Although fall tillage reduced surface trash and thus facilitated the preparation of the seedbed the following spring, some treatments, such as plowing, produced soil clods that broke down over the winter and depleted the trash cover, predisposing the soil to erosion. When weed control was a problem, fall tillage with the discer or cultivator was effective, reducing surface trash by 25–30% and providing satisfactory trash and clod characteristics for seedbed preparation and erosion control. Fall burning in conjunction with cultivating resulted in the lowest yields and made the soil more susceptible to erosion. Unless fall tillage is required for weed control or trash reduction, there appears to be no advantage in working the field until spring.

Barnyard manure. On a Gray Wooded soil, Garrick loam, at Snowden, 34 metric tons of manure/ha applied once in a 3-year rotation increased the yield of wheat on summerfallow from 1,747 to 2,899 kg/ha over 11 years. The manure also increased the yield of the second crop of oats from 1,752 to 2,475 kg/ha. At Star City, a similar rotation on another Gray Wooded soil, Waitville loam, increased the yield of wheat and oats by 403 and 228 kg/ha over 8 years.

On a Dark Gray soil at Parkside, manure at 34 metric tons/ha applied every 5 years over a 30-year period increased the average yield of wheat in the first and second crops by about 470 kg/ha and increased the yield of each of two hay crops in the same rotation by about 1,120 kg/ha. This treatment also improved the chemical and physical properties of the soil as indicated by soil analysis. The most striking difference occurred in the P content of the surface soil, which was 4.6 and 13.7 ppm for the check and manure treatments averaged over the past 3 years. Other tests revealed that the manure also significantly increased the water-stable aggregate, the organic matter content, and the water-holding capacity of the surface soil.

Dates of seeding rapeseed. Rapeseed varieties were sown at weekly intervals from May 8 to June 19 over the last 4 years to determine the effect of seeding date on yield. On summerfallow, Target yielded best when sown during the last 2 weeks of May. Echo and S-62-64 (intermediate in maturity between Target and Echo) yielded best when sown during the last 2 weeks in May or the first week in June. Fertilizing with 11-48-0 at 45 kg/ha had no effect on the yield of Target, but increased the yield of Echo by 8%. Highest yields were obtained from plots sown on May 29. Yields of Target, S-62-64, and Echo averaged 1,900, 1,800, and 1,600 kg/ha, respectively.

When grown on stubble without fertilizer, Target, Echo, and S-62-64 yielded 1,200, 1,150, and 1,225 kg/ha respectively. When fertilized with 11-48-0 at 45 kg/ha and 22.5-0-0 at 140 kg/ha, only Target responded, with a 200 kg/ha increase in yield. In all cases, best yields were obtained from plots sown between May 22 and June 5.

Legume seed production. Alfalfa leafcutter bees, *Megachile rotundata* (Fabricius), work only in bright sunshine with temperatures

above 20.5 C. In 1970, such conditions occurred for a total of 277 hr during the alfalfa-pollinating period (July 1 to August 25) compared with a 5-year average of 238 hr. At Melfort, female bees produced an average of 11.5 cocoons (compared with the 5-year average of 10.0 cocoons); in an alfalfa field 48 km northeast of Nipawin, at the northern limit of agriculture, the average was 6.2 cocoons.

ANIMAL MANAGEMENT

Calves purchased in fall. Charolais × Angus calves, averaging 180 kg on arrival from Fort McLeod, Alta., were divided into two groups and fed good-quality grass hay, free choice, plus 0.9 kg dry-rolled barley containing 3% molasses, with and without 350 mg chlortetracycline and 350 mg sulfamethazine (Aureo S700) per head daily. Average daily gain, feed intake, and feed-to-gain ratio, with and without the medication, respectively, during the 30-day test were 1.10 and 0.93 kg; 5.46 and 5.50 kg; and 5.04:1 and 5.90:1. Despite the long trip and their arrival during a snowstorm, only one of the 86 calves in the test required treatment for shipping fever.

SWINE

Supplementary Cu in sow rations. Gilts, which had shown a 9% improvement in average daily gain (ADG) and efficiency of feed conversion (FCE) from the addition of 125 ppm Cu to rations fed ad lib. from 23 to 91 kg liveweight, were fed breeding rations with 0 or 125 ppm Cu for up to four reproductive cycles. For the control and Cu-added groups, respectively, the lengths of the gestation period were 116.2 and 115.5 days; the average numbers of pigs weaned at 4 weeks were 9.4 and 10.1; the litter weights at farrowing were 13.5 and 13.9 kg and at weaning were 69.0 and 68.6 kg.

The response of litters from both sow groups to the addition of 125 ppm Cu to rations was investigated. From weaning to 23 kg average weight, Cu markedly improved the performance of pigs from the control sows with respect to ADG (0.36 vs. 0.40 kg) and FCE (2.38 vs. 2.19), but had limited effect upon pigs from sows fed added Cu,

ADG (0.36 vs. 0.36 kg) and FCE (2.28 vs. 2.24). For the growing-finishing period combined (23-91 kg), the addition of Cu resulted in an overall improvement of 9% in ADG (0.67 vs. 0.73) and 6% in FCE (3.98 vs. 3.73).

As before, the response to Cu was greater for pigs from the control sows. Carcass quality, as measured by R.O.P. scores, was marginally increased (70.2 vs. 71.0) by Cu in both litter groups.

PUBLICATIONS

Research

- Beacom, S. E. 1970. Symposium on pasture methods for maximum production in beef cattle: finishing steers on pasture in northeastern Saskatchewan. *J. Anim. Sci.* 30:148-152.
- Keys, C. H., Anderson, C. H., Bowren, K. E., and Dew, D. A. 1970. Effect of seed bed preparation and soil aggregation, surface moisture and crop production. *Can. J. Soil Sci.* 50:347-352.
- Knowles, R. P., Cooke, D. A., and Buglass, E. 1970. Breeding for seed yield and seed quality in smooth brome grass, *Bromus inermis* Leys. *Crop Sci.* 10:539-542.
- Nuttall, W. F. 1970. Effect of organic amendments on some physical properties of luvisolic soils in relation to emergence of rapeseed in a growth chamber. *Can. J. Soil Sci.* 50:397-402.
- Robertson, J. A., and Beacom, S. E. 1970. Effect of quality and level of ground roughage in rations for finishing steers. *Can. J. Anim. Sci.* 50:677-684.
- Troelsen, J. E., and Beacom, S. E. 1970. The feeding value of forage as fed to steers and as estimated by *in vitro* digestion. *Can. J. Anim. Sci.* 50:547-555.
- Hanna, M. R., Cooke, D. A., and Goplen, B. P. 1970. Melrose sainfoin. *Can. J. Plant Sci.* 50:750-751.
- Hanna, M. R., Cooke, D. A., Goplen, B. P., and Smoliak, S. 1970. Sainfoin. Processed Publ., Res. Sta., Lethbridge, Alta.
- Bowren, K. E. 1970. The value of barnyard manure. *Canadex* 100.538.
- Beacom, S. E., and Bowren, K. E. 1970. The economics of grain vs pasture production at Melfort. *Canadex* 110.820.
- Cooke, D. A. 1970. Alfalfa leaf-cutter bee (*M. rotundata*) in northeastern Saskatchewan. *Canadex* 121.615.
- Robertson, J. A., and Cooke, D. A. 1970. Crested wheatgrass vs Russian wild ryegrass for pasture. *Canadex* 127.53.
- Beacom, S. E., and Bowren, K. E. 1970. Economics of producing grass and feeding grain to steers on pasture. *Canadex* 130.860.
- Nuttall, W. F. 1970. Yield, protein and oil content of rape grown on Whitewood loam (Black-Gray soil). *Canadex* 149.25.
- Robertson, J. A. 1970. Marsh hay for finishing steers. *Canadex* 420.52.
- Robertson, J. A. 1970. Forage quality, fineness of grind and initial level in wheat-based rations. *Canadex* 420.52.
- Robertson, J. A. 1970. Processing roughage for wintering calves. *Canadex* 420.52.
- Beacom, S. E. 1970. Marketing wheat through steers. *Canadex* 420.52.
- Robertson, J. A., and Cooke, D. A. 1970. Four systems of managing beef steers on pasture. *Canadex* 420.56.
- Beacom, S. E. 1970. Crested wheatgrass hay in lamb finishing rations. *Canadex* 430.52.
- Castell, A. G. 1970. Backfat probing. *Canadex* 440.41.
- Castell, A. G. 1970. Protein levels and sources for market pigs. *Canadex* 440.52.

Research Station Regina, Saskatchewan

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Departure

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INTRODUCTION

This is a report of the work carried on at the Research Station, Regina, in 1970. The Station is the main center for research on the control of weeds in the Prairie Provinces. Work continues on the development of new methods of weed control. However, the effect of herbicides on the environment is presently of major concern. Considerable attention is being paid to the fate of the herbicides in plants and in the soil, and to the materials that drift out of the target area during and immediately after spraying.

Formal arrangements have been made for training graduate students in weed science. In 1970 two postgraduate students from the University of Saskatchewan, Regina Campus, started their thesis research at the Station under the direction of our Staff.

Work on cereal breeding has been discontinued at Regina, but evaluation of cereal varieties will still be done. Production and distribution of seed of new varieties of cereal, oilseed, and forage crops developed by the Research Branch is still a major function of the Station.

Construction of a new office-lab building began in 1970. When this building is completed in spring of 1971, all the staff will be moved into the Station for the first time since 1964.

J. R. Hay
Director

WEED SCIENCE

Crop tolerance to herbicides. Postemergence applications of alachlor, and preemergence applications of chloramben at rates up to 4.5 kg/ha (4 lb/acre), did not seriously injure wheat in the first year of testing at Regina. Wheat and sunflowers were tolerant of preemergence applications of metoxuron at rates up to 4.5 kg/ha. When trifluralin was incorporated into the soil before seeding, flax tolerated 0.56 kg/ha (8 oz/acre), but was injured by 1.1 kg/ha (16 oz/acre).

Dowco 221 (Dow Chemical Co.) was tested on flax and sunflowers. Flax tolerated 8.9 kg/ha (8 lb/acre) incorporated before seeding and 6.7 kg/ha (6 lb/acre) incorporated preemergence. Sunflowers tolerated 8.9 kg/ha (8 lb/acre) incorporated either before seeding or preemergence.

Chemical summerfallow. In a summerfallow experiment, applying herbicides to the first growth of weeds in the spring and cultivating the second growth was compared with cultivating the first growth of weeds and spraying the second. The herbicides used were amitrole-T, ametryne, and a mixture of ametryne and an ester of 2,4-D. The second growth was delayed 10 to 14 days when the first growth was controlled by spraying. This indicates the herbicide residue was effective for a short time after spraying, or that germination was slower when the soil was not disturbed. In September, plots that were

sprayed for the first weed growth and cultivated for the second were cleaner than those that were cultivated first and then sprayed.

Green foxtail. The emergence of green foxtail was studied at depths of 0 to 12.7 cm in a heavy clay, a loam, and a sandy loam soil and at three levels of soil moisture, 0%, 10%, and 20% above field capacity. At 10 C to 24 C, planting at depths below 5 cm in all three soils reduced emergence. Depth of planting had a direct effect on emergence but soil texture did not, even though green foxtail is much more common on coarse-textured soils than on fine-textured soils.

After 4 years burial in soil, 7% to 26% of the green foxtail seeds were viable and 1% to 3% of these were dormant. Viability increased with depth; 23% to 26% of the seeds were viable at 7.5 and 10 cm. Twenty-two percent of the seeds were viable at 10 cm and 56% at 15 cm, after 3 years burial. At 15 cm, 16% of the seeds were dormant. The high incidence of dormancy at lower depths was attributed to the development of secondary dormancy.

Trifluralin, chloramben, and alachlor, which are already registered in Canada for control of other weeds, gave good control of green foxtail and increased yields of wheat. Trifluralin at 1.12 to 1.68 kg/ha (1.0 to 1.5

lb/acre) and chloramben at 2.24 to 4.48 kg/ha (2 to 4 lb/acre) were applied and shallowly incorporated with harrows immediately after seeding the crop. Alachlor at 1.68 to 2.80 kg/ha (1.5 to 2.5 lb/acre) was applied when both the wheat and green foxtail were at the two-leaf stage. More testing is required to determine the reliability of these treatments under various growing conditions from year to year.

Persian darnel. Emergence of Persian darnel from depths of 0 to 12.7 cm in heavy clay, loam, and sandy loam soil was not affected by soil type. Emergence decreased markedly below 5 cm in loam and sandy loam, and below 7.6 cm in Regina heavy clay. Persian darnel did not emerge as readily as green foxtail from depths of 10 cm or more, even though its seed is relatively large. The seeds of Persian darnel did not persist as long in the soil as those of green foxtail. Very few viable seeds were recovered after 3 years burial in soil and most of these were dormant.

In 2 years of testing, diallate, triallate, and trifluralin, incorporated with a disc before seeding, controlled Persian darnel in flax. Rates required were 1.12 to 2.24 kg/ha (1 to 2 lb/acre) of diallate, 1.68 to 2.80 kg/ha (1.5 to 2.5 lb/acre) of triallate, and 1.12 to 1.68 kg/ha (1.0 to 1.5 lb/acre) of trifluralin. The weed infestation was light in 1970, in contrast to a heavy infestation in 1969. At least another year is required to establish the minimum effective rates. Trifluralin thinned the flax in some tests, so more precise data on crop tolerance are required.

Persistence of herbicides in soil. Small field plots were treated with triallate, at 2.8 kg/ha (2.5 lb/acre) at five sites in Saskatchewan. After a 5-month growing season the residues at the 0 to 5-cm and 5 to 10-cm levels were analyzed gas chromatographically. At all locations 16% to 27% of the applied herbicide was in the top 5 cm, whereas negligible residues were detected at the 5 to 10-cm level.

Work with ^{14}C -triallate indicated that over 90% of the radioactivity extracted from warm, moist Regina heavy clay after 3 months was unmetabolized triallate.

The compound formed by treatment of triallate with methanolic potassium hydroxide has been tentatively identified, on the

basis of spectroscopic data, as *cis*-*S*-2,3,3-trichloroprop-1-ene,*N,N*-diisopropylthiolcarbamate. This compound showed no herbicidal activity against wild oat seedlings germinated in Regina heavy clay treated at 1, 2, and 4 ppm.

The degradation of bromoxynil in Regina heavy clay was studied under laboratory conditions. At various moisture levels, the degradation of bromoxynil was rapid and over 50% was degraded in 2 weeks. Using paper and thin-layer chromatographic techniques, two metabolites were identified.

A thin-layer chromatographic method has been developed for the detection of herbicides commonly used in Saskatchewan, in a variety of soils and waters.

Tolerance of canary grass (*Phalaris canariensis* L.). Canary grass seedlings were severely damaged when the seeds were sown in soil treated with diallate at 1.37 kg/ha (24 oz/acre). No damage was evident from soil treatments of triallate at 1.37 kg/ha (24 oz/acre), nor from postemergence applications of barban at 0.34 kg/ha (5 oz/acre). Under greenhouse conditions all these treatments gave satisfactory control of wild oats. Green foxtail control was also obtained with diallate and triallate at 1.37 kg/ha (24 oz/acre).

Control of wild oats. WL 17731 (Shell Oil Co.) as a 40% wettable powder was tested in growth chambers for the control of wild oats in spring wheat and barley. It suppressed growth of wild oats. The wettable powder formulation was also compared with two emulsifiable concentrates, FX-2000 and FX-2062, which contained 20% and 40% material, respectively. The chemicals were applied when the wild oats were at the two- and four-leaf stages.

The FX-2000 formulation had the greatest effect on the wild oats at both stages and did not damage the wheat. FX-2062 gave similar control of wild oats when applied at the four-leaf stage and caused the least damage to barley. Green foxtail seedlings were also included in the test, but they were unaffected by the treatments.

Persistence of picloram. Picloram, in aqueous solution, was readily degraded by ultraviolet light at 254 and 360 nm, and also by sunlight. The rate of breakdown at 254 nm was not affected by temperature but was dependent on light intensity and on the initial concentration of the solution. Over a 60-day

period, there was no measurable loss of picloram from moist Regina heavy clay soil by volatility.

Adsorption of herbicides. The Kd values (μg adsorbed/g of soil when the equilibrium concentration is $1\ \mu\text{g}/\text{ml}$) of diuron for several prairie soils ranged from 2.8 for Asquith sandy loam to 76.1 for Lacombe loam. In all but two soils, the degree of adsorption of diuron was correlated with the soil organic matter content, the K value (μg adsorbed/g of organic matter) being 158 ± 10 . The adsorption of diuron in Lacombe and Melfort loams greatly exceeded the calculated values based on organic matter content only.

The Kd values of picloram for several adsorbents were: activated charcoal, 232; anion exchange resin, 79; peat moss, 3.7; cellulose triacetate, 0.9. There was no adsorption of picloram on montmorillonite and kaolinite clays, cellulose powder, cation exchange resin, or wheat straw. The absence of adsorption on clay minerals and cellulose powder suggests that picloram is not attracted to hydrophilic surfaces.

Presence of 2,4-D esters in air. A simplified apparatus was developed to detect 2,4-D in the atmosphere. Air was drawn through a silica gel trap connected to an air pump. The 2,4-D was washed from the silica gel with methanol. Butyl esters of 2,4-D were detected on only 5 days during the entire spraying season, at concentrations ranging from 0.07 to $0.26\ \mu\text{g}/\text{m}^3$. Isooctyl ester was not detected during the 1970 season. The spotty occurrence and the low levels of 2,4-D esters in the 1970 season may have been caused by the extended spraying season with intermittent wet weather, and the reduced use of the herbicides.

2,4-D drift. Six trials were carried out at the Defense Research Establishment, Suffield, using ^{14}C -labeled 2,4-D. Outside the target area, 3% to 4% of both the butyl ester and amine formulations of 2,4-D were recovered in 0 to 3-min samples (droplet drift). In 3 to 30-min samples, 20% to 24% of the applied ester was recovered. The latter was assumed to represent vapor drift because droplets would not linger in the target area for that length of time. No additional 2,4-D amine was recovered during the 3 to 30-min period.

Leafy spurge. Under experimental conditions, competition within the plant between

buds on the root and the apical and lateral buds on the shoot for a limited supply of N was a major factor in determining the degree of inhibition of root buds. In peas, correlative inhibition has been shown to be controlled by N supply, carbohydrate level, and the degree of water stress. This work is being extended to elucidate the role of water stress in inhibition of buds of leafy spurge.

SEED SECTION

Seed distribution. In Manitoba, Saskatchewan, and Alberta, 138 Select seed growers received 3,304 bu of Select seed of Bonanza, a new barley developed at Brandon. In addition, 300 bu of Foundation seed was used to produce grain for large-scale malting tests in the fall of 1970. This provision for early, full-scale malting trials is expected to shorten the time required for the maltsters to decide on the acceptance of Bonanza.

With Bonanza, the seed trade was invited to participate in the initial distribution of a new variety for the first time. The Seed Multiplication Division of the Canadian Seed Trade Association was allotted 1,860 bu of Foundation seed of Bonanza to distribute to seed growers. Eleven members of the seed trade received an allotment of seed from the Seed Multiplication Division. Their distribution followed the basic criteria set down by the Research Branch.

Trapper peas, developed at Morden, was distributed to seed growers in Alberta, Saskatchewan, Manitoba, and Nova Scotia. Seven growers received 210 bu of Select seed, and 200 bu of Foundation seed were allotted to another seven growers.

Morsoy soybeans was also developed at Morden. In Manitoba and Ontario, 114 bu of Select seed went to 8 growers, and 10 growers received 190 bu of Foundation seed.

Variety verification. In 1970, 2,871 samples of seed, collected by the Plant Products Division from seed growers and the seed trade, were tested for purity under field conditions. Many samples contained some impurities, but only 18 exceeded the tolerance for their respective pedigree status.

Winter increase. The winter increase of plant breeding material at Brawley, Calif., for Canadian plant breeders continued in 1970. Material from 16 plant breeders was

seeded on 3 acres in November 1969 and harvested in April 1970. In November 1970, material from 18 plant breeders was seeded on 6.88 acres.

PUBLICATIONS

Research

- Banting, J. D. 1970. Effect of diallate and triallate on wild oat and wheat cells. *Weed Sci.* 18:80-84.
- Grover, R. 1970. Influence of soil moisture content on the bioactivity of picloram. *Weed Sci.* 18:110-111.
- Grover, R., and Hance, R. J. 1970. Effect of ratio of soil to water on adsorption of linuron and atrazine. *Soil Sci.* 109:136-138.
- McIntyre, G. I. 1970. Studies on bud development in the rhizomes of *Agropyron repens*. 1. The influence of temperature, light intensity and bud position on the pattern of development. *Can. J. Bot.* 48:1903-1909.
- Smith, A. E. 1970. Degradation, adsorption and volatility of diallate and triallate in Prairie soils. *Weed Res.* 10:331-339.
- Smith, A. E., and Fitzpatrick, A. 1970. The loss of five thiocarbamate herbicides in non-sterile soils and their stability in acidic and basic media. *J. Agr. Food Chem.* 18:720-722.

Research Station Saskatoon, Saskatchewan

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G. R. F. DAVIS, B.Sc., M.Sc., Ph.D.	Insect nutrition
J. F. DOANE, ¹ B.S.A., M.Sc., Ph.D.	Wireworm ecology
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L. S. CROSSON, B.S.A., M.Sc.	Pedological characterization
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R. J. LEDINGHAM, B.Sc., M.Sc.	Cereal root diseases
G. A. PETRIE, B.A., M.A., Ph.D.	Oilseed diseases
J. D. SMITH, B.Sc., M.Sc.	Forage grass diseases

Experimental Farm, Scott, Sask.

C. H. KEYS, B.S.A.	Superintendent; Weeds and crop management
H. UKRAINETZ, B.S.A.	Soil fertility

Departures

R. L. RANDELL, B.Sc., M.Sc., Ph.D. Resigned September 30, 1970	Grasshopper demography
W. A. RUSSELL, B.S.A. Transferred to Morden, November 16, 1970	Potato isolation

VISITING SCIENTISTS

National Research Council postdoctorate fellows

I. J. ANAND, B.Sc., M.Sc., Ph.D., 1969-71	Oilseed crops
G. S. DOGRA, B.Sc., M.Sc., Ph.D., 1968-71	Insect physiology
J. C. KARAPALLY, B.Sc., M.Sc., Ph.D., 1969-71	Pesticide chemistry

Colombo Plan graduate student

M. A. SALAM, M.Sc., 1969-71	Oilseed crops
<i>University of Saskatchewan graduate student</i>	

J. MADILL, B.Sc., M.Sc., 1970-71	Oilseed crops
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¹On transfer of work at Wädenswil, Switzerland.

INTRODUCTION

The Research Station at Saskatoon and the Experimental Farm at Scott conduct a broad research program on crop and animal production. Included are the breeding of rapeseed, mustard, wheat, barley, alfalfa, sweetclover, brome grass, reed canarygrass, slender wheatgrass, and crested wheatgrass; physiology of drought tolerance in cereals; ecology and control of some of the most important plant diseases and weeds, insect pests affecting plants, man, and animals; the histophysiology and nutrition of insects; the characterization and fertility of soils; and pesticide residues in both crops and soils. The accomplishments during 1970, for selected subjects, are summarized in this report.

J. E. R. Greenshields
Director

CROPS

Oilseeds

Rapeseed breeding. Varieties of rapeseed that contain low levels of erucic acid in their seed oil are expected to become the dominant varieties in Canada in 1972. This depends largely on the successful multiplication, by the Research Branch, of the new *Brassica campestris* L. variety Span on approximately 800 ha (2,000 acres) in California for spring seeding in 1971. Span and the *B. napus* L. variety Zephyr, which was increased in Canada in 1970, will be licensed early in 1971 to meet the demand for seed oil low in erucic acid. Both varieties were developed at the Research Station at Saskatoon. Zephyr is an early-maturing, higher-yielding replacement for Oro, the only low erucic acid variety in commercial production. Zephyr equals the standard variety Target in yield and maturity, and is expected to replace Target where this variety is now grown. Span is the first Polish or turnip rape variety that produces seed whose oil is low in erucic acid. Span originated from crossing a single plant of Polish, found in 1964, with the recurrent parent varieties Arlo and Echo. In the final stage of formation the two recurrent lines were combined to form the variety. In Western Canada Span yielded on the average 92.6% as much as Echo, 95% as much as Polar, and the same amount as Arlo. All low erucic acid varieties are slightly lower in oil content than the standard varieties, and intensive selection for higher oil content is being applied.

The yellow-seeded characteristic in *B. campestris* is being combined with the low erucic acid feature to serve as a varietal

marker and to increase the oil content. A study of seed coat morphology of yellow and brown seed of *B. campestris* has shown that brown seed coats are approximately 25% thicker than yellow seed coats from the same strain or than yellow seed coats of seeds in the same pod. Work has been started on the production of a synthetic *B. napus* strain with yellow seed coats.

The crossing program with Bronowski, a *B. napus* glucosinolate-free variety, produced several lines combining the desirable agronomic characteristics and low glucosinolate content. One of these lines, tested at four locations in Western Canada in 1970, was satisfactory in seed yield and equal or better than the standard variety Target in number of days to mature and content of oil and protein. Unfortunately this strain contains 30% erucic acid. Commercial production of low-glucosinolate *B. napus* varieties will be delayed until the low erucic character has been incorporated.

Preliminary studies on the proteins of rapeseed meal, in cooperation with Dr. A. Finlayson, Prairie Regional Laboratory of the National Research Council, Saskatoon, suggested that through selection and hybridization it is possible to alter the relative proportions of the various proteins and to influence the amino acid composition within some of these protein groups.

Genetic markers. A new genetic character identified in *B. campestris* has eliminated chlorophyll in the developing seed. The use of this character may be important in the program to reduce or eliminate the problem of green oil from immature or frozen rapeseed.

Slender Wheatgrass

Breeding. A selection of native and slender wheatgrass, *Agropyron trachycaulum* (Link) Malte, was licensed as the variety Revenue. This strain was chosen from over 750 selections for its good hay and seed yield, superior leafiness, and tolerance of saline soils. Foundation seed was released in 1970, and Certified seed should be available in the fall of 1971. Because this grass is easy to establish and the sod is easy to break, this variety should be useful for short-term retirement of cropland.

Legumes

Sweetclover breeding. A regionally adapted strain of yellow-blossomed sweetclover, which traces back to the Madrid variety, was licensed as Yukon. Yukon has good seedling vigor and winterhardiness, and above-average forage and seed yields. Approximately 2,268 kg (5,000 lb) of Foundation seed was produced under the Canadian Forage Seed Project in 1970. This will result in the production of a considerable amount of Certified seed by 1972.

Another sweetclover strain, S-7115, of the white-blossomed type was licensed as the variety Polara. This variety is distinctive in having a low level of coumarin, which makes it a safe feed as far as the hemorrhagic sweetclover disease is concerned. Over 1,360 kg (3,000 lb) of Foundation seed was distributed in 1970, and a substantial amount of Certified seed should be harvested in 1971.

Alfalfa breeding. The development of a nonbloating alfalfa was a major objective in 1970. Bloat from feeding alfalfa has been a serious factor in deterring farmers from using this valuable crop. Personnel were temporarily assigned to the Research Station at Summerland, B.C., where analytical techniques for factors causing bloat have been developed. Extensive populations and collections of alfalfa are being tested. This project is expected to be of long-term duration.

Irrigated Crops

Crop sequence. Dry matter hay production (based on two cuts per year at both Outlook and Saskatoon during 1967 to 1970) averaged 8,970 kg/ha (8,000 lb/acre) for both brome-grass-alfalfa and crested wheatgrass-alfalfa, 7,850 kg/ha (7,000 lb/acre) for reed

canarygrass-alfalfa, intermediate wheatgrass-alfalfa, intermediate wheatgrass, brome-grass, and alfalfa, and 6,730 kg/ha (6,000 lb/acre) for reed canarygrass and crested wheatgrass. The use of alfalfa with each of the four grasses not only increased hay yields by 560 to 2,240 kg/ha (500 to 2,000 lb/acre), but also increased soil NO₃-N levels by substantial amounts (56 kg/ha; 50 lb/acre) for use by the succeeding crop. These yields under irrigation are estimated to be two to four times higher than those expected on dry land.

The yields of five succeeding crops, flax, corn, potatoes, wheat, and barley, were significantly increased when fertilizer was applied after plowdown of the preceding forage crop. Yields of flax and potatoes were not affected by the type of preceding forage crop. Preliminary results from 2 years data indicated that wheat, barley, and flax produce the most grain after fertilized forage sod of intermediate wheatgrass-alfalfa, reed canarygrass-alfalfa, or alfalfa, and the least after brome-grass. Maximum yields of sweet corn followed fertilized sod of intermediate wheatgrass-alfalfa and crested wheatgrass-alfalfa, and minimum yields followed reed canarygrass and crested wheatgrass.

ENTOMOLOGY

Grasshoppers

Radiation sterilization. The radiation sterilization of adult *Melanoplus sanguinipes* (Fabr.), using X-ray dosages of 2,000 down to about 60 rad, indicated that this species is extremely radiosensitive. Reproductive cells were destroyed at dosages as low as 250 rad, whereas 50,000 rad were needed to sterilize codling moths. The lack of any evidence of the inducement of dominant lethals and the absence of transmitted lethality to the F₁ generation would seem to rule out any application of the sterile-male technique as a method for biological control of grasshoppers.

Effect of juvenile hormone analogues on egg hatchability. Application of juvenile hormone (JH) analogues to the eggs of *M. sanguinipes* during the first 3 days of embryonic development prevented most of the eggs from hatching; the nymphs from the few that did hatch were often grossly deformed

and all died before they reached the adult stage. Results were similar whether applications were made directly to the egg, to the surface of the sand or filter paper on which the eggs were resting, or to the surface of the soil in which the eggs were laid. Some preliminary results have shown that treating the adult females with these JH analogues can result in the eggs laid by their second- or third-generation progeny being severely affected; presumably the hormone analogue is transferred into the developing oocytes by the female and can affect eggs produced by her offspring and by their offspring.

Effect of temperature on egg hatchability. Because field experiments have consistently shown that many of the eggs of *M. sanguinipes* laid late in the season do not hatch, low temperatures were suspected to be the causative agent. Temperature studies conducted in the laboratory showed that freshly laid eggs were destroyed after exposure to -5 C for 40 min or longer, but hatched normally after exposure for 20 min or less. Eggs that were several hours old were more resistant to the cold and those several days old considerably more resistant.

Control. A week after treatment of 0.8-ha (2-acre) replicated plots of good mixed stands of alfalfa and grass moderately infested with *M. sanguinipes*, Accothion (American Cyanamid) at 280 g/ha (4 oz/acre) toxicant, Baygon (Chemagro Corporation) at 210 g/ha (3 oz/acre), Furadan (Niagara Chemicals) at 52.5 g/ha (0.75 oz/acre), Dursban (Dow Chemical Company) at 140 g/ha (2 oz/acre), and Phosvel (Velsicol Corporation) at 560 g/ha (8 oz/acre) gave about the same control (85% to 95%) as dimethoate at the currently recommended rate of 210 g/ha (3 oz/acre).

Wireworms

Chemical control with insecticide soil treatments. In four seasons of testing, broadcast and band treatments in the spring with emulsions and granules of Dyfonate (Stauffer Chemical Company of Canada Ltd.) at 5.6 kg/ha (5 lb/acre) of toxicant gave more than 90% damage-free tubers, except in one instance when the soil was unusually dry. By late fall of the year of application the soil from broadcast treatments was still toxic to larvae of *Ctenicera destructor* (Brown), the

most destructive species. No undesirable residues or other adverse effects occurred on the potatoes.

A heptachlor-free formulation of chlordane emulsion, broadcast at 11.2 kg/ha (10 lb/acre) of toxicant, gave good protection to potatoes against wireworm damage. Because chlordane is the only organochlorine insecticide still registered for this use, further trials will be carried out with the new formulation to determine efficacy, residues in root crops, and persistence in the soil.

Hazards to wildlife from insecticide seed treatments on cereals. A study to determine the hazards to wildlife of heptachlor and lindane seed treatments on cereals in Saskatchewan was begun in 1970, in cooperation with the Saskatchewan Department of Agriculture, the Saskatchewan Department of Natural Resources, and commercial firms that sell registered seed dressings in the province. The results from questionnaires to farmers indicate that seed treatments are used most in the southwestern quarter of the agricultural area, and least in the extreme eastern and northern areas; the amount of seed dressing sold in the whole province in either 1968 or 1969 would treat less than 27 million kg (1 million bu) of wheat seed. Feeding caged pheasants with treated wheat seed showed that the residues were highest in fat and progressively less in liver, brain, and breast muscle. Three months after the birds were fed treated seed, all tissues contained detectable residues of heptachlor epoxide but no detectable residues of lindane. Preliminary field trials indicated that during normal seeding operations some seed is left exposed on the soil surface, where it may be picked up by birds; the largest amounts were found where there was heavy straw or where double seeding had been carried out. Residues of insecticides in samples of birds from wild populations have not yet been determined.

Sweetclover Weevil

Damage potential. Laboratory and field experiments showed that, under temperature and moisture conditions favorable to the normal emergence and growth of seedlings, infestations of one adult sweetclover weevil per three seedlings caused an 18% reduction in stand and an 86% reduction in green plant weight 50 days after emergence of the seedlings. Under moderate drought conditions,

when seedling growth was retarded, infestations of one weevil per five seedlings caused a 45% reduction in stand and a 90% reduction in green plant weight. Under both growing conditions lighter infestations caused negligible thinning of stand but some loss of green weight. The effect of seedling damage on the productivity of the crop in its second or producing year is being investigated.

Black Flies

Control. Methoxychlor applied to the Saskatchewan River was ineffective against larvae of *Simulium arcticum* Mall. at 0.2 ppm for 15 min (unlike results in 1969), but at 0.4 ppm it virtually eliminated larvae through a 38.6-km (24-mile) section. Larvae of Ephemeroptera, Plecoptera, Trichoptera, and Chironomidae were less affected than were black-fly larvae.

Fish of several trophic levels were collected from the North and South branches of the Saskatchewan River after completion of a 20-year program to control black flies by using DDT. The muscle tissue of the fish contained only insignificant amounts (0.1 ppm or less) of DDT residues.

Insecticide Residues

Extraction. Studies with radioactive-labeled dieldrin and lindane showed that acetonitrile, the most commonly used solvent for the extraction of pesticide residues from plants, extracted only 68% of the dieldrin and 75% of the lindane from wheat plants. Residue data obtained by this procedure will indicate lower residue levels than actually exist.

Endrin residues in rapeseed. Application of endrin at up to 560 g/ha (8 oz/acre), twice the rate recommended for cutworm control, as a seedling foliage spray did not result in a detectable residue (less than 0.05 ppm) in the extracted rapeseed oil. Because more than 99% of the oil was extracted from the seed, presumably the meal was also residue-free.

Metabolism. Rabbits fed lindane-C¹⁴ by capsule for 26 weeks had excreted 54% of the radioactivity in the urine and 13% in the feces by the end of the feeding period. Fifteen compounds were isolated and identified from the ether-soluble fraction of the urinary metabolites. Work on the hydrophilic metabolites is continuing.

PLANT DISEASES AND PLANT PHYSIOLOGY

Common Root Rot of Cereals

Multiple infections. Subcrown internodes of wheat were readily infected with *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur at any stage of plant development. Prepossession of the tissue by one isolate did not restrict its subsequent invasion by another isolate or by *Fusarium culmorum* (W.G.Sm.) Sacc., or *F. acuminatum* Ell. & Ev. However, when the *Fusarium* species were primary invaders, later inoculations of the tissue with *C. sativus* were usually unsuccessful.

Losses. In 1970 the estimated loss of wheat in Saskatchewan due to common root rot was 11.5%, or 734 million kg (27 million bu). The estimate was derived from a comparison of grain yields of healthy with diseased plants in paired sq-yard samples obtained from 73 fields, and from disease ratings made in 137 other fields.

Resistance. Species of *Triticum* and lines of wheat and barley from various crosses differed markedly in disease reaction in the field. Those that exhibited a high level of resistance were selected for further study and possible use in breeding programs. Although seedlings responded differently to inoculation with *C. sativus* in laboratory tests, there appeared to be no consistent relationship between seedling and field plant reaction.

Soil microbiology. A bioassay method was developed to determine the influence of fungicides in soil on various microorganisms. Inhibition spectra varied with fungicides. Two fungicides incorporated in soil at dosages sublethal to *C. sativus* promoted growth of certain other fungi and reduced the level of common root rot.

Diseases of Grasses

Leaf and stem spots. *Phleospora idahoensis* Sprague causes a severe stem eyespot in creeping red fescue crops in the Peace River region. The perfect state of the fungus was found on diseased material in that region and on native fescues throughout Western Canada and northwestern United States. The widespread occurrence of the perfect state is considered significant in disease epidemiology. The cause of a leaf disease that was

severe in some fields of creeping red fescue in the Peace River region was identified as *Scolecotrichum graminis* Fckl. Some lines of smooth bromegrass, timothy, and bluegrass were selected for resistance to certain diseases.

Diseases of Alfalfa

In 1970, black stem was present in many alfalfa fields, but appeared to be serious only in some seed crops. A high percentage of 1969 seed samples were infested with the causal fungus. Yellow leaf blotch caused some serious defoliation, especially in the latter part of the season. At midseason no consistent relationships were apparent between disease severity, stem height, and leaflet-to-stem ratio.

Diseases of Oilseed Crops

Rapeseed. White rust (staghead) infections occurred in all field survey collections of *B. campestris*, but did not occur in any collections of *B. napus*. These findings are fully compatible with the results of seedling inoculation tests, which indicated that *B. napus* is completely resistant. Several fungi, especially *Fusarium*, *Rhizoctonia*, *Sclerotinia*, and *Plenodomus lingam* (Tode ex Fries) Hohn., appeared to be involved in a foot rot disease. The two pathogens that cause black spot showed some host preference; on seed, one occurred more commonly in *B. napus* than *B. campestris*, and the reverse was found with the other pathogen. In combination the pathogens were more prevalent on seed of *B. campestris* than of *B. napus*. Methods were developed for screening plants for resistance to white rust, black spot, and blackleg.

Drought Resistance in Wheat

Drought avoidance. Stomatal apertures, as indices of gas exchange, and the water status of varieties were measured. Consistent differences in the factors were recorded between the varieties when stress conditions prevailed. However, a definite relationship was not observed between the factors and productivity.

Pedology

Classification and mapping. Good progress was made in the soil survey and assessment of the agricultural capabilities of the soils in several map sheet areas. Reports were completed for the forest reserves in the Shellbrook map sheet area and nearly completed for the St. Walburg and the Saskatoon areas; field surveys and sampling of soils for analysis were completed or nearly completed for the Waterhen, Pasquia, Le Pas (Sask.), Hudson Bay, Swan Lake (Sask.), and Prince Albert areas, and the field survey was started for the Swift Current and the Green Lake areas.

Soil characterization. In continuing studies to develop an improved basis for the classification and mapping of Saskatchewan soils, it was established that few soils of northern Saskatchewan that exhibit strong podzol morphology meet the requirements established by the Canada Soil Survey Committee for f horizons. It was shown that more refinement in the definition of ca horizons, those with secondary carbonate enrichment, is necessary because many of the soils studied had horizons with pronounced accumulations of calcite, but which nevertheless were not ca horizons by definition. The nature and content of carbonate in the parent material of some Saskatchewan soils has a bearing on the type and thickness of soil horizons and on the stage of mineral weathering of these horizons.

None of the physical properties measured, such as porosity, density, compaction, permeability, and aggregate analyses, appeared to be closely related to primary soil structure, but more closely related to soil texture and secondary and tertiary structure.

Contamination of soils by K salts. Monitoring of soils at permanent sites surrounding potash mines was continued to establish bench marks and the buildup of K salt concentrations in the soil by contamination.

Application of up to 11.2 thousand kg/ha (5 tons/acre) gave no reduction in yields of wheat in field plots.

In growth-chamber experiments, leaching with 22.4 thousand kg/ha (10 tons/acre) of salt dust had some restriction on germination

and response to fertilizer; 44.8 thousand kg/ha (20 ton/acre) severely reduced germination and yield.

Soil Fertility

Response of wheat and barley varieties to N and P fertilizers. The wheat varieties Neepawa, Stewart 63, QK-13, Opal, Pitic 62, and the barley variety Galt were compared after fertilizer N and P were applied at rates up to 179.4 and 44.8 kg/ha (160 and 40 lb/acre) respectively. On Scott loam, Pitic 62 seeded on fallow outyielded Neepawa by 43%, and on stubble by 34%. Responses on fallow were mainly to P and on stubble to N. Of the wheats, the variety QK-13 responded most to N and P fertilizers on both fallow and stubble. On stubble, N at 179.4 kg/ha (160 lb/acre) increased yields of Galt barley by 3,026 kg/ha (2,700 lb/acre). With high rates of N, Galt produced more grain than the wheats, but had the lowest protein content. Protein content in Neepawa was 2% higher than in Pitic 62 and 4% higher than in Galt barley. High rates of N raised the protein content by 1% to 3%, with lowest increases in those varieties whose yields were

increased most by N fertilizer. On Elstow silty clay loam, average yields of wheat and barley were considerably higher than on Scott loam, but responses to N fertilizer were similar.

Movement of applied phosphate in soils. Under dryland conditions, without cropping, maximum movement of P in three loam soils was 2.54 cm (1 inch) horizontally, and 3.81 cm (1.5 inches) downward over a period of 5.5 months. The treatments consisted of ammonium phosphate and triplesuperphosphate at 78.6 kg P/ha (70 lb P/acre) banded at a depth of 6.35 cm (2.5 inches) in the soils in May.

When P was broadcast annually for 4 years to brome grass on Scott loam soil at 78.6 kg/ha (70 lb/acre), the maximum downward movement was approximately 8.89 cm (3.5 inches). By September the P that had been broadcast in April at 116.6 kg/ha (104 lb/acre) had moved down less than 5.08 cm (2 inches).

PUBLICATIONS

Research

- Bechyne, M., and Kondra, Z. P. 1970. Effect of seed pod location on the fatty acid composition of seed oil from rapeseed (*Brassica napus* and *B. campestris*). Can. J. Plant Sci. 50:151-154.
- Buckley, D. J., and Stewart, W. W. A. 1970. A light activated switch for controlling battery-operated light traps. Can. Entomol. 102:911-912.
- Church, N. S., and Kroeger, P. G. 1970. Discharging static electricity from paraffin ribbons by use of a moist conveyor belt. Stain Technol. 45:240.
- Church, N. S., Salkeld, E. H., and Rempel, J. G. 1970. The structure of micropyles of *Lytta nuttalli* Say and *L. viridana* LeConte (Coleoptera: Meloidae). Can. J. Zool. 48:894-895.
- Crowle, W. L. 1970. Revenue slender wheatgrass. Can. J. Plant Sci. 50:748-749.
- Davis, G. R. F. 1970. Protein nutrition of *Tenebrio molitor* L. XI. Effect on growth of partial replacement of dietary casein by lactalbumin

or lactalbumin hydrolysate and of partial replacement of these two proteins by casein. Arch. Int. Physiol. Biochem. 78:29-36.

- Davis, G. R. F. 1970. Protein nutrition of *Tenebrio molitor* L. XII. Effects of dietary casein concentration and of dietary cellulose on larvae of race F. Arch. Int. Physiol. Biochem. 78:37-41.

- Davis, G. R. F. 1970. Protein nutrition of *Tenebrio molitor* L. XIII. Consideration of some dietary factors of casein, lactalbumin, and lactalbumin hydrolysate. Arch. Int. Physiol. Biochem. 78:467-473.

- Dogra, G. S., and Ewen, A. B. 1970. Egg laying by allatectomized females of the migratory grasshopper, *Melanoplus sanguinipes*. J. Insect Physiol. 16:461-469.

- Dogra, G. S., and Ewen, A. B. 1970. Histology of the neurosecretory system and the retrocerebral endocrine glands of the adult migratory grasshopper, *Melanoplus sanguinipes* (Fab.) (Orthoptera: Acrididae). J. Morphol. 130:451-466.

- Finlayson, A. J., Christ, C. M., and Downey, R. K. 1970. Changes in the nitrogenous components of rapeseed (*Brassica napus*) grown on a nitrogen and sulfur deficient soil. *Can. J. Plant Sci.* 50:705-709.
- Fowler, D. B., and Downey, R. K. 1970. Lipid and morphological changes in developing rapeseed, *Brassica napus*. *Can. J. Plant Sci.* 50:233-247.
- Fredeen, F. J. H. 1970. A constant-rate liquid dispenser for use in blackfly larviciding. *Mosquito News* 30:402-405.
- Fredeen, F. J. H. 1970. Sexual mosaics in the black fly *Simulium arcticum* (Diptera: Simuliidae). *Can. Entomol.* 102:1585-1592.
- Fredeen, F. J. H., and Duffy, J. R. 1970. Insecticide residues in some components of the St. Lawrence River ecosystem following applications of DDD. *Pestic. Monit. J.* 3:219-226.
- Fredeen, F. J. H., and Glen, G. S. 1970. The survival and development of *Leptocera caenosa* (Diptera: Sphaoceridae) in laboratory cultures. *Can. Entomol.* 102:164-171.
- Gillott, C., Dogra, G. S., and Ewen, A. B. 1970. An autoradiographic study of endocrine activity following frontal ganglionectomy in virgin females of *Melanoplus sanguinipes* (Orthoptera: Acrididae). *Can. Entomol.* 102:1083-1088.
- Hanna, M. R., Cooke, D. A., and Goplen, B. P. 1970. Melrose sainfoin. *Can. J. Plant Sci.* 50:750-751.
- Harding, H. 1969. Diseases of alfalfa and other forage legumes in Saskatchewan in 1968 and 1969. *Can. Plant Dis. Surv.* 49:126-127.
- Keys, C. H., Anderson, C. H., Bowren, K. E., and Dew, D. A. 1970. Effect of seedbed preparation on soil aggregation, surface moisture and crop production. *Can. J. Soil Sci.* 50:347-351.
- Kirk, H. D., Ewen, A. B., and Emson, H. E. 1970. Melanotic lesions in two insect species: *Drosophila melanogaster* (Diptera) and *Melanoplus sanguinipes* (Orthoptera). *J. Invertebr. Pathol.* 15:351-355.
- Knowles, R. P. 1970. Performance of synthetics and sib lines in Fairway crested wheatgrass, *Agropyron cristatum* (L.) Gaertn. *Crop Sci.* 10:642-645.
- Knowles, R. P., Cooke, D. A., and Buglass, E. 1970. Breeding for seed yield and seed quality in smooth brome grass, *Bromus inermis* Leyss. *Crop Sci.* 10:539-542.
- Kondra, Z. P., and Downey, R. K. 1970. Glucosinolate content of rapeseed (*Brassica napus* L. and *B. campestris* L.) meal as influenced by pod position on the plant. *Crop Sci.* 10:54-56.
- Ledingham, R. J. 1970. Effects of straw and nitrogen on common root rot of wheat. *Can. J. Plant Sci.* 50:175-179.
- Ledingham, R. J. 1970. Survival of *Cochliobolus sativus* conidia in pure culture and in natural soil at different relative humidities. *Can. J. Bot.* 48:1893-1896.
- McLintock, J., Burton, A. N., McKiel, J. A., Hall, R. R., and Rempel, J. G. 1970. Known mosquito hosts of western encephalitis virus in Saskatchewan. *J. Med. Entomol.* 7:446-454.
- Morgan, A., Church, N. S., and Rempel, J. G. 1970. The structure and function of the digestive system during postembryonic development in *Lytta nuttalli* Say (Coleoptera: Meloidae). *Can. J. Zool.* 48:337-350.
- Rostad, H. P. W., and St. Arnaud, R. J. 1970. Nature of carbonate minerals in two Saskatchewan soils. *Can. J. Soil Sci.* 50:65-70.
- Saha, J. G., and Lee, Y. W. 1970. The metabolic fate of ¹⁴C-dieldrin in wheat plants and in agricultural soil. *J. Econ. Entomol.* 63:670-671.
- Saha, J. G., Lee, Y. W., Tinline, R. D., Chinn, S. H. F., and Austenson, T. M. 1970. Mercury residues in cereal grains from seeds or soil treated with organomercury compounds. *Can. J. Plant Sci.* 50:597-599.
- Saha, J. G., Nielsen, M. A., and Sumner, A. K. 1970. Effect of commercial processing techniques on lindane- and DDT-¹⁴C residues in rapeseed oil. *Agr. Food Chem.* 18:43-44.
- Shoemaker, R. A., and Smith, J. D. 1970. *Melanospora sphaerodermoides* on seed of *Agrostis palustris*. *Can. J. Bot.* 48:1657-1658.
- Smith, J. D. 1969. Char spot on wheatgrass. *Can. Plant Dis. Surv.* 49:140-141.
- Smith, J. D. 1970. Seed-borne *Drechslera phlei* on *Phleum* species. *Can. J. Plant Sci.* 50:746-747.
- Smith, J. D. 1969. Snow mold on lawns in Saskatchewan. *Can. Plant Dis. Surv.* 49:141-142.
- Smith, J. D. 1970. Viability of stored brome grass seed and seed-borne spores of a leaf spot pathogen. *Phytopathology* 60:1470-1471.
- Smith, J. D., and Maginnes, E. A. 1969. Scale rot tests of hardy hybrid lilies. *Can. Plant Dis. Surv.* 49:43-45.
- Stewart, W. W. A. 1970. A modified CDC light trap. *Mosquito News* 30:188-191.

- Stringam, G. R. 1970. A cytogenetic analysis of three asynaptic mutants in *Brassica campestris* L. *Can. J. Genet. Cytol.* 12:743-749.
- Stringam, G. R. 1970. A simple mordant technique for plants with small chromosomes. *Can. J. Bot.* 48:1134-1135.
- Stringam, G. R. 1969. Inheritance of chlorotic cotyledon in *Brassica campestris* L. *Can. J. Genet. Cytol.* 11:924-927.
- Sweeney, P. R., Church, N. S., Rempel, J. G., and Frith, W. 1970. An electron microscopic study of vitellogenesis and egg membrane formation in *Lytta nuttalli* Say (Coleoptera: Meloidae). *Can. J. Zool.* 48:651-657.
- Miscellaneous**
- Ellis, J. G., Acton, D. F., and Moss, H. C. 1970. The soils of the Rosetown map area, 72O. *Sask. Inst. Pedol. Publ. S3.* 159 p.
- Fredeen, F. J. H. 1970. Meet "Buffalo Gnat" the black-fly bandit! *Can. Agr.* 15(2):28-30.
- Shields, J. A., Rostad, H. P. W., and Clayton, J. S. 1970. Inventory of Saskatchewan soils and their capability for agricultural use. *Sask. Inst. Pedol. Publ. M13.* 60 p.
- Shields, J. A., Stonehouse, H. B., and Clayton, J. S. 1970. Soil capability for agriculture, Canada Land Inventory (map and general description), North Battleford, 73C. ARDA.
- Smith, J. D. 1970. Diseases of grasses in the prairie provinces. *Can. Agr.* 15(1):18-20.
- Stonehouse, H. B., and Shields, J. A. 1970. Acreage summary and soil capability inventory for the Indian reserves in the agricultural region of Saskatchewan. *Sask. Inst. Pedol. Publ. M14.* 56 p.
- Tinline, R. D., and staff. 1969. Plant diseases. *In* 64th Annu. Rep. *Sask. Dep. Agr.*, p. 74-75.

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Departures

K. F. BEST, B.S.A. Transferred to Research Station, Regina, Sask., April 1970	Botany
J. B. CAMPBELL, C.D., B.Sc., F.A.I.C. Retired January 1970	Head of Section; Pasture management
W. S. FERGUSON, B.S.A., M.Sc., Ph.D. Transferred to Ottawa as Research Coordinator (Soil Fertility), August 1970	Head of Section; Plant nutrition
P. J. JANZEN, B.S.A. Retired February 1970	Research Information
D. T. STOKES, B.Sc. Transferred to Data Processing Service, Ottawa, October 1970	Computer Programmer

INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on a variety of soils, and cattle are raised in large numbers on natural grasslands and on grass-alfalfa mixtures. Some small areas are irrigated. Research is focused on improving the economy and stability of this production.

Crop production was excellent in southwestern Saskatchewan in 1970. Soil moisture was adequate at seeding time and a record June precipitation of more than 20 cm provided moisture for above-average grain yields. Rainfall was well distributed for both crop use and summerfallow storage with six storms of over 12 cm during the month of June. There was no frost damage to crops during the 120-day growing season mid-May to mid-September.

The Animal and Pasture Science, Engineering Science, and Plant Science sections were rearranged into two sections: Cereal Production and Utilization, and Forage Production and Utilization. This arrangement will help to focus research activities on the solution of cereal and forage production and utilization problems. The other two sections are Soils and Agrometeorology, and Equipment Design.

During the year C. H. Anderson completed 5 years of research on a summerfallow-wheat rotation and found that the summerfallow can be maintained by using only weed control chemicals. In fact, where weeds were controlled preseeding cultivation had no advantage for the production of wheat. However, under most conditions a combination of chemical weed control and cultivation was the most practical means of summerfallowing.

Drs. C. A. Campbell and V. O. Biederbeck found that thawing a frozen soil at a fluctuating temperature reduced the number of bacteria, fungi, and actinomycetes more than thawing the soil at a constant temperature. In Western Canada, these reductions could reduce the amount of N available to crops in the spring.

These and other research accomplishments during 1970 are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report or from individual research scientists.

A. A. Guitard
Director

CEREAL CROPS

Cereal Crops

Breeding

Hard red spring wheat. Dr. E. A. Hurd transferred from the Research Station, Regina and brought with him an extensive wheat-breeding program. This program has been combined with the cereal breeding research lead by D. S. McBean. Now Swift Current is responsible for wheat breeding and variety testing for the southern half of Saskatchewan. Technical assistance with this program is being continued at the research stations at Regina and Indian Head. Breeding programs to develop both bread-quality and low-grade milling or feed wheats were reorganized to place special emphasis on tolerance for drought. Drought tolerance is

being combined with resistance to wheat stem sawfly, root rot, leaf rust, and stem rust. Studies of root patterns of varieties and the relationships of the stomata-transpiration-assimilation phenomena to moisture stress in plants are being conducted to provide a more complete understanding of how plants respond to drought.

Durum wheat. A selection was developed that yields 15% more than Stewart 63 in Saskatchewan. It has good resistance to loose smut, bunt, and leaf and stem rust. The selection will be licensed if it has suitable quality. A number of lines in earlier stages of development outyield Stewart 63 by 25%.

Rye. A tetraploid strain of Frontier was developed by the use of colchicine. It shows promise as a means of combining large-kernel and winter-hardy characteristics.

Minimum Tillage of Summerfallow for Wheat Production

When spring wheat is grown in rotation with summerfallow, low-cost herbicides can be used to control weeds and to replace one or more tillage operations during the 21-month summerfallow period. In five summerfallow-wheat sequences, the yield of wheat was not influenced by using chemicals rather than cultivation to control weeds on the summerfallow. In 4 of the 5 years the protein content was as high from the chemical summerfallow as from the cultivated summerfallow. In 1 year the protein content of wheat grown on total chemical summerfallow was 13.8% compared with 16.0% for wheat grown on cultivated summerfallow. This difference was associated with a lower $\text{NO}_3\text{-N}$ content in the chemically summerfallowed soil.

Summerfallowing only with chemicals conserved 62% of the original crop residue compared with 35% where the summerfallow was maintained only by cultivation. Where summer cultivation was preceded by cultivation the previous fall, only 24% of the crop residue was conserved. In the fall, soil that had been summerfallowed chemically had a smaller proportion of particles of less than 1 mm in diameter than soil maintained by cultivation. However, cultivation of soil decreased the soil particles of less than 1 mm in diameter from 39% to 18% from fall to spring, whereas chemical summerfallow decreased them from 32% to only 24%. The standing stubble in the chemical summerfallow plots appears to influence the degree of overwinter aggregation.

Where weeds and volunteer grain were satisfactorily controlled by herbicides, chemical summerfallow conserved as much moisture as cultivated summerfallow. Soil temperatures were generally 2 C to 4 C higher under chemical summerfallow and it was concluded that the conditions for N mineralization were about the same for both chemical and cultivated summerfallow. However, there were indications that the total chemical summerfallow may aggravate the N deficiencies often associated with stubble mulch tillage.

On both chemical and cultivated summerfallow, spring seeding of wheat directly into the undisturbed soil produced yields similar to those obtained when the soil was cultivated before seeding. When winter annual

weeds were controlled by late autumn spraying and where there was little volunteer wheat the discer, hoe-press drill, and the double-disc press drill produced similar yields. Where winter annual weeds were not controlled the discer gave higher yields because of the complete cultivation associated with the seeding.

Preparation of Grass-Legume Sod for Wheat Production

When producing wheat on land that had been in a Summit crested wheatgrass - Rambler alfalfa mixture for forage production for 2, 3, or 4 years, there was no advantage to summerfallowing for more than 12 months before seeding. Breaking the sod in the spring before seeding was more efficient than breaking it the previous fall and maintaining the land through two winters in a cultivated state before seeding.

Control of Winter Annual Weeds in Spring Wheat

A late fall application of 2,4-D ester at 0.42 kg/ha controlled stinkweed, *Thlaspi arvense* L., and flixweed, *Descurainia sophia* (L.) Webb., in newly seeded Winalta winter wheat. There was no visible injury to the seedlings nor reduction in yield the following year. Spring spraying was also used, but in many years the weeds were too advanced for satisfactory control by the time that spring spraying was possible.

Chemically Induced Cold Tolerance of Winter Wheat

In freezing tests with Kharkov MC22 winter wheat at the three-leaf stage, mannitol, a nonphytotoxic sugar alcohol, was less effective than sucrose or glucose in increasing frost tolerance. Survival of mannitol-treated plants was similar to plants treated with polyethylene glycol.

Effects of Moisture Content at the Time of Threshing Spring Wheat

Combining spring wheat at kernel-moisture contents as high as 35% followed by drying with heated air at 43 C did not adversely affect 1,000-kernel weight or crude protein content. These qualities appear to have been maximized at an early stage of kernel development.

Germination percentage and P content of

the kernels were lower in samples that were threshed at kernel moistures above 20% than in samples that had been allowed to dry naturally in the windrows. An examination of these quality factors showed that air drying in the laboratory at 20 C and drying with heated air at 43 C produced similar results. Reduced germination and P content were not caused by heat during the drying process. This damage was attributed to the separation of the kernel from the plant, which removed the source of nutrients required for mature kernel development.

Apparently commercial grades of spring wheat may be combined at kernel moistures of up to 35% and dried with heated air at 43 C without damage. However, wheat that is going to be used for seed should not be combined until the kernel moisture has decreased naturally in the field to about 20%.

TURKEY NUTRITION

Dietary Fat

Fat intake. Dietary fat levels of 0%, 3%, and 9% had little effect on carcass composition of Large White male turkeys. Growth rate increased with increasing dietary fat levels. Poults fed diets with no added fat produced faster early growth on a narrower calorie-to-protein ratio than poults fed 3% and 9% added fat.

Two strains of broiler turkeys fed 0%, 3%, and 9% dietary fat were slaughtered at 10, 12, and 14 weeks of age. Market grade at 10 weeks was improved by each addition of dietary fat. The addition of 9% dietary fat gave no significant improvement over 3% added fat on the finish of males at 12 and 14 weeks of age or females at 12 weeks. Strains differed in growth rate, finish, and market grade, and body conformation as shown by body measurements. The faster-growing strain was delayed approximately 2 weeks in reaching the equivalent market grade.

Rapeseed oil. Growth rate of turkeys decreased linearly when 10% beef fat was replaced by 2.5% increments of rapeseed oil (30% erucic acid content). Heart and liver enlargement and histopathological changes were observed in poults 6 weeks of age that had been fed 10% rapeseed oil.

Metabolizable energy values obtained for mixtures of beef fat and rapeseed oil were

higher than expected from energy values of diets containing each individual fat source. The synergism was explained by improved absorption of palmitic and stearic acids from these mixtures. The addition of soybean lecithin significantly improved the feed conversion of poults fed diets containing beef fat. The addition of 3% crude rapeseed gums to starter diets did not affect early growth or feed conversion.

Amino Acids

Modified amino acid procedure. An amino acid procedure described by Gehrke (1968) was modified by using gas-liquid chromatography for physiological fluids. At the present time, 12 and 15 plasma or acid hydrolysate samples are being analyzed a week and nor-leucine is used as the internal standard. Identification of cysteic acid and methionine sulfide peaks increased the recovery values of cystine and methionine.

Amino acid balance. A purified amino acid diet supplemented with threonine, lysine, arginine, valine, methionine, and glutamine increased the growth rate of Large White male turkeys to approximately 90% of the intact protein control growth (26 g/bird per day). This growth rate was achieved with 80% of the control feed intake during 7 to 21 days of age.

Limiting amino acids in protein sources. The addition of methionine to a wheat basal diet in which pea protein concentrate is used as the only protein source significantly increased the growth rate; threonine gave no further growth improvements. The addition of lysine significantly improved the growth rate over soybean meal supplemented with methionine. Amino acid supplementation failed to improve the growth rate over the fish meal basal diet. Poultry by-product meal supplemented with lysine increased the growth rate and tyrosine gave further improvement.

Nutrient Density

In a test four turkey strains utilized dietary nutrients with the same efficiency at each of the three nutrient density levels. Feed intake and feed conversion were inversely related to nutrient density level regardless of strain, sex, or variety. The strain with the highest level of feed intake produced the heaviest birds at all nutrient density levels. Meat yield data indi-

cated that the percentage of breast meat and skin increased with chronological age, whereas the percentage of wing, thigh, and drumstick decreased with age. The proportion of bone remained relatively constant. The cooking loss data indicated a lower loss for females than for males primarily because males have a higher drip loss at comparable ages. The breast and back fat scores were highly correlated to drip loss for both males and females.

FORAGE CROPS

Breeding

Alfalfa. Genetic analysis of 100 clones that vary in the content of Fraction 1 protein gave a component of variance of 46% for this characteristic. *Medicago falcata* L. plants contained 2% Fraction 1 protein compared with 4% for *M. sativa* L., and plants of *M. media* Pers. were intermediate between the two. Thus, *M. falcata* appears to be a good source for low Fraction 1 protein content. The characteristic is sufficiently heritable to make breeding and selection practical.

Russian wild ryegrass. Selections were made within a population of *Elymus junceus* Fisch. that had previously undergone three cycles of selection for increased seedling vigor based on seed size and the capacity of seedlings to emerge from a depth of 6 cm. Leaf spot resistance, leafiness, and good seed culm formation were emphasized in making these selections. The selections will be progeny-tested before new strains are synthesized.

Altai wild ryegrass. One cycle of selection was completed within a population of *Elymus angustus* Trin. Selection was for improved seed yield, uniform plant type, freedom from leaf spot disease, and resistance to aphid-transmitted virus attack. The selections will be screened for seed quality and used to establish new nurseries for a second cycle of selection.

Intermediate wheatgrass. In a progeny test of 292 breeding lines approximately one-third produced more forage than Chief in 2 years. Selections were made within the offspring of superior lines for further evaluation and probable combining into synthetic strains.

Establishment of Grasses

Seedling vigor. Russian wild ryegrass, Altai wild ryegrass, and crested wheatgrass had similar net assimilation rates for 16 weeks after emergence. However, Russian wild ryegrass developed more slowly than the other grasses and had a smaller leaf area. The root-to-shoot ratio of crested wheatgrass was 2:1 at the end of the period and the ratio of the ryegrasses was 1:1.

Salinity tolerance. Russian wild ryegrass, Altai wild ryegrass, slender wheatgrass, tall wheatgrass, and brome grass emerged well in moderately saline soils with an $EC \times 10^3$ of 18 mmhos/cm or less. Moderate salinity caused a 50% reduction in the yields of brome grass, reed canarygrass, and slender wheatgrass. Yields of Russian wild ryegrass and Altai wild ryegrass were not reduced to 50% until soils had an $EC \times 10^3$ of 25 mmhos/cm.

Companion crops. Chinook wheat seeded parallel to or across rows of Summit crested wheatgrass spaced 91.5 cm apart did not influence the establishment of the grass plants, but decreased their vigor. The higher the density of the companion crop the greater the depression of seedling vigor. Despite the initial reduction in plant vigor, the companion crop only slightly reduced seed and forage yield of crested wheatgrass. The production of wheat in the seeding year more than compensated for any decrease in yield of grass seed or dry matter in subsequent years.

Survival

Flooding tolerance of legumes. Birdsfoot trefoil, white clover, and strawberry clover tolerated up to 20 days of flooding without severe reduction in productivity. Red clover, alsike clover, and alfalfa could tolerate only 15 days, and sweet clover and Cicer milk vetch only 10 days. Sainfoin was the least tolerant of flooding and was damaged when covered by water for 5 days.

Sick alfalfa. Both the roots and the shoots of alfalfa growing on "alfalfa-sick soil" contained less methionine than normal plants. Feeding methionine and precursor amino acids through the roots failed to alleviate the symptoms.

The nematode *Paratylenchus projectus* Jenkins was isolated from soil upon which alfalfa grows poorly. The numbers of nemas

per unit of soil agreed fairly well with the severity of alfalfa sickness on some soils.

Forage and Seed Yield

Comparative yields of annuals and perennials. During the past 5 years alfalfa and a crested wheatgrass - alfalfa mixture yielded more than spring cereals and corn grown on dryland in rotation with summerfallow. The perennial crops produced continuously, but the annual crops produced only every second year. On this basis, alfalfa and the crested wheatgrass - alfalfa mixture produced an average annual yield of 2,900 kg/ha of dry matter. Wheat gave an annual yield of dry matter of 1,340 kg/ha, oats 1,790, fall rye 2,000, sunflowers 2,000, and corn 1,340.

Time of grazing Russian wild ryegrass - alfalfa pastures. During the last 3 years beef gain from Russian wild ryegrass - Rambler alfalfa pastures was higher when the pastures were grazed for 28 days starting in early June than when they were grazed for a similar period beginning in early or mid-May. Forage production was highest from pastures used from early June, whether used for 28 days or for a longer period. Grazing for 28 days commencing in early June produced on the average 511 kg/ha total digestible nutrients and 97 kg/ha of beef gain.

Effect of aftermath removal on seed yield of Russian wild ryegrass. The 5-year average seed yields of Russian wild ryegrass were 294 kg/ha when the forage aftermath was removed each fall by grazing with sheep, 505 kg/ha when the aftermath was removed by a rotary mower, and 336 kg/ha when the aftermath was desiccated by spraying with diquat and then burned. Where the aftermath was not removed, the average yield was 223 kg/ha. Although the removal of the aftermath stimulated seed production, repeated close grazing with sheep commencing immediately after seed harvest and continuing through mid-October eventually reduced seed yield.

Forage Quality

Protein content of grasses. During 1963 to 1965 the crude protein content of irrigated intermediate wheatgrass was increased by the addition of N fertilizer. Increasing the periods between times of clipping tended to reduce protein content, but the result was not consistent. Apparent N recoveries ranged

from 27% in the first crop year to over 50% in subsequent years.

In another test where pasturing of irrigated forage was simulated by clipping, the first removed forage of reed canarygrass was higher in protein content than that of bromegrass and both were higher than that of intermediate wheatgrass. When cut at the vegetative and the shot-blade stages, all grasses had higher protein contents than when cut at either the flower or seed stage. Annual yield of crude protein was not influenced consistently by species or by the stage of growth at which the forage was first removed each year.

Protein content of alfalfa. Study of the crude protein content of alfalfa showed that the protein content of "leafy" types is considerably higher than that of the "stemmy" types. The differences became progressively greater as the plants aged: June 3, 23.1% vs. 22.4%; June 17, 20.5% vs. 19.5%, July 1, 20.2% vs. 18.2%, and July 21, 17.7% vs. 15.5%.

Cattle preference among legumes. In a legume-grass mixture trial in which the legumes were seeded in alternate rows with grasses, cattle ate alfalfa first, sainfoin next, and Cicer milk vetch and crown vetch last. After the initial grazing of tops, the cattle ate grass at the same time as the "stemmy" parts of the legume. No preference differences were apparent among alfalfa varieties.

Leafiness of hay. The percentage of leaf in alfalfa, bromegrass, and reed canarygrass was studied from early growth in late May to seed maturity in late August. In each species there was a close association between the stage of development and leafiness ($r = 0.79$ to 0.85). Reduction in the percentage of leaf as the species developed declined at a decreasing rate with time. Leafiness was highly associated with digestibility, rate of physical breakdown, and crude protein content.

In another trial, three oat varieties were harvested at weekly intervals commencing when the plants were 25 cm high. In the early stages of growth the plants were 90% leaf. At the boot stage, leafiness ranged from 50% to 70% depending on the variety, at the heading stage from 35% to 50%, during anthesis from 25% to 35%, at the milk stage of the kernel from 20% to 25%, at the dough stage from 15% to 20%, and at maturity from 12% to 15%.

In vitro determination of digestible energy

in forage. A laboratory procedure was developed to determine the in vitro digestible energy in forage. It was digested in a small polyethylene bag and the liquid phase was centrifuged off. The undigested energy was then determined by combustion of the residue and the bag in a bomb calorimeter. The method was assessed by using 102 different hays, which when fed to sheep showed a high association ($r = 0.85$) between in vitro and in vivo digestible energy. Regressions were similar for several species of grasses and legumes during 4 years. The only apparent inconsistency was that very low quality hays showed in vivo values considerably higher than those obtained in vitro and conversely very high quality hays showed higher in vitro values. The method appears promising for quality determination of forage for ruminants.

Collection and Classification of Native Species

A total of 350 sites were examined in Alberta, Saskatchewan, and Manitoba. More than 1,500 specimens of plants were collected for the herbarium, and an additional 800 specimens were acquired in exchange. About 30 species were collected for the *Plantae Exsiccatae Canadensis* to be issued by the Plant Research Institute.

Oxytropis besseyi (Rydb.) Blank., *Astragalus vexilliflexus* Sheldon, *Hymenopappus filifolius* Hooker, and *Phlox alyssifolia* Greene were chosen as the species that will be used for the first part of a Biological Flora of the prairies and parklands of the Prairie Provinces.

SOILS AND AGROMETEOROLOGY

Fertility

Residual phosphorus. In 1967, 0, 100, 200, or 400 kg/ha of P was applied to a Wood Mountain loam and a Sceptre heavy clay cropped in a wheat–summerfallow rotation. Tracer phosphorus “A” values for samples collected in the fall of 1968 were 10, 30, 60, and 108 kg/ha and in 1969, 10, 31, 49, and 94 kg/ha. Thus, by 1969 the level of available P where no P was added was in the low range where yield response from fertilizer P would be expected. Where 100 kg P had

been added, the level of P was in the range where response to added P would be infrequent. No yield response from the addition of further P would be expected where 200 and 400 kg of P/ha had been added in 1967.

Available P was also determined by extraction with NaHCO_3 solution. Preliminary indications are that this method will be reliable for estimating available soil P where there is residual P from previous fertilizer applications.

Effect of freezing and thawing on release of soil nutrients. Numerous cycles of alternate freezing and thawing of soil at constant temperatures resulted in a large increase in exchangeable $\text{NH}_4\text{-N}$ and a small decrease in exchangeable K. Dilute NaHCO_3 -extractable N and water-soluble carbohydrates increased after one freeze–thaw cycle, but there was no further increase from continued freezing and thawing. There was an increase in extractable P after one freeze–thaw cycle and further increases after several cycles. When barley was grown on the frozen and thawed soil, there was a close relationship between available N in the soil and uptake of N by the seedlings. However, the uptake of P did not reflect the increase in extractable P caused by freezing and thawing.

Influence of Freezing on Soil Structure

In a study of the effect of moisture, freezing and thawing, and freeze-drying on the ultimate structure of soils it was found that when moisture is removed from frozen soil by sublimation a breakdown of aggregates occurs. If moisture is not removed from the soil when it is frozen and it is subsequently thawed and dried, there is no reduction in soil aggregates and the soil may be more aggregated than before. The measurement of integral heat of immersion showed that freeze-drying did not change the surface area relative to oven-drying. Therefore, although freeze-drying destroys soil clods and makes surface soils more erosive than air-drying, the physical effect is transient and inherent clod formation properties of the soil are not altered.

Influence of Fall and Spring Temperatures on the Soil System

In 1969 it was reported that when frozen soil was thawed for 4 days at fluctuating temperatures from 14 C to 3 C, there was no

nitrification because the alternating low thawing temperature reduced the number of viable bacteria by as much as 90%. This bacterial effect was confirmed and it has been found that when fresh soil is frozen and then thawed at fluctuating temperatures from 14 C to 3 C for 16 days, 92% of the bacteria, 55% of the fungi, and 33% of the actinomycetes are killed. There was a similar trend, but there was not as much killing, when the soil was stored for 1 year before freezing or when fresh or stored soil was subjected to the temperature cycles without prior freezing. When soil dilution plates were incubated at 14 C to 3 C, damage to the microflora was more pronounced than when frozen soil was incubated at 14 C to 3 C.

The adverse effect of low alternating temperatures on the microbial population was substantiated by nitrification results. Soils frozen and then incubated at 14 C to 3 C showed considerably lower rates of nitrification than soils frozen and incubated at a constant mean temperature of 8.5 C. The addition of $(\text{NH}_4)_2\text{SO}_4$ reduced the detrimental effects of fluctuating low temperatures during thawing.

Soil sterilization with ethylene oxide was used to isolate the physical-chemical from the biological changes resulting from freezing and thawing. The ethylene oxide was an effective soil sterilant, but caused a small increase in exchangeable NH_4 . In sterile soils, freezing and thawing increased the exchangeable NH_4 , but did not influence the NO_3 content.

Climate

Evapotranspiration measurements. Empirical methods proposed by Thornthwaite, Blaney and Criddle, and Penman for estimating evapotranspiration were evaluated for application under the semiarid climatic conditions of the Canadian Prairies. Lysimeter measurements of the amount of water used by alfalfa were used as the standard of comparison. The Thornthwaite and the Blaney-Criddle methods were not adequate for use on a daily basis, but can be used to predict with reasonable accuracy the water requirement of alfalfa on a weekly basis. Penman's method accounted for about 65% of the variation in daily evapotranspiration, but it requires modification before it can be recommended for general use in semiarid climates.

Relating weather variables to crop growth. Visible, solar and net radiation; air temperature; air vapor pressure; soil temperature; and soil heat flux were measured continuously during the growing season in dryland and irrigated Manitou wheat. Precipitation, irrigation supplements, and soil moisture were also recorded. Foliage area and plant dry matter were measured biweekly and the amount of dry matter accumulated in the crowns, stems, leaves, and heads was determined. A leaf chamber system was designed to measure photosynthesis and the transpiration of individual leaves. A mathematical growth model is being developed to describe the soil-plant-atmosphere system as a functioning entity.

RESEARCH EQUIPMENT

Plot Seeders

The self-propelled four-row seeder described in the Research Report for 1969 was designated Model SC 701. It was used at the research stations at Lethbridge and Swift Current for seeding cereal rod-row plots. The performance was generally satisfactory, but it was shown that versatility and precision could be improved by the addition of a variable speed drive to the dividing cones to give an infinite selection of row length and the use of a 26.7-cm rather than a 35.6-cm cone to feed the four-way centrifugal divider. These changes were made, construction blueprints of the whole unit were prepared, and arrangements were made for commercial production.

Model SC 701 was redesigned to provide a six-row unit for seeding forage and was designated SC 702.

Plot Harvesters

A survey of plot equipment requirements indicated that the greatest need is for a system for harvesting, threshing, and determining yield of large numbers of cereal plots. Lack of suitable equipment is greatly reducing the capability of breeders attempting to incorporate high yield into cereal varieties. Based on this need, design of equipment that will harvest one or two rod-row plots at the rate of one per minute and place the material in suitable containers for easy drying and transport to threshing equipment was com-

menced. There is also a need for equipment to thresh the harvested material.

PUBLICATIONS

Research

- Biederbeck, V. O., and Paul, E. A. 1970. Bacteria and actinomycetes, p. 150-154. *In* Matador Project, International Biological Programme, Third Annu. Rep. 1969-70.
- Bisal, F., and Ferguson, W. S. 1970. Effect of nonerodible aggregates and wheat stubble on initiation of soil drifting. *Can. J. Soil Sci.* 50:31-34.
- Campbell, C. A., Biederbeck, V. O., and Warder, F. G. 1970. Simulated early spring thaw conditions injurious to soil microflora. *Can. J. Soil Sci.* 50:257-259.
- Campbell, C. A., Ferguson, W. S., and Warder, F. G. 1970. Winter changes in soil nitrate and exchangeable ammonium. *Can. J. Soil Sci.* 50:151-162.
- Dodds, M. E., and Warder, F. G. 1970. The combining and drying of high moisture spring wheat. *Can. J. Plant Sci.* 50:67-70.
- Green, D. G., Ferguson, W. S., and Warder, F. G. 1970. Effects of decenylsuccinic acid on ^{32}P uptake and translocation by barley and winter wheat. *J. Plant Physiol.* 45:1-3.
- Heinrichs, D. H. 1970. Flooding tolerance of legumes. *Can. J. Plant Sci.* 50:435-438.
- Heinrichs, D. H., and Miltimore, J. E. 1970. Variation of Fraction 1 protein content in alfalfa. *Can. J. Plant Sci.* 50:537-539.
- Hergert, G. B., and Dyck, F. B. 1970. A four-way divider for plot seeders. *Can. J. Plant Sci.* 50:513-515.
- Hinman, W. C. 1970. Effects of freezing and thawing on some chemical properties of three soils. *Can. J. Soil Sci.* 50:179-182.
- Keys, C. H., Anderson, C. H., Bowren, K. E., and Dew, D. A. 1970. The effect of seedbed preparation on soil aggregation, surface moisture and crop production. *Can. J. Soil Sci.* 50:347-351.
- Kilcher, M. R., and Lawrence, T. 1970. Emergence of Altai wild ryegrass and other grasses as influenced by depth of seeding and soil type. *Can. J. Plant Sci.* 50:475-479.
- Lawrence, T. 1970. Effect of a wheat companion crop on the seed and dry matter yield of crested wheatgrass. *Can. J. Plant Sci.* 50:81-86.
- Lawrence, T. 1970. Influence of method of aftermath removal on the seed yield of Russian wild ryegrass. *Can. J. Plant Sci.* 50:87-89.
- Lawrence, T., and Heinrichs, D. H. 1970. Pasture attributes of Altai wild ryegrass. *Can. J. Plant Sci.* 50:743-745.
- Lawrence, T., Warder, F. G., and Ashford, R. 1970. Effect of fertilizer N and clipping frequency on the crude protein content, crude protein yield, and apparent N recovery of intermediate wheatgrass. *Can. J. Plant Sci.* 50:723-730.
- Lodge, R. W. 1970. Complementary grazing systems for the Northern Great Plains. *J. Range Manage.* 23(4):268-271.
- McElgunn, J. D., and Heinrichs, D. H. 1970. Effect of root temperature and a suspected phytotoxic substance on the growth of alfalfa. *Can. J. Plant Sci.* 50:307-311.
- McElgunn, J. D., and Lawrence, T. 1970. A minirhizotron for *in situ* observation of seedling development. *Can. J. Plant Sci.* 50:754-756.
- Pelton, W. L., and Korven, H. C. 1969. Evapotranspiration estimates in a semiarid climate. *Can. Agr. Eng.* 11(2):50-53, 61.
- Salmon, R. E. 1969. The effect of histomonostats on the performance of growing turkeys. *Poultry Sci.* 48:2188-2189.
- Salmon, R. E. 1970. Rapeseed gum in poultry diets. *Can. J. Anim. Sci.* 50:211-212.
- Salmon, R. E. 1970. Rapeseed meals in diets for growing turkeys. *Can. J. Anim. Sci.* 50:157-160.
- Troelsen, J. E. 1970. Digestible energy in forage by *in vivo* and *in vitro* assays. *Can. J. Anim. Sci.* 50:557-562.
- Troelsen, J. E., and Beacom, S. E. 1970. The feeding value of forage as fed to steers and estimated by *in vitro* digestion. *Can. J. Anim. Sci.* 50:547-555.

Miscellaneous

- Heinrichs, D. H. 1970. Variation in chemical constituents within and between alfalfa populations. *Proc. XI Int. Grassland Congr. University of Queensland Press, Brisbane, Australia.* p. 267-270.

- Kilcher, M. R. 1970. Feed crops and livestock: the principal alternatives. *Farm Light & Power* 12(2):2.
- Kilcher, M. R., Winch, J. E., and Watkin, E. M. 1970. More beef per acre with cultivated forage. *Cattlemen* 33(5):12-13, 58-59.
- McElgunn, J. D. 1970. Sick alfalfa in some Alberta soils. *Can. Agr.* 15(1):14-15.
- Troelsen, J. E., Campbell, J. B., and Heinrichs, D. H. 1970. The effect of physical breakdown on the voluntary intake of coarse roughage by sheep. *Proc. XI Int. Grassland Congr.* University of Queensland Press, Brisbane, Australia. p. 747-750.

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INTRODUCTION

The Research Station, Beaverlodge, and its associated experimental farms at Fort Vermilion, Alta., and Prince George, B. C., comprise the Northern Research Group. Research in soils, apiculture, and cereal, forage, horticultural, and oilseed crops is aimed at increasing the efficiency of production under northern conditions and assessing the agricultural potential of areas not yet developed.

This report emphasizes research that was completed during 1970. The research is not described in detail, and unless significant, the location is not specified.

In the vast area served by the Northern Research Group the climate and crop response are extremely variable. A better understanding of the crop-environment relationship is essential to the development of new varieties and improved agricultural practices. Accordingly, a new section, Environment and Special Crops, was formed to emphasize research on crop-climate and soil relationships.

The Slave River Lowlands program, started in 1968 at Grande Detour, N.W.T., to determine the forage production potential of the area gave interesting results. Forage production from the native vegetation was almost doubled by applying fertilizer. Chief intermediate wheatgrass, Manchar and Polar bromegrass, Rambler alfalfa, pubescent wheatgrass, and Revenue slender wheatgrass established well and were the best producers in forage trials and plant nurseries. Plant survival during the next 2 or 3 years will determine the usefulness of these species.

L. P. S. Spangelo
Director

APICULTURE

Wintering of California and New Zealand colonies for production of package bees. In a 2-year wintering study from 1968 to 1969 at the Clearbrook, B.C., substation, California queens produced an average of 7.5 one-kg packages of bees compared with 6 one-kg packages for the New Zealand queens.

CROPS

Cereal and Oilseed

Effect of plant density on growth correlations in the barley plant. A morphogenetic examination of barley plants at densities of 50 to 1600 plants/m² suggested that, at high densities, plants produce high concentrations of gibberellins. The high concentration promotes rapid apex development, which gives rise to early competition for nutrients diffusing through the apex and causes starvation and early death in the apex tip, reducing the number of spikelets. This research was conducted at the Plant Breeding Institute, Cambridge, England, in cooperation with Dr. E. J. M. Kirby.

Effects of controlled environmental factors

on floret number and fertility in barley. A series of experiments was conducted in growth cabinets using combinations of 17 barley cultivars. The treatments were 12, 18, and 24 C constant and 18/12 C day/night temperatures; 12-, 16-, and 24-hr photoperiods; 5,500 and 22,000 lux light intensities; and light low and high in far-red energy. The number of florets/head was increased by low temperature, short days, high light intensity, and low far-red energy. Percent fertility was highest at 18 C, long days, high light intensity, and high far-red energy. The percent fertility was further increased by use of the alternating temperature treatment. The cultivars responded differently to these environmental factors, indicating the danger of generalizations based on the study of only one cultivar.

Forage Crops

Meadow foxtail. To make seed of meadow foxtail easier to handle, the outer glumes and the glumes plus lemma were carefully removed from normal whole seed. The dehulled seed showed no decline in germination after dry storage for 1 year. Dry storage for a year, at either 29 C or 5 C, resulted in little or no loss of germination regardless of seed

treatment. However, after storage at 29 C and high relative humidity, germination of seed deteriorated rapidly for both seed treatments. Germination was reduced from 96% to 63% in 1 month and to 0% in 3 months. Mechanical dehulling without damaging the caryopsis would greatly facilitate the use of meadow foxtail in forage mixtures.

Reed canarygrass. In cooperation with Dr. K. W. Clark, University of Manitoba, 71 clonal selections were screened for gramine and tryptamine. All contained gramine, an alkaloid that affects forage palatability. Seven contained tryptamine, an alkaloid that is toxic to sheep and causes low weight gains in cattle.

Forages for acid soils. Forages varied considerably in their tolerance to three diverse acid soils ranging in pH from 4.1 to 5.1. Timothy and brome grass were consistently good herbage yielders. Timothy was particularly productive where moisture was adequate, whereas under dry conditions brome grass proved best. Red clover and birdsfoot trefoil showed a surprising tolerance to moderate levels of acidity. Alsike clover, though reputed to have acid tolerance, produced significantly higher yields at all test sites when soils were limed. Alfalfa showed very low tolerance to slight soil acidity. Russian wild ryegrass failed to germinate unless soils were limed.

In the forage seed trials, timothy, creeping red fescue, and red clover exhibited a distinct tolerance to soil acidity.

Bovine copper and zinc status in the South Peace area. Herbage produced in the South Peace area was deficient in Cu and Zn when surveyed in 1968. In July and August 1970, analyses of liver and hair samples from beef animals of known diets confirmed nutritional inadequacies.

Copper content of liver varied greatly; of the 86 samples, 44 were below the adequate level of 60 ppm, and 15 were less than 20 ppm. Four samples were over 160 ppm.

Zinc content of 43 hair samples ranged from 100 to 200 ppm; 18 were less than the adequate level of 140 ppm, and 2 were over 180 ppm.

Animals not receiving a supplement rarely exceeded minimum levels of either Cu or Zn. Certain mineral supplements were more effective in raising micronutrient levels than others. Area differences were not observed.

The results indicated a widespread low Cu level and, to a lesser degree, a deficiency in Zn unless additional mineral was made available.

A subclinical Cu deficiency may exist in the area and minerals that contain much more Cu and Zn may be needed for optimum beef production. Further research is in progress.

Rates of seeding and spacing in red clover seed production. Rates of seeding, ranging from 1.12 kg/ha to 11.2 kg/ha (1 to 10 lb/acre), did not affect seed production in the first seed crop year. Yields from spacings of 91 cm (36 inches) were lower than those from 61, 45, 30, and 15 cm (24, 18, 12, and 6 inches).

Effect of N fertilizer and grain supplement on pasture production. Levels of forage and beef production on the major soils of central British Columbia are being determined by a series of grazing studies. In 1970, grazing was confined to a silt loam soil in the Giscome series. The put and take stocking system was practiced, using a uniform group of yearling 281-kg steers for 135 days. The seasonal carrying capacity of unfertilized pasture was 2.77 steers/ha. N fertilizer (112 kg/ha) increased the capacity by 52%. Beef production from unfertilized pasture was 326 kg/ha but a grain supplement (0.90 kg/steer per day) raised production to 592 kg of beef/ha. Dry matter herbage consumption for the grazing season was 5493 kg/ha from unfertilized pasture and 7510 kg/ha from fertilized pasture.

Yields of cereal crops harvested at silage stage. Fifteen cereal combinations were harvested at silage stage at three locations in central British Columbia for 2 years. Jubilee barley, grown alone or in a mixture with Glen oats (4 parts Glen: 6 parts Jubilee), gave the highest forage yield. The mixture permitted the barley component to maximize its energy yield, whereas the oats contributed sufficient moisture to make a good silage.

Pitic 62 spring wheat and Rosner triticale were consistently low yielding in grain content and in total dry matter.

Mineral content of cereals harvested at silage stage. Cereals harvested at silage stage were analyzed for Ca, K, Mg, Cu, Zn, and Mn content. Location, climate, species, and variety caused differences in mineral content.

Ca, Mg, and K levels were generally adequate for livestock production. Depending on location and year, oat forage tended to be deficient in Mg and adequate in Zn. All cereal forage from all locations was deficient in Cu.

Effects of dates of seeding on yields of hay from an alfalfa-bromegrass sward. About 2.5 metric tons/ha were produced in the year of establishment by seeding between May 16 and June 27. Seedings made later than June 27 produced no yield.

In the first year after seeding, yields of hay from several dates were: May 16 - June 27, 10.6 metric tons/ha; July 11 - July 25, 8.6 metric tons/ha; August 8 - August 12, 5.8 metric tons/ha. Seeding dates had little effect on second-year yields.

ENVIRONMENT AND SPECIAL CROPS

Vegetable Crops

Productivity in tomatoes. Two heat set (Narcarlang and FR-112) and two cold set (NRG-6803 and Sub-Arctic Plenty) cultivars were grown at constant temperatures of 10, 12.8, 18.3, and 26.7 C, and 10-, 14-, and 18-hr photoperiods. The number of flowers decreased with an increase in temperature and photoperiod, and the percentage of viable pollen was greatest when the petals were fully expanded but had not reflexed. Stigmas were most receptive when the petals were fully reflexed, but the differences in time of maximum pollen viability and stigma receptivity were not major factors in fruit set. Stigma levels in the antheridial cones rose with increasing temperatures and photoperiods, reducing the opportunity for pollen to reach the stigma. Maximum fruit set was obtained at 18.3 C and increased with increase in photoperiod. Poor pollen viability was the main cause of poor fruit set at low temperatures, but in some cultivars stigma level may be a contributing factor. Too high a stigma level in the antheridial cone was the main cause of poor fruit set at high temperatures, but poor stigma receptivity was a contributing factor in some selections. Tapping the flowers increased fruit set at 26.7 C, indicating that the inability of pollen to reach the stigma was a cause of poor fruit.

Sub-Arctic Plenty had the lowest stigma

level at all temperatures, followed by NRG-6803 and Narcarlang. Narcarlang had the highest pollen viability at all temperatures, followed by NRG-6803, Sub-Arctic Plenty, and FR-112. Highest percentage fruit set at 12.8 C was obtained with Narcarlang, closely followed by Sub-Arctic Plenty. Neither NRG-6803 nor FR-112 set fruit at 12.8 C. Highest percentage fruit set at 18.3 C and 26.7 C was obtained with Sub-Arctic Plenty, followed by NRG-6803, Narcarlang, and FR-112.

New tomato cultivars. Three new tomato cultivars were released. All three have excellent cold set ability in the field, strong cotyledonary activity, even ripening, good flavor, plant spread of 45-60 cm (18-24 inches), with large clusters of 12 to 20 fruits. No blossom end rot, large blossom scars, or catfacing was observed in any of the new cultivars.

All three cultivars are progeny of Fireball, and either BEF 56-1 or BEF 56-7. The two latter selections are from the cross (Farthest North × Fargo Yellow Pear) × Firesteel × L3700 #2. L3700 #2 is a selection from the cross Farthest North × Polar Circle from the Canada Department of Agriculture, Research Station, Lethbridge, Alta.

Early Sub-Arctic. Early Sub-Arctic (Fireball × BEF 56-1) × BEF 56-1 ripens 40-50 days after flowering and yields up to 2.4 kg (5.25 lb) per plant, 75.5% of which is ripe and marketable at one harvest. This cultivar is about a week earlier than Sub-Arctic Plenty. The round fruit averages 3.8 cm (1.5 inches) in diameter, has good shipping and shelf life, and good field color, but the green shoulders detract from the color under artificial light. The fruits are larger and slightly earlier than Sub-Arctic Delight.

Sub-Arctic Midi. Sub-Arctic Midi (BEF 56-1 × Fireball) × BEF 56-1 matures slightly later than Early Sub-Arctic, ripening 45-55 days after flowering, and yields up to 2.8 kg (6.2 lb) per plant, a high percentage of which is ripe and marketable at one harvest. The round fruit averages 4.4 cm (1.75 inches) in diameter, has good shipping and shelf life, and good field color, but the green shoulders detract from the color under artificial light. This cultivar has better shipping and shelf life than Sub-Arctic Plenty.

Sub-Arctic Plenty. Sub-Arctic Plenty (Fireball × BEF 56-7) × Fireball is a very heavy

producer. It ripens 45–55 days after flowering and yields up to 4.1 kg (9 lb) per plant. The fruit does not ripen as evenly as Early Sub-Arctic and Sub-Arctic Midi, but up to 70% of the yield is ripe and marketable at one harvest. The round fruit averages 4.4 cm (1.75 inches) in diameter, and has moderately good shipping and shelf life and good color in the field and under artificial light.

Fruit Crops

The variation of some characters in Rubus idaeus strigosus Michx. Significant differences between raspberry population samples were found for the following characters at the Experimental Farm, Prince George: cane length, number of buds per cane, percentage of buds growing (after a severe winter), number of inflorescences per bud, number of flowers per bud, fruit weight, number of seeds per fruit, and weight of seeds.

Autumn flowering occurred in some collections and accessory buds were observed in all but one. Self-incompatibility seemed evident because all population samples failed to set drupelets or fruits when selfed.

SOILS

Correlation of soil test values with response of oats to fertilizer. Data from 1970 confirmed the first year results from 1969 that N and P are the main requirements for stubbled in cereals on Gray Wooded soils.

Good correlations were shown between crop response to applied N and soil NO₃-N test and response to applied S and soil S. Sampling deeper than 15 cm did not significantly change the correlation values for N or S.

The mean yields of Pendek oats were 1483–3272 kg/ha from 15 tests on Gray Wooded soils that extend from Fairview into the Fort Vermilion area. The test plots received treatments of N, P, K, S, and no fertilizer. Nitrogen increased the yields in 14 tests, P in 12 tests, and K in only 1 test. Three tests showed yield increases from S that averaged 1020 kg/ha, but in two tests S decreased the yield by an average of 623 kg/ha.

Rates and depths of seeding barley. Galt barley was seeded at three rates (54, 108, and 162 kg/ha), each at three depths (2.5, 5.0, and 7.5 cm), with and without fertilizer for 3 years on fallowed Black soil. The lowest seeding rate produced the lowest yields. Differences between yields were least when fertilizer was added. Depth of seeding had no effect, either with or without fertilizer.

PUBLICATIONS

Research

- Carder, A. C. 1970. Climate and rangelands of Canada. *J. Range Manage.* 23:263-267.
- Harris, R. E. 1970. Laboratory techniques for assessing winterhardiness in strawberry (*Fragaria × ananassa* Duch.). *Can. J. Plant Sci.* 50:249-255.
- Harris, R. E. 1970. Shrub rose 'Kakwa'. *Can. J. Plant Sci.* 50:357.
- Harris, R. E. 1970. Crabapple 'Arctic Red'. *Can. J. Plant Sci.* 50:11.
- Kirby, E. J. M., and Faris, D. G. 1970. Plant population induced growth correlations in the barley plant main shoot and possible hormonal mechanisms. *J. Exp. Bot.* 21:787-798.
- Nyborg, M., and Hoyt, P. B. 1970. Boron deficiency in turnip rape grown on Gray Wooded soils. *Can. J. Soil Sci.* 50:87-88.
- Pankiw, P., Bailey, L., Gochnauer, T. A., and Hamilton, H. A. 1970. Disinfection of honeybee combs by gamma irradiation. II. European foul brood disease. *J. Apicult. Res.* 9(3):165-168.
- Pankiw, P., and Corner, J. 1970. Production of package bees in southern British Columbia, Canada. *J. Apicult. Res.* 9(1):29-32.
- Tingle, J. N., Faris, D. G., and Ormrod, D. P. 1970. Effects of temperature, light, and variety in controlled environments on floret number and fertility in barley. *Crop Sci.* 10:26-28.
- van Adrichem, M. C. J. 1970. Assessment of winterhardiness in red raspberries. *Can. J. Plant Sci.* 50:181-187.

Miscellaneous

- Elliott, C. R., and Bolton, J. L. 1970. Licensed varieties of cultivated grasses and legumes. Can. Dep. Agr. Publ. 1405. 340 p.
- Elliott, C. R. 1970. Forage introductions. Northern Research Group Publ. 70-16. 16 p.
- Harris, R. E. 1970. Gardening on permafrost. Can. Dep. Agr. Publ. 1408. 16 p.
- Harris, R. E. 1970. The *Amelanchier*. J. Roy. Hort. Soc. HCV: Part III. p. 116-118.
- Pringle, W. L. 1970. Forages in the Peace. Cattleman 33(6):12-38.

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VISITING SCIENTIST

T. FUJISHIMA, B.A., M.A., D.A.
National Research Council postdoctorate
fellow September 1969 to August 1970

Poultry genetics

INTRODUCTION

This report is a summary of the results of our research activities in 1970. Details are available on request.

Interest is extremely high in our evaluation of some of the newly imported European breeds of cattle. Cattle breeders and feeders, many from the United States, are following closely the performance of the crosses of these new breeds on the traditional British beef breeds, the Hereford, Angus, and Shorthorn.

Beef producers, and consumers as well, are also keenly interested in our research on methods of measuring and predicting the relative value of individual carcasses.

This interest is appreciated and gratifying.

Dr. Tohru Fujishima returned to Japan with his family in September 1970, having completed a 2-year National Research Council postdoctorate fellowship in livestock genetics research with us.

Dr. Jorgen Mandrup Jensen, Research Leader, Biochemical Section, Danish Meat Research Institute, Roskilde, Denmark, spent a 2-week period at Lacombe studying our research program in quantity and quality evaluation of beef carcasses.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Control vs. select line feedlot performance of beef cattle. Bulls from the select line grew faster (1.16 kg/day vs. 1.08 kg/day) and at the same average age had heavier average slaughter and carcass weights than bulls from the unselected control population. No significant differences in carcass composition were detected between lines, and chemical composition and tenderness evaluation of selected muscles were equivalent. Select line carcasses yielded on the average 6.2 kg more prime cuts and 5.0 kg more total lean from the prime cuts than did carcasses of the same age from the control line. Muscle-to-bone and muscle-to-fat ratios in the prime cuts were the same for both lines.

Foreign cattle breed evaluation. Preliminary results are available from records of 563 Charolais-sired and 515 Simmental-sired calves produced in 27 commercial cow herds under contract. Gestation interval averaged close to 285 days, birth weight 85 lb, and weaning weight 500 lb. No differences attributable to breed of sire have been detected, but there are meaningful differences among sire progenies within breed of sire. Feedlot performances show that the Charolais-sired and Simmental-sired calves are very similar in feedlot gain and carcass traits.

Carcass Research

Characteristics of commercial beef carcasses in Canada. With 26,368 steer and heifer carcasses, grade differences in rib-eye area were negligible, but carcasses graded Good had approximately 25% less fat over the rib eye than those graded Choice. Females averaged 54 kg lighter in carcass weight than males, but when compared on an equal weight basis had approximately the same rib-eye area and slightly greater fat over the rib eye. In the six carcass traits studied, regional differences were negligible for both sexes.

Characteristics of youthful beef carcasses in relation to weight, age, and sex. With 168 steer, 147 heifer, and 259 bull carcasses, there were minor but statistically significant sex differences in percentage of hide, percentage of shank, and percentage of head, with steers > bulls > heifers. Heifers had more and steers less kidney fat than bulls. Bulls dressed approximately 1% higher than steers and heifers 1% lower. Total recorded slaughter loss expressed as a percentage of carcass weight decreased slightly with increasing slaughter weight, but slaughter weight accounted for less than 5% of the variance in dressing percentage. Age independent of slaughter weight had little influence on any of the traits studied.

Carcass weight was the only factor that influenced carcass length, leg length, depth at

flank and rib, and thickness and width of round, all of which increased with increasing weight. Sexes compared at the same weight were identical in all these measurements. There was a tendency for percentage of hindquarter to decrease and percentage of plate and flank to increase with increasing weight, but the influence of weight was not statistically significant. Sexes compared on an equal weight basis were similar in carcass proportions, although bulls had a slightly higher percentage of chuck and forequarters and heifers had the lowest percentage of shank. Sex and source of stock were the main contributors to differences in carcass composition. At equal weight, heifers had an average of about 20% more fat cover over the ribs than either bulls or steers. Because of less bone, however, they were virtually equivalent to steers of the same carcass weight in proportion of boneless defatted product. Entire males were superior to steers in lean content, averaging approximately 10% greater in rib-eye area, 30% less in fat cover over the rib, and 3% greater in proportion of boneless defatted product.

Feedlot costs in relation to fatness in beef. With 66 steers and 179 bulls, fatter carcasses tended to have higher dressing percentages and lower cooler shrink. They were also longer on feed, consumed more feed daily, and required more feed per unit of lean produced. With both sexes the leaner animal provided the greatest proportion of retail product per unit of live weight. Over the range of carcass fatness in this test, carcass value decreased by 15% to 20% as fat increased, and feed costs increased by 13% or more. This experiment was conducted in cooperation with the Research Station at Lethbridge, Alta.

Prediction of lean yield of beef carcasses. Simple carcass measurements were used singly and in multiple regression to predict lean meat content. With 149 bull carcasses slaughtered at approximately 14 months of age, significantly larger average loin-eye area measurements and smaller average rib-fat measurements were obtained at the 12th-13th rib face than at the 11th-12th rib face ($P \leq 0.05$). Fat measurements taken at the 12th-13th rib were more highly related to lean yield at all levels of trim (closely trimmed, bone-in, and boneless) than were fat measurements taken at the 11th-12th rib.

Two intrascop measurements of the subcutaneous fat taken on unribbed carcasses and used in multiple regression had predictive value equivalent to the sum of three rib-fat measurements at the 12th-13th rib. Rib-fat measurements plus loin-eye area provided equations that predicted carcass yield with good precision. Inclusion of carcass weight in the equation improved precision slightly. Inclusion of percentage of kidney fat was of no value. Maximum precision was achieved by including the percentage of variable trimmed round.

Tenderness in beef. Tenderness was evaluated subjectively by means of a six-member taste panel and objectively with a Warner-Bratzler shearing device, on a sample of 69 beef carcasses. With both methods, steak at the 11th-12th rib were significantly more tender than steak farther back along the loin. There was considerable within-steak variation, which was of a systemic nature, cores from the region of the backbone being significantly more tender than cores located toward the lateral edge of the rib-eye. Between-carcass variation was much larger than the variation within carcasses, and important differences in tenderness between steaks from bulls of very similar background were established. All measures of fatness: intramuscular, intermuscular, and subcutaneous, were positively correlated. Correlations with tenderness evaluations were significant for percentage of intramuscular fat only. These were not large, however, and the variation in fat accounted for less than 10% of the variance in tenderness.

Detection of taint in pork. A simple technique that requires an instrument like an electric soldering gun has been devised for instantaneous detection of undesirable cooking aromas associated with some pork carcasses. The method was tested by rating the aroma given off from the fat of carcasses from boars, gilts, and cryptorchids followed by a taste-panel evaluation of steaks from these carcasses. The results demonstrated that individuality of taste has an important bearing on reaction to flavor in pork. They also demonstrated that the hot-iron technique was as effective as actual taste-panel evaluation in detecting taint.

Physiology

Blood characteristics and carcass composition in swine. Barrows and gilts differed in the relationship between certain blood characteristics and carcass composition. For gilts ($n = 21$) statistically significant correlations of .63 and -.50 were obtained for red-cell volume with percentage of protein and percentage of fat respectively; red-cell volume was identified as the most useful predictor of protein content. For barrows ($n = 23$) these correlations were not significant and the percentage of protein was best predicted by backfat thickness. In both sexes backfat thickness was the most important factor for predicting percentage of fat.

Endocrine studies with poultry. Compared with a control (unselected) population, adult birds of two strains selected for increased egg production had smaller thyroids, smaller anterior pituitaries, and larger adrenal glands. Response to gonadotrophin, measured as the change in the weight of chick testis after injection of the equivalent of 3 mg fresh anterior pituitary, was 20.6% greater ($P < 0.10$) for the selected lines.

Body composition in poultry. Selection for increased egg production resulted in a significant decrease in body weight and significant differences in body composition. Percentages of protein and moisture were higher and percentage of fat lower in the selected strains than in the control. This suggested that selection caused a shift toward greater use of feed energy for egg production and less transfer into body storage.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Random oats licensed. Some 31,000 kg (2,000 bu) of seed of Random oats will be distributed to seed growers in the Canadian prairies for planting in 1971. This variety, a selection from the cross Glen \times Pendek, was developed at Lacombe; it is medium in days to maturity and has short, strong straw. From 1967 to 1969 it outyielded all varieties in the Western Cooperative Oat Tests, including several that matured later. It lacks resistance to the smuts and stem rust, but is somewhat

resistant to crown rust and is highly resistant to gray speck.

Progress in barley breeding. A selection from the cross Harlan \times Wolfe gave top yields from 1966 to 1970 on the Black and Gray soils of central Alberta. Through backcrossing, reconstituted Jubilee selections have been developed that are resistant to scald, net blotch, and loose smut. Promising short, strong-strawed selections with good yield and promising malting quality are entering advanced stages of testing.

Net blotch of barley. In the absence of polyphenol oxidase, β -glucosidase and phenylalanine-ammonialyase were activated upon infection. Activity of these enzymes increased the level of phenolic compounds often found in diseased leaves. Marked increases in peroxidase activity were shown to be associated with an increase in staining activity of existing isozyme bands rather than the increase in number of such bands when barley leaf peroxidase protein is separated by electrophoresis.

Root rot of barley. The beneficial effects of fertilizer N and P in reducing common root rot in barley were again demonstrated. Stubble-sown wheat and barley continued to show less common root rot than summerfallow-sown crops. A survey in central Alberta in 1970 suggested that root rot caused yield losses ranging up to 20%.

Effect of seed size and seeding depth on early growth of cereals. In greenhouse tests shallow seeding (2.5 cm) produced heavier initial leaves of wheat, oats, and barley than deep seeding (7.5 cm). In barley and wheat the initial leaves were shorter when the seeding was shallow, but the length of the initial leaf of oats was not influenced by depth of seeding. Seminal root weights decreased with increased depth for all crops. Large and medium-sized seeds produced seedlings with heavier, longer leaves and heavier roots at all depths of seeding.

Forage Crops

Fertilizers for creeping red fescue on Gray Wooded soils. Forage and seed yields of creeping red fescue were not affected by sulfur application of 11 and 22 kg/ha at two locations on Gray Wooded soil. Nitrogen, applied at 56, 112, and 224 kg/ha, gave a significant increase in seed yield at 112 kg.

There was no significant difference between fall (mid-September) and spring application.

Northern anthracnose of red clover. *Kabatella caulivora* (Kirchn.) Karak. was shown to lose viability when inoculum was produced by standard methods, but by using low temperatures, acidic media, and younger cultures, viable spores were produced. Isoflavones, released when red clover is injured, inhibited the growth of *Kabatella*, and they appeared to be a factor in the resistance to northern anthracnose.

Mycodiplosis impatientis on clover rusts. Larvae of small flies identified as *Mycodiplosis impatientis* Felt. were found feeding on uredospores of clover rust, caused by *Uromyces trifolii* (Hedw. f. ex DC.) Lév., on alsike and white clover. Investigations indicated that spore numbers were not reduced sufficiently to be of importance in limiting the severity of rust.

Horticultural Crops

Cabbage varieties. Little Leaguer showed more resistance to splitting when planted early than Viking Extra Early or Golden Acre. Viking Extra Early and Golden Acre required 4 and 7 days longer than Little Leaguer to reach marketable stage. Comparative head weights for the season were: Little Leaguer, 0.9 kg; Viking Extra Early, 1.5 kg; and Golden Acre, 2.2 kg.

Frost injury to woody ornamentals. Immediate injury to woody perennials from a reading of -7.5 C on June 12, 1969, varied from complete defoliation to leaf injury of varying degrees. A red oak was completely defoliated and recovered satisfactorily, but suffered 80% kill back the next winter. Some specimens of bur oak and all green ash were defoliated, but recovery was complete. Ten-year-old stands of Colorado blue spruce suffered 90% damage, but white spruce showed only 3%. Recovery in 1970 was good, but multiple heading occurred where apical shoots were frozen.

CROP MANAGEMENT AND SOILS

Soils

Nitrogen fraction and enzymatic activity in a Gray Wooded soil as influenced by long-term cropping systems and fertilizer. Protein materials in the soils formed under different cropping and fertilizer programs for 40 years were similar in their amino acid composition. However, the quantities were altered somewhat by the kind of crop. The dehydrogenase, urease, catalase, phosphatase, and invertase activities in soils under the long-term grass-legume rotation were significantly greater than those under a wheat-fallow rotation. Manure, and NPKS and NS fertilizers, also increased enzyme activity but to a lesser extent.

Organic matter association with soluble salts. The water-soluble organic matter obtained from a Black Solonetzic soil consisted of two molecular-weight fractions. Relatively small quantities of Na and SO_4 and no Ca and Mg were associated with the high molecular weight fraction (mol wt $> 10,000$). However, appreciable amounts of Na, Ca, Mg, and SO_4 were found in the lower molecular weight fraction (mol wt $< 10,000$).

Distribution of N in the Black Solonetzic and Black Chernozemic soils of Alberta. The acid hydrolysates of the water extracts of the horizons showed higher values for the molar distribution of threonine, serine, glycine, and alanine and lower values for aspartic acid and glutamic acid than composites of the same soils; the amounts of free amino acids in these extracts were very small.

The data suggest that the differences in salt regime in the Solonetzic, Solodic, and Chernozemic soils affect the microflora or the activity of enzymes, thereby inhibiting the conversion of organic N compounds into forms more available for plant growth.

Effect of seedbed preparation on soil aggregation, surface moisture, and yield. In a 3-year study at four soil sites in Western Canada, the erodible aggregates increased in the surface 2.5 cm of undisturbed soil as initial tillage was delayed for 1 to 3 weeks after the soil could first be worked. Changes in erodible material due to initial tillage were minimal, but after secondary tillage there was an increase in erodible material at each site. The differences in soil aggregates, moisture loss, and crop yield were rather small,

but were inconsistent between years and location.

Soil test for sulfur. Water-soluble sulfate in the 0 to 15-cm surface layer of 150 soils was found to be 90% accurate for predicting the S fertilizer requirement of the legumes alfalfa, alsike clover, and red clover growing on these soils. Water-soluble sulfur (HNO_3 oxidation of the extract) was equally effective. A slight improvement in prediction accuracy was obtained by sampling the soils to a depth of 30 cm; deeper sampling did not increase accuracy.

Selenium content of forage species. The low level of Se reported in some Alberta soils last year was confirmed this year. All the alsike clover, red clover, timothy, and brome-grass samples and two-thirds of the alfalfa samples in the 2 years (over 130 in all) contained less than 0.1 ppm Se. Over 75% of the alsike, red clover, and timothy, 40% of the brome-grass and 12% of the alfalfa samples contained less than 0.02 ppm Se. Average Se levels decreased in the order alfalfa > brome-grass > alsike > red clover > timothy.

Weed Research

Weed control in rapeseed. Trifluralin at 840–1120 g/ha sprayed on the soil and disked in immediately to a depth of 5 cm before seeding rapeseed in the spring was used to a limited extent for the first time by farmers to control wild oats, green foxtail, lamb's-quarters, and hemp-nettle. Fall application on stubble, which had been double-disked before spraying and disked immediately after spraying, gave control of these species equal to the spring application. Fall application avoided the serious drying out of the surface soil by the tillage that was needed to incorporate the herbicide, especially on stubbled-in land.

Competition between barley and wild oats as affected by N, barban, and time of seeding. Number of culms and yield of barley were increased by N and barban in both the growth-chamber and field experiments, but were increased by each delay in seeding in the growth chamber only. Culms and yield of

wild oats were increased by N in the growth cabinet, and were decreased by barban and delayed seeding in both experiments. Competition between the two species growing together is demonstrated by reciprocal relationships between number of culms and yield of the two species. The close agreement between the two tests suggests that short-term growth-chamber experiments can be used to predict competitive and nutrient stresses in the field.

Optimum levels of fertilizer N were calculated by the method of Heady and Dillon. Where barban was not applied, the optimum level of N was 22.7 kg/ha and the yield of barley was 1378 kg/ha. When the wild oats were controlled with barban, the optimum level of N was 53.2 kg/ha and the barley yield was 2142 kg/ha.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Simulated deep plowing. Mixing the Ap, Bn, and Csk horizons of four central Alberta Solonetz soil types to simulate deep plowing resulted in greater growth of alfalfa than from the Ap horizon alone on two of the four soils. Leaching the mixtures resulted in lower alfalfa yields. Mixed horizons had higher infiltration rates and lower breaking strengths than the Bn horizon.

Long-term fallow of Solonetz soil. There were unexpected results when land that had been fallowed for a number of years was seeded to a mixture of brome-grass and alfalfa with barley as a nurse crop. There was, as expected, a great beneficial effect of fallowing on the barley crop. This was expected to rapidly disappear, but it was still very apparent in the hay crop after 4 years of continuous cropping.

Analyses of crop and soil samples showed an increase in soil N, attributable to long-term fallowing, of over 75 and 40 kg/ha per year in the A and B horizons, respectively. Because no significant quantities of soluble N have been detected in the groundwaters of these soils, it would appear that there was nonsymbiotic fixation of an unusually large quantity of N during the fallow period.

PUBLICATIONS

Research

- Berkenkamp, B. 1969. Viability of *Kabatiella caulivora*. Can. J. Bot. 47:453-456.
- Cairns, R. R. 1969. Canadian Solonetz soils and their reclamation. Agrokem. Talajtan Tom. 18:233-238.
- Cairns, R. R. 1970. Effect of Solonetz soil horizon mixing on alfalfa growth. Can. J. Soil Sci. 50:367-371.
- Cairns, R. R. 1970. Effect of long-term fallow on Solonetz soil and crop rotation. Can. J. Soil Sci. 50:449-452.
- Doornenbal, H., and Frankham, R. 1970. A comparison of blood characteristics and backfat thickness as predictors of carcass composition of market weight pigs. Can. J. Anim. Sci. 50:617-620.
- Doornenbal, H., Frankham, R., and Weiss, G. M. 1970. Physiological differences associated with genetic differences in egg production. II. Gross chemical composition of the body. Poultry Sci., Nov.
- Frankham, R., and Doornenbal, H. 1970. Physiological differences associated with genetic differences in egg production. I. Organ and endocrine gland weights. Poultry Sci., Nov.
- Frankham, R., and Doornenbal, H. 1970. Physiological differences associated with genetic differences in egg production. III. Gonadotrophin sensitivity. Poultry Sci., Nov.
- Fredeen, H. T. 1970. Beef carcass value and production costs in relation to grade standards. Canada's Beef Industry. Canadian Agricultural Economics Society Proceedings. p. 127-139.
- Fredeen, H. T. 1970. Programs to utilize breed differences. Proceedings, Regional Beef Cattle Breeding Technical Committee, USDA.
- Fredeen, H. T., and Weiss, G. M. 1970. Some characteristics of commercial beef carcasses in Canada. Can. J. Anim. Sci. 50:227-234.
- Jarmoluk, L., Martin, A. H., and Fredeen, H. T. 1970. Detection of taint (sex odor) in pork. Can. J. Anim. Sci. 50:750-752.
- Keys, C. H., Anderson, C. H., Bowren, K. E., and Dew, D. A. 1970. Effect of seedbed preparation on soil aggregation, surface moisture and crop production. Can. J. Soil Sci. 50:347-352.
- Khan, S. U. 1970. Enzymatic activity in a gray wooded soil as influenced by cropping systems and fertilizers. Soil Biol. Biochem. 2:137-139.
- Khan, S. U. 1970. Humic acid fraction of a gray wooded soil as influenced by cropping systems and fertilizers. Geoderma 3:247-254.
- Khan, S. U. 1970. Effect of moisture variation on sulfate concentration in a black solonetz soil. Soil Sci. Plant Analysis Comm. 1:7-12.
- Khan, S. U. 1970. Organic matter association with soluble salts in the water extract of a black solonetz soil. Soil Sci. 109:227-228.
- Khan, S. U. 1970. The effect of moisture variation on some characteristics of a black solonetz soil. Z. Pflanzenernaehr. Bodenk. 124:253-258.
- Khan, S. U. 1970. Interaction of metallic cations with humic acids extracted from a solonetz-solod-black soil sequence in Alberta. Z. Pflanzenernaehr. Bodenk. 127:121-128.
- Martin, A. H., Fredeen, H. T., and Newman, J. A. 1970. Live performance and carcass characteristics of beef bulls in relation to selection for yearling weight. Can. J. Anim. Sci. 50:491-498.
- Martin, A. H., Fredeen, H. T., and Weiss, G. M. 1970. Effects of sampling location and carcass fatness on tenderness of steaks from the *longissimus dorsi* of yearling Shorthorn bulls. Can. J. Anim. Sci. 50:235-242.
- Martin, A. H., Fredeen, H. T., Weiss, G. M., and Newman, J. A. 1970. Prediction of lean yield of beef carcasses. Can. J. Anim. Sci. 50:31-42.
- McBeath, D. K., Dew, D. A., and Friesen, H. A. 1970. Competition between barley and wild oats as affected by nitrogen, barban and time of seeding. Can. J. Plant Sci. 50:541-550.
- McFadden, A. D. 1970. Influence of seeding dates, seeding rates and fertilizers on two cultivars of barley. Can. J. Plant Sci. 50:693-699.

Miscellaneous

- Berkenkamp, B. 1969. Mycoidiplosis (Diptera: Cecidomyiidae) feeding on clover rust (*Uromyces trifolii*) spores. Can. Plant Dis. Surv. 49:65.
- Dew, D. A. 1968. Agricultural potential of peat soils in Alberta. Proceedings of the Third International Peat Congress, Quebec, Canada. p. 258-260.
- Piening, L., Edwards, R., and Walker, D. 1969. Effects on some cultural practices on root rot of barley in central Alberta. Can. Plant Dis. Surv. 49:95-97.

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J. WEINTRAUB, B.A., M.S.	Physiology (reproduction)

Departures

L. J. SUMPTION, B.S., M.S., Ph.D. Resigned January 30, 1970	Beef cattle breeding
R. W. SALT, B.Sc., M.S., Ph.D. Retired December 30, 1970	Insect coldhardiness

VISITING SCIENTISTS

M. D. KRUNIC, B.S., M.S., Ph.D. National Research Council postdoctorate fellow	Forage crop insect pollinators
C. BOULARD (Miss), Ph.D. National Research Council grant	Warble grub host-parasite relationship

INTRODUCTION

This report reviews briefly the main accomplishments in 1970 in the widely diversified fields of research conducted at the Research Station, Lethbridge. Detailed information can be obtained from the scientists or from the publications listed herein.

Reorganization was completed of all Station research under mission-orientated programs to facilitate group action by teams of specialists from many disciplines. New programs were established in pollution control relating to the biological disposal of animal and crop wastes, the management of pesticide residues to avoid contamination of the environment or agricultural products, and the accumulation of plant nutrients in the soil. Activities were increased to develop new crops or enterprises to replace those now surplus.

Research results have enabled field corn to become established as an economic crop on irrigated land. A new, creeping-rooted, wilt-resistant, winter-hardy alfalfa variety was developed and licensed under the name of Kane.

The Station was host to an advanced study institute on "Toxicity of pesticides used on livestock" sponsored by NATO. Station staff cooperated with the Lethbridge Community College, University of Alberta, and the Alberta Department of Agriculture by participating in numerous farmer short courses and vocational training programs.

J. E. Andrews
Director

ANIMAL SCIENCE

Poultry

Energy value of feeds. Adding up to 10% acidulated rapeseed-oil soap stock or animal tallow to a poultry ration increased the energy level of the diet and resulted in improved weight gains and feed efficiency. Supplementation with either energy source over 10% did not improve growth over that obtained with 10%, but did improve feed efficiency. No differences in either growth or feed efficiency due to energy source were significant. Supplementation with 10% tallow and 5% soap stock significantly reduced growth rate below that obtained with the 10% levels of supplementation. The results indicated that the energy values of the two supplements were about equal.

Sheep

Sheep crossbreeding. Suffolk surpassed the Romnelet, Columbia, and N.C. Cheviot in weaning weight by 4.1-5.9 kg (9-13 lb), in final market weight by 5.4-8.6 kg (12-19 lb), and in weight/day of age by 32-50 g (0.07-0.11 lb). Twelve single crosses were produced, but only two excelled the Suffolk in performance; these differences were not significant. Single crosses had a 4-5% higher

performance in the four traits and three-breed crosses had 7-18% higher performance than that of the pure breeds.

Genotype-sex interactions. Analyses of genotype-sex interactions showed that they were not significant for any of the 11 traits studied. Genetic correlations of each trait between sexes were not significant either. These results indicate that genotype-sex interactions are not likely to be important in formulating breeding plans.

Beef Cattle

Selection in crossbred and straightbred populations. "The Breed" (Brown Swiss × Hereford and Holstein × Hereford cattle intermated) bull calves that completed a performance test in 1970 gained 11% faster and weighed 18% more than Hereford controls at 1 year of age. "The Breed" heifer calves fed a maintenance ration were 32% heavier than comparable controls at 1 year. Of the calves of "The Breed" the bulls were 33% and the heifers were 30% heavier at weaning than control calves.

Protein for wintering calves. A protein supplement containing 13% urea and 6% fat was provided free choice to calves fed a basal ration of equal parts of straw and grass hay. Intake of the supplement was about 0.85 kg/head per day. The daily gain of 0.13 kg was

similar to that of calves fed the same roughage with 0.45 kg of a commercial type protein supplement per day. The chief advantage of the high urea supplement is that it can be self-fed. This could lead to greater protein supplementation on range in the fall and winter when the protein content of the forages is low.

Precipitation of silicic acid by urine protein. Silicic acid precipitated from solutions containing silicic acid, protein, and salt, but did not precipitate when salt was absent. It precipitated in the absence of protein only at the highest concentrations of silicic acid and salt and at the highest pH. The amount of precipitate formed increased as the concentration of each constituent increased. As the concentration of salt increased, the amount of precipitate formed tended to be greatest at an even higher pH value. The ratio of protein to silicic acid in the precipitates was related to that in the original mixtures. These results suggest that urine protein contributes to the formation of siliceous urinary calculi by affecting the solubility of silicic acid in urine.

Urea and biuret supplement for wintering cows. A basal ration of barley straw fed ad libitum and 3.1 kg alfalfa hay fed once weekly supplemented with 6.5% urea, 6.5% biuret, and 3.0% fat in a barley base fed to appetite (1.85 kg/head per day) maintained pregnant cows as well as the basal ration with a supplement of 2.15 kg/head per day of barley and dried molasses beet pulp.

Beef female performance. At 180 days of age male calves ranged in body weight from 43% to 55% and female calves from 29% to 48% of the weight of their dams (2-year-old heifers) at calving. Nutrient intakes of the dams together with their calves for the 180-day period were 1,135 to 1,750 kg of digestible dry matter and 138 to 242 kg of digestible protein. These amounts represent 5.9 to 9.9 kg of digestible dry matter per kilogram of calf weaned or 7.1 to 13.3 kg of digestible dry matter per kilogram of calf gain from birth to 180 days of age.

Pelleted whole barley feedlot ration. Bulls fed a pelleted all-concentrate ration containing 50% whole barley gained 1.22 kg per day and had a feed-to-gain ratio of 5.7:1. The addition of good-quality long alfalfa hay (0.38 kg/head daily) made no difference in daily gains or feed efficiency. Adding 10% or 20% alfalfa to whole barley pellets increased

feed intake, but made no difference to rate of gain in beef heifers.

PLANT SCIENCE

Cereals

Chromosomes of spring wheats and winter-hardiness. A pair of chromosomes 5A of Rescue spring wheat substituted for the 5A chromosomes in Cadet spring wheat made the substitution line more resistant to freezing than Cadet. The reciprocal substitution line of Cadet 5A chromosomes into Rescue was less hardy than Rescue. In descending order of hardiness the 5A substitutions and the cultivars were: Cadet-Rescue 5A, Cadet, Rescue, and Rescue-Cadet 5A. The mode of action of the genes of Rescue chromosome 5A in promoting winterhardiness was not determined.

Root rot resistance in winter wheat. In the wheat breeding program 16 winter wheat cultivars, when tested in field soil in a controlled environment for resistance to common root rot, were all significantly superior to the susceptible spring wheat cultivar, Cypress. Resistance of five of the winter wheat cultivars equaled that of Thatcher, the resistant spring wheat control. Among the winter wheats, Comanche ranked highest in resistance to common root rot.

Wheat streak mosaic. The three *Agropyron* chromosomes that substituted for wheat chromosomes 4D, 5D, and 6D in a *Triticum-Agropyron* hybrid immune to wheat streak mosaic virus (WSMV) have been isolated in individual disomic substitution lines in the cultivar Rescue. All three lines are fertile. The AD substitution line is short and susceptible to WSMV; its seeds have blue aleurone. The 5D line has a slender spike, and is completely awnless, vigorous, and probably immune to WSMV. The 6D line is vigorous and not morphologically distinct from Rescue; it probably has no resistance to WSMV.

Low-dosage irradiation of cereal seed. Reports on a number of crops indicated that irradiation of seed could affect yield, maturity, and other characters of the resulting plants. To determine if irradiation affected the agronomic characters of spring wheat and barley, seed of Manitou and Pitic wheat

and Herta and Conquest barley was subjected to 100, 300, and 1,000 rad in 1969, and seed of Pitic wheat and Galt barley to 100, 300, 1,000, and 2,000 rad in 1970. The wheat plants from the irradiated seed did not differ significantly from the controls in either of the 2 years. There was an indication that the 1,000-rad irradiation may have increased the yields of both varieties of barley in 1969, but it had no effect in 1970.

Field corn for southern Alberta. Through evaluation trials several corn hybrids suitable for grain or silage in southern Alberta were identified. On irrigated land early planted corn (April 22) matured earlier and yielded more than late-planted corn. Yields of both grain and silage increased with increasing plant populations up to 173,000 plants/ha (70,000/acre), but maturity was delayed and lodging increased at higher populations. On dryland summerfallow highest grain yields (3,264 kg/ha; 52 bu/acre) were obtained from 50,000 plants/ha (20,000/acre). Ear and kernel size decreased as population exceeded 25,000 plants/ha.

Forage Crops

Alfalfa cutting practices have carry-over effects. Forage yields and vigor of irrigated Beaver alfalfa were reduced in 1970 as a result of taking fall (third) cuttings between August 27 and October 8 in the previous year. Early fall cutting was more deleterious than late fall cutting. Taking the first two cuttings at the early bloom stage rather than the bud stage also depressed yields the following year, regardless of the date of the third cutting. The length and time of year of the regrowth period after a second cutting appeared to strongly affect stand survival and plant vigor.

Root zone competition between grass and clover. In a greenhouse with an ambient air temperature of 22 C vegetative growth of orchardgrass exceeded that of white clover when the soil temperature was 7 C. At soil temperatures of 12, 20, and 26 C clover growth exceeded that of orchardgrass. Though the clover roots were well nodulated, grass yields were the same whether roots of the two species were associated or separated. Added N had no effect on clover yields. Seedling growth of clover was enhanced by N at a soil temperature of 7 C but not at higher temperatures.

Long-term grazing effects on Stipa-Bouteloua prairie soils. Heavy grazing of *Stipa-Bouteloua* prairie by sheep, compared with light or no grazing, caused a decrease in the pH of the soil from 6.4 to 5.8, a decrease in percent spring soil mixture, and an increase in percentage of total C, alcohol/benzene-extractable C, alkaline-soluble C, and polysaccharides. The changes were apparently caused by changes in amounts and kinds of roots resulting from species changes caused by grazing and increased amounts of manure deposited by sheep on the more heavily grazed fields.

Long-term grazing effects on fescue grassland soils. Very heavy grazing by cattle, compared with light grazing, resulted in the color of the Ah horizon changing from black to dark brown and the pH from 5.7 to 6.2. The available P and soil temperature increased, but the percentage of organic matter, total P, and soil moisture decreased. The changes appeared to be due to increased use of vegetation by cattle and hence increased erosion from the more heavily grazed fields.

Alfalfa breeding. A winter-hardy, bacterial-wilt-resistant, creeping-rooted alfalfa cultivar was developed and licensed under the name of Kane. In tests across Western Canada during the past 5 years it has yielded 7% more dry matter than Roamer. Its bacterial wilt resistance is equal to that of Beaver. It is adapted to normal dryland and irrigated soils throughout Western Canada.

Horticulture

Effects of a growth retardant on potato growth and development. Foliar treatment of Nette Gem potatoes with succinic acid-2,2-dimethylhydrazide, at three concentrations and three application times at and after full bloom had no apparent effect on vine growth. Only one treatment, 1,000 ppm applied at full bloom and again 1 week later, produced significantly higher yields than the untreated check. The most obvious effect of treatment was a change in the width-to-length tuber shape index, which decreased from 0.50 for tubers from untreated plants to 0.22 for those from the 2,000-ppm treatment.

Low-temperature tolerance in beans. In controlled-environment chambers two early

maturing bean cultivars, Limelight and Probatine, were more tolerant of low temperatures (12.5 C) than were Glamis and Tendercrop. Variations were observed at 12.5 C, but not at 18 C in the rate of germination, leaf expansion, flower-bud development, and pod set. This suggests that low temperature tolerance could be included in a variety improvement program.

Weeds

Weed control in sugar beets. Good to excellent control of mixed broad-leaved annual weeds and green foxtail was obtained from incorporated preplanting treatment with cycloate at 5.04 kg/ha (4.5 lb/acre), cycloate plus R-11913 (Stauffer Chemical Company) at 2.80 + 2.80 kg/ha (2.5 + 2.5 lb/acre), and cycloate at 3.36 kg/ha (3 lb/acre) followed by a postemergence application of phenmedipham at 1.68 kg/ha (1.5 lb/acre). Although phenmedipham alone controlled most broad-leaved annuals and green foxtail fairly well, it did not provide satisfactory control of redroot pigweed. An analogue of phenmedipham, EP-475 (Schering AG), gave better control of the pigweed but a reduction in the control of green foxtail.

Control of aquatic plants. Excellent seasonal control of the 12 most common rooted submerged aquatic plants found in standing water on the prairies was achieved with a 1:1 mixture of diquat and paraquat diluted and injected 60 to 90 cm underwater. Effective dosages ranged from 0.1 to 1.0 ppm depending on aquatic plant species present. Potential aquatic plant infestation the following year was reduced by application of a herbicide mixture before the formation of seeds and tubers of sago pondweed, *Potamogeton pectinatus* L., turions of green water milfoil, *Myriophyllum verticillatum* L., and northern water milfoil, *M. exalbescens* Fern., and dormant apices of coontail, *Ceratophyllum demersum* L.

Soil Fertility and Management

Fertilizer and irrigation practices for potatoes. Forty-four metric tons of potatoes per hectare were obtained by applying N at 224 kg/ha and P at 99 kg/ha and by maintaining the soil water in the upper 60% of the available range. Very high rates of fertilizer increased the proportion of cull tubers but not total yields. The use of mercury-manometer tensiometers proved very satisfactory for predicting irrigation needs.

Fertilization of grassland. Increasing rates of N fertilizer resulted in higher total N and NO₃-N content of six grass species. The insoluble protein N reached a maximum at about 550 kg/ha of N fertilizer and beyond this rate leveled out or declined slightly. As maturity of the grass advanced, the total and insoluble protein N content declined at all levels of N fertilizer. The NO₃-N followed the same pattern except that in three grass species it increased from heading to anthesis. N fertilizer increased the three N fractions in Russian wild ryegrass, *Elymus junceus* Fisch., more than in the other five species.

Dryland rotations. Twenty years of cropping with seven rotations involving combinations of fallow, wheat, grass, legume, and manure treatment has changed the nutrient content of a dryland Lethbridge loam. The organic matter and N contents of the soil remained highest where spring wheat was grown continuously and were depleted most severely under a spring wheat - fallow rotation. Total P and exchangeable K in the soil were highest under a fallow - spring wheat rotation that received 11.2 metric tons of manure/ha during the fallow year. The amount of available P in the soil actually increased under this manured rotation, which also produced the greatest amount of total digestible nutrients per hectare of land in the rotation.

Crop residue production and conservation. Production and conservation of residue during summerfallowing with a wide-blade cultivator were studied over 4 crop years with eight crops. Surface plant residue was measured each fall and spring during the summerfallow period. Reduction of residue during each overwinter period averaged 11% for the spring wheats and barley. Oats lost 10% during the first and 25% during the second

winter period. Winter wheat, fall rye, and flax lost 21%, 30%, and 39% during the first winter but less than 10% during the second winter period. Losses of residue during the tillage season averaged 18% for fall rye and flax, 25% for oats, 30% for spring wheat, and 47% for barley and winter wheat. Total losses ranged from 50% to 60% for all crops except barley and winter wheat, which lost about 70%. If materials that break down readily, such as winter wheat and barley residue, are used as a protective trash cover, they must be managed carefully to avoid excessive loss.

Root hairs and nutrition of the wheat plant. Exploratory studies have indicated a major difference in root hair development between S-615 and Chinese Spring cultivars of spring wheat. Disomic chromosome substitution lines of these cultivars have given an indication that several chromosomes may be associated with prolific root hair development. Research is under way to confirm this chromosomal association and to determine the importance of root hairs in the uptake of plant nutrients from the soil.

Irrigation and Drainage

Irrigation practices. An 8-year study showed that storage in the soil of overwinter precipitation was inversely related to the soil moisture content at harvest. Gains of soil moisture were directly related to spring precipitation but not to fall or winter precipitation. Fall irrigation is advisable, therefore, when soil moisture after harvest is in the lower half of the available moisture range.

Sprinkler irrigation for daily replacement of water loss or for environmental cooling when air temperature exceeded 26.7 C did not significantly change yields or quality of potatoes from those obtained with conventional irrigation practices. The numerous applications of irrigation water during the season deposited noticeable amounts of Na, Ca, and K on plant leaves, but did not affect crop productivity. Soil moisture was continuously higher where cooling was applied than where it was not, even though the same amounts of irrigation water, aside from cooling water, were used. This indicated that cooling inhibited evapotranspiration.

Water and salt movement. During the winter, upward translocation from shallow water tables to the upper 60 cm of the profile

totaled only 1 to 2.3 cm of water. Upward translocation above the 30-cm depth generally did not occur in soil that was dry before freeze-up. An increase in moisture at this depth could only be obtained by snowmelt or fall irrigation.

Studies of salt movement in irrigated soils indicated that the rate of water infiltration had no influence on the total downward migration provided that the same amount of water was applied.

Performance of soil drains. Tile and perforated corrugated flexible drains were equally suitable for drainage of either clay loam or sandy loam soils. In a clay loam the performance of lined mole drains was satisfactory, but unlined mole drains were not acceptable.

Soil Chemistry

Organic matter. The characteristics of humic substances extracted and purified by various methods often differed significantly between Ah horizons and between methods. This was particularly noticeable for such characteristics as N content and carboxyl acidity of the humic acids, and Si, Ca, and P content of the ash of the humic acids. High carboxyl acidities, as confirmed by infrared spectra, often existed notwithstanding high ash contents.

The total lipid phosphate content of 12 Chernozemic soils representing three great groups ranged from 0.089 to 13 μ g/g. Several distinctive fractions were obtained. A minimum clay content of about 30% was related to a shift in the amount and quality of the phospholipids present in these soils.

Clay - organic matter complexes. An ultrasonic method of separating clay - organic matter complexes from soil has been developed. Different batches of these complexes separated from the same soil have similar thermogravimetric and infrared spectral properties. Serial extraction of the same soil sample produces complexes with differing properties. Samples that resist extraction show a high-temperature peak, whereas those that extract easily do not. The same peak can be induced in the easily extracted complexes by precipitation with acid. This relationship appears to be a function of polymerization, or condensation, or both, of organic matter and seems to be strengthened by the presence of clay.

Microbiological activity. Substantially

higher phosphatase activity was found in soil containing growing plants that are dominant on overgrazed native grasslands than in soils with normal climax species of ungrazed or moderately grazed grasslands.

A comparison of the rhizosphere microflora characteristics of two spring wheat cultivars, Chinook and Apex, and a simulated root system made from nylon filaments conclusively demonstrated the ability of living plant roots to stimulate selectively or to depress segments of the soil microflora population.

Sodic soils. Experiments to clarify the effect of ammonium ions in reclaiming sodic soils confirmed that the addition of ammonium chloride increased the permeability. Colorimetric studies indicated that ammonium bentonite was less dispersed than sodium bentonite. These results would suggest that more ammonium than sodium ions were located in the Stern layer.

Reducing the pH of loam soil from 8.0 to 6.0 resulted in a sevenfold increase in water movement in the soil. This was apparently owing to a reduction in the exchangeable sodium (cation-exchange capacity) and the electrophoretic mobility properties.

Pollution control. Pollution of surface and groundwater by $\text{NO}_3\text{-N}$ from six feedlot sources was not found to be a problem. The $\text{NO}_3\text{-N}$ concentration in the groundwater immediately under two of the feedlots was high, but within 120 m most of the NO_3 had dissipated, apparently through denitrification and sorption by the soil.

Movement of $\text{NO}_3\text{-N}$ in soil under irrigation was greater in two fine-textured soils than in a coarse-textured soil. Differences in irrigation practices are thought to be responsible for these results.

VETERINARY-MEDICAL ENTOMOLOGY

Biting Flies

Mosquitoes. Embryonic development in eggs of *Aedes vexans* (Meigen) and *A. dorsalis* (Meigen) was complete within 5 days at 20 C on a moist substrate after oviposition. Only a portion of the eggs hatched during a single exposure to an optimum hatching

medium. Intermittent desiccation at 4 C stimulated eclosion in additional portions of unhatched eggs. Because larval development is optimal at 25 C and is completed within 7 days, mosquito control had to be started within 1 week of the first flooding of oviposition sites.

New pests. *Culicoides yukonensis* Hoffman was identified as a serious pest causing concern in new areas of residential and industrial development at Fort McMurray, Alta. It abounded throughout the summer.

Western Encephalomyelitis

Inoculations in colts with Eight-Mile Lake strain of virus produced maxima in circulating antibodies within 16–42 days. A nonspecific inhibitor of western encephalomyelitis virus was detected in two of the six colts inoculated. Circulating antibodies in indicator chicken flocks have shown a continuing focus for the disease at Eight-Mile Lake near Lethbridge since 1964. No virus activity was detected in areas extending northward to Fort McMurray in Alberta.

Ectoparasites

Host resistance. Acquired resistance developed by mice to the mouse louse, *Polyplax serrata* Burm., was characterized by arteriolar vasoconstriction in the skin. The lice were prevented from feeding by the resulting reduced blood flow and either failed to develop or died. This host-parasite mechanism was similar to that produced by the sheep ked, *Melophagus ovinus* (Linnaeus), in sheep.

Warble Flies

Aggregation behavior. Up to 80% of released laboratory-bred males of *Hypoderma bovis* (L.) and *H. lineatum* (de Villers) were resighted or recaptured at a previously discovered *H. bovis* male aggregation site within 2 hr after release. Males released near locations with similar physical and topographical characteristics failed to return to the release site. Male aggregation sites are highly characteristic in some way but not specifically exclusive.

Serology. Precipitating antibodies to *H. lineatum* were identified in the sera of infected cattle. Their occurrence was not correlated with host age or previous infections. Anaphylaxis caused by hypodermatoxin produced

some of the toxic symptoms that are observed in infected cattle after treatment with systemic parasiticides.

Pesticides

Pest control. Low-volume dermal application of 12% formulation of crufomate or a 20% formulation of fenthion gave highly effective systemic control of cattle grubs *H. lineatum* and *H. bovis*. Acute esophagitis was associated with use of both pesticides in cattle, however, if gullets were infected with *H. lineatum* at the time of treatment.

Warble eradication. A further decline was observed in numbers of grubs in cattle in the County of Wetaskiwin. Organized chemical treatment of the total cattle population was achieved during 1969 and 1970. As a result of successful grub control in the County of Wetaskiwin, the Warble Eradication Program has been expanded to include several other counties in central Alberta.

Toxicology. Cattle treated with coumaphos, phosmet, and trichlorfon developed acute esophagitis when infected with esophageal grubs. Esophageal lesions appeared to be caused by proteolytic enzymes released from dead larvae and severe lesions were caused by the rapidly acting compounds. Advance of the deadline to October 30 for grub-control treatments should reduce the incidence of systemic side effects in southern Alberta.

Residues. Chemical residues in the fat of yearling cattle treated with DDT at the minimum frequency required for effective fly control and then fed to finish at 450 kg exceeded the tolerance of 7 ppm at slaughter. Fly control with DDT must be limited to three treatments with supplementary use of nonresidual pesticides during the summer grazing period to prevent buildup of residues above actionable levels in prime slaughter animals.

PLANT PATHOLOGY AND PHYSIOLOGY

Cold Hardening of Wheat

Differences in the properties of invertase from hardened and unhardened Kharkov 22 MC winter wheat suggest that the protein responsible for invertase activity is changed during hardening. Knowledge of the basis of

this difference should reveal one of the biochemical mechanisms involved in the hardening process. There are several possible bases for this difference such as changes in the relative proportions of the different structural isozymes present, dimerization of the protein, binding of the protein with some substance that modifies its properties, and changes in conformation of the invertase. Distinguishing between these alternatives requires purification of the invertase and separation on a preparative scale of the invertase isozymes present, if such exist. During the past year purification of the enzyme has shown that invertase from unhardened leaves consists of several isozymes that differ in molecular weight and isoelectric points. These differences have been used to separate the isozymes.

Alfalfa and Turf Diseases

An ectoparasitic nematode, *Paratylenchus projectus* Jenkins, was found to be associated with an alfalfa reestablishment problem (alfalfa sickness) in central Alberta. Soil containing 2,000 nematodes/kg produced poor seedling growth in glass frames. Sainfoin was not affected by the stem nematode, *Ditylenchus dipsaci* Kühn, beyond the seedling stage. An antagonistic strain of the alfalfa wilt bacterium was not transmitted to alfalfa by the stem nematode. Good differential infection was obtained on selections of alfalfa being tested for resistance to winter crown rot. In 15 strains of sainfoin assessed for susceptibility to winter crown rot, infection ranged from 36% to 77% indicating some lines were more resistant than others.

In an experiment conducted over 3 years with electrically heated turf at Banff, Alta., air temperatures and persistence of snow cover varied greatly. Yearly power consumption to maintain required soil temperature averaged 395 kw hr/93 m² (1,000 ft²). Heated turf had growth in April comparable to that of unheated turf in June.

Crop Residue

A naturally occurring toxin that affects cereal crops was found primarily in the stems, branches, and roots of rape plants. The toxin was readily leached from the residue and was quite stable in soil. A second cereal crop on rape stubble was not adversely affected, but the growth of an oat cover crop, sown about 1 year after the rape was harvested,

was stunted. The initial leachate from partially green residue (the condition it is usually in when the crop is harvested) stimulated the growth of wheat. Subsequent leachates up to at least 24 weeks were phytotoxic.

Barley was the most tolerant and rye the most adversely affected by the phytotoxin; wheat and oats were moderately and about equally susceptible.

Resistance to Common Root Rot

An integrated approach comprising cytogenetics, soil microbiology, and plant pathology is being followed in investigating the mechanisms involved in the reaction of wheat to common root rot. Bacteria, antagonistic in vitro to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, were isolated from the rhizosphere of the root-rot-resistant chromosome substitution line, S-A5B, and its resistant donor parent, Apex (A), but none from the rhizosphere of the susceptible recipient parent, S-615 (S). Although "priming" seed with cultures of these antagonists did not alter characteristic disease reactions, additional evidence suggests that the gene (or genes) conditioning reaction to common root rot on chromosome 5B does so indirectly through its effect on nonpathogenic soil microorganisms. Though S-A5B was as resistant as Apex when tested in normal field soil, it was as susceptible as S-615 when tested in uncropped but cultivated soil. The addition of field soil to uncropped soil in the ratio of 1 to 10 resulted in S-A5B again exhibiting the resistance of Apex. These results also demonstrate that, under certain conditions, the resistance of Apex is conditioned by genes in addition to those on chromosome 5B, providing additional evidence for the probable involvement of genes on chromosomes 2B or 2D or both.

Soil-borne Pathogens

A soil-borne *Pythium* sp. previously reported as pathogenic to cereal seedlings was highly pathogenic to the seedlings of five of nine grass species assayed in naturally infested soil. Asexual bodies of the *Pythium* sp. were stimulated to germinate in aqueous solutions containing rye seeds and in exudates collected from germinating rye but not in water or sterile extracts from soil. A sample of Thatcher wheat, which was not colonized by *Pythium* in soil, stimulated the fungal bodies by its exudates. However, a higher

concentration of the exudate from Thatcher was necessary for stimulation.

CROP ENTOMOLOGY

New Insect Pests

A grass bug, *Irbisia brachycera* (Uhler), (Miridae: Hemiptera) was recorded for the first time in Alberta damaging pubescent wheat grass south of Fort Macleod. Laboratory tests indicated that dimethoate at 0.21 kg/ha (3 oz/acre) or malathion at 0.43 kg/ha would give control.

Rye Jointworm

The rye jointworm, *Harmolita secale* (Fitch), continued as a pest. Infested stems had an average of 21 galls. Adults emerged in early June. The 30% of the larvae that survived the winter weather were protected by snow cover.

Cutworms

Infestations of pale western cutworm occurred in southern Saskatchewan but not in Alberta. Moth numbers, which have been increasing in both provinces since 1968, indicate that crop damage can be expected in 1971. Light infestations of redbacked cutworm occurred in sugar beets in southern Alberta in 1970. The beets were more heavily damaged than cereals by low populations.

Eliminating the diapause caused female army cutworms to release pheromones. Exposure of the moths to a photoperiod of 10–12 hr at 15 C halved the diapause period.

Of 50 insecticides tested on army cutworm larvae, Phoxim (Chemagro), Dursban (Dow), Phosvel (Velsicol), N2596 (Stauffer), and Cyolane (Cyanamid) were found to be effective.

Simulated field tests with redbacked cutworm larvae indicated that Dursban at 0.14–0.56 kg/ha; Phosvel at 0.28–0.56 kg/ha; Phoxim at 0.42–0.84 kg/ha; and trichloronat, Cyolane, and AC47470 (American Cyanamid) at 0.56–0.84 kg/ha were as effective as endrin at 0.14–0.28 kg/ha applied to wheat plants. Phosvel at 0.28 kg/ha was less effective than endrin when applied to bare soil, whereas trichloronat at 0.42 kg/ha was equal to endrin. Cyolane and AC47470 were ineffective on bare soil.

Adult males of the army cutworm, but not

of the redbacked cutworm, exhibited strong sexual response to 2 of 29 synthetic compounds supplied by Martin Jacobson, USDA, Beltsville.

Grasshoppers

Numbers of grasshoppers are expected to increase in 1971. In 1970, the low point of the population had passed and about 10,000 km² of cropland was threatened with light to moderate damage.

A study of the influence of grasshoppers and other insects in native and improved rangeland, initiated in 1970, indicated species that may be economically important. More species and more individuals were found on the native ranges than on reseeded range. Besides grasshoppers several species of Heteroptera have been the most abundant and their importance in damaging range grasses is being determined.

Aphids

In control of pea aphids excessive use of insecticides may reduce effectiveness of natural control by parasites and predators. In addition to aphids, four orders of parasites and predators were present in examined alfalfa fields.

Aphids and barley yellow dwarf virus transmitted by the aphids reduced the protein content of barley 60% and of oats almost 50% in the greenhouse. The protein content of an oat cover crop from infested fields was reduced 17-27%.

Wheat Stem Sawfly

The major sawfly infestations in 1970 were in southwestern Saskatchewan where marginal stem cutting exceeded 20% in many fields.

The sawfly resistance of Rescue was 58% and Chinook 31%. Loss of resistance was apparently related to the number of rainy June days.

Infrared light may affect locations at which the larvae cut the stems, but the main effect was caused by light in the visible range.

Pollinating Insects

The behavior of *Monodontomerus obscurus* Westw., *Pteromalus venustus* Wlker., and *Melittobia chalybii* Ashm., parasites of the alfalfa leafcutter bee, *Megachile rotundata* (Fabricius), was examined so that measures

to control them could be devised. Parasitism by the first two was reduced by hives that prevented their movement from the back of one tunnel to another.

A study of *M. rotundata* has added evidence that nucleative freezing occurs in the gut and that the numbers of nucleators are significant. A study of wing venation showing that the numbers per year of generations of *M. rotundata* are genetically controlled led to the first selection for a strain producing only one generation per year.

Glycerol in prepupae of *M. rotundata* and *M. relativa* Cress. decreases as diapause progresses. It had been thought that glycerol did not decrease until diapause was ended.

Potato Insects

Fensulfothion, C18244 (Ciba), and aldrin at 2.24 kg/ha band and diazinon at 5.6 kg/ha broadcast gave 90% protection to potatoes against the sugarbeet wireworm. The aldrin and fensulfothion treatments were more effective than carbofuran at 5.6 kg/ha broadcast.

Sugarbeet Insects

Field tests of insecticides against the sugarbeet root maggot showed that carbofuran, 0.84 kg/ha spray; diazinon, 1.12 kg/ha spray; carbofuran, 0.84 kg/ha granular; fenofos, 1.12 kg/ha spray; and carbophenothion, 1.12 kg/ha, gave effective control and saved up to 17 metric tons of beets per ha. Heptachlor was ineffective, indicating that the maggots may have developed resistance to it.

Cabbage Maggot

Granular chlorfenvinphos at seeding and the wettable powder drench 4 weeks later was the most effective method of controlling cabbage maggot on rutabaga. Carbofuran controlled cabbage maggot on radish and flea beetle on radish, rutabaga, and rape. Flea beetle control increased rapeseed yield.

Four insecticides were tested on the dieldrin-resistant strain of the cabbage maggot. Carbofuran was equal to chlorfenvinphos, twice as toxic as trichloronat, six times more toxic than fensulfothion, and 45 times more toxic than dieldrin. There was no evidence of cross resistance.

Isolation of rutabagas by 3-6 km from previous cruciferous crops effectively avoided

maggot damage at Taber and Edmonton. Marked adults, however, migrated up to 880 m in 24 hr.

Insecticide Residues

An electron capture detector bypass developed for a gas chromatograph for residue analysis reduced the frequency of cleaning

the detector by one-third, thus saving time and cost of replacing radioactive detector foils.

Twenty to 25% of the aldrin applied to dryland plots in 1955 and to irrigated plots in 1956 was detected. The rate of loss from irrigated soil was triple that from dryland soil.

PUBLICATIONS

Research

- Bailey, C. B. 1970. Renal function in cows with particular reference to the clearance of silicic acid. *Res. Vet. Sci.* 11:533-539.
- Bailey, C. B., and Hironaka, R. 1970. Maximum loss of feed from nylon bags in the rumens of steers as related to apparent digestibility. *Can. J. Anim. Sci.* 50:325-330.
- Dormaar, J. F. 1970. Aspects of infrared spectra of humic acids in relation to methods of preparation: A reply. *Can. J. Soil. Sci.* 50:89-91.
- Dormaar, J. F. 1970. Differentiating chernozemic soil organic matter by acriflavine adsorption. *Plant Soil* 33:729-732.
- Dormaar, J. F. 1970. Phospholipids in chernozemic soils of southern Alberta. *Soil Sci.* 110:136-139.
- Dormaar, J. F. 1970. Seasonal pattern of water-soluble constituents from leaves of *Populus* × 'Northwest' (Hort.). *J. Soil Sci.* 21:105-110.
- Dormaar, J. F., Metche, M., and Jacquin, F. 1970. Extraction and purification of humic acids from a Rendzina Ah and a Podzol Bh horizon. *Soil Biol. Biochem.* 2:285-293.
- Gardiner, E. E. 1970. Comparison of acidulated rapeseed-oil soapstock with animal tallow as a source of energy in broiler diets. *Can. J. Anim. Sci.* 50:529-534.
- Gardiner, E. E. 1970. Fluoride in poultry nutrition—A review. *Fluoride Quart. Rep.* 3(1):36-39.
- Gardiner, E. E. 1970. Weight at 425 days of age in six strains of broiler-type males as influenced by different systems of management. *Can. J. Anim. Sci.* 50:217-218.
- Grant, M. N., and McKenzie, H. 1970. Heterosis in F_1 hybrids between spring and winter wheats. *Can. J. Plant Sci.* 50:137-140.
- Gupta, V. C., Chipman, E. W., and MacKay, D. C. 1970. Influence of manganese and pH on chemical composition, bronzing of leaves, and yield of carrots grown on acid sphagnum peat soil. *Soil Sci. Soc. Amer. Proc.* 34:762-764.
- Hanna, M. R., Cooke, D. A., and Goplen, B. P. 1970. Melrose sainfoin. *Can. J. Plant Sci.* 50:750-751.
- Haufe, W. O., and Morley, H. V. 1970. Residues in cattle treated with DDT for control of horn flies on pasture. *Bull. Environ. Contam. Toxicol.* 5:389-396.
- Hawn, E. J. 1970. New technique for studying a bacterium/nematode interaction in alfalfa. *J. Nematol.* 2:272-273.
- Hironaka, R., Bailey, C. B., and Kozub, G. C. 1970. Metabolic fecal nitrogen in ruminants estimated from dry matter excretion. *Can. J. Anim. Sci.* 50:55-60.
- Hobbs, E. H., and Krogman, K. K. 1970. Evaluation of a method of irrigation scheduling. *Can. Agr. Eng.* 12:25-27, 32.
- Holmes, N. D. 1970. Sexing larvae of the wheat stem sawfly, *Cephus cinctus* (Hymenoptera: Cephidae). *Can. Entomol.* 102:713-715.
- Jacobson, L. A. 1970. Laboratory ecology of the red-backed cutworm, *Euxoa ochrogaster* (Lepidoptera: Noctuidae). *Can. Entomol.* 102:85-89.
- Jacquin, F., Calvez, D., Dormaar, J. F., and Metche, M. 1970. Contribution à l'étude des processus d'extraction et de caractérisation des composés humiques. *Bull. Ass. Fr. Etude Sol.* 1970(4):27-38.
- Johnston, A. 1970. A history of the rangelands of Western Canada. *J. Range Manage.* 23:3-8.
- Johnston, A. 1970. Blackfoot Indian utilization of the flora of the Northwestern Great Plains. *Econ. Bot.* 24:301-324.
- Johnston, A. 1970. Distribution of golden-mantled marmot in Alberta. *Can. Field Nat.* 84:180.
- Johnston, A., and Dormaar, J. F. 1970. Observations on *Danthonia parryi*. *Can. J. Plant Sci.* 50:115-117.

- Krogman, K. K. 1970. Species composition of an irrigated grass mixture at varying fertilizer rates. *Can. J. Plant Sci.* 50:505-507.
- Larson, Ruby I., and Atkinson, T. G. 1970. A cytogenetic analysis of reaction to common root rot in some hard red spring wheats. *Can. J. Bot.* 48:2059-2067.
- Larson, Ruby I., and Atkinson, T. G. 1970. Identity of the wheat chromosomes replaced by *Agropyron* chromosomes in a triple alien chromosome substitution line immune to wheat streak mosaic. *Can. J. Genet. Cytol.* 12:145-150.
- McGinnis, A. J., and Kasting, R. 1969. Use of glutamic acid-U-C¹⁴ to determine nutritionally essential amino acids. *Entomol. Exp. Appl.* 12:467-468.
- Neal, J. L., Jr., Atkinson, T. G., and Larson, Ruby I. 1970. Changes in the rhizosphere microflora of spring wheat induced by disomic substitution of a chromosome. *Can. J. Microbiol.* 16:153-158.
- Nelson, W. A., Shemanchuk, J. A., and Haufe, W. O. 1970. *Haematopinus eurysternus*: Blood of cattle infested with the short-nosed cattle louse. *Exp. Parasitol.* 28:263-271.
- Pittman, U. J. 1970. Magnetotropic responses in roots of wild oats. *Can. J. Plant Sci.* 50:350-351.
- Pittman, U. J., and Ormrod, D. P. 1970. Physiological and chemical features of magnetically treated winter wheat seeds and resultant seedlings. *Can. J. Plant Sci.* 50:211-217.
- Rapp, E., Schaik, J. C. van, and Khanal, N. N. 1969. A hydrologic budget for a southern Alberta irrigation district. *Can. Agr. Eng.* 11:54-57.
- Roberts, D. W. A. 1970. A survey of the wheat leaf phosphatases using gel filtration with Sephadex G200. *Enzymologia* 39:151-165.
- Salt, R. W. 1970. Analysis of insect freezing temperature distributions. *Can. J. Zool.* 48:205-208.
- Schaik, J. C. van. 1970. Soil hydraulic properties determined with water and with a hydrocarbon liquid. *Can. J. Soil Sci.* 50:79-84.
- Schaik, J. C. van, and Rapp, E. 1970. Water table behavior and soil moisture content during the winter. *Can. J. Soil Sci.* 50:361-366.
- Shemanchuk, J. A., and Kiceniuk, J. W. 1970. *Ixodes spinipalpis* Hadwen and Nuttall (Ixodidae) from southern Alberta. *Can. J. Zool.* 48:1142-1143.
- Smith, D. S. 1970. Crowding in grasshoppers. I. Effect of crowding within one generation on *Melanoplus sanguinipes*. *Ann. Entomol. Soc. Amer.* 63:1775-1776.
- Smoliak, S., Johnston, A., and Wilson, D. B. 1970. Seedling growth of crested wheatgrass and Russian wild ryegrass. *Can. J. Plant Sci.* 50:559-563.
- Spencer, J. F. T., Gorin, P. A. J., Hobbs, G. A., and Cooke, D. A. 1970. Yeasts isolated from bumblebee honey from Western Canada: identification with the aid of proton magnetic resonance spectra of their mannose-containing polysaccharides. *Can. J. Microbiol.* 16:117-119.
- Struble, D. L. 1970. A sex pheromone in the forest tent caterpillar. *J. Econ. Entomol.* 63:295-296.
- Struble, D. L. 1970. An electron capture detector bypass system. *Bull. Environ. Contam. Toxicol.* 5:452-454.
- Struble, D. L., and Jacobson, L. A. 1970. A sex pheromone in the red-backed cutworm. *J. Econ. Entomol.* 63:841-844.
- Trpiš, M. 1970. A new bleaching and decalcifying method for general use in zoology. *Car. J. Zool.* 48:892-893.
- Trpiš, M., and Shemanchuk, J. A. 1970. Effect of constant temperature on the larval development of *Aedes vexans* (Diptera: Culicidae). *Can. Entomol.* 102:1048-1051.
- Vesely, J. A., Peters, H. F., Slen, S. B., and Robison, O. W. 1970. Heritabilities and genetic correlations in growth and wool traits of Rambouillet and Romnelet sheep. *J. Anim. Sci.* 30:174-181.
- Wells, S. A., and Dubetz, S. 1970. Reaction of two barley cultivars to a period of soil water stress during heading. *Can. J. Plant Sci.* 50:701-704.
- Wilson, D. B., and Robson, M. J. 1970. Regrowth of S24 ryegrass and its relation to yield measurement of grazed swards. *J. Brit. Grassland Soc.* 25:220-227.

Miscellaneous

- Allan, J. R. 1970. Explosion of aquatic growth. *Can. Agr.* 15(3):28-29.
- Atkinson, T. G., and Grant, M. N. 1970. Wheat streak mosaic virus, 3.3, Serial 45. *In* Crop loss assessment methods. FAO manual on the evaluation and prevention of losses by pests, diseases and weeds. AGP:CP/22. FAO, United Nations, Rome.
- Dormaar, J. F. 1970. Methods of extraction of soil organic matter and the relevancy of the extracted and unextracted material, p. 52-55. *In*

- Proc. soil organic matter work planning meeting, April 22-23, 1970. Res. Br., Can. Dep. Agr., Ottawa.
- Dormaer, J. F. 1970. Review of soil organic matter work at Lethbridge, Alberta, p. 21-23. *In* Proc. soil organic matter work planning meeting, April 22-23, 1970. Res. Br., Can. Dep. Agr., Ottawa.
- Freyman, S., and Tennant, J. B. 1970. Heat units available for corn production in Alberta—corn hybrids suitable for Alberta, 1970. Alberta Corn Committee Leaflet.
- Hanna, M. R., Cooke, D. A., Goplen, B. P., and Smoliak, S. 1970. Sainfoin. Publ. Can. Dep. Agr. Res. Sta., Lethbridge, Alta.; Melfort and Saskatoon, Sask. 9 p.
- Harper, A. M. 1970. Poplar galls, p. 66-69. *In* G. S. Reycraft [ed.] *The Prairie Garden*, 1970 ed. Winnipeg Horticultural Society, 92 Queenston Street, Winnipeg, Man.
- Hironaka, R. 1970. Feedlot starter rations. *Can. Agr.* 15(3):6-7.
- Hironaka, R. 1970. How barley performs as a protein supplement. *Good Farming (Eastern edition)* 21(7):28.
- Hobbs, E. H. 1970. The agricultural climate of the Lethbridge area. *Agrometeorology Publ. 1.* Can. Dep. Agr. Res. Sta., Lethbridge, Alta. 13 p.
- Hobbs, G. A. 1970. Alfalfa leafcutter bee beekeeping, Alberta style, 1969, p. 80-83. *In* *The indispensable pollinators. A report of the Ninth Pollination Conference*, Hot Springs, Arkansas, Oct. 12-15, 1970. Univ. Ark. Agr. Ext. Ser. MP 127.
- Lawson, J. E. 1969. "Tell it like it is" (improving the performance of Highland cattle), p. 27-29. *In* *An Tarbh Treun 1969*. Can. Highland Cattle Soc., Duncan, British Columbia.
- Lutwick, L. E. 1970. Identification of phytoliths in soils, p. 77-82. *In* S. Pawluk [ed.] *Pedology and Quaternary Research*, a symposium held at University of Alberta, Edmonton, May 13-14, 1969. Alberta Institute of Pedology, Edmonton.
- MacKay, D. C., and Anderson, D. T. 1970. Chemical and microbiological factors in minimum tillage in Western Canadian soils, p. 74-82. *In* *Proceedings of the symposium on minimum tillage*, Feb. 23-25, 1970. Can. Soil Fertility Comm., Res. Br., Can. Dep. Agr., Ottawa.
- Schaik, J. C. van, Sommerfeldt, T. G., and Rapp, E. 1970. Drainage and salinity. *Can. Agr.* 15(2):9-11.
- Sexsmith, J. J., and Trimmer, R. M. 1970. Chemical control of weeds in specialty crops for Alberta. *Alberta Dep. Agr. Publ.* 641/250. 12 p.
- Slen, S. B. 1970. Une solution: les croisements entre races. *L'Éleveur* 24(4):5-6.
- Wroe, R. A., Smoliak, S., Johnston, A., Forbes, L. M., Hanson, W. R., and Maduram, G. H. [ed. comm.] 1970. *Range, its nature and use*. 3rd ed. Lands Div., Alberta Dep. Lands and Forests Publ. 146.

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INTRODUCTION

This report summarizes the main research findings for 1970 at the Research Station, Agassiz, and the Small Fruits Substation, Abbotsford. Completed research is reported in more detail in the scientific journals and other publications listed at the end of this report. In addition, the Station publishes a Quarterly Report to provide extension specialists, agricultural business, and progressive farmers with up-to-date information on the developments in the research program.

A new variety of strawberry that was developed in the small fruit breeding program of the Station was named and released this year. The strawberry cultivar Totem is intended as a replacement for Northwest and has shown improved hardiness and lower susceptibility to fruit rot in extensive tests in British Columbia and Washington State.

M. F. Clarke
Director

SOILS

Computerized Acquisition and Interpretation of Chemical Data

An off-line computerized data acquisition system was tested for automatic storage of chemical information. Programs were written for processing the raw data, merging with other physical and chemical data, and retrieving for interpretation. Instrumentation included an autoanalyzer, atomic absorption spectrophotometer, analogue-digital converter, and teletype. Instrument readings were converted to punched tapes and later transferred to a central computer by telephone. Chemical data were merged after transformation with existing soils data on magnetic tapes. Data were then recalled according to any level of soil classification scheme, horizons, parent materials, and geographic location. Statistical analyses were performed by means of a remote terminal with Michigan Terminal System commands.

Lead Contamination of Some Agricultural Soils

The content of nitric acid soluble lead in 700 soils samples, mostly from agricultural areas in British Columbia, was influenced by proximity to industrial and population centers. Soluble Pb was found to be immobilized in surface horizons and ranged from 0.5 ppm to 180.4 ppm in agricultural soils. Surface soils sampled near a battery smelter had a soluble-Pb content as high as 5,958 ppm. Fractionation of Pb into total mineral and soluble forms was found to be useful in assessing the degree of soil pollution.

Effects of Lime and Manganese Supply on the Mineral Composition and Growth of Peas

The effects of varying levels of Mn in nutrient culture and of lime on a Mn-deficient soil were investigated in greenhouse experiments. On the Mn-deficient soil, lime increased the height, number of nodes, and dry weights of pea leaves and stems. Lime reduced leaf P and Mg and stem Zn but increased Mn in the pods. In the nutrient culture study, 1.00 ppm of Mn increased the dry weight of stems, leaves, pods, total tops, and whole plants. The top-to-root and pod-to-stem-and-leaf ratios were increased over the control. The 1.00 ppm level of Mn generally decreased pod and stem P, pod K, pod and stem Mg, root Cu, and leaf Na, and significantly increased pod Fe, pod Al, and Mn in all tissues.

VEGETABLES

Response of Muck-grown Carrots to Fumigation and Soil Water Stress

Soil fumigation with methyl bromide greatly reduced *Pythium debaryanum* Hesse infection on carrots. Irrigation produced a significant yield response on fumigated soil and no response on nonfumigated soil. A soil water stress equivalent to 20% of available water at field capacity gave the lowest yield.

Effect of Fumigation and Soil Moisture on Mineral Content of Carrots

The mineral content of carrots grown in a Lumbum muck soil was affected by soil fumigation and by soil water regime. Foliage of plants grown in fumigated soil had greater levels of P, Ca, Mn, Fe, and Zn but lower levels of N and Al; roots had greater levels of P, Na, Mn, Zn, Cu, and Pb and a lower level of N in fumigated than in nonfumigated soil. Plants provided with ample soil water tended to have higher levels of Ca and P in roots and P in foliage than plants grown under a dry regime. Ca and Pb levels in the foliage were affected in the opposite manner.

Herbicides for Vegetable Crops

Several herbicides were tested in preplanting, preemergence, and postemergence treatments for bush beans, carrots, sweet corn, and potatoes. A summary of some of the results follows. Rates are expressed in acid equivalent of active ingredient in kilograms per hectare.

Bush beans. Seven herbicides were tested singly, or in combination, or both, as preemergence treatments on bush beans. Linuron at 2.24 kg (2 lb) ranked first in control of weeds and grasses. Combinations of chloramben at 2.24 to 3.36 kg (2 to 3 lb) with linuron at 0.56 to 1.12 kg (0.5 to 1 lb) were only slightly less effective than linuron at 2.24 kg (2 lb). C 6989 (CIBA Company Ltd.) did not control common chickweed, wild buckwheat, and grasses. NIA 20439 (Niagara Chemicals Ltd.) gave poor control of grasses and weeds. No treatment adversely affected crop growth or yield.

Carrots. Six herbicides were tested as preemergence treatments on Red Cored Chantenay carrots. C 6313 (CIBA Company Ltd.) at 1.12 to 1.68 kg/ha (1 to 1.5 lb/acre) gave good control of broad-leaved weeds and grasses. Bay 94337 (Bayer) at 2.24 kg (2 lb) completely controlled weeds and grasses but killed carrots. Prometryne at 2.24 and 3.36 (2 and 3 lb) gave good control of broad-leaved weeds, but the 3.36-kg rate was required for satisfactory grass control. Metoxuron gave satisfactory control of broad-leaved weeds but was ineffective on grasses. GS 14260 (Fisons Canada Ltd.) at 2.24 and 3.36 kg (2 and 3 lb) gave good weed and grass control, but the 3.36-kg rate reduced the yield of carrots.

Sweet corn. Herbicides were tested singly and in combination as postemergence treatments applied as overall and directed sprays to sweet corn when it was approximately 30.48 cm (1 ft) in height. As an overall spray, SD 15418 (Shell Canada Ltd.) alone or combined with Tronic (Colloidal Products) or Kornoil (Shell Canada Ltd.) gave excellent control of broad-leaved weeds and grasses. Kornoil caused some injury to corn, but the effect on yield was not significant. All formulations of atrazine gave excellent weed control but poor control of grasses and had no effect on yield. Applied as a directed spray, the mixture of dicamba, 2,4-D, mecoprop, and dalapon gave excellent weed control but very poor grass control. Bay 94337 (Bayer) alone and with Kornoil gave effective weed and grass control but caused significant crop injury.

Potatoes. The herbicides SD 15418 (Shell Canada Ltd.), VC 438 (Velsicol Corp.), alachlor, and the mixtures of alachlor plus linuron and propachlor plus linuron were tested as preemergence treatments on Kennebec and Pontiac potatoes. Alachlor at 2.80 kg/ha (2.5 lb/acre) gave good weed and grass control and the addition of linuron at 1.12 kg (1 lb) slightly increased efficacy. The mixture propachlor 2.24 kg (2 lb) and linuron 1.12 kg (1 lb) was equally effective. VC 438 at 2.24 kg (2 lb) gave good control of broad-leaved weeds, but the 3.36-kg (3-lb) rate was required for satisfactory grass control. SD 15418 gave fairly good grass control but was ineffective for redroot pigweed. Of the five herbicides applied at varying rates or combinations or both after potatoes had emerged, PP 493 (Chipman Ltd.) plus paraquat gave the best control of grasses. All other treatments gave very good grass control, except A 3623 (Fisons Canada Ltd.) at 2.24 and 3.36 kg/ha (2 and 3 lb/acre) and GS 14260 at 2.24 kg (2 lb). GS 14260 at 3.36 kg (3 lb) gave very good control of grasses. PP 493 at 1.12 kg (1 lb) applied when potatoes were at least 10.16 cm (4 inches) high caused crop injury ranging from interveinal chlorosis to necrosis coupled with a significant drop in yield. GS 14260 caused chlorosis on early leaves, but yield was not affected adversely.

SMALL FRUITS

Totem Strawberry

The strawberry cultivar Totem (BC-18) was released by the Station. It is being released as a possible replacement for Northwest, which is currently the most important strawberry cultivar in coastal British Columbia and Washington State. Totem has many of the characteristics of Northwest but shows greater winterhardiness, produces higher yields, and is less susceptible to fruit rot caused by *Botrytis cinerea* Pers. ex Fr.

Effects of Virus Infection on Drupelet Set of Red Raspberry

The effect of viruses on drupelet set was examined for clones of four raspberry cultivars. Fairview, Newburgh, Sumner, and Willamette were infected with black raspberry necrosis (BRNV), raspberry mosaic (RMV), tomato ringspot (Tom RSV), and raspberry vein chlorosis (RVCV). One clone of each cultivar was maintained free from virus infection. Significant reductions in drupelet set, expressed as crumbliness, occurred in fruit from plants of Sumner and Fairview infected with Tom RSV. In the Fairview clone, significant reductions were observed only in fruit from plants that showed severe symptoms of decline. Fruit from Tom RSV-infected Fairview showing no symptoms or only mild decline did not have reduced drupelet set. Except for Tom RSV-infected clones of Sumner and Fairview, reduction in drupelet set or crumbly fruit or both was not a feature of virus infection in the other clones examined.

Influence of Date of Digging and Cold Storage on Starch Content and Growth of Strawberry Cultivars

Starch content in the root cortex of the strawberry cultivars British Sovereign, Siletz, and Northwest followed a general pattern of being low in early fall, increasing in late fall, and decreasing at planting time in the spring. A relationship between starch content of strawberry roots and subsequent survival and growth in the field was apparent only when weather conditions were unsatisfactory for growth. Under such conditions, plants with low starch reserves showed poor field survival and weak growth. The time of digging runner plants for cold storage was the most important factor affecting the amount of

mold on plants in storage and the degree of field survival and growth. The fungicides captan and quintozone were more effective than thiram in controlling mold during storage. Runner plants of British Sovereign and Siletz responded well to cold storage and subsequent field planting when dug about mid-November. Digging prior to December 1 was unsatisfactory for Northwest.

Root Cuttings for Direct Planting of Raspberries

Results from two trials show that direct field planting of root cuttings is feasible for the establishment of commercial raspberry plantations. The cultivars Matsqui and Willamette grew equally well irrespective of whether cuttings were taken in February or March and placed 6.35 or 12.70 cm (2.5 or 5 inches) deep when direct planted. Cuttings should be 12.70 to 16.24 cm (5 to 6 inches) long, but it did not appear necessary for buds to be visible. Captan dust provided effective protection against soil-borne organisms when applied to cuttings at the time of planting.

Herbicides for Strawberries

Fall applications. Several herbicides were tested singly and in combinations as fall treatments for the control of winter weeds and grasses in strawberry plantations. Treatments were made before and after emergence of weeds. In plots treated early in October (prior to weed emergence), terbacil at 1.12 and 2.24 kg/ha (1 and 2 lb/acre) gave excellent weed control, but strawberry plants were damaged sufficiently to reduce fruit yield significantly the following year. RH 315 (Rohm and Haas) at 3.36 kg/ha (3 lb/acre) controlled bluegrass but failed to control dandelion and pineappleweed. This treatment also caused considerable injury to strawberries and a marked reduction in fruit yield. Lenacil at 2.24 to 4.48 kg/ha (2 to 4 lb/acre) gave the best control of weeds and grasses. The rates used caused marginal chlorosis of strawberry leaves, but yield was not affected adversely. For treatments applied in mid-November (weeds fully emerged), RH-315 gave good control of grasses and common chickweed. The effect on grass was not apparent until early March. RH 315 at 3.35 kg/ha (3 lb/acre) proved injurious to strawberry plants and caused a marked yield reduction the following season. A mixture of chloroxuron 5.6 kg (5 lb) and simazine 1.68

kg/ha (1.5 lb/acre) gave the best control of broad-leaved weeds but only fair control of grasses and no significant reduction in yield.

Postplanting applications. Several herbicides were tested singly and in combinations applied immediately after planting strawberries. Lenacil at 2.24 and 4.48 kg/ha (2 and 4 lb/acre) gave excellent grass control but failed to control lamb's-quarters and redroot pigweed. The application of chloroxuron at 4.48 kg/ha (4 lb/acre) on plots previously treated with lenacil 2.24 kg/ha (2 lb/acre) resulted in the control of redroot pigweed, shepherd's-purse, and common chickweed but only partial control of lamb's-quarters. Clover and timothy were not controlled. Mixtures of chlorthal and chloroxuron gave fairly good control of broad-leaved weeds and grasses. Chlorthal did not control shepherd's-purse, low cudweed, pineappleweed, or clover seedlings. Chloroxuron alone gave poor grass control, but the addition of Nufilm (Miller Chemical and Fertilizer Corporation) resulted in some improvement in effectiveness. In general, all treatments could be considered to give satisfactory weed control if followed by some tillage.

ANIMAL SCIENCE

Effect of Single and Double Hormone Implants on Performance and Carcass Characteristics of Holstein-Friesian Steers

Implanting Holstein-Friesian steers twice during the finishing phase did not improve growth performance beyond that obtained from a single implant. Steers implanted twice and finished on a 40% concentrate and 60% hay ration grew as well as steers finished on 100% concentrate. Significant differences were evident in the fat content but not in the bone or lean portions of the carcass rib sections. However, when the rib data were expressed on a percentage basis the animals in the roughage-fed group had significantly less lean and more bone ($P < 0.05$) as well as less percentage fat in the rib sections than the concentrate-fed animals.

Loss of Nutrients Through Passage of Corn Grain

An assessment was made of the nutrients lost through voiding of kernel by cows fed all roughage as corn silage that was 28.6% dry

matter. Kernel represented 34% of the total dry matter of the whole corn plant as harvested but only 16.1% after ensiling. The kernel voided averaged 0.1 kg of dry matter per cow per day. Dry matter lost represented 7.1% of the kernel dry matter and 0.2% of the whole silage dry matter fed. Average digestibility of the whole ration dry matter was 66.2% by lactating cows compared with 67.9% and 67.8% by *in vitro* analysis for the whole silage and silage grain respectively. An *in vitro* method was used to determine the loss of digestible dry matter in the voided kernel. Slightly over 4.8% of the *in vitro* digestible dry matter was lost in the voided kernel, but this loss was only 0.9% of the *in vitro* digestible dry matter of the whole silage. Water-soluble carbohydrates of harvested whole corn were reduced during ensiling, whereas soluble carbohydrates of the kernel increased from 26.8% to 51.3%. Loss of soluble carbohydrate in voided kernels was only 6.0% of the soluble carbohydrate in the silage kernel and 3.1% of that in the whole silage.

A Rapid Microdigestion Procedure for Neutral and Acid Detergent Fiber

A microdigestion procedure was developed for the determination of neutral (NDF) and acid detergent fiber (ADF) employing 0.35 g of a sample. Four roughages and corn grain were digested by the standard Van Soest macro acid and neutral detergent fiber methods and by the micro method. Differences between two-thirds of the means for NDF and ADF by the two methods were statistically significant ($P < 0.05$). Absolute differences between means for all samples analyzed were small, with a range from 1.41 to 2.82 percentage units for NDF and 0.14 to 0.85 percentage units for ADF. Neutral detergent fiber determinations of corn grain were completed without filtration problems when the microdigestion method was employed. Difficult to impossible filtrations were encountered with the macro method. Standard deviations of means for samples digested by the micro method were small except for corn grain.

POULTRY

Effect of Incubating Chicken Semen in the Hen's Oviduct

The effect of incubating chicken semen for 2 hr at 41 C in different parts of the excised oviduct on the activity of 10 enzymes, pH, sperm motility, and fertility was studied and compared with fresh and incubated controls.

For all the enzymes studied, sperm of the incubated control had a lower activity than the fresh control. All parts of the oviduct maintained sperm fumarase and aconitase activity above that of the incubated control, whereas incubation in the oviduct resulted in lower lactic dehydrogenase and aldolase activity than in the incubated control. There was no difference in activity between sperm incubated in the oviduct and the incubated control for creating kinase, acetylcholinesterase, or malic or isocitric dehydrogenase. The isthmus and infundibulum caused a reduction in glutamic-oxaloacetic transaminase compared to the control. Sperm incubated in the isthmus and lower magnum had a higher aminopeptidase activity than the fresh control. The effect of incubating sperm in the magnum of the oviduct in situ was found to be the same as for the excised oviduct for fumarase, aconitase, lactic dehydrogenase, and aldolase. Semen incubated in the excised oviduct had slightly lower pH than the incubated control. There was no difference in motility between semen incubated in the excised oviduct and the incubated control.

Sperm of the incubated control had less than one-half the fertilizing capacity of the fresh control, whereas semen incubated in the excised oviduct had essentially zero duration and percentage fertility.

Comparison of Diluents for Chicken Semen

The effectiveness of six semen diluents was compared using three methods for measuring fertility. These were: (i) duration of fertility, i.e., the number of days from the day after insemination until the last fertile egg was laid; (ii) percentage fertility, i.e., calculated for eggs laid during the fertile period; (iii) total sperm survival time, i.e., the total number of days (storage plus duration) from the time semen was collected until the last fertile egg was laid. The foregoing parameters were calculated on: all laying hens, and fertile hens only.

Phosphate-base diluents were superior to citrate diluents. Fertility decreased with increasing storage time and there was no effect of storage time on total sperm survival time when based on fertile hens only, or on storing semen 1 to 4 days when based on all laying hens. This indicated that present storage methods maintain sperm fertilizing capacity nearly as well as the hen's oviduct in vivo. Compared with the undiluted fresh control, however, stored semen did not give satisfactory fertility. Percentage and duration of fertility based on all hens was more sensitive in demonstrating the effect of storage on fertility than when based on fertile hens only.

PUBLICATIONS

Research

- Bowden, D. M. 1970. Achondroplasia in Holstein-Friesian cattle. *J. Hered.* 61:163-164.
- Buckland, R. B. 1970. Effect of incubating chicken semen in the hen's oviduct on sperm enzyme activities, semen pH, motility and fertility. *Biol. Reprod.* 3:120-127.
- Buckland, R. B. 1970. Effect of cold stressing chicken embryos and preincubation storage on hatchability, post-hatching body-weight, mortality and sex ratios. *Can. J. Anim. Sci.* 50:243-252.
- Buckland, R. B. 1970. Some enzyme activities of chicken spermatozoa. *Poultry Sci.* 49:1638-1641.
- Buckland, R. B., and Hill, A. T. 1970. Effects of continuous and intermittent light on broilers cold stressed as embryos. *Can. J. Anim. Sci.* 50:735-738.
- Daubeny, H. A., Freeman, J. A., and Stace-Smith, R. 1970. Effects of virus infection on drupelet set of four red raspberry cultivars. *J. Amer. Soc. Hort. Sci.* 95:730-731.
- Daubeny, H. A., Norton, R. A., Schwartz, C. D., and Barritt, B. H. 1970. Winterhardiness in strawberries for the Pacific Northwest. *Hort-Science* 5:152-163.

- Davis, W. E. P., and Waldern, D. E. 1970. Loss of nutrients through passage of corn grain by cows fed all roughage as corn silage. *J. Dairy Sci.* 53:893-897.
- Freeman, J. A., and Pepin, H. S. 1969. Effect of postharvest infection of powdery mildew on yield of the strawberry cultivar Northwest. *Can. Plant Dis. Surv.* 49:139.
- Freeman, J. A., and Carne, I. C. 1970. Use of succinic 2,2-dimethyl hydrazide (Alar) to reduce winter injury in strawberries. *Can. J. Plant Sci.* 50:189-190.
- Freeman, J. A., and Finlayson, D. G. 1970. Incompatibilities between herbicides and insecticides in direct-seeded brassica crops. *HortScience* 5:177-178.
- Freeman, J. A., and Stace-Smith, R. 1970. Effects of raspberry mosaic viruses on yield and growth of red raspberries. *Can. J. Plant Sci.* 50:521-527.
- John, M. K. 1970. Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. *Soil Sci.* 109:214-220.
- Ormrod, D. P., Maurer, A. R., Mitchell, G., and Eaton, G. W. 1970. Shoot apex development in *Pisum sativum* L. as affected by temperature. *Can. J. Plant Sci.* 50:201-202.
- Miscellaneous**
- Buckland, R. B. 1970. Tips for improving fertility when turkeys are inseminated. *Can. Poultryman* 57(8):18.
- Buckland, R. B. 1970. The effect of stress in intensive livestock production. *Proc. Can. Soc. Anim. Prod.* 20:73-80.
- Buckland, R. B., and Gasperdone, J. C. 1970. Effect of intermittent light and dark periods vs. 24 hours of light on broiler performance. *Can. Poultryman* 57(10):40-41.
- Daubeny, H. A. 1970. Strawberry and red raspberry breeding. *Can. Agr.* 15(1):12-13.
- Daubeny, H. A. 1970. Progress in selecting for greater winterhardiness in strawberries for the Pacific Northwest. *Proc. Lower Mainland Hort. Impr. Ass.* 12:4-6.
- Davis, W. E. P. 1970. For 1970, forage varieties and recommendations. *Butterfat* 48(2):5-6.
- Freeman, J. A. 1970. Commercial raspberry planting from root cuttings. *Proc. West. Wash. Hort. Ass.* 60:95-98.
- Freeman, J. A. 1970. Weed control in vegetables and small fruits. *Proc. Lower Mainland Hort. Impr. Ass.* 12:53-56.
- Freeman, J. A. 1970. Use of root cuttings for direct planting of raspberries. *Proc. Lower Mainland Hort. Impr. Ass.* 12:34-36.
- Forrest, R. J., and Lister, E. E. 1970. Meat production potential in dairy cattle. *Can. Dep. Agr. Publ.* 1397. 17 p.
- Hill, A. T. 1970. Summarizing egg quality influences. *Poultry Digest* 29(336):72.
- Hill, A. T. 1970. Oiling helps hold egg quality. *Can. Poultry Rev.* 94(8):32-34.
- John, M. K. 1970. Agriculture and eutrophication. *B.C. Rancher* 1(7):9.
- Maurer, A. R. 1970. The relationship between tenderometer reading and yield. *Pea Res.* 7:17-18.
- Maurer, A. R. 1970. Time and rate of DMSO and Cycocel application to peas. *Pea Res.* 7:19.
- Maurer, A. R., and Ormrod, D. P. 1970. Dimethyl sulfoxide affects pea yield. *Pea Res.* 7:5-6.
- Maurer, A. R., and Watson, T. K. 1970. Pea internode lengths affected by dimethyl sulfoxide. *Pea Res.* 7:3-4.
- Maurer, A. R., and Watson, T. K. 1970. Snap bean quality. *Proc. Lower Mainland Hort. Impr. Ass.* 12:19-24.
- Ormrod, D. P., Maurer, A. R., and Eaton, G. W. 1970. Temperature effects on the developing pea plant. *Pea Res.* 7:1-2.
- Taylor, D. K. 1970. Progress report on turfgrass research. *Proc. British Columbia Turf Grass Conf.* 8:86-92.
- Waldern, D. E. 1970. Corn protein. *Butterfat* 48(1):30-32.
- Waldern, D. E. 1970. Extra protein for cows. *Butterfat* 48(3):37.
- Waldern, D. E. 1970. Nutritive value and suitable levels of wheat for dairy cattle, p. 134-176. *In* Wheat in livestock and poultry feeds. *Proc. Int. Symposium, Oklahoma State University, June 18-19.*
- Waldern, D. E. 1970. Wheat and wheat by-products for dairy cattle. *Proc. Pacific Northwest Anim. Nutr. Conf.* 5:118-129.

Research Station Kamloops, British Columbia

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Departure

R. H. HANDFORD, B.S.A., M.Sc., Ph.D.	Director
Retired May 29, 1970	

INTRODUCTION

The program of the Research Station, Kamloops, B.C., is directed toward solving problems of the ranching industry. Because public lands are used for grazing, some of the problems involve aspects of forestry, wild game, and recreation. Consequently, the research program includes some aspects of resource management.

This report summarizes the important results from research in 1970. Additional details may be found in the scientific papers and other publications listed at the end of this report. Further information can be obtained by contacting the Station.

For the first time, it was demonstrated that the saliva of the Rocky Mountain wood tick (RMWT), induces paralysis when injected into a hamster. Field tests demonstrated that lindane satisfactorily protected cattle from the RMWT. Killing shrubs in a RMWT habitat did not reduce the RMWT population.

Forested range at Kamloops and in the Cariboo, which have about equal areas of grass and trees, produced comparable yields of beef per hectare. Complete protection from grazing increased yields of forage threefold and reduced the knapweed population to one-third in 3 years.

Charcoal fragments 9,120 years old, determined by carbon dating, were found in an alpine soil.

J. E. Miltimore
Director

PESTS OF LIVESTOCK

Rocky Mountain Wood Tick and Paralysis

The overlapping unknowns of tick virulence and host susceptibility have hampered the study of the cause of tick paralysis. To separate and solve these problems, over 700 Rocky Mountain wood ticks, *Dermacentor andersoni* Stiles, from a dozen localities were tested on 483 hamsters by using a special infesting device designed for this purpose.

By repeatedly transferring ticks that caused paralysis to new hamsters, it was found that about 6.6% of the collection of ticks were much more virulent than the others. The virulence was less in ticks from east of the Kamloops-Nicola area. Ticks never caused paralysis before the 4th day and seldom after their 7th day of feeding. The most virulent ticks paralyzed up to seven hamsters during successive transfers. The hamsters appeared to be susceptible to solitary, virulent ticks. The intensity and rapidity of onset of paralysis was in direct relationship to the number of 6- to 7-day fed ticks. Large batches of these ticks caused paralysis in hamsters and marmots within 5 hr.

For the first time, paralysis was positively shown to be related to tick saliva. One milliliter of saliva continuously injected into a

hamster subcutaneously for 16 hr produced typical paralysis, which disappeared 3 hr after the injection ceased.

A large-scale field test performed under range conditions confirmed the results of small-scale tests completed in 1969 and showed that 0.25% lindane spray protected cattle from paralysis caused by RMWT for 5 to 6 weeks.

Rabbits were substituted for groundhogs as host mammals for rearing RMWT in outdoors rodentaria. They produced a comparable yield of 1,000 ticks per animal, but many of the adults were small. This was apparently due to sensitization of the hosts that reduced the feeding period.

The shrubs on tick habitats were killed with herbicides in 1966 on large and small areas, and the ticks were counted on the treated and adjacent control areas in 1970. The average concentration of ticks on the two small sites was 5.8/100 sq m for the treated area and 5.6 for the control. On the large areas, the average concentration of ticks was 3.6/100 sq m on the treated area and 3.1 on the control area. The lack of a decline in tick numbers indicated that shrubs are a less important part of the tick environment than was previously thought.

Crufomate as a Control for the Common Cattle Grub

Tests made with crufomate as a systemic insecticide for the control of the common cattle grub have been conducted for 10 years. Spraying was the least effective and the most wasteful method of application. Intramuscular injection was consistently effective and the least wasteful method. Crufomate added to feed was effective, but intake was variable because of the differences in the feeding behavior of cattle. Crufomate pour-on applied in December was significantly more effective than when it was applied in September. After the dosage of 20 mg/kg liveweight was reached, there was only a moderate increase in effectiveness as the rate increased up to 50 mg/kg with single pour-on applications. The most practical treatment was a pour-on applied in two applications, 3 weeks apart, at 20 mg/kg per application. The split application allowed late treatment with improved control, and it did not cause posttreatment reaction in cattle.

RANGE AND FORAGE MANAGEMENT

Pine Grass as Range for Beef Cattle

Yearling steers on lodgepole pine – pine grass summer range in the Cariboo District had a 3-year average daily gain of 0.8 kg for 97 days starting in early June. The average gain was 20 kg/ha. The average carrying capacity was 1.9 ha/animal unit month. The results were similar to those from previous grazing trials near Kamloops and showed that the findings of pine grass studies at Kamloops apply in the Cariboo. The two trials were located on sites that had similar grass and tree populations. This is the first known report of yields of beef confirming the ecological site concept.

Rain Interception by Bluebunch Wheatgrass Foliage

Aerial parts of the caespitose type of bluebunch wheatgrass, *Agropyron spicatum* (Pursh) Scribn. & Sm., have been shown to direct rain and to concentrate it in the soil immediately beneath individual plants. The degree to which water collected beneath the bunches appeared to be related to the size of the canopy. It is suggested that the rapid

decline of bluebunch wheatgrass on heavily grazed rangelands may result from a reduction in available soil moisture due to the removal of aerial parts.

Plant Zone Productivity Studies

The plant communities on the ponderosa pine zone provide maximum returns from grazing by domestic and wild ungulates. The communities of the Douglas fir zone gave highest returns when used for both grazing and timber production. Timber production was most valuable in the subalpine fir zone. But significant grazing activity usually persisted for many years in the lower part of the zone after logging or burning. The upper part of the subalpine fir zone is suited mainly for grazing. Although the alpine tundra has very limited forage production, it provides summer range for bighorn sheep.

Biological Control of Knapweeds

A gall fly, *Urophora affinis* Frauenfeld, was released on plots of both diffuse and spotted knapweed, *Centaurea diffusa* Lam. and *C. stoebe*, in a cooperative study with the Research Institute at Belleville, Ont. The release on diffuse knapweed was not successful, but 3% of the seed heads of spotted knapweed were attacked.

Good range management has been shown to increase the forage production on badly infested range. Complete protection from grazing increased plot yields twofold in the second and third year. The knapweed population was reduced from seven to two plants/sq m. The herbicide picloram at 420 g of active material/ha eliminated knapweed, but was expensive.

Frost-churned Alpine Soils

Charcoal fragments, 9,120 years old, were found in a buried (50–70 cm deep) surface sample of an alpine soil in south central British Columbia at an elevation of 2,469 m. The age of the charcoal, determined by radiocarbon dating, indicates that it was probably buried by frost action after the retreat of the last Cordilleran glaciation (about 11,500 years ago). Tentative identification of volcanic ash in the same sample suggests that it fell on the site less than 6,600 and probably less than 3,200 years ago. The ancient vegetation from which the charcoal was derived was probably a tree or shrub type, much

larger than present vegetation, and grew in a warmer and moister period. It was destroyed, almost certainly, by fire and buried during a cool period that may have occurred as recently as a few hundred years ago.

Soils and *Agropyron* Communities

Bluebunch wheatgrass is the dominant grass of climax stands on Brown Chernozemic soils near Kamloops. On localized areas, however, needle-and-thread, *Stipa*

comata Trin. & Rupr., has been dominant. Needle-and-thread grows on coarse-textured soils with low available-water-storage capacities, but bluebunch wheatgrass grows on finer-textured soils with higher capacities. In the early part of the growing season, measurements showed that soils where bluebunch wheatgrass was growing had a higher moisture content than did soils where needle-and-thread was growing. Needle-and-thread, however, matured faster and appeared to be better adapted to drought than bluebunch wheatgrass.

PUBLICATIONS

Research

- Freyman, S. 1970. Chemical curing of pinegrass with atrazine and paraquat. *Can. J. Plant Sci.* 50:195-197.
- Freyman, S. 1970. Effects of clipping on pinegrass. *Can. J. Plant Sci.* 50:736-739.
- Gregson, J. D. 1970. Antigenic properties of tick secretions. *J. Parasitol.* 56:1038-1039.
- McLean, A. 1969. Fire resistance of forest species as influenced by root systems. *J. Range Manage.* 22:120-122.
- McLean, A. 1970. Plant communities of the Similkameen Valley, British Columbia and their relationships to soils. *Ecol. Monogr.* 40:403-424.
- Rich, G. B. 1970. The economics of systemic insecticide treatment for reduction of slaughter trim loss caused by cattle grubs, *Hypoderma* spp. *Can. J. Anim. Sci.* 50:301-310.
- Sonenshine, D. E., and Gregson, J. D. 1970. A contribution to the internal anatomy and histology of the bat tick *Ornithodoros kelleyi* Cooley & Kohls, 1941. 1. The alimentary system with notes on the food channel in *Ornithodoros denmarki* Kohls, Sonenshine, & Clifford, 1965. *J. Med. Entomol.* 7:46-64.
- Sweatman, G. K., and Gregson, J. D. 1970. Feeding electrograms of *Hyalomma aegyptium* ticks at different temperatures. *J. Med. Entomol.* 7:575-584.

Wilkinson, P. R. 1970. A preliminary note on predation of free-living, engorged, female Rocky Mountain wood ticks. *J. Med. Entomol.* 7:493-496.

Wilkinson, P. R. 1970. *Dermacentor* ticks on wildlife and new records of paralysis. *J. Entomol. Soc. Brit. Columbia* 67:24-29.

Miscellaneous

- Gregson, J. D. 1969. Ticks and travel in the Middle East. *Entomol. Newsletter, Can. Dep. Agr.* Aug. 1, p. 1-3.
- Gregson, J. D. 1970. World-wide research on tick feeding in relation to transmission of disease organisms. *Misc. Publ. Entomol. Soc. Amer.* 6:348-351.
- van Ryswyk, A. L. 1970. Alpine ranges in south central British Columbia. *Can. Agr.* 15(4):12-13.
- van Ryswyk, A. L. 1970. Interpretive soil classification for ranching use. *Proc. Univ. B.C. Short Course, Univ. B.C. Jan.* 1970. 15 p.
- Wilkinson, P. R. 1969. Birds as predators of ticks in Canada. *Can. Field Natur.* 83:400.
- Wilkinson, P. R. 1970. Ticks and technology. *Can. Agr.* 15(2):31.

Research Station Saanichton, British Columbia

PROFESSIONAL STAFF

H. ANDISON, B.S.A.	Director
R. M. ADAMSON, B.A., B.Sc., M.Sc.	Weed control and vegetables
R. G. ATKINSON, B.S.A., Ph.D.	Diseases of glasshouse crops
J. H. CROSSLEY, B.S.A., M.S.A.	Ornamental crops
E. F. MAAS, B.S.A., M.Sc.	Soils and plant nutrition
N. V. TONKS, B.S.A., M.S.	Insects of ornamentals
K. W. CHONG, B.S.A. (Production and Marketing Branch)	Supervisor, Post Entry Quarantine Station

Departure

W. R. ORCHARD, B.A., M.S. Died July 20, 1970	Nematodes
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INTRODUCTION

Research at Saanichton emphasizes the improvement, culture, and protection of ornamental and greenhouse crops. Accomplishments in 1970 that merit special attention include the following. High rates of D-D soil fumigant applied late in the fall to control the golden nematode in the field adversely affected the subsequent crop of field-grown tulips and potatoes and greenhouse-forced tulips and iris. Soilless culture of greenhouse tomatoes in sawdust has proved to be so successful that over half of the industry on Vancouver Island has switched from soil and have almost doubled their yields and halved the cost of production.

We were greatly shocked and saddened by the sudden death of Mr. W. R. Orchard on July 20, 1970. He served in the Department for nearly 20 years. Early in his career, he specialized in nematodes and made important contributions in taxonomy and control of several economic species.

H. Andison
Director

PLANT SCIENCE

Grapes

Evaluation of early grape varieties. Although the heat units in degree-days above 10 C were marginal for grapes, at least 15 early varieties produced good sugar content and yields. Three wineries (Andres, Growers' Wine, and Villa) have evaluated samples of grapes from us and indicate that, at present, they are most interested in growing the following varieties in the coastal area of British Columbia: Aurora, Bath, Diamond, Foch, Himrod, N.Y. Muscat, Schuyler, Seyval, and Vineland 37034.

Naled injury. Suspected injury from naled, which was vaporized from the heating pipes to control the greenhouse whitefly, was confirmed in a fall crop. The stringent treatment program involved five applications at 1.5 times the standard rate at 4-day intervals. The first application was made when the second flower cluster was in bloom, and the last when flowers in the fourth cluster were beginning to open. Some failure to set fruit occurred in the second cluster, but the greatest damage was to the third cluster, which yielded only 8.2% as much weight of marketable fruit as comparable untreated plants.

After the final application, the plants recovered quickly and set freely, and produced a good yield in the latter part of the season. Of the two varieties tested, Vantage was more sensitive than Vendor.

Beds vs. bags in soilless culture. Fall and spring crops were grown in white plastic bags of 10-liter capacity and yields of marketable

fruit comparable with those from plants grown in wooden-sided beds of equal capacity per plant were obtained. Yields from beds that had twice the capacity per plant were no higher. These disposable bags eliminated the need to steam, and permitted flexibility in the cropping schedule.

Alternative soilless media. Because of the prospect of curtailed supplies of sawdust, alternative media were examined. Yields in peat tended to be slightly higher than in sawdust, but marketability lower because of a greater incidence of blotch. Finely ground fir bark produced good yields of both spring and fall crops. Saturnalite, an expanded shale, in a 4- to 8-mesh screen size, produced a satisfactory fall crop, but a finer grade was necessary for the more demanding spring crop. Medium-coarse washed sand was also promising.

Growth Regulators

The effect of Phosfon on rhododendrons. Established rooted cuttings of Anna Rose Whitney treated with a Phosfon soil drench (Mobil Chemical Co.) at 337 ppm produced flower buds on all the standard-grown and single-pinch plants in November, under natural days in the greenhouse. With 4 hr night lighting added, flower buds were fewer and smaller. Plants pinched twice produced no flower buds irrespective of light regime or Phosfon treatment.

In 1969, all Sappho plants produced flower buds under natural days and the Phosfon treatment, and 60% produced buds

when night lighting was added. In 1970, plants produced no flower buds at all.

Weed Control

Herbicidal control of yarrow in turf grass. A single dicamba spray at 0.56 kg/ha applied in late August to an artificially established yarrow infestation in a lawn area produced very good control. Adequate but less effective results were obtained with two applications of the alkanolamine salt of 2,4-D and silvex at 1.12 kg/ha and mecoprop at 1.68 kg/ha applied 12 days apart.

Soil Fumigation

The effect of D-D on tulips and irises. At the request of the Golden Nematode section of the Plant Protection Division, we evaluated possible injury to tulips and irises resulting from 45, 112, and 225 liters/ha of D-D soil fumigant (Shell Chemical Co.) applied in the field in 1968. D-D mixture applied at 45 liters/ha in either August or September to control nematodes did not reduce tulip yields in 1969 or 1970. The August application of 112 or 225 liters/ha did not reduce the yields, but the September applications did, in 1969 only.

The grade of Elmus tulips was reduced when they were grown in the greenhouse in February 1969 in soil fumigated the previous September at the high rate of D-D mixture. The blooming of forced Wedgewood iris was also delayed in February 1969 by the high rate of D-D applied in August and September and by the lowest rate in September.

The effect of D-D on potatoes. Yields and percentage culls of White Rose potatoes were unaffected by D-D 18 months after soil fumigation, but cooking tests revealed a slight off-flavor in tubers from the 45 liters/ha D-D treatment, and tubers treated at higher rates were unacceptable for eating again in 1970, 2 years after treatment.

PLANT PATHOLOGY AND ENTOMOLOGY

Diseases

Root rot and wilt of greenhouse tomatoes. Some batches of sawdust used as a growing medium by greenhouse tomato growers have become contaminated with a wilt-producing

species of *Fusarium*. The mauve-colored *Fusarium*, probably *F. oxysporum* f. *lycopersici*, has been consistently isolated from these plants. Tomatoes, under growth-room conditions, failed to develop wilt symptoms when grown in fresh sawdust incorporated with pure cultures of the *Fusarium*. The fungus was readily reisolated, however, from the plant roots and the discolored vascular tissues of the lower stems.

Insects

Control of the greenhouse whitefly with TD-8550 and aldicarb. TD-8550 (Pennsalt Agricultural Chemicals) and aldicarb systemic insecticides applied as 10% granules to the soil surface of bush beans (Stringless Green) grown in pots in a sand-peat-soil mix in the ratio of 1:2:3 gave the following results. TD-8550 at 1.1, 2.2, and 4.4 kg/ha of toxicant gave no significant control of whitefly scales; at 8.8, 13.2, and 22.0 kg/ha, 80% to 90% control was obtained. Aldicarb at 2.2 kg/ha of toxicant killed 80% of whitefly scales; at 4.4 and 8.8 kg/ha, control was almost complete. No plant damage or significant growth effect was evident from any treatment.

Effectiveness of a greenhouse whitefly parasite. The whitefly parasite, *Encarsia formosa*, introduced on heavily infested greenhouse tomatoes on April 29 at two parasites/0.09 m² of space reached levels of 8% parasitism by May 19 and 69% by July 17, when cropping ended.

In a second trial on greenhouse tomatoes, parasites introduced April 7 at one parasite/0.9 m² of space reached a level of 30% parasitism by July 20, when cropping ended. At this time whitefly populations were heavy on the plants, but fruit spotting from honeydew had not become serious.

SOILS

Organic Soils

Characterization. Correlations have been established in the organic soils between wet bulk density, fiber content, shrinkage on drying to 30 C, and volume recovery on rewetting. The importance of controlled drainage in maintaining the elevation and depth of organic soil deposit is emphasized.

Crop production. Our experiments have

shown yield increases of 30% to be obtainable from forage crops on sedge peat soils by

doubling the recommended N-P-K fertilizer rates and applying N and K in split applications.

PUBLICATIONS

Research

Adamson, R. M., and Turley, R. H. 1970. Effects of 2,4-D and ioxynil on seedling fescue, bluegrass and bentgrass. *Weed Sci.* 18:77-80.

Atkinson, R. G. 1970. Evaluation of some dithiocarbamate fungicides as soil drenches against *Phytophthora* root rot of *Chamaecyparis lawsoniana*. *Can. J. Plant Sci.* 50:565-568.

Crossley, J. H. 1969. Some long-term residual effects of retardants on *Chamaecyparis lawsoniana* 'Ellwoodii' and *Rhododendron* 'A. R.

Whitney'. *Proc. Int. Plant Prop. Soc.* 19:149-153.

Peschken, D., Friesen, H. A., Tonks, N. V., and Banham, F. L. 1970. Releases of *Altica carduorum* (Chrysomelidae: Coleoptera) against the weed Canada thistle (*Cirsium arvense*) in Canada. *Can. Entomol.* 102:264-271.

Miscellaneous

Turley, R. H., revised by Adamson, R. M., and Tonks, N. V. 1970. Lawns for coastal British Columbia. *Can. Dep. Agr. Publ.* 1306. 13 p.

Research Station Summerland, British Columbia

PROFESSIONAL STAFF

D. V. FISHER, B.S.A., M.S.A., Ph.D.	Acting Director
E. F. BELL	Administrative Officer
J. C. LAVERY, B.Sc., B.L.S.	Librarian

Agricultural Engineering Section

A. D. MCMEECHAN, B.A.Sc.	Head of Section; Sprayer and fruit-handling equipment
P. PARCHOMCHUK, B.A.Sc.	Harvesting equipment

Animal Science Section

J. E. MILTIMORE, B.S.A., M.S., Ph.D.	Head of Section; Ruminant nutrition and bloat
J. M. MCARTHUR, B.A., M.A., Ph.D.	Bloat research in cattle
F. M. CHAPMAN, B.S.A.	Cereals, forage crops

Entomology Section

H. F. MADSEN, B.A., Ph.D.	Head of Section; Integrated control
F. L. BANHAM, B.A.	Vegetable insects
R. S. DOWNING, B.A., M.S.	Control of mites
R. D. MCMULLEN, B.Sc., M.Sc., Ph.D.	Bionomics of pear psylla
C. V. G. MORGAN, B.S.A., M.Sc.	Biology, ecology, and taxonomy of mites
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

Fruit and Vegetable Processing Section

D. R. MACGREGOR, B.S.A., M.S., Ph.D.	Head of Section; Biochemistry and microbiology
J. F. BOWEN, B.S.A., M.S.A., Ph.D.	Microbiology
D. BRITTON, (Miss), Dip. H.Ec.	Home economist
J. A. KITSON, B.A., M.S.	Process and product development
A. W. MOYLS, B.S.A.	Fruit and vegetable processing

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J. L. MASON, B.S.A., M.Sc., Ph.D. Head of Section; Plant nutrition
D. S. STEVENSON, B.S.A., M.S., Ph.D. Soil physics and irrigation

Plant Pathology Section

M. F. WELSH, B.S.A., Ph.D. Head of Section; Virus diseases of
apple
A. J. HANSEN, Dip. Agr., M.Sc., Ph.D. Virus diseases of stone fruits and
grapes
L. E. LOPATECKI, B.A., B.S.A., M.S.A., Ph.D. Parasitic tree fruit diseases
D. L. MCINTOSH, B.S.A., Ph.D. Parasitic tree fruit diseases
R. M. ROSHER, B.A., M.A. Parasitic tree fruit diseases

Pomology Section

D. V. FISHER, B.S.A., M.S.A., Ph.D. Head of Section; Varieties,
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K. O. LAPINS, Agr., M.S.A., Ph.D. Fruit breeding and hardiness
N. E. LOONEY, B.S., M.S., Ph.D. Agrometeorology, growth regulators
M. MEHERIUK, B.Sc., B.Ed., M.Sc., Ph.D. Postharvest physiology,
biochemistry
S. W. PORRITT, B.S.A., M.S., Ph.D. Fruit harvesting and storage

Vegetables Section

L. G. DENBY, B.S.A., M.S.A. Head of Section; Breeding

Departures

J. A. MARCHAND, B.Comm. Administrative Officer
Resigned October 2, 1970
J. A. RUCK, B.S.A., M.S. Chemistry
Transferred to Calgary Personnel Office as
Personnel Adviser, April 24, 1970
C. C. STRACHAN, B.S.A., M.S., Ph.D. Director
Died December 7, 1970
K. WILLIAMS, B.S.A. Chemistry of pesticides
Died July 30, 1970

VISITING SCIENTISTS

J. M. ERSKINE, Ph.D. Microbial genetics
National Research Council postdoctorate
fellow 1969-1970
B. P. GOPLEN, B.S.A., M.Sc., Ph.D. Legume breeding
Research Station, Saskatoon, Sask.

INTRODUCTION

This report summarizes the principal findings of our research programs in the production of deciduous tree fruits, grapes, and vegetable crops; in fruit and vegetable processing; in agricultural engineering; and in the cause and prevention of bloat in cattle.

Detailed scientific and technical accounts are found in journals and reports listed under Publications. Reprints for most of the papers are available from the authors.

It is with a profound sense of loss that we record the death on December 7 of our Director Dr. C. C. Strachan, and of Mr. K. Williams on July 30, 1970. Dr. Strachan made a most important contribution to Canadian agriculture, first as a research food technologist and later, from 1956 to 1970, as Director of the Research Stations at Morden, Man., and Summerland, B.C. Mr. Williams was a specialist in pesticide chemistry, and served this station and the industry with diligence and concern since he joined the staff of the Entomology Section in 1946.

D. V. Fisher
Acting Director

AGRICULTURAL ENGINEERING

Harvesting Aid for Tree Fruits

A fixed-width, self-propelled work platform, designed as a harvest aid for hedgerow plantings that have a tree thickness limited to 6 ft and a height limited to 12 ft, was constructed and given preliminary evaluation. Two workers standing on the ground just ahead of the machine pick the fruit up to a height of about 6.5 ft. Workers on the platform pick the remainder of the fruit. The platform accommodates two to six pickers.

Orchard Air-blast Sprayer Development

Sprays for controlling the codling moth were applied in replicated plots in a high-density apple planting by using the experimental tower-type sprayer reported last year. Good control was obtained at speeds up to 3.2 mph when the spray mixture was applied at rates as low as 25 gal/acre. Directing the airstream horizontally through the various levels of the trees permits considerable flexibility in the placement of spray chemical, and greatly reduces the likelihood of losing spray to the atmosphere above the trees.

ANIMAL SCIENCE

Alfalfa Tannins and Fraction 1 Protein in Bloat

Two hydrolyzable tannins were found in nonbloating forages, but no significant quantities were found in bloating forages. Five varieties of sainfoin contained sufficient tannin to precipitate all Fraction 1 protein in the plant. Some birdsfoot trefoil and crown vetch samples did not contain tannins. Some alfalfa genotypes apparently contained two Fraction 1 proteins. Alfalfa genotypes with less than 2.0% Fraction 1 protein have been found and can be used as parents for breeding a nonbloating alfalfa.

ENTOMOLOGY

Codling Moth

Autocidal control. Investigations on codling moth control by release of gamma-irradiated adults were continued in three apple orchards. The largest orchard was divided into two blocks, 90 acres to the north and 10 to the south. Fully sterile male and female moths (40-krad dose) were released by helicopter in the north block, and partially sterile males and fully sterile females (25-krad dose) were released in the south block. Examination of the fruit at harvest showed 0.02% infested apples where fully sterile moths were released and 0.08% where partially sterile males and fully sterile females were liberated. The higher percentage was

not considered inferior because the 1969 infestation in the south block was much higher than in the north.

Approximately 3.5 million moths were produced on an artificial diet during a 5-month period. Fourteen percent of the moths were used to maintain the colony, an appreciable improvement over the 25-30% used in 1969.

A method of free release of moths from a helicopter was devised where cold-immobilized moths were fed into a discharge tube through a rapidly vibrating trough. A ground release system was developed in which moths were fed through a vibrating trough into the airstream of a tractor-mounted small electric fan. Moth survival was good, and recovery of released male moths in female-baited traps was 46% with the helicopter and 44% with the ground release.

Integrated control. Phosalone, tetrachlorvinphos, and chlorphenamide gave good control of the codling moth in a heavily infested orchard. Phosvel (Velsicol Chemical Corp.) did not give satisfactory control; a high percentage of stung fruit was recorded, indicating a lack of persistence. Phytophagous mites increased to high numbers on trees treated with tetrachlorvinphos. Mites did not reach treatment levels on trees treated with phosalone, chlorphenamide, or Phosvel, but chlorphenamide was toxic to predacious mites.

Fruittree Leafroller

Integrated control. Diazinon or chlorphenamide applied to McIntosh apple trees at the pink bud stage gave satisfactory control of the fruittree leafroller and a green fruitworm, *Lithophane georgii* (Grt.). Neither phosalone nor phosmet gave commercially acceptable control. None of the treatments except chlorphenamide affected phytophagous or predacious mites. There were very few European red mites or predacious mites on chlorphenamide-sprayed trees, but McDaniel spider mites increased to damaging numbers in August.

Orchard Mites

Ecology. Sprays of an organophosphorus compound were applied in 1968 and 1969 to half of a cultivated but nonsprayed orchard to eliminate two resident phytoseiid mites,

Neoseiulus caudiglans (Schuster) and *Typhlodromus pyri* Scheuten. An organophosphorus-resistant strain of *Metaseiulus occidentalis* (Nesbitt) was released into the sprayed section of the orchard. *M. occidentalis* increased rapidly in 1969, but when spraying ceased in 1970, *N. caudiglans* began to repopulate the trees and become the dominant species.

Overtree sprinkling on dwarf trees reduced populations of phytophagous mites, especially the European red mite. Predacious mites were not affected by overtree sprinkling, and some species evidently thrived in the moist environment created by this method of irrigation.

Integrated control. Plictran (Dow Chemical of Canada Ltd.) and SD 14114 (Shell Canada Ltd.) gave good control of the European red mite and were only slightly toxic to the predator *M. occidentalis*. Chlorphenamide was equally toxic to both mite species. Tetrachlorvinphos was ineffective against the European red mite and toxic to the predator mite. Plictran applied by low-volume sprayer to 2 acres of mature Red Delicious apple trees controlled a heavy infestation of the European red mite. The mite predator *M. occidentalis* was not adversely affected, and enough European red mites survived to provide food for the predator.

Pear Psylla

Ecology. Neither rate of development nor mortality were influenced by pear psylla density. Mortality of all stages was greater in an orchard with high predator density, especially in April and May. At low predator density, mortality was greatest in late June and July. These data suggest that predators are the main mortality factor early in the season, but that temperature is important later in the season.

Biological control. *Endopsylla agilis* de Meijere, a European parasite of the pear psylla, was released in 1969, but no recoveries were made in 1970. Another release of *E. agilis* was made in August 1970, and in mid-September a few adults were recovered as well as parasitized adult pear psylla. This suggests that the parasite reproduced after the release, but its establishment will depend on the amount of reproduction in 1970 and the ability of the parasite to overwinter successfully.

Western Cherry Fruit Fly

Ecology. In the Okanagan Valley, the first western cherry fruit fly was trapped on June 8 and the peak emergence was from June 12 to July 20. The presence of early instar maggots in cherries as late as September 8 may indicate a partial second generation. The native host of the fly, *Prunus emarginata*, was found in three locations in the Okanagan, but during the season only two flies were trapped on this host. No flies or infested fruit were found on choke cherry, *P. virginiana demissa*.

Control. One, two, or three applications of dimethoate prevented maggots from damaging Bing cherries. The treatments were equal to three and superior to two applications of diazinon. A modified hydrolysate of corn protein incorporated with Stikem (Michele and Pelton Co.) on yellow sticky-board traps increased fly catches threefold over standard traps.

FRUIT AND VEGETABLE PROCESSING

Fruit Aroma Powder

The production of apple aroma powder has been increased from 250-g laboratory batches to batches of 1,500 to 2,000 g prepared in small-scale pilot-plant equipment. Cost of ingredients for 100-fold apple aroma powder has been estimated at 80 cents a pound. Because of the rather low estimated cost for processing, the product should be an economically feasible additive for applesauce flakes.

Stripping aroma volatiles from applesauce during and after cooking but before drum-drying may provide a satisfactory solution to the problem of recovering volatiles from sauce for drum-drying.

Dehydrochilled Apple Slices

Dehydrochilled apple slices, a product prepared by sulfiting, vacuumizing, and dehydrating to 50% net weight, are superior in texture to either frozen or dehydrofrozen slices. In addition, color and flavor are superior to that of conventionally dried apples. Shelf life is at least 6 months at 0 C.

Optimum Processing Conditions for Dehydrofrozen Apples

The effects of drying vacuum-sulfited apple slices to half weight under varying humidity and temperature conditions were studied. Rapid drying did not significantly affect the rehydration of apple slices that had been sulfited before drying. Vacuum-sulfited dehydrofrozen apples occupied 15–20% less volume and absorbed an average of 6.4% more water upon rehydration than did slices prepared by the present commercial process.

Coliform Organisms in Plant Wastes

Analysis of waste water from several food-processing plants showed that the standard coliform test does not adequately indicate fecal pollution in plant wastes. It is uncertain that the presence of *Streptococcus fecalis* or typical *Escherichia coli* is of sanitary significance.

Grape Cultivar Testing

Red cultivars of grapes that consistently yielded the most desirable wines were Seibel 9549 and Marechal Foch (Kuhlmann 188-2). Vincent and Seibel 1000 showed promise after 2 years of testing. Seibel 1000 may also yield a good white or rose wine (from pressed juice) because it has white flesh.

White cultivars that have shown good potential for wine are Seibel 9110, Riesling, Diamond, Vineland 37022, Vineland 37034, and Vineland 35122. The Hungarian Riesling grown in this area is not identical with the German Riesling cultivar, but it is apparently well suited to the Okanagan. Other promising cultivars are New York 11927, New York 12128, and New York Muscat. The first yields a rose wine and the other two are muscat flavored.

Microwave-processed Peaches and Apples

Previous storage tests of chilled sliced peaches held near 0 C with either benzoate or sorbate as a preservative have shown that although samples are microbiologically stable, an almond-like off-flavor develops. Use of microwave heating to achieve enzyme inactivation temperatures without causing cooking is very promising and storage tests are under way. Golden Delicious apple slices, microwave-processed in plastic laminate bags, were equal in texture to canned solid-pack slices and far superior in flavor. The

slices became translucent and had a bright attractive yellow color.

Juice Volatiles

Gas-chromatographic examination of the volatiles in juices from Golden Delicious, Red Delicious, and Spartan showed a decrease in the ratio of low-boiling to high-boiling compounds as the fruit matured. This may provide a possible method for determining maturity in apples. The low boilers consist mainly of methyl and ethyl alcohols.

PLANT NUTRITION, SOILS, AND IRRIGATION

Breakdown in Apples

A considerable amount of breakdown occurred in commercial lots of Spartan apples in ordinary cold storage following the cold winter of 1968-69. Analysis of 180 lots of commercially grown and stored Spartans showed an excellent relationship between percentage of fruits with breakdown and Ca concentration in the fruit. No breakdown occurred when the amount of Ca in sectors of peeled fruit was above 230 ppm on a dry-weight basis.

Breakdown occurred in Golden Delicious following the cold winter of 1968-69. Samples from commercially grown and stored lots were analyzed for Ca and also for K, Mg, Zn, Mn, Fe, and Cu. The relationship between calcium concentration in the fruit and the percentage of fruits with breakdown was highly significant. No breakdown occurred when the fruit sectors contained more than 250 ppm calcium.

Irrigation Management of Grapes on Sandy Soils

Grape yields were 32, 30, and 25 lb/vine when the grapes were irrigated 18, 12, and 8 times respectively. Average irrigation intervals for the three treatments were 6.5, 10, and 14 days. Seasonal amounts of water were nearly the same, at 22, 24, and 21 inches for the three intervals. Yields averaged 24 lb/vine with cover crop and 34 lb/vine without, a highly significant difference. The absence of cover crop slightly increased the acidity of the grapes, but irrigation treatments had no effect on acidity.

Effect of Soil Volume and Water Content on Water Uptake

Over a range of soil volumes, N and P fertilizers have not compensated for volumes that limit the growth of sunflower plants under ordinary once-a-day watering. Continuous watering by a solution-balance technique, in which water is replaced as rapidly as it is used, has not compensated for the limiting soil volumes either. However, fertilizers and continuous watering together appear to interact strongly to compensate in large part for limiting soil volumes. Some of the restrictive effects of small volumes of soil remain unexplained.

PLANT PATHOLOGY

Crown Rot of Apple Trees

Surveys in 1970 revealed this disease to be present in one planting on M.26 rootstocks. Thus, crown rot is known to affect M.IV, M.IX, and M.26, but is much less damaging in plantings of these clones than in those on M.II, M.VII, M.M.104, M.M.106, and M.M.111.

Dexon (Chemagro Corp.), difolatan, and maneb were more effective against the crown rot fungus when they were mixed with soil than were several other fungicides. Dexon was more persistent and more selective than the others and at the concentrations tested was innocuous to tree roots.

Zoospores of this fungus survive in soil for appreciable periods, and longer in rather dry soil than in wet soil.

Control of Bull's-eye Rot and Perennial Canker of Apple

Two of several tested postharvest fungicidal treatments gave outstanding control of bull's-eye rot in the susceptible variety Newtown. Benomyl (Benlate; DuPont of Canada Ltd.), at 0.25 lb/100 gal, reduced rot from 93% to 7.5%; thiabendazole (Tecto-50; Merck & Co.), at 1.5 lb/100 gal, to 9%. For the cultivar McIntosh in controlled-atmosphere storage, these two materials and NF-35 (Green Cross Ltd.) reduced rot, but less effectively.

Fungicidal paints for control of perennial canker combined maneb, ferbam, and ziram, each with its corresponding metallic oxide

(Mn, Fe, Zn) and linseed oil. These mixtures had excellent weathering properties, they prolonged fungicidal activity, and they repulsed the woolly apple aphid. By agar plate tests, the ziram - zinc oxide mixture retained highest fungicidal activity after 4 months.

Apple Virus Diseases

Comparison of apple virus diseases on other continents and in British Columbia. The apple varieties used as virus indicators in European and Southern Hemisphere countries were inoculated with viruses that cause fruit, foliage, and bark symptoms on commonly grown British Columbia varieties. Because none showed symptoms of diseases reported from these other continents, diseases such as star crack, green crinkle, and rough skin are distinct from our diseases and should continue to be listed in Canadian quarantine regulations.

Suppression of apple virus disease symptoms by virus interference. A Blackstayman apple clone from which viruses had been eliminated by heat therapy was much more sensitive to Stayman blotch virus than test clones in which latent virus infections occurred. When a virus isolate from a symptom-suppressing clone was introduced to the sensitive clone, it lost its sensitivity. This supports similar demonstrations of virus suppression of leaf pucker symptoms on McIntosh and Spartan.

Brown Rot Control in Cannery Peaches

A large number of fungicides applied as postharvest dips gave satisfactory control of brown rot in spore-loaded peaches. When spores were applied to breaks in the skin, control was essentially nil except for three fungicides, benomyl, NF-35, and thiabendazole. Botran (Upjohn Co.) applied alone to control rhizopus rot had little effect on brown rot, but in combination with the above fungicides, increased their effectiveness 34%, 126%, and 160% respectively.

Detection of Strawberry Latent Ringspot Virus in Cherry

Three virus isolates previously obtained from Stella sweet cherry are closely related to the European strawberry latent ringspot virus (SLRV). SLRV was apparently introduced to Canada with a variety collection, and Stella was propagated on these frameworks before

the virus infection was discovered. Indexing of young field trees has indicated that less than 10% are infected with SLRV, and that no natural spread has occurred so far. A testing method, based on herbaceous hosts, has been developed to detect SLRV in future importations.

Identity of a Virus from Golden Elderberry

Further work with a virus (GEV) from golden elderberry, *Sambucus nigra aurea* L., has been carried out in cooperation with the Research Station, Vancouver, B.C. The virus is seed transmissible; it forms two bands in a density gradient with sedimentation constants of 114 S and 132 S; it is serologically unrelated to 15 other spherical viruses; and it therefore presumably is a hitherto undescribed virus. A wide range of *Prunus* hosts was susceptible to sap inoculation. Genetic experiments have shown that GEV is not involved in the yellow leaf coloration of the original host, but that it does induce the modifying ring patterns. A very similar golden elderberry, *S. canadensis aurea* L., was found to be virus-free. It is suggested that the latter be used exclusively by the nursery trade.

POMOLOGY

Rootstocks and Training Methods for High-density Peach Culture

The 1967 planting of six peach cultivars on *Prunus tomentosa* rootstock, spaced at 6x12 ft, produced good-sized fruit of uniform maturity at the rate of 11 tons/acre in 1970. Seventy-five percent of the fruit was picked from the ground. Trees are well anchored.

The 1967 planting set at 12 x 18 ft and trained to a two-arm palmette with a height of 6.5 ft, produced fruit in 1970 at the rate of 8 tons/acre. Because all trees were pruned, thinned, and picked from the ground, labor costs were greatly decreased.

Grape Fruiting Habit

An extensive study was conducted on fruiting habit of 13 grape cultivars representing different species and interspecific hybrids. With four cultivars on which detailed blossom records were taken, highly significant differences of up to 3.5 days occurred

between full bloom dates of the first and fourth flower clusters on a shoot. For 13 out of 14 cultivars, significantly more crop was produced on the ninth shoot than on the fifth or first shoot. Only slight and generally non-significant differences in acid and solids content were found between fruit on the first, fifth, and ninth shoots. With most cultivars there were significantly fewer fruit clusters on the first and second than on the fourth to eighth shoots on a 10-shoot cane; numbers of fruit clusters tended to be constant from the fourth to the ninth shoot on a cane. Characteristic numbers of flower clusters per shoot are reported for different cultivars. With 9 out of 13 cultivars, weight of fruit on an individual shoot decreased from proximal to distal bunch; in some cases the first bunch weighed more than twice as much as the fourth. Significant decreases in solids and increases in acid content were found between proximal and distal bunches in only four cultivars.

An Early Maturing Mutant of McIntosh Induced by Ionizing Radiation

A mutant of McIntosh with early maturing fruit has been under observation for several years. In 1964 to 1968, observations were based on one tree only, but in 1970 a replicated planting produced the first crop and confirmed the earlier observations. The mutant, 8F-2-32, comes into bearing relatively early, and the fruit is of normal size and shape and has the normal number of seeds. In 1970, the standard McIntosh apple at picking was rated, on the average, 7.53 and 6.48 for skin and flesh color respectively; the corresponding ratings for the mutant were 8.11 and 8.19. The red color of the mutant fruit is much brighter than that of the standard. The great difference in flesh color between standard and mutant indicates that the fruit of the mutant matures about 1 week earlier.

Growth Regulants to Improve Quality and Earliness of McIntosh Apples

Experiments conducted in 1969 and 1970 have shown clearly that a combination of 500 ppm Ethrel (Amchem Products Inc.) and 20 ppm fenoprop induces early ripening and intensifies color development of McIntosh apples.

Fruits treated as early as August 12, 1969, had 100% red color and highly acceptable

eating quality by August 25. Normal harvest in the same orchard was September 16.

In the 1970 experiments the same results were obtained. Trees treated in both seasons behaved similarly each season and no side effects were evident.

Because Ethrel alone induced early and rapid fruit abscission, fenoprop had to be included as a crop preventative. Alar (UniRoyal Ltd.) applied at relatively high levels also prevented drop induced by Ethrel, and resulted in fruit suitable for a storage period of 1 or 2 months.

Ethrel plus fenoprop applied to trees without a previous Alar treatment resulted in fruits of high quality for immediate marketing or short storage, but if the harvest was unduly delayed, fruit quality and shelf life deteriorated rapidly.

Preliminary work with other varieties indicates that McIntosh is the most responsive cultivar so far tested.

Waxing of Apples

Effects of waxing three commercial varieties of apples on respiration, ethylene production, internal levels of CO₂ and ethylene, chlorophyll degradation, firmness, acidity, soluble solids, and physiological disorders were studied. The last five parameters were evaluated on apples kept in storage at -1 C for 100 days.

The waxed apples had lower respiration and ethylene production than the nonwaxed controls, and higher internal levels of CO₂ and ethylene. However, no effects on internal color, acidity, firmness, or soluble solids were evident. No effect was noted on scald and breakdown, although one lot of waxed Spartans had three times as much breakdown as the nonwaxed control.

The Relationship of Form of N in Spartan Apples

Total N by Kjeldahl and soluble N in the form of amino N were determined at 3-week intervals during growth of Spartan apples between June 17 and October 5.

The concentration of total N decreased rapidly during the first period of measurement to about 60 days after bloom. The main concentration of amino N declined in the same way and appeared to have a fairly direct relationship to total N. In some previous studies there has been a correlation between tree vigor, fruit size, amino N, and

incidence of breakdown in Spartan apple. Last year, however, when incidence of breakdown was unusually high, there appeared to be no relationship between amino N and incidence of breakdown.

Relative Coldhardiness of Sweet Cherry Interstock Selections

Dormant shoots of 1 sour cherry and 13 sweet cherry cultivars were exposed to artificial freezing with minimum temperatures of -22°C to -23°C . The cultivars included Montmorency sour, three Glenn Dale selections of European origin, seven Minnesota selections of Norwegian origin, and three commercial sweet cultivars. The Montmorency, Glenn Dale, and Norwegian cultivars showed good recovery ratings of 61-73% in the greenhouse, compared with recovery ratings of 53% for Van and Lambert and 41% for Bing. Glenn Dale 6 was considered to have the best overall performance and is now recommended as a hardy stem-builder for sweet cherries in the British Columbia Interior.

VEGETABLES

Three new tomato varieties are being introduced for grower trial. Two of these, Summerjet and Smoothie, are early bush types of Vinered x Summerdawn parentage, notable for resistance to *Verticillium* spp., heavy early yields, and smoothness and uniformity of the medium-small red fruit. Sutomi is an indeterminate greenhouse variety, immune to TMV, vigorous, and prolific, and bears medium-sized red fruit.

Small, maneuverable picking aids that transport one or two pickers over single-row or bed plantings of tomatoes increased picker efficiency by over 100% in the harvest of semiripes and turnings for the fresh market. Gains depended on fruit size, ease of picking, uniformity of plant stand, and crop intensity.

PUBLICATIONS

Research

- Banham, F. L. 1970. Notes on diapause in the tomato hornworm (Lepidoptera: Sphingidae) in British Columbia. *J. Entomol. Soc. Brit. Columbia* 67:16-17.
- Clarke, R. T. J., Jones, W. T., Lyttleton, J. W., McArthur, J. M., and Reid, C. S. W. 1970. The contribution of Fraction 1 (18S) protein of legumes to the occurrence of bloat in cattle. *Proc. XI Int. Grassland Congr.* 777-780.
- Downing, R. S., and Moilliet, T. K. 1970. Plictran as an orchard acaricide. *Can. Entomol.* 102:1604-1607.
- Eaton, G. W., and Lapins, K. O. 1970. Identification of standard and compact apple trees by discriminant function analysis. *J. Appl. Ecol.* 7:267-272.
- Heinrichs, D. H., and Miltimore, J. E. 1970. Variation of Fraction 1 protein content in alfalfa. *Can. J. Plant Sci.* 50:537-539.
- Hikichi, M., and Miltimore, J. E. 1970. A laboratory mixer for homogenizing plant tissue ground with liquid nitrogen. *Lab. Pract.* 19:383.
- Kitson, J. A. 1970. A continuous process for dehydrofreezing apples. *Can. Inst. Food Technol.* J. 3(4):136-138.
- Lapins, K. O., and Hough, L. F. 1970. Effects of gamma rays on apple and peach leaf buds at different stages of development. II. Injury to apical and axillary meristems and regeneration of shoot apices. *Radiat. Bot.* 10:59-68.
- Looney, N. E. 1970. Metabolic control of ripening. *HortScience* 5:39-40.
- Looney, N. E., and McMechan, A. D. 1970. The use of 2-chloroethylphosphonic acid (Ethrel) and succinic acid 2,2-dimethyl hydrazide (Alar) to aid in mechanical shaking of sour cherries. *J. Amer. Soc. Hort. Sci.* 5:452-455.
- Madsen, H. F. 1970. Control of the fruit-tree leafroller and notes on its biology in British Columbia. *Can. Entomol.* 102:746-749.
- Madsen, H. F. 1970. Insecticides for codling moth control and their effect on other insects and mites of apple in British Columbia. *J. Econ. Entomol.* 63:1521-1523.
- Madsen, H. F. 1970. Observations on *Rhagoletis indifferens* and related species in the Okanagan Valley of British Columbia. *J. Entomol. Soc. Brit. Columbia* 67:13-16.

- Madsen, H. F., and Morgan, C. V. G. 1970. Pome fruit insects and their control. *Annu. Rev. Entomol.* 15:295-320.
- Mason, J. L., and Miltimore, J. E. 1970. Yield increases from fertilizer on reed canarygrass and sedge meadows. *Can. J. Plant Sci.* 50:257-260.
- Mason, J. L., and Welsh, M. F. 1970. Cork spot (pit) of Anjou pear related to calcium concentration in fruit. *HortScience* 5:447.
- McMullen, R. D. 1970. *Psylla pyricola* (Foerster), pear psylla (Homoptera: Psyllidae), p. 33-38. In *Biological control programmes against insects and weeds in Canada 1959-1968*. Technical Communication of the Commonwealth Institute of Biological Control 4. 266 p.
- McMullen, R. D., and Jong, C. 1970. The biology and influence of pesticides on *Campylomma verbasci* (Heteroptera: Miridae). *Can. Entomol.* 102:1390-1394.
- Miltimore, J. E., Mason, J. L., and Ashby, D. L. 1970. Copper, zinc, manganese and iron variation in five feeds for ruminants. *Can. J. Anim. Sci.* 50:293-300.
- Miltimore, J. E., and McArthur, J. M. 1970. Bloat investigations. Prevention with poloxalene, tallow, pluronic, and phosphorus on alfalfa. *Can. J. Anim. Sci.* 50:651-656.
- Miltimore, J. E., McArthur, J. M., Mason, J. L., and Ashby, D. L. 1970. Bloat investigations. The threshold Fraction 1 (18S) protein concentration for bloat and relationships between bloat and lipid, tannin, Ca, Mg, Ni and Zn concentrations in alfalfa. *Can. J. Anim. Sci.* 50:61-68.
- Peschken, D., Friesen, N. A., Tonks, N. V., and Banham, F. L. 1970. Releases of *Altica carduorum* (Chrysomelidae: Coleoptera) against the weed Canada thistle (*Cirsium arvense*) in Canada. *Can. Entomol.* 103:264-271.
- Porritt, S. W., and Meheriuk, M. 1970. Chemical control of scald on waxed apples. *Can. J. Plant Sci.* 50:313-317.
- Proverbs, M. D., and Logan, D. M. 1970. A rotating oviposition cage for the codling moth, *Carpocapsa pomonella*. *Can. Entomol.* 102:42-49.
- Stevenson, D. S. 1970. Soil volume and fertilizer effects on growth and nutrient contents of sunflower plants. *Can. J. Soil Sci.* 50:353-361.
- Stevenson, D. S., and Munn, D. M. 1970. A simple automatic waterer for growth room or greenhouse. *Can. J. Soil Sci.* 50:461-462.
- Sugisawa, H., and Komura, T. 1970. Thermal degradation of sugars. Quantitative analysis of sugar components and determination of degree of polymerization. *Can. Inst. Food Technol. J.* 3(2):33-35.
- Welsh, M. F., and May, J. 1970. Fruit wrinkle, a graft-transmissible abnormality of Newtown apple. *Plant Dis. Rep.* 54:493-496.
- Welsh, M. F., and May, J. 1970. Transmissible and nontransmissible fruit-blotching syndromes. *Plant Dis. Rep.* 54:490-493.
- Whelan, E. D., Hornby, C. A., and Lapins, K. O. 1970. Variation in pollen viability and induced chromosome aberrations among and within propagates of irradiated *Prunus avium* L. cv. Lambert. *J. Amer. Soc. Hort. Sci.* 95:763-765.
- Wilcox, J. C. 1970. Credit to give for an irrigation when scheduling irrigations. *Can. Agr. Eng.* 12:28-32.
- Wilcox, J. C. 1970. Credit to give for rain when scheduling irrigations in semi-humid areas. *Can. Agr. Eng.* 12:33-37, 51.

Miscellaneous

- Banham, F. L. 1970. The tuber flea beetle in British Columbia. *Can. Agr.* 15(3):26-27.
- Banham, F. L., and Arrand, J. C. 1970. Recognition and life history of the major insect and allied pests of vegetables in British Columbia. *B.C. Dep. Agr., Entomol. Br.* 70-9:1-43.
- Fisher, D. V. 1970. Present status of the tree fruit industry in the Pacific Northwest. *B.C. Orchardist* 10(8):16-19.
- Fisher, D. V. 1970. Spur strains of McIntosh discovered in British Columbia, Canada. *Fruit Variety Hort. Dig.* 24(2):27-32.
- Fisher, D. V. 1970. Varieties, rootstocks, and interstocks currently recommended for British Columbia orchards. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):75-78.
- Fisher, D. V. 1970. Will consumer tastes change? Evaluation of new varieties and strains and their market potential. *Proc. Oregon State Hort. Soc.* 61:28-36.
- Fisher, D. V., Meheriuk, M., and Swales, J. E. 1970. Spur and standard strains of Delicious compared. *B.C. Fruit Growers' Ass. Quart. Rep.* 14(4):7-19.
- Fisher, D. V., Welsh, M. F., and Christie, W. D. 1970. A short history of the BCFGF budwood program. *B.C. Orchardist* 11(1):11-13.
- Lapins, K. O. 1970. Dense orchard plantings. *B.C. Orchardist* 10(2):27-29.

- Lapins, K. O. 1970. Hardy cherry framebuilders may provide the solution to trunk killing in winter freezes. *B.C. Orchardist* 10(10):8-9.
- Lapins, K. O. 1970. Progress in selecting better apricots. *N. Amer. Pomona* 3:86-87, 94.
- Lapins, K. O. 1970. Radiation puts B.C. researchers on the trail of a dwarf cherry. *Western Fruit Grower* 24(3):16, 18.
- Lapins, K. O. 1970. The Sierra pear. *Fruit Variety Hort. Dig.* 24:2.
- Lapins, K. O. 1970. The Stella cherry. *Fruit Variety Hort. Dig.* 24:19-20.
- Looney, N. E. 1970. How research in apple ripening paid off with a possible technique to improve fruit color. *Western Fruit Grower* 24(10):14-16.
- Looney, N. E. 1970. Metabolic control of ripening. *HortScience* 5:39-40.
- Looney, N. E. 1969. The use of Alar and other growth regulators in modern apple growing. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):125-129.
- Looney, N. E., and McMechan, A. D. 1969. Progress report on the mechanical harvesting of sour cherries. *B.C. Orchardist* 10(2):13-14.
- Lopatecki, L. E. 1969. Disease problems associated with overtree sprinkling. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):96-98.
- Madsen, H. F. 1970. Integrated pest control in tree fruits. *Sci. Aff.* 4:61-62.
- Madsen, H. F., and Arrand, J. C. 1970. The biology and control of cherry fruit flies in the Okanagan Valley of British Columbia. *B.C. Dep. Agr., Entomol. Br.* 70-2:1-5.
- Mason, J. L. 1970. Big research program for Spartan apple. *B.C. Orchardist* 10(8):8.
- Mason, J. L. 1970. Breakdown in Spartan apples. *Can. Agr.* 15(3):30-31.
- McIntosh, D. L. 1969. Effects of cultural practices on crown rot susceptibility of rootstocks to the disease. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):91-95.
- McIntosh, D. L. 1970. Old disease becomes new threat. *Amer. Fruit Grower*, March, p. 14.
- McMechan, A. D. 1969. Apple and pear harvesting—present and future. *Proc. Nova Scotia Fruit Growers' Ass. 106th Annu. Meeting.* p. 95-100.
- McMechan, A. D. 1970. How well do you know your sprayer? *Proc. Oregon Hort. Soc.* 61:37-41.
- McMechan, A. D., and Williams, K. 1970. Tower sprayer for compact tree undergoing tests. *B.C. Orchardist* 10(4):10.
- Miltimore, J. E., and Mason, J. L. 1970. Fertilize, irrigate, graze. *N.O.C.A. Pict. Quart.* 4:16.
- O'Reilly, H. J., Welsh, M. F., and Hansen, A. J. 1970. Little cherry disease, a renewed threat to British Columbia fruit districts? *B.C. Dep. Agr., Plant Pathol. Br., Bull.* 70-10. 8 p.
- Porritt, S. W., and Meheriuk, M. 1969. Modern harvesting, handling and storage techniques. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):108-116.
- Proverbs, M. D. 1970. Autocidal control of an orchard pest. *Sci. Aff.* 4:63-65.
- Rasper, V., and MacGregor, D. R. 1969. Starchy root crops in the Ghanian diet and aspects of their industrial utilization. *Gordian West Africa Ed. #1631B*, 47-50.
- Stevenson, D. S. 1969. Fruit residue problems associated with over-tree sprinkling. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):99-101.
- Stevenson, D. S. 1970. Low soil water reserve areas welcome moisture. *Free Press Weekly* 90:16. May 9.
- Strachan, C. C. 1970. Research Report 1969. Research Station, Summerland, B. C., *Can. Dep. Agr., Ottawa.* p. 337-348.
- Sugisawa, H., and Kitson, J. A. 1970. High powered apple aroma. *B.C. Orchardist* 10(7):4.
- Welsh, M. F. 1969. Rubbery wood and brown line decline virus effects on B.C. apple plantings in 1969. *Proc. 1st B.C. Fruit Growers' Ass. Apple Forum* (1969):80-82.
- Welsh, M. F., and May, J. 1970. Trees of 200-year-old Newtown apple cultivar found free of commonly-occurring viruses. *Fruit Variety Hort. Dig.* 24:56-57.

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INTRODUCTION

The Research Station, Vancouver, is the main center in Canada for research on plant viruses. It also serves the coastal areas of British Columbia on general problems of insects and plant diseases, and the whole province on problems of stored-products and vegetable insects, forage-crop and potato diseases and insects, and soil surveys.

This report, the eighth, covers work completed and in progress in 1970. Both the report and reprints of the publications listed are available on request. Correspondence should be addressed: Research Station, Research Branch, Canada Department of Agriculture, 6660 N.W. Marine Drive, Vancouver 8, B.C., Canada.

R. E. Fitzpatrick
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Aster yellows disease. Studies were carried out on mycoplasma media enriched with extracts from roots of aster, periwinkle, and carrot, and on the medium of Chen and Granados. Initial results from negative staining and electron microscopy appeared to be positive for mycoplasma-like organisms. Further study showed that similar bodies were present in uninoculated media and some preparations of horse serum.

The isolation of genetic repressors, which control the infectious cycle of the disease, is in progress. The postulated repressors were extracted from plant material and fractionated by two-dimensional thin layer chromatography. The metabolism of these components was followed as a function of the time of infection, for more than 2 months. The substances were characterized by their ultraviolet spectra and by their mobilities in different chromatographic systems.

Cellular ultrastructure and virus synthesis. Controlled intracellular degeneration was achieved by exposing attached and detached leaves to complete darkness. The degenerative changes induced were different from those resulting from excision and aging in the light, and more highly synchronized. Virus establishment and synthesis proceeded in the leaves, despite the structural degeneration caused by extreme starvation. The primary phase in virus establishment was elucidated by preservation of an early macromolecular host-virus complex and its isolation and identification by combined differential centrifugation, electron microscopy, and infectivity tests. Preservation of the complex and

its release from cell wall structures were attempted by low temperature treatment of inoculated leaves before their maceration. Evidence for the effectiveness of such a treatment was obtained from experiments that showed that the processes of virus establishment and virus synthesis could be affected independently by pre- or post-inoculation cold treatment of the leaves. Differential centrifugation of extracts from inoculated cold-treated leaves resulted in 50% of total infectivity being recovered in fractions sedimenting at 20,000 g or less.

A large-scale scheme for purification of the virus inhibitor from *Dianthus caryophyllus* L. yielded very pure, but highly dilute, solutions of the biologically active agent. When attempts to concentrate these solutions were made under the mildest possible conditions by using ultrafiltration, biological activity was largely lost and could not be restored by mixing ultrafiltrate and concentrate. However, incompletely purified inhibitor solutions did not suffer from ultrafiltration and therefore could be concentrated.

Amino acid composition and serological properties of viruses. Trypsin acting on cowpea chlorotic mottle virus (CCMV) in 0.02 M tris-HCl buffer, pH 7.4, released 37 amino acid residues from the N-terminal of the virus protein accompanied by a disassembly of the virus into 6 S nucleoprotein units. During the first 3 min the rate of disassembly and release of amino acids was rapid, but after this period the reaction rate was slower. Kinetic studies demonstrated that both were first-order reactions, i.e., the rates were determined by the concentration of the undegraded virus. At pH 5.0 the altered protein formed viruslike particles (55 S) containing

8% RNA and smaller spheres (34 S) containing 5% RNA. After the removal of residual RNA from the altered protein in 1 M NaCl, the altered protein was reassembled at pH 5.0 in the presence of undegraded virus RNA. Although the altered protein assembled to form particles, it did not encapsulate RNA; under similar conditions, native CCMV protein will encapsulate RNA. Therefore the loss of the 37 amino acid residues from the N-terminal of CCMV protein results in a loss of the RNA binding site. The 37 amino acids lost after tryptic action compose 20% of the original protein molecule, but contain 50% of the basic amino acids, which have a charge opposite to that of RNA. The cleavage of 18 amino acid residues from the N-terminal by chymotrypsin did not alter the morphology of the virus particles, but the RNA content decreased from 25% to 20%. Carboxypeptidase cleaved a single amino acid residue, tyrosine, from CCMV protein in the virus particle.

When tested with antisera of native CCMV, particles formed by the action of chymotrypsin and carboxypeptidase on the virus were serologically identical with the virus. Particles formed by the action of trypsin on the virus showed an additional antigenic specificity. The presence of this specificity in sera from rabbits injected with native virus was unexpected, but it is of practical relevance, because, in the production of antisera in animals, antigens are exposed to proteolytic enzymes when they are ingested by the white blood cells.

Antibodies induced by the injection of alfalfa mosaic virus (AMV) or turnip crinkle virus (TCV) protein reacted with the viruses and their respective protein subunits in gel-diffusion tests. The ratios of virus-reactive antibodies to protein-reactive antibodies were different in two fractions obtained by chromatography of the sera on DEAE-Sephadex. Antibodies induced by acidic antigens were found predominantly in the first DEAE-Sephadex fraction, and those induced by basic antigens in the second fraction. Electrophoretic mobility measurements of TCV, AMV, and their proteins indicated that the viruses had a greater negative charge per unit surface area than their respective proteins.

Cytology and physiology of virus-infected plants. After the three-dimensional structure of crystals formed by Southern bean mosaic

virus in cowpea was analyzed, the chemical composition of the crystals and the icosahedral particles of which they are formed was studied. The crystals were shown to consist of protein and RNA. The individual particles were normally 276 Å in diam, but after pepsin digestion were only 205 Å. Treatment with ribonuclease produced electron transparent centers having a maximum diameter of 118 Å. Digestion with pepsin followed by ribonuclease produced doughnut-shaped particles with outer diameters of 205–210 Å. These facts suggest the presence of an inner spherical shell about 43 Å thick, not readily digestible by either pepsin or ribonuclease, and situated between a central RNA core and an outer protein shell. This inner shell may be an area where protein and RNA meet and are tightly linked.

Intranuclear crystals from leaves of *Dianthus barbatus* L. and perinuclear crystals from leaves of *Lychnis chalconica* L., which were originally thought to be of viral origin, were found in apparently healthy tissues. Their presence appeared to depend upon the environment and nutrition of the plants. The chemical composition of the crystals was determined by differential enzyme digestion, which showed the *Lychnis* crystals, and also apparently the *Dianthus* crystals, to be composed of protein. The unusual amino acid composition or conformation of the *Dianthus* crystals may result in complex reactions with fixatives, which would impede digestion by some proteinases.

POTATO PATHOLOGY

Potatoes

Potato viruses X and S. Eradication of potato virus X (PVX) and potato virus S (PVS) by nutrient culture of axillary buds excised from heat-treated plants was continued in 1970. In addition to the 41 cultivars and seedlings previously reported, the following were freed from PVX and PVS: Menominee, six more selections of Nette Gem, Norchip, Pungo, Purple Chief, Saco, Up-to-Date, and Frederickton seedling F5889. Neither PVX nor PVS was detected in the cultivars Arran Consul and Early Epicure imported from Great Britain, and these two selections have also been added to our list of virus-free nuclear stocks.

Potato leaf roll virus. Three potato clones infected with potato leaf roll virus (PLRV) and PVS were subjected to heat therapy followed by bud culture. Ease of eradication of PLRV varied with the source plant. The percentage of plantlets freed from PLRV by this method ranged from 84 to 100. From one cultivar PLRV was more difficult to eradicate than the concomitant strain of PVS.

Potato virus M. One potato selection subjected to the virus eradication program was infected with potato virus M (PVM) as well as PVS and PLRV. From this clone, PVM was the most readily eradicated. Of 190 plantlets that developed, the numbers infected with PVS, PLRV, and PVM were 65, 23, and 15 respectively.

Potato spindle tuber virus. Nutrient culture of buds excised from heat-treated plants showed that potato spindle tuber virus (PSTV) was far more difficult to eradicate by this technique than PVX, PVS, PLRV, or PVM. Severe PSTV was eradicated from only 4 of 66 plantlets; mild PSTV from 6 of 248.

Field propagation of virus-free cultivars. One or more clones are being maintained of 52 cultivars and 6 seedlings that are free from all known viruses. Each winter, tests are made for mild leaf roll, spindle tuber, PVX, PVS, and PVM. Annual tests for PVX and PVS are made in the field. Virus-tested cultivars propagated by Elite seed growers in British Columbia in 1970 were Epicure, Early Rose, Fundy, Kennebec, Nettle Gem, Norgold Russet, Norland, Red La Soda, Red Pontiac, Sebago, Warba, and White Rose.

Small Fruits

Mummy berry of highbush blueberry. Economic losses in highbush blueberry production caused by *Monilinia vaccinii-corymbosi* (Reade) Honey were determined in 1970 by using previously published methods. Sample size and numbers of fields surveyed were increased to determine their effects on the efficiency of the survey. No differences were detected. Overall losses due to mummy berry were 7.4%, or about \$73,000.

A field plot of seven treatments with six replicates was set out in a commercial planting of Rancocas. Sprays of ferbam, thiophanate, and benomyl (Benlate; DuPont of Canada Ltd.) were applied starting on March 26. All benomyl sprays significantly reduced

infections of leaf shoot, flower cluster, and mummy berry, and significantly increased yields; a single spraying was the most effective. Thiophanate gave effective control, but did not increase yields.

Postharvest strawberry and raspberry fruit rot. In cooperative studies with the Research Station, Agassiz, *Botrytis cinerea* Pers. was found to be the most prevalent fungus causing deterioration of strawberries and raspberries in cold storage, regardless of pretreatment. A *Rhizopus* sp. caused a lot of damage in the first two pickings of raspberries, but was less injurious to later pickings. Fungicide treatments that controlled *Botrytis* favored the development of *Rhizopus*. *Cladosporium* sp., *Penicillium* spp., powdery mildew, and *Rhizoctonia* caused minor damage.

Nematodes

Host range of Xiphinema bakeri. Forty kinds of plants, including 11 weeds, were tested as hosts for *X. bakeri* Williams, 1961, based on population increase and damage to the plants. Eight of the weeds supported large to very large population increases, but suffered little damage. Strawberry, raspberry, tomato, and potato were most severely damaged. Broccoli, cauliflower, cabbage, and Brussels sprouts reduced population levels below that of a fallow check. Other crops, such as rye, orchard grass, and clovers, normally used in rotations in the Fraser Valley were excellent hosts.

Control of Pratylenchus in apple understocks. Tests were conducted on the treatment of nursery apple understocks against *Pratylenchus* spp. Three dip treatments were tested: DP 1410 (DuPont of Canada Ltd.) at seven rates, thionazin at four rates, and water at 115 F for 30 min. Based on the number of nematodes killed and the amount of damage to plants, the treatment with hot water was the most effective. High rates of thionazin and all rates of DP 1410 showed some plant damage.

Virus Multiplication

Excised tissue and Actinomycin D in the study of plant virus replication. Whole Chinese cabbage leaves or leaf discs were cut and placed in water for up to 28 hr, followed by 2 hr for uptake of P^{32} -labeled phosphate. There was a progressive increase in the

amount of label accumulated by the cut surface and a decrease in the amount of label taken up into the leaf or the center of the disc. This increase, referred to as the aging phenomenon, was suppressed by pretreating with 10 μ g of Actinomycin D per milliliter instead of water. When leaves were placed in the RNA precursor uracil- C^{14} the same results were found as with labeled phosphate. The incorporation into TCA-insoluble material (mainly RNA) was higher with Actinomycin D-treated leaf tissue than with water-treated controls.

The aging phenomenon has not been taken into account by virologists. The suppression of this phenomenon by Actinomycin D means that experiments concerning virus synthesis might be subjected to serious distortions. Actinomycin D is used in virus synthesis studies in animal and bacterial systems to suppress normal RNA synthesis and to allow virus synthesis to proceed. With plant tissue, misinterpretation of results could occur because, although the antibiotic suppresses uptake, incorporation into RNA may be increased.

ENTOMOLOGY

Vectors

Mycoplasma-like organisms. Ultramicroscopic study of sections of bark, leaf veins, petals, fruit, and embryos from sweet cherry trees infected with little cherry disease failed to reveal mycoplasma-like organisms (MLO). These have been suspected as causal agents.

MLO were found in salivary sheaths of unfed nymphs, newly hatched from eggs of leafhoppers infective and noninfective with aster yellows disease. MLO are thus shown to be inherent, and must be transmitted transovarially. This circumstance complicates the proposed mycoplasma etiology of yellows diseases.

Morphology and fine structure. The stylets of winged and wingless forms of five species of vector aphids were compared by using scanning electron microscopy. These data supplement previous conclusions and show remarkable similarity in the stylets. Apparently the theory that specificity of transmission of viruses is a function of structural differences between stylets is incorrect. The five species of aphids examined were green

peach aphid, *Myzus persicae* (Sulz.); bean aphid, *Aphis fabae* Scop.; cabbage aphid, *Brevicoryne brassicae* (L.); potato aphid, *Macrosiphum euphorbiae* (Thomas); and pea aphid, *Acyrtosiphon pisum* (Harris).

Sensory structures on the labium of these species were studied and compared by the same means, as well as the stylets of the leafhoppers *Aceratogallia californica* (Bak.), *Macrosteles fascifrons* (Stål), *Scaphytopius delongi* Young, and the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). Stylet sections of *A. californica* and the pear psylla, *Psylla pyricola* Foerster, were examined in the transmission electron microscope.

Root Weevils

Black vine weevil larvae and strawberry cultivars. Six cultivars were tested in the greenhouse for resistance to larvae. The plants were infested with 30 eggs each, and examined after 10 weeks. Most cultivars were severely damaged or dead, except EC-25, which hardly differed from uninfested plants. Moreover, the largest larvae and the greatest numbers were recovered from EC-25. The extensive root growth of these plants apparently allows them to survive attacks of the larvae by providing abundant roots as food, thereby avoiding damage to the vulnerable crown. Other cultivars in ascending order of survival were Cheam, Siletz, British Sovereign, Northwest, and Agassiz.

In the field these cultivars were tested in plots enclosed by 20-cm barriers, which contained controlled infestations of marked adult weevils. The barriers consisted of black 4-mil polyethylene, sprayed with the slippery compound Fluon, on wire strung between stakes. The barriers may be commercially practical in preventing the invasion of new plantings from old infested ones.

Egg parasites. Parasitized eggs of the obscure root weevil, *Sciopithes obscurus* Horn, were collected from spent rhododendron blooms. Two species of parasites emerged, one of which, *Trichogramma minutum* Riley, was cultured successfully on eggs of the black vine weevil. Several generations of this thelytokous strain of *T. minutum* were reared. The weevil was not previously known to have parasites on its eggs.

Wireworms

Chemical control. In silt loam, single applications of Bux (Ortho 5353; Chevron Chemical Co.) in 15% granules, fonofos in 20% granules, and carbofuran in 5% and 15% granules were incorporated to a depth of 10 cm to control *Agriotes obscurus* (L.). The treatment was 5.6 kg of toxicant/ha (5 lb/acre). When the soil was treated with fonofos 20% or carbofuran 5% granules, the wireworm population was reduced by 85%; with carbofuran 10% granules by 82%; and with Bux by 76%. The population in the check plots averaged 80 wireworms per sq m.

Leatherjackets

Chemical control. In pastures, single applications of insecticides were tested for control of larvae of the European crane fly, *Tipula paludosa* Meigen. Treatments in late February with parathion, chlordane, and diazinon reduced the population by more than 95%; fenitrothion (Sumithion; Sumitomo Chemical Co.) and diazinon by 90% and 92% respectively; bromophos by 82%; chlorfenvinphos by 81%; Perthane (Rohm & Haas Co. of Canada Ltd.) by 75%; Bux by 74%; and methoxychlor by 49%. The untreated population averaged 366/sq m (34/sq ft). In the fall chlordane granules and diazinon granules or spray reduced the population by more than 97%; bromophos by 91%; phosmet by 51%; carbaryl by 35%; and methoxychlor by 30%. Naled was ineffective. The untreated population was 1,249/sq m (116/sq ft).

Tansy Ragwort

Biological control. The cinnabar moth, *Tyria jacobaeae* L., which was released in the Nanaimo area in 1964-1967 to control tansy ragwort, *Senecio jacobaea* L., ate all the foliage on this weed for the third successive year. The number of flowering stalks did not differ from that in previous years, about 2.9/sq m, but the size of the plants was reduced. Of the stripped stalks, 50% had regrowth, and some flowers were produced late in the season.

Root Maggots

Compatibility. In peat and sandy loam, granular carbofuran, chlorfenvinphos, or fensulfothion were applied over seeded rows of cauliflower that had been previously

treated with the fungicides benomyl, calomel, NH_4OH , and quintozene. The insecticides were reapplied as drenches over the plants 28 days after seeding. In peat the fungicides, except benomyl, reduced germination by more than 20%, but did not reduce clubroot, *Plasmodiophora brassicae* Wor. The insecticides reduced germination by less than 20%, but damage was below 5%, whereas the controls had 55% damage. In sandy loam the fungicides reduced germination, with or without insecticides, but NH_4OH reduced clubroot. The insecticides held damage below 2%, whereas the controls had 47%. Despite the damage, the yields from control plots generally exceeded those from treated plots. Carbofuran caused noticeable mortality in earthworms.

An extensive greenhouse experiment was conducted on two types of soil to determine the effectiveness of four fungicides against clubroot in cauliflower. No insecticides were used. NH_4OH reduced germination, but was effective against the pathogen and lowered the pH.

Alone or in combination, herbicides were applied before seeding or emergence of broccoli, cabbage, cauliflower, and rutabaga on silt loam. Granular carbofuran, fensulfothion, and thionazin were applied over the treated rows, and reapplied as drenches 28 days after seeding; for rutabaga they were applied again after 49 and 70 days. There were no apparent incompatibilities, but germination was significantly reduced.

Carrot rust fly. To prevent damage by *Psila rosae* (Fab.), 14 granular organocarbamate and organophosphorus insecticides were applied in the seed furrow at two locations in muck soil, and supplemented with two, three, four, or eight sprays. All treatments except chlorfenvinphos and ethion reduced germination up to 40%. Damage was light up to 100 days after seeding, but by 160 days only plots treated with six of the compounds had less than 20% damage.

Residue Chemistry

D-D residues in soil. After 1 year residues in a loam soil treated with D-D (Shell Chemical Co.) soil fumigant at three rates decreased from 50 ppm to 0.5 ppm at 200 gal of fumigant/acre; from 31 ppm to 0.2 ppm at 100 gal/acre; and from 21 ppm to 0.1 ppm at 40 gal/acre.

Organophosphorus residues. A gas chromatographic method was developed for the determination separately of fensulfothion and three important metabolites in plants. The method was applied successfully to cauliflower, carrots, and potatoes. Fensulfothion sulfone, the principal metabolite, averaged 14% of the total insecticide in carrots harvested 10 days after the last treatment and 18% of those harvested 30 days later. Little of the oxygen analogue and none of the oxygen analogue sulfone were found in carrots.

Organocarbamate residues. Work was started on determination of carbofuran residues with the use of methods other than microcoulometric detection. Derivatization techniques with trichloroacetyl chloride and trifluoroacetic anhydride followed by electron capture detection appear promising, in spite of interference from plant extractives. These are still a problem in certain crops.

PEDOLOGY

Classification and Mapping

The inventory and classification of the soils of British Columbia continued as a cooperative project with the Provincial Department of Agriculture and the Department of Soil Science, University of British Columbia.

The reconnaissance soil survey was completed in the Peace River area along with laboratory analyses of selected soil profiles. Approximately 647,600 ha were covered in map sheets: Charlie Lake 94A, Halfway 94B/E half, Beatton River 94H/S half, Pine Pass 93O/E half, and Dawson Creek 93P. Soil Capability for Agriculture ratings and maps were completed for an additional 2,179,000 ha in the same area. Reports and maps have been completed for Fort Nelson 94J/NE, Clinton - Lac La Hache, Tulameen 92H/NE, and Tofino-Ucluelet Lowland.

PUBLICATIONS

Research

- Cadman, C. H., and Stace-Smith, R. 1970. Raspberry vein chlorosis, p. 119-120. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Converse, R. H., Stace-Smith, R., and Cadman, C. H. 1970. Raspberry mosaic, p. 111-119. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Cram, W. T. 1970. Acceptability of cultivars of highbush blueberry at varying temperatures by adult black vine weevils (Coleoptera: Curculionidae). *J. Entomol. Soc. Brit. Columbia* 67:6-7.
- Cram, W. T. 1970. Incongruity between larvae and adults in the acceptability of highbush cultivars by the black vine weevil. *J. Entomol. Soc. Brit. Columbia* 67:17.
- Cram, W. T. 1970. Unacceptability of cultivars of highbush blueberry by adult black vine weevils (Coleoptera: Curculionidae). *J. Entomol. Soc. Brit. Columbia* 67:3-6.
- Finlayson, D. G., Fulton, H. G., Kore, R., and Williams, I. H. 1970. Fensulfothion and thionazin residues in carrots. *J. Econ. Entomol.* 63:1304-1306.
- Forbes, A. R., and Mullick, D. B. 1970. The stylets of the balsam woolly aphid, *Adelges piceae* (Homoptera: Adelgidae). *Can. Entomol.* 102:1074-1082.
- Frazier, N. W., and Mellor, F. C. 1970. Strawberry crinkle, p. 18-23. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Frazier, N. W., and Mellor, Frances C. 1970. Tomato ringspot virus in strawberry, p. 43-45. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Frazier, N. W., and Stace-Smith, R. 1970. Necrotic shock in strawberry, p. 48-49. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Freeman, J. A., and Finlayson, D. G. 1970. Incompatibilities between herbicides and insecticides in direct seeded brassica crops. *HortScience* 5:177-178.
- Freeman, J. A., and Pepin, H. S. 1969. Effect of post-harvest infection of powdery mildew on yield of the strawberry cultivar Northwest. *Can. Plant Dis. Surv.* 49:139.
- MacCarthy, H. R. 1970. A newly recorded virus disease of sugar beet in British Columbia. *Can. Plant Dis. Surv.* 49:135-138.

- Mellor, Frances C., and Frazier, N. W. 1970. Mild yellow-edge, p. 14-16. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Mellor, Frances C., and Frazier, N. W. 1970. Strawberry mottle, p. 4-8. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Mellor, Frances C., and Stace-Smith, R. 1970. Virus strain differences in eradication of potato viruses X and S. *Phytopathology* 60:1587-1590.
- Pepin, H. S., and Toms, H. N. W. 1969. Economic loss from mummy berry of highbush blueberry in coastal British Columbia. 1969. *Can. Plant Dis. Surv.* 49:105-107.
- Ragetli, H. W. J., and Weintraub, M., and Lo, Ester. 1970. Degeneration of leaf cells resulting from starvation after excision. I. Electron microscopic observations. *Can. J. Bot.* 48:1913-1922.
- Ragetli, H. W. J., Weintraub, M., and Lo, Ester. 1970. Degeneration of leaf cells resulting from starvation after excision. II. Correlation with water movement and effect on virus synthesis. *Can. J. Bot.* 48:1923-1929.
- Stace-Smith, R. 1970. Thimbleberry mosaic, p. 124-126. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Stace-Smith, R., and Converse, R. H. 1970. Raspberry leaf curl, p. 120-122. *In* Virus diseases of small fruits and grapevines. University of California, Division of Agricultural Sciences, Berkeley, California, U.S.A.
- Stace-Smith, R., and Mellor, Frances C. 1970. Eradication of potato spindle tuber virus by thermotherapy and axillary bud culture. *Phytopathology* 60:1857-1858.
- Stace-Smith, R., and Tremaine, J. H. 1970. Purification and composition of potato virus Y. *Phytopathology* 60:1785-1789.
- Tremaine, J. H. 1970. The composition of tomato bushy stunt virus from *Prunus avium*. *Phytopathology* 60:454-456.
- Tremaine, J. H. 1970. Physical, chemical and serological studies on carnation mottle virus. *Virology* 42:611-620.
- Valentine, K. W. G. 1970. Ground infrared photography to distinguish vegetation and terrain characteristics. *Can. J. Soil Sci.* 50:465-467.
- Valentine, K. W. G. 1970. Use of land classification concepts as a basis for a reconnaissance soil survey in northeastern British Columbia. *Can. J. Soil Sci.* 50:71-77.
- Weintraub, M., and Ragetli, H. W. J. 1970. Electron microscopy of the bean and cowpea strains of Southern bean mosaic virus within leaf cells. *J. Ultrastruct. Res.* 32:167-189.
- Weintraub, M., and Ragetli, H. W. J. 1970. Identification of the constituents of Southern bean mosaic virus in crystals of infected cells, and their distribution within the virion. *Virology* 41:729-739.
- Weintraub, M., and Ragetli, H. W. J. 1970. The distribution of virus-like particles in leaf cells of *Dianthus barbatus* infected with carnation vein mottle virus. *Virology* 40:868-881.
- Williams, I. H. 1970. Some problems in the determination of carbamates by gas chromatography with microcoulometric detection. Proc. 5th Pestic. Residue Analysts' Seminar (W. Canada), 1970.
- Wright, N. S. 1968. Evaluation of Terraclor and Terraclor Super-X for the control of *Rhizoctonia* on potato in British Columbia. *Can. Plant Dis. Surv.* 48:77-81.
- Wright, N. S., MacCarthy, H. R., and Forbes, A. R. 1970. Epidemiology of potato leaf roll virus in the Fraser River delta of British Columbia. *Amer. Potato J.* 47:1-8.

Miscellaneous

- Finlayson, D. G. 1970. Prevention of damage by root maggots and compatibility of pesticides. Proc. Lower Mainland Hort. Impr. Ass. 12:28-33, Abbotsford, B.C.
- MacCarthy, H. R. 1970. The future role of pesticides. Proc. Lower Mainland Hort. Impr. Ass. 12:40-43, Abbotsford, B.C.
- McElroy, F. D. 1970. Nematode survey of the Fraser Valley. Proc. Lower Mainland Hort. Impr. Ass. 12:25-27, Abbotsford, B.C.
- Stace-Smith, R. 1970. Strawberry certification problems. Proc. Lower Mainland Hort. Impr. Ass. 12:6-8, Abbotsford, B.C.
- Valentine, K. W. G., and Sprout, P. N. 1970. Soil capability for Agriculture, Canada Land Inventory (map and general description), Fort Nelson 94J/NE. ARDA.
- Van Den Bosch, R., Frazer, B. D., Davis, C. S., Messenger, P. S., and Hom, R. 1970. *Trioxys pallidus*, an effective new walnut aphid parasite from Iran. *Calif. Agr.* 24(11):8-10.
- Warren, H. V., Green, A. J., and Cross, C. H. 1970. Agricultural data as a mine-finding tool. *West. Miner* 43:50-54.

PROGRAM STRUCTURE

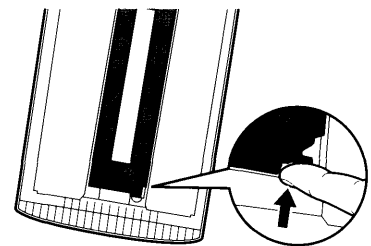
RESEARCH BRANCH CANADA AGRICULTURE

AIM	OBJECTIVES	GOALS
FORAGE CROPS	<p>1 To improve the efficiency of production and the quality of forage crops.</p> <p style="text-align: right;">Man Years 89.8</p>	<ol style="list-style-type: none"> 1 By 1974, through the development of superior varieties and by improved management practices, to raise the unit yield of dry matter or seed of legume crops by 10%. 2 By 1974, through the development of superior varieties and improved management practices, to raise the unit yield of dry matter or seed of grass crops by 10%. 3 By 1974, to classify the vegetative cover and potential productivity of range-land and other permanent-type pasture, and to determine those management practices that will increase production by 10%.
OILSEED CROPS	<p>2 To improve the efficiency of production, adaptability, and quality of oilseed crops.</p> <p style="text-align: right;">Man Years 21.9</p>	<ol style="list-style-type: none"> 1 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of rapeseed and mustard by 10%, and to improve quality to meet market demands. 2 By 1973, through the development of superior hybrids and varieties, and improved management practices, to increase the unit yield of sunflowers by 10%. 3 By 1974, through the development of superior varieties and improved management practices to increase the unit yield of soybeans by 10%. 4 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of flax in western Canada by 10%, while maintaining quality to meet market demands.
HORTICULTURAL CROPS	<p>3 To improve the efficiency of production and the quality of horticultural crops.</p> <p style="text-align: right;">Man Years 193.7</p>	<ol style="list-style-type: none"> 1 By 1974, through the development of superior varieties and improved management practices, to increase the unit yield of tree fruits by 10% while maintaining required standards of fresh and processed quality. 2 By 1973, through the development of superior varieties and improved management practices, to increase the unit yield of small fruits by 10% while maintaining required standards of fresh and processed quality. 3 By 1973, through the development of superior varieties and improved management practices, to increase the unit yield of vegetable crops by 10% while maintaining required standards of fresh and processing quality. 4 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of potatoes by 5% while maintaining or improving the required standards of fresh and processed quality. 5 By 1973, to develop superior varieties of ornamentals and turf grasses, and to improve their management practices.
CEREAL CROPS	<p>4 To increase the efficiency of production and the quality of cereal crops.</p> <p style="text-align: right;">Man Years 137.9</p>	<ol style="list-style-type: none"> 1 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of durum, winter, and spring wheats by 10%, while maintaining quality of each crop to meet market standards. 2 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of barley by 15%, while maintaining the quality to meet market demands. 3 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of oats by 10%. 4 By 1972, produce superior variety inbreds and hybrids of grain and silage corn which, when used with improved management practices, will give 10% greater unit yield return and increase the area of adaptation. 5 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of <u>rye</u> by 5%.
FIELD CROPS	<p>5 To improve the efficiency of production and the quality of field crops such as tobacco, buckwheat, field peas and beans, and sugar beets.</p> <p style="text-align: right;">Man Years 20.3</p>	<ol style="list-style-type: none"> 1 By 1973, to improve the quality of tobacco by 20% to meet current demands, through the development of superior varieties and by improved management practices and still maintain or increase the yield. 2 By 1974, through the development of superior varieties and improved management practices to increase the unit yields of field peas and white beans by 10%. 3 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of buckwheat by 20%. 4 By 1974, through better management practices to increase the returns from sugar beets by 20%. 5 By 1973, to complete the assessment of 10 alternate crops which may be suitable for Canadian production and specific markets.

DEPARTMENTAL AIM
To develop a viable and self-sustaining agricultural industry based on free trade and international agricultural prices.

PLANT PESTS	6 To develop and improve methods for the protection of crop plants from insects and related pests. Man Years 54.3	1 By 1974, to elucidate properties of selected compounds used for the control of insects and related pests. 2 By 1974, to develop pest control programs using methods that do not employ, or make least possible use of, persistent non-selective chemicals. 3 By 1973, to devise control measures for economically important nematodes.
PLANT DISEASES	7 To maintain or increase productivity and quality through reduction of losses from plant diseases. Man Years 28.5	1 By 1973, to have developed techniques for the determination of plant disease losses and to have applied the techniques to selected crops. 2 By 1973, to have developed further information on the physiology, biochemistry and ecology of soil-borne fungi; on the specificity, uptake and degradation of synthetic fungicidal compounds; on the presence and chemical nature of naturally occurring compounds and the mechanisms by which they confer resistance to diseases; and to apply this information in plant disease control. 3 By 1973, to have obtained further information on the properties of plant viruses and mycoplasmas, their mode of transmission, and the mechanisms and consequences of infection. 4 By 1973, to have obtained further information on bacteria and show how they relate to control systems under normal and pathogenic systems.
WEEDS	8 To develop and improve methods for the control of weeds. Man Years 17.5	1 By 1972, to improve control recommendations for selected weeds through elucidation of principles involved.
PLANT ENVIRONMENT	9 To explore and identify environmental factors and examine their effects on plant growth and development and show how such knowledge may be exploited. Man Years 13.4	1 By 1973, to determine the quantitative effect of climate-weather on selected economic crop plants and to show how the information can be used to stabilize or improve crop production. 2 By 1973, to explain physiological activity in plants related to winterhardness and to show how the information can be used to improve the efficiency of crop production.
SOIL MANAGEMENT	10 To develop improved soil and water management practices and to obtain a better knowledge of factors affecting fertility and productivity for more efficient crop production. Man Years 29.8	1 By 1973, to establish principles of water movement in soils and to develop improved practices for irrigation, drainage, and desalinization, to increase the efficiency of production by 10%. 2 By 1974, to elucidate selected basic chemical, physical and biological properties of and reactions in soils.
SOIL SURVEY	11 To obtain a reliable inventory of Canadian soil resources (nature, extent and distribution pattern of total environment) and to interpret the capabilities of these resources of agriculture and other uses. Man Years 43.0	1 By 1973, to complete the inventory of our basic resources for the following regions and to interpret the capabilities of these resources based on our present state of knowledge. 2 By 1974, to develop an improved basis for the classification of soils and for a more accurate interpretation and grouping of soils for more efficient land use.
BIOSYSTEMATICS	12 To improve our understanding of the taxonomic relationship of plants, insects, and micro-organisms. Man Years 67.1	1 By 1974, to complete the taxonomic revision of selected orders of economically important plants, and maintain a national collection of vascular plants. 2 By 1974, to complete the taxonomic revision of selected groups of economically important agricultural and forest insects, arachnids, and nematodes, to maintain and develop the Canadian National Collections of insects, arachnids and nematodes, and to provide an efficient identification and information service arising from this function. 3 By 1973, to complete the taxonomic revision of selected groups of economically important fungi, to provide for a continued growth of the National Collection of fungal specimens and cultures, and to maintain an identification function in mycology.
DAIRY CATTLE	13 To improve the efficiency of production and the quality of dairy products. Man Years 21.7	1 By 1978, to develop improved breeding procedures for dairy cattle to result in 10% greater efficiency. 2 By 1974, to develop improved nutritional, physiological, environmental and management procedures for dairy heifers and cows which will improve growth rate and increase milk production efficiency by 10%. 3 By 1974, to develop new methods of processing milk and new or modified dairy products.
BEEF CATTLE	14 To improve the efficiency of production and quality of beef products. Man Years 30.6	1 By 1978, to develop improved breeding procedures for beef cattle to result in 15% greater efficiency. 2 By 1974, through elucidation of nutrient requirements, physiological processes, levels and availability of nutrient in feeds and management procedures, improve quality of beef and veal and increase production by 10%. 3 By 1974, develop new ration concept and new systems of management for the pregnant and lactating beef cow in cold climates to reduce the cost of wintering by 25%.
SHEEP	15 To improve the efficiency of production and the quality of products from sheep. Man Years 4.2	1 To develop by 1975 procedures for increasing the productivity of sheep by 25%, with emphasis on year-round lamb production.

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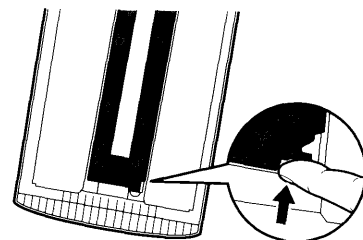


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