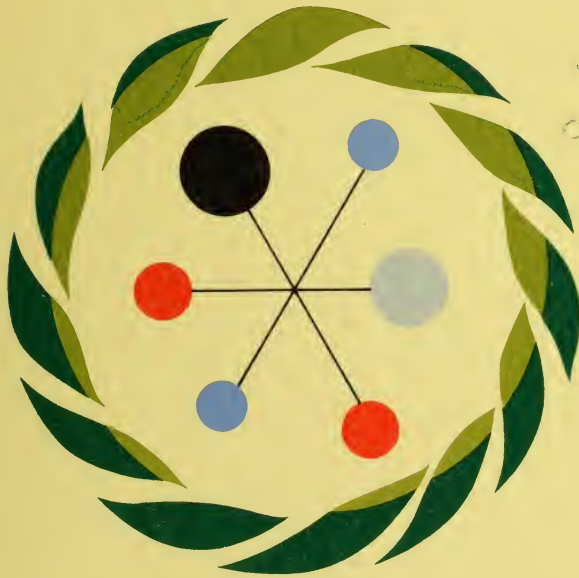


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# RESEARCH REPORT

## 1968

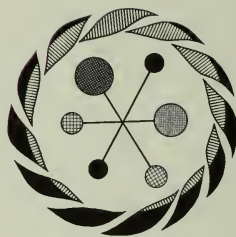


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The symbol used on the cover is the one that has been used in the floor of the entrance to the K. W. Neatby Building, Central Experimental Farm, Ottawa. The center of the symbol is composed of an asymmetrical arrangement of the basic chemical elements of agricultural science as represented by Daltonian symbols. The colors represent 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  
1968

Research Branch

CANADA DEPARTMENT OF AGRICULTURE

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Dr. B. B. Migicovsky



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Dr. D. G. Hamilton

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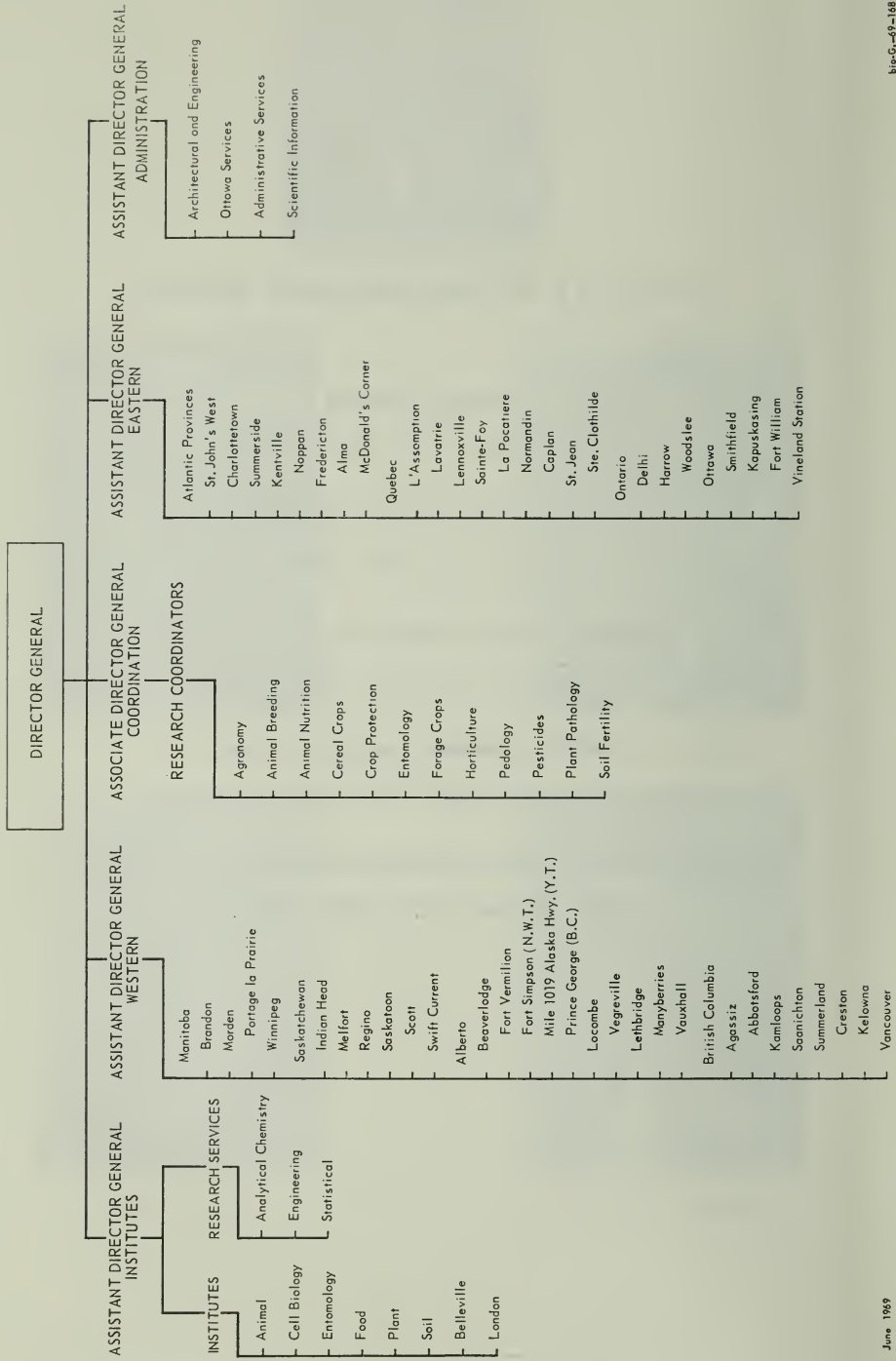
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**D. G. HAMILTON, B.Sc., M.S., Ph.D., F.A.A.A.S.**

### **Assistant Director General (Research Institutes and Services)**

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CANADA DEPARTMENT OF AGRICULTURE  
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## ADMINISTRATION

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C. E. CHAPLIN, B.Sc., M.Sc., Ph.D.	Chief of Scientific Information Section
A. I. MAGEE, B.Sc. (Agr.), M.S.A.	Chief of Ottawa Services Section

## FOREWORD

This, the second annual report of the Research Branch, presents the significant findings and advancement in our many types of activity in 1968. Additional details and offprints of the separate chapters are available from the directors of the establishments.

The contents give an account of the broad scope of Research Branch investigation of agricultural problems, the various scientific disciplines represented, and the regional distribution of our pursuits. The Branch program reflects present needs and attempts to anticipate future exigencies. It is structured to embrace both changing circumstances in the agricultural industry

and continuing effort in the application of new knowledge and technology.

The year 1968 saw several changes in the Executive of the Research Branch. Dr. J. A. Anderson retired as Director General. Dr. J. C. Woodward was promoted to Assistant Deputy Minister (Research), Canada Department of Agriculture. I was appointed Director General of the Research Branch and Dr. K. Rasmussen became Associate Director General (Coordination). Dr. E. J. LeRoux was promoted to Assistant Director General (Institutes) and early in 1969 Dr. T. H. Anstey was appointed Assistant Director General (Western).

B. B. Migicovsky  
Director General



# Research Station St. John's West, Newfoundland

## PROFESSIONAL STAFF

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

### Entomology Section

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

G. T. MORGAN, B.Sc., M.Sc. Nematodes

### 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  
and diseases

### Soils and Agronomy

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

P. K. HERINGA, B.Sc., M.Sc. Pedology

A. G. VALENTI, B.Sc., Dr. (Geol.), M.Sc. Soil survey

## INTRODUCTION

The objectives of the Research Station at St. John's West are to solve regional agricultural problems affecting vegetables, forages, and cereals, and to participate in national research programs. The Station cooperates with other establishments of the Research Branch in the Atlantic Provinces, and is actively engaged in joint re-

search on potato breeding and poultry nutrition. Emphasis is on research in peat soil reclamation and in potato breeding for resistance to potato wart disease and the golden nematode.

H. W. R. Chancey  
Director

## SOIL SCIENCE

### Soil Survey

A reconnaissance soil survey was started in the southern section of the Burin Peninsula during the 1968 field season. Most of the soils in the area have been formed on glacial till, but organic soils and rock outcroppings are common. The till is derived from siltstone, graywacke, conglomerate, rhyolite, and basalt. The soils are generally fairly coarse and strongly leached, but many are poorly drained and have an accumulation of moss and peat on the surface. Organic deposition in the profile is quite common and leaching of Fe and Al is apparent in well-developed pans or compact soil horizons. Undecomposed sphagnum peat deposits are widespread throughout the area.

Field survey work was completed on the Avalon Peninsula and soil maps are being compiled. Iron-manganese or iron-humus pans are common along the coast, and the southern part of the peninsula has extensive areas of organic soils. Mineral soils in this area are rather coarse and poorly drained, and many of them have a high organic content in the A and B horizons.

Studies on seasonal changes in soil color and extractable Fe, the influence of frost on soil development, and the forest productivity, vegetative growth, and nutrient content of a number of soil series are in progress. Soil-test calibration work is continuing in the laboratory, field, and greenhouse to determine more efficient fertilizer

recommendations and to supply the increasing demand for soil tests by farmers.

### Peat Soils

*Fertility.* The exceedingly cool, wet season caused greater responses to increments of P fertilizers in grass seedings than had previously been experienced. In cabbage variety trials, visible responses occurred when extra P was added after side-dressing with N and K. It had previously been noted that in peat soils P could leach for considerable distances, and, where the water table approached the surface as a result of plugged ditches, severe loss of nutrients occurred. Nevertheless, this is the first time that a response to P side-dressing has been observed.

*Drainage.* Superficial examination of results from ditch spacing showed that the narrowest spacing caused overdrainage, but poor growing conditions throughout the season made such a hypothesis doubtful. When individual yields were plotted against water tables, there was no evidence of overdrainage, and differences could probably be attributed to varying drainage characteristics of the peat. Further studies will be required before drainage characteristics of the area can be properly assessed.

A study on the formation of flashets, or muck ponds, in peat soils showed that they may be caused by the lateral growth of bog flora aided by groundwater nutrient movement.

## ANIMAL SCIENCE

### Grazing Trials on Peat Pastures

Early results from an experiment comparing the growth of lambs pastured on three different forage-crop mixtures grown on peat soil showed: a mixture of timothy (Climax), tall fescue (Alta), and Ladino clover (Merit) produced an average gain of 39.6 lb/lamb in a 120-day grazing period; 34.9 lb from a mixture of reed canarygrass, tall fescue, and clover; and 32.4 lb from a mixture of reed canarygrass and clover. When put on pasture on

June 10, the lambs, mainly Border Cheviot breed, averaged 39.8 lb. A copper bullet placed in the rumen of each lamb appeared to depress gains somewhat where no maintenance treatment of fritted trace elements (FTE) was applied to the sward in the spring. However, neither FTE alone nor Cu plus FTE had any noticeable effect. Further experiments will be required to substantiate these results, and to determine the effects of time on any "masking effect" caused by treatments with FTE in the seeding year.

## PLANT SCIENCE

### Weed Control in Vegetables

*Peat soil.* UC-22463 at 6, 8, 10, 12, 14, and 16 lb/acre (active); linuron at 2, 3, and 4 lb/acre (active); and prometryne at 3, 4, and 5 lb/acre (active) were tested as preemergence treatments on carrots grown at the Colinet Peat Substation. UC-22463 at 14 and 16 lb/acre (active) were the only treatments that reduced the carrot stand, but none of the treatments gave satisfactory weed control.

*Mineral soil.* Preplanting incorporated treatments tested on rutabagas grown at St. John's included vernolate at 3, 4, and 5 lb/acre (active); DCPA at 8, 10, and 12 lb/acre (active); nitralin at 1, 1.5, and 2 lb/acre (active); EPTC at 2, 3, and 4 lb/acre (active); and cycloate at 4, 4.5, and 5 lb/acre (active). In addition post-emergence treatments of nitrofen at 1.8, 2.4, and 3 lb/acre (active) were also tested. DCPA and nitralin were the only treatments that did not cause any visible crop injury, but weed control was not as good as with the other treatments. Cycloate at 4 lb/acre (active) was the best treatment, because it gave good weed control and did not reduce yields as much as the other treatments that gave similar weed control.

### Storage of Late Cabbage

The following cabbage varieties grown at St. John's were placed in root-cellar storage on October 13, 1967: Houston

Evergreen, Evergreen Ballhead, Danish Ballhead, Green Winter, Eastern Ballhead, Badger Ballhead, Penn State Ballhead, and Durel Oseno Novelty. By November 20, 50% of Danish Ballhead, Eastern Ballhead, Badger Ballhead, and Penn State Ballhead were infected with *Sclerotinia* storage rot. On February 2, 1968, all the rest were disease free, although very pale in color, and were still firm and green except for the outermost leaves. The trial ended then, and approximately 65% of Houston Evergreen, Evergreen Ballhead, Green Winter, and Durel Oseno Novelty were still saleable.

### Forage Crops

*Annual fodder crops.* In the Research Report for 1967 we stated that "it is unlikely that corn silage in the commonly accepted sense will be a suitable crop for eastern Newfoundland" on the assumption that dry matter yields would be at least equal to oats, but that maturity would be poor. The unusually cold season experienced in 1968 (513 degree-days, base 50 F, from seeding date to first frost) has shown that in some years there is not enough heat to grow corn, whereas under similar conditions, Fundy oats produced over 2 tons of dry matter (fodder) per acre. Sorghum - Sudan grass hybrids, the most sensitive crop in the 1968 test, grew only a few inches high.

## ENTOMOLOGY

### Cabbage Maggot

Eighteen insecticide treatments and a control were established at St. John's and St. David's for root maggot control in swede turnips. In both areas Dasanit, Birlane, Dyfonate, and Furadan gave good control. Split applications of insecticides, half at seeding and half as a drench after thinning, were less phytotoxic and gave more effective control than single applications at seeding. Split application of emulsifiable Dyfonate caused 44% seedling reduction at St. David's and 31% at St. John's. In both localities Dasanit gave the most effective control (99% and 80%) without any significant phytotoxicity.

### Antler Moth

A single antler moth, *Cerapteryx graminis* Linn., was taken at St. John's in 1967 and additional moths were taken at St. John's and Kilbride in 1968. This species is of European origin and has evidently only recently been introduced into Newfoundland. It is a pest of some importance in grassland areas in the British Isles. Observations on development and distribution of this species in Newfoundland will be undertaken.

### Blow Fly Control

Experiments conducted in 1967, and subsequent residual analysis determinations, resulted in a temporary registration of Pyrethrum as a dip solution to control

blow flies attacking Spanish and Madeira grades of lightly salted sun-dried codfish. Pyrethrum dip was used in limited quantities by fishermen during 1968; it controlled blow flies and was an excellent repellent.

### Biology and Behavior of the Golden Nematode

A monoculture of the potato variety Urgenta on land lightly infested with *Heterodera rotochiensis* (Cobb) was begun in 1964. The crop increased annually, reaching a peak in 1966. In 1967 the yield began to decline, and in 1968 was not significantly higher than in 1964. Over this period the cyst index (total cyst count per gram of soil) increased from 3.1 to 7.2.

After 5 years of continuous potato culture, positive evidence of pathotype B of the potato root eelworm was obtained. One plant, variety Peconic, resistant to pathotype A was found infested with a few cysts. Greenhouse propagation of these cysts on Peconic confirmed them to be pathotype B.

Further work on the dissemination of the potato root eelworm showed that besides pigs and rabbits, meadow mice passed viable cysts through their gastrointestinal tracts. Negative results were obtained with two ruminants, sheep and calves. No viable cysts were passed in the feces of pigeons, chickens, ravens, and two species of sea gull.

## PLANT BREEDING AND PATHOLOGY

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

To incorporate resistance to wart disease and golden nematode crosses were continued utilizing European wart-resistant varieties and seedlings produced at the Station. In attempts to produce resistant seedlings that would be early maturing, crosses were made with the susceptible varieties Chisago and Sable, and the wart-resistant varieties Mira, Hilla, Erdkraft, and Fecula. Pentland Crown, which has produced high-yielding, scab-resistant, attractive seedlings was also crossed with wart-resistant seedlings.

The popularity of the blue-skinned variety Arran Victory in Newfoundland and the demand for a blue-skinned wart-resistant variety of similar cooking quality presents considerable breeding difficulties because the number of parents available is limited. However, crosses have been made between a blue-skinned seedling received from Guelph, Ont., and other blue or colored selections and varieties, including the varieties Purple Viking and Furore.

Seedling production increased during the year, some 9,000 seedlings from 72 crosses being produced from seed sown in February and a further 9,000 from 44



crosses from seed sown in July. Single tubers from each seedling have been retained for planting in the field in 1969.

Evaluation of 166 advanced selections for desirable commercial attributes and for wart resistance was carried out at St. John's and at Avondale. Thirty-five wart-susceptible selections were discarded, and 90 were rejected in the field, because of poor yield, shape, and size. The remaining 41 selections will be evaluated for cooking quality, and those regarded as being satisfactory will be included in large-scale tests in 1969.

### Testing for Resistance to Wart and Golden Nematode

Among varieties tested for reaction to the wart organism the following were susceptible: Chieftain, Chinook, Manota, Early Pink Eye, Magdalen Island Black, Alaskan Frostless; and the European varieties: Jubel, Libertas, and Hindenburg. Of the varieties previously found substantially free from wart infection, Superior and Peconic again appeared resistant, and Sable was susceptible.

Testing of selections produced at Fred-erickton was continued, and 27 selections that remained uninfected have been retained for testing in 1969. Retests of 28 seedlings included in replicated trials showed two seedlings definitely susceptible and two doubtfully attacked.

A high percentage of resistant seedlings was obtained from crosses in which both parents were known to be resistant, particularly where the varieties Mira and Apollo were included in the cross.

The resistance of the varieties Amelio, Amaryl, and Peconic to the strain of eelworm occurring in the trial plots at Cupids was confirmed. The British varieties Ulster Glade and Maris Piper showed resistance by being free from cysts at harvest. A segregating population from a cross of the variety Amelio with a susceptible seedling gave a ratio of 18 resistant to 25 susceptible, which was close to the expected 1:1 ratio.

Occasional cysts have been observed on selections and varieties that derive resistance from *Solanum tuberosum* ssp. *andigena* (Juz. et Buk.) Hawkes. There-

fore, a mixture of strains may be present in the test plots.

### Replicated Potato Yield Trials

Fourteen named varieties and 28 seedlings were included in a six-replicate trial at St. John's West. Three named varieties, Furore, Grand Falls, and Kennebec, and nine seedlings gave a significantly higher marketable yield than Arran Victory. Of these nine seedlings, all remained free of wart when tested at Avondale. Dry matter contents were significantly higher.

Eight seedlings and four varieties were compared in five trials at St. John's, Doyles, Cormack, Lethbridge, and Robinsons. Severe attack by the blackleg organism reduced yields of Urgenta and Sebago as well as those of three seedlings. Two seedlings previously tested, SJ6226-9 and SJ6226-61, again performed well, exceeding Arran Victory in marketable yields at all centers. In over 15 trials, SJ6226-9 has outyielded Arran Victory in both marketable and total yield by over 30% and has had a similar total yield to Kennebec. Tubers tend to be rather numerous and the percentage of tubers graded as marketable has been lower than that of Kennebec. Cooking quality has been similar to that of Arran Victory. This seedling appears to be highly resistant to blackleg attack and has remained free of wart during 5 years of trials. It is proposed to name this seedling Pink Pearl and in 1969 supplies of seed will be distributed to areas known to be wart infested.

### Potato Plant Spacing Experiment

Eight seedlings and two named varieties, Kennebec and Arran Victory, were included in a trial to study the effects of 8-, 12-, and 18-inch spacings in the row. The highest total yield and the greatest number of tubers were produced at the 8-inch spacing, but the weight of individual tubers of No. 1 grade was lower (0.28 lb) than that at the 18-inch spacing (0.34 lb).

The percentage weight of marketable tubers varied considerably among varieties and among spacings. Kennebec had the highest marketable yield with over 95%

marketable at the 8-inch spacing and 97% at the 18-inch spacing. The percentage marketable yield of Arran Victory increased from 84% to 92% at these spacings. The seedling SJ6226-9 produced the most tubers of all the entries, and had the greatest percentage of unmarketable tubers: 37% at the 8-inch spacing and 23% at the 18-inch spacing. Despite this, its yield of marketable tubers was still in excess of that produced by Arran Victory. Compared with a similar trial in 1967, tuber size and total yields were reduced, but number of tubers was increased.

#### Chemical Control of Wart Disease

Studies with the herbicide dinoseb, known to be effective in reducing the incidence of infection by the wart organism, were continued in 1968. In addition, the herbicide nitrofen was included in the trial.

Plant damage and yield reduction were evident following application of dinoseb at 10 lb/acre when dug in before planting, or applied preplanting or as a preemergence spray. Early frost killed potato vines before the crop had properly developed, but sufficient data were obtained to show that dinoseb had a significant effect on the reduction of wart infection. Nitrofen had little effect on plant vigor or yield when applied before planting at 5 or 10 lb/acre, but it only slightly reduced wart infection.

The persistence of dinoseb in the soil was checked by growing turnips in samples of soil collected from the plots 4 weeks

after the chemical had been applied. Germination was completely inhibited at the highest level of application (40 lb/acre), and it was reduced at the other levels. Subsequent tests conducted with the same soil showed that dinoseb persisted for at least 6 months after application at the highest rate. Analyses for residues of dinoseb in tubers from plots treated in 1967 were conducted in the spring of 1968. No evidence of dinoseb was found in the tubers tested.

#### Breeding Swede Turnips for Clubroot Resistance

Seeds were obtained from  $F_1$  plants of the crosses York  $\times$  Gelria, Wilhelmsburger  $\times$  Gelria, and Wilhelmsburger  $\times$  Novitas, which had remained free from clubroot infection in 1967. Beginning on July 9 this seed and seed of commercial varieties was sown in land infested with the clubroot organism. The weather during the growing season was such that plant development was extremely poor, and, because of wet ground conditions, harvesting was not started until December 7. However, clubroot infection was extensive, and over 90% infection was recorded for the varieties York, Wilhelmsburger, and Laurentian. Novitas and Tetra remained free from infection, whereas only 5% of Gelria plants were infected. Roots from the hybrid seed, which were free of clubroot infection at harvesting, have been retained for use as future parental material.

### MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Birlane	Allied Chemical Corporation
Cycloate	Stauffer Chemical Company
Dasanit	Chemagro Corporation
DCPA	Diamond Alkali (Canada) Ltd.
Dyfonate	Stauffer Chemical Company
EPTC	Stauffer Chemical Company
Furadan	FMC Corporation
Nitralin	Shell Canada Limited
Nitrofen	Rohm & Haas Co. of Canada Ltd.
Pyrethrum	Pyrethrum Bureau of Kenya
UC-22463	Union Carbide Canada Ltd.
Vernolate	Stauffer Chemical Company

## PUBLICATIONS

### Research

- MCKEAGUE, J. A., A. W. H. DAMMAN, and P. K. HERINGA. 1968. Iron-manganese and other pans in some soils of Newfoundland. *Canadian Journal of Soil Science* 48:243-253.
- MORGAN, G. T., and A. A. MACLEAN. 1968. Influence of soil pH on an introduced population of *Pratylenchus penetrans* (Cobb). *Nematologica* 14:311-312.
- MORRIS, RAY F. 1968. A case of urogenital myiasis caused by larvae of *Anisopsus fenestralis* (Diptera: Anisopidae). *The Canadian Entomologist* 100:557.
- MORRIS, RAY F., and D. ANDREWS. 1968. Investigation into the use of Pyrethrum and other insecticides for the control of the blowfly, *Calliphora terraenovae* (Macq.), infesting light-salted codfish in Newfoundland. *Pyrethrum Post* 9(4):9-13.



# Research Station

## Charlottetown, Prince Edward Island

### PROFESSIONAL STAFF

G. C. RUSSELL, B.S., M.S., Ph.D.	Director
A. C. FLEMING, B.A.	Administrative Officer

### Crop Protection Section

G. W. AYERS, B.Sc., M.Sc.	Head of Section; Clubroot of crucifers, storage rots of potatoes
L. C. CALLBECK, B.Sc.	Potato diseases, evaluation of fungicides
F. M. CANNON, B.Sc., M.Sc.	Potato insects, barley jointworm
D. C. READ, B.Sc., M.Sc., Ph.D.	Root maggots in crucifers
L. S. THOMPSON, B.Sc., Ph.D.	Forage and vegetable insects
C. B. WILLIS, B.Sc., Ph.D.	Forage diseases

### Genetics and Plant Breeding Section

J. D. E. STERLING, B.S.A., M.Sc.	Head of Section; Cereal breeding
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K. E. LELACHEUR, B.Sc.	Tobacco studies
R. B. MACLAREN	Cereal breeding
K. A. WINTER, B.Sc., M.Sc., Ph.D.	Animal science

### Soils and Plant Nutrition Section

L. B. MACLEOD, B.Sc., M.Sc., Ph.D.	Head of Section; Nutrition of forage and cereal crops
W. N. BLACK, B.Sc.	Soil fertility, pasture and weed studies
J. A. CUTCLIFFE, B.Sc., M.Sc.	Nutrition of horticultural crops
U. C. GUPTA, B.Sc., M.Sc., Ph.D.	Chemistry of micronutrients in soils and plants
D. C. MUNRO, B.S.A., M.Sc.	Soil fertility, plant nutrition
M. SUZUKI, B.Sc., Ph.D.	Plant physiology, biochemistry
R. P. WHITE, B.S., M.S., Ph.D.	Soil chemistry and fertility

## INTRODUCTION

This report presents the main findings from research conducted during 1968. The scope of the research program is indicated by the fields of responsibility of the research staff. Further information may be obtained by contacting the Research Station or individual scientists.

During 1968 three staff members were appointed. Their fields of interest are: animal nutrition, diseases of cereal crops, and soil chemistry and fertility.

G. C. Russell  
Director

## CEREALS

### Variety Testing Highlights

The German barley variety Volla gave outstanding yield performance in 1967 and 1968 trials. Volla is a two-rowed type and is medium maturing. Kolibri, a spring wheat variety developed in Germany, yielded well and proved to be immune to *Erysiphe graminis* DC. ex Mérat f. *s. tritici* Marchal, whereas the range of infection among all other varieties was 20 to 90%.

### Cereal Nutrition

*Spring N fertilization boosts winter wheat yields.* Richmond and Genessee winter wheat, each grown at two locations, produced average yields of 3,628 and 3,900 kg/ha. The application of 34, 68, and 102 kg/ha of N on the surface of the soil in the early spring resulted in yields of 3,225, 3,760, and 4,030 kg/ha for Richmond; and 4,100, 4,570, and 4,910 kg/ha for Genessee. With wheat valued at \$3/cwt, this represents a return of at least \$3 for every \$1 invested in N fertilizer above the 30-lb rate (34 kg/ha).

*Banded fertilizer increases barley yields.* Fertilizer in a 1:1:1 ratio, banded 2 inches to one side and 2 inches below barley seed, resulted in yields that were consistently higher than when comparable amounts of fertilizer were broadcast or sown with the seed. All fertilized plots gave a significantly higher yield than the

unfertilized plots. In almost all cases, fertilized plots matured earlier than unfertilized plots, and the banded plots were generally earlier than those where fertilizer was broadcast or sown with the seed.

*Potassium important for early barley growth.* Analyses of early vegetative barley tissue grown in hydroponic culture indicated that chlorosis of tissue is accompanied by a low tissue K content. Yield reductions caused by a low K supply were most severe with a high ammonium source of N. The chlorotic symptoms normally attributed to N deficiency, because of slow nitrification on cold soils in early spring, were aggravated by a high ammonium source of N and by levels of K below 5% in early vegetative tissue.

*Fractionation of N in barley tissue.* Nonprotein N, occurring in barley tissue grown in hydroponic culture and sampled in the boot stage, was fractionated into ammonia-, amino-, and amide-N fractions. Approximately 80% of the total soluble N was in the amino-N fraction. A high K treatment (100 ppm) markedly reduced the contents of every soluble-N fraction when compared to a low K treatment (10 ppm). A high P treatment (100 ppm) stimulated the incorporation of  $\text{NH}_4^+\text{-N}$  in the solution into ammonia- and amide-N fractions. The percentage of nonprotein N occurring in all fractions increased as the proportion of N supplied as  $\text{NH}_4^+$  was increased.

## POTATO INSECT AND DISEASE CONTROL

Twenty spray materials were screened for insecticidal properties and six proved satisfactory for the control of all species of foliage insects. These were formothion (Anthio 40), phosphamidon, methidathion, carbofuran, dimethoate, and endosulfan.

Eight granular systemic insecticides were applied to the soil at the time of planting. Of these only aldicarb and disulfoton gave good control of foliage insects. In previous years, fensulfothion proved effective both as a spray and soil application, but in 1968 poor control resulted from the use of this chemical.

In ultralow-volume foliage sprays, using 420 cc/ha of concentrated material, good insect control was obtained with phenothoate 85%, malathion 95%, and phosphamidon 90%. Control with phosphamidon proved equivalent to that obtained with the best high-volume sprays.

The chemicals RH-90, Daconil 2787, mancozeb, and Polyram gave the best control of foliar late blight in the 1968 national screening test of potato fungicides. Two copper compounds, copper oxychlor-

ide and Kocide 101, were relatively poor. Nabac 25EC showed no merit. Difolatan 80W, as in several previous years, allowed the least amount of tuber rot.

In a test with Difolatan, the 4 Flowable type was superior to the 80W type in both control of the disease on the foliage and in the tubers. The addition of a small amount of  $\text{CuSO}_4$  to spray mixtures of both types increased their rot control efficiencies.

Control of seed-borne infection caused by two *Fusarium* species was achieved with Polyram 7% dust and Dithane M-45, 8% dust + 0.1% diazinon. Sebago seed was cut, artificially contaminated with inoculum of *Fusarium sambucinum* Fckl. f.6 Wr., and then treated with chemicals at the rate of 0.45 kg to 45.4 kg of seed. A similar test was conducted with *Fusarium coeruleum* (Lib.) Sacc. as the contaminant and Hunter as the test variety. The Polyram and Dithane treated plots had greater yields, better plant stands, and more vigorous foliage growth than those recorded for other treatments.

## FORAGES

### Root-lesion Nematode and *Fusarium* Root Rot Studies on Forage Legumes

Reproduction of the root-lesion nematode *Pratylenchus* spp. in the roots of Empire birdsfoot trefoil was significantly greater when the soil moisture was maintained at 70–100% field capacity (f.c.) (pF 2.2–1.7), 100% f.c. (pF 1.7), and 150% f.c. (pF 1.2) than at 50% f.c. (pF 3.0). The invasion of roots by *Fusarium* spp. was not affected by soil moisture.

The root-lesion nematode significantly and equally reduced root and foliage yields of eight varieties and two selections of birdsfoot trefoil when studied in a greenhouse. Field data on seven trefoil varieties showed high nematode infestation levels throughout.

Greenhouse studies were conducted in which five levels of root-lesion nematode infestations (0, 2,500, 5,000, 10,000, and 20,000 nematodes per 5 kg of soil) were

compared on Empire birdsfoot trefoil, either seeded directly or transplanted at 4 weeks of age. Both root and foliage yields were significantly reduced by all infestation levels as compared to the 0 level. Foliage yield reductions were observed earlier and plant mortality was greater when direct seeded.

Fungicide 1991 (DuPont), when mixed with sterilized greenhouse soil prior to planting at rates of 25 and 50 ppm, prevented soil contamination and infestation of Empire birdsfoot trefoil roots by *Fusarium* spp. for a period of 27 weeks. When mixed with soil contaminated with *Fusarium* spp. and root-lesion nematodes, the percentages of rootlet sections from which *Fusarium* spp. were recovered were 98, 51, and 14 after 27 weeks for the 0, 25, and 50 ppm rates. Greater root-lesion nematode reproduction occurred in treatments where fungicides were added to the soil.

Seven nematocides, applied broadcast, were all effective in significantly reducing the number of root-lesion nematodes in the soil and the rootlets of red clover, alfalfa, and birdsfoot trefoil plots. Significant increases in yields were recorded at the time of the first cut of hay in all treated plots. A reduction in the nematode population resulted in a very small decrease in the infection of the plant roots by *Fusarium* spp.

### Physiology and Management

*Physiology of regrowth of alfalfa and timothy.* Viability of alfalfa plants grown in the field under different fertilizer treatments was evaluated chemically by using a triphenyltetrazolium chloride test in conjunction with an etiolated regrowth test. There was no conclusive evidence that fertilization with P or K stimulated the viability of individual buds, but the number of viable buds per plant subjected to cold treatment at  $-15^{\circ}\text{C}$  did increase with increasing rates of fertilization.

The  $\text{C}^{14}$  isotope was used to trace the utilization of labeled food reserves in the roots of alfalfa and the stem base tissue of timothy during regrowth following removal of the top tissue. The new growth of alfalfa and timothy received 13 and 5% of the total  $\text{C}^{14}$ -labeled food reserves that were present in the storage organs at cutting. The  $\text{C}^{14}$  distribution pattern differed widely between the two species. In alfalfa the  $\text{C}^{14}$  translocates were distributed uniformly to each of the new shoots. With timothy, the newly elongated leaves, which had been initiated prior to the time of cutting, received most of the  $\text{C}^{14}$ , whereas only a small amount of  $\text{C}^{14}$  moved into the leaves that were initiated and developed after cutting.

Timothy plants that were grown in a greenhouse on a low P and low K soil

and treated with different rates of N, P, and K fertilizer had an increased fructosan accumulation when there was adequate P and K fertilization. The N rate did not significantly influence the fructosan content. Removal of the top growth resulted in a sharp decrease in fructosan in the stem base tissue with all treatments.

*Fall-applied N encourages early spring growth.* Nitrogen carry-over from a heavily fertilized second-cut crop or moderate applications of N (56 kg/ha) in late August, after removal of second-cut brome-grass or timothy, encouraged metabolism and storage of N within the plants. This stored N promoted vigorous regrowth in the early spring when the soil was cold and the plant uptake of N was slow. Growth resulting from early fall N fertilization was grazed in late October after plants had been hardened for the winter.

*Irrigation of pastures.* In a grazing experiment conducted on a sandy loam soil, irrigated plots consistently outyielded non-irrigated plots, particularly during August, September, and October. The average yield of irrigated and nonirrigated plots was 13.93 and 10.73 metric tons/ha of dry matter.

Irrigation was used to maintain the soil moisture content at or near the field capacity level of 27%. Moisture levels within the nonirrigated plots declined from a high of 23% in June to a low of 7.8% in August, with slight fluctuations following periodic rainfall. Moisture levels increased progressively from August until late in October.

P and K were supplied at adequate levels to meet crop needs, whereas N was applied in split treatments ranging from 112.1 to 280.3 kg/ha. Although there was a response to increased levels of N, the yield increase was significant on only the nonirrigated plots.

## CRUCIFERS AND OTHER HORTICULTURAL CROPS

### Crucifers

*Brown heart of rutabagas.* The B content of top tissue ranged from 6 to 20 ppm for rutabagas showing moderate to very severe brown heart condition. When tops

contained over 38 ppm B, the roots were free of this disorder; whereas those containing over 250 ppm showed toxicity symptoms. No brown heart was observed when soil B (hot-water soluble) was above



1.3 ppm. Soils containing over 3.1 ppm B were toxic to rutabagas.

*Clubroot of crucifers.* York rutabaga was developed at Charlottetown and registered in 1963 on the basis of high table quality and resistance to races 2, 3, 5, 6, and 7 of the clubroot organism. It is now grown extensively throughout Canada and has produced clubroot-free crops except where races 1 and 4 were soil contaminants. Race 1 infestations are rare in Prince Edward Island, Ontario, and British Columbia, but may be found in restricted areas of Quebec, Nova Scotia, and New Brunswick. Race 4 has been found at two locations only, both in Prince Edward Island. This variant of the pathogen was found to cause severe clubbing in all differentials used in the classification of races. Meetjeslander turnip proved to be resistant to both races 1 and 4 and was crossed with York in an attempt to incorporate further resistance in a rutabaga line. Resistance to race 1 was transferred to only a minor extent in the  $F_1$  progeny and no figures are available on  $F_1$  resistance to race 4.

The York variety is susceptible to a nondestructive type of race 2 nodulation, chiefly on the secondary roots, and Wilhelmsburger rutabaga is resistant to this form of the disease. An experiment was conducted in 1968 in which these varieties, the  $F_1$  progeny of their crosses, and  $F_2$  progeny from selfs of these crosses were planted in randomized plots in an area heavily infested with race 2. Results showed that Wilhelmsburger (160 plants) and the  $F_1$  progeny (22 plants) were free from nodules. The York parent (490 plants) showed 89.6% nodulation, whereas in the  $F_2$  progeny (312 plants) 29.8% of plants developed nodules. This represents an  $F_2$  ratio of nodular-resistant to nodular-susceptible of 2.35:1 and indicates that resistance to nodulation in Wilhelmsburger is controlled by a single dominant gene.

*Biology and control of cabbage maggot.* The results of bioassay tests on sandy and fine sandy loam soils treated with various insecticides in microplots in the greenhouse and in an open field using first instar larvae of the cabbage maggot, showed that carbofusan was initially the most toxic and also the most persistent of the compounds tested. Thionazin rated

second on the initial toxicity, but residues gradually decreased with approximately a 90% breakdown occurring in 100 days. Fensulfothion, chlorfenvinphos, and fonofos were not as toxic to the larvae immediately after application as thionazin or carbofuran, but they showed little deterioration in toxicity 90 to 100 days after application. Phorate was not as toxic immediately after application as the above persistent compounds and it degraded rapidly in the soil. Diazinon showed a rapid breakdown initially, but appeared to level off after about 20 to 30 days, and at higher rates, this material was much more toxic after 100 days than equivalent rates of thionazin or phorate.

In replicated field experiments, a single preplanting treatment of fensulfothion or carbofuran continued to give all-season control of root maggots in rutabagas. Chlorfenvinphos, trichloronat, and fonofos gave 80 to 90% control. However, phorate and thionazin broke down more rapidly in the 1968 tests than in previous years and both materials were rather ineffective in controlling maggot infestations occurring late in the season. Heptachlor-treated plots were much more severely damaged by maggot infestations than untreated plots.

Induction of diapause in the pupal stage of this insect was found to be affected by larval rearing temperatures, and either directly or indirectly by photoperiod and light intensity. With larvae subjected to a 12 to 16 hr daily photoperiod, a light intensity of 500+ ft-c, and night and day temperatures of 15 and 22 C, there was little or no diapause; whereas with a photoperiod ranging from 10 to 15 hr/day, a low light intensity of about 35 ft-c, and temperatures of 14 and 19 C, close to 100% of the pupae entered diapause. Intermediate conditions gave a range in percentage of pupae entering diapause from about 5 to 95%.

## Broccoli

*Effect of spacing and nitrogen on incidence of hollow stem of broccoli.* Broccoli growers in the Maritimes have found a high percentage of hollow stem in crops for freezing. The hollow stem conditions begin following the initiation of the central inflorescence, the "center bud." There

is ordinarily no discoloration of the surfaces of the openings at harvest. However, discoloration may develop if affected heads are not processed soon after harvest.

The results of experiments conducted in 1968 showed that the incidence of hollow stem was affected by plant spacing and the amount of N applied. Plants grown at  $30.5 \times 30.5$  cm and closer had very little hollow stem at all N levels. However, as plant spacing increased beyond  $30.5 \times 30.5$  cm, hollow stem progressively increased to a high of 73% at  $50.8 \times 50.8$  cm, the greatest spacing tested.

At plant spacings greater than  $30.5 \times 30.5$  cm, N applications of 89.7, 179.4, and 269 kg/ha resulted in 22, 33, and 36% hollow stem.

### Peas

*Weed control in peas.* A number of herbicides have been tested individually and in combinations during the past 6 years. All trials were conducted on sandy loam soils with the variety Dark Skin Perfection. The most prevalent weeds were: lambsquarters, groundsel, shepherdspurse, corn spurrey, hemp nettle, and low cudweed. Dinoseb at 5 kg/ha (preemergence) gave satisfactory weed control except for inconsistent results with corn spurrey. Prometryne at 2.2 kg/ha (preemergence) provided improved corn spurrey control, but was rated equal to dinoseb in overall effectiveness. The combination of prometryne at 2.2 kg and simazine at 0.56 kg/ha was slightly more effective than prometryne alone, and the addition of simazine at this rate did not reduce yields.

### Brussels Sprouts

Applications of 110 to 220 kg/ha of S to the soil reduced Mo in the plant tissue. On soils where Mo supply was limited, fertilizers with a high S content aggravated Mo deficiency problems and reduced the effectiveness of applications of Mo fertilizers.

Yields of Brussels sprouts were affected only slightly by applications of K. Experiments were conducted over a 3-year period on a total of 12 farms where soil tests indicated low to medium K levels. The results showed that the K requirements of Brussels sprouts are modest.

A difference of 25% in the availability of soil N, as indicated by a nitrate incubation test, showed an average difference of 25% in yields of Brussels sprouts from field plots. Similarly, a 25% difference in the available P (Bray  $P_1$ ) indicated an average difference of 25% in yield. For K, a 25% difference in exchangeable K indicated only 7% difference in average yields. Response to applied P and K usually increased as soil test values decreased. However, response to applied N showed little relationship to soil test values.

Most of the reported work on N availability has been performed with air-dried soil samples. At Charlottetown, better correlations were obtained between nitrate incubation values and Brussels sprouts yields or N-uptake in the greenhouse when the incubation was carried out with field-moist rather than air-dried soil samples. The correlation coefficient for nitrate test versus yields was 0.59 with moist samples and 0.15 with air-dried samples.

### Strawberries

Veestar and Vibrant, new strawberry varieties from the Horticultural Research Institute of Ontario, were fruited for the first time in Prince Edward Island in 1968. Veestar produced 27,291 kg/ha and Vibrant 24,643 kg/ha, and were the highest yielding varieties under test. Redcoat produced 17,433 kg/ha in these trials. Both varieties were slightly earlier, smaller, and less susceptible to botrytis than Redcoat. Vibrant berries had excellent interior color for freezing, but, like Redcoat, were difficult to hull.

## TOBACCO

Various sources of Mg (fertilizers containing Mg) were applied at different rates for 2 years to tobacco in localities where the pH values of the soil were 5.0 or less.

Control plots receiving no Mg averaged 0.40% Mg in uncured oven-dried tissue. Langbienite ( $MgSO_4 \cdot 6H_2O$ ), applied at 24.4 kg/ha Mg, increased levels of Mg

in tobacco tissue to 0.64%. Dolomitic limestone at the same rate did not improve Mg tissue levels over the control plots, but when applied at 208.8 kg/ha Mg, levels of Mg in tissue increased to 0.68%.

Where pH levels such as those studied are involved, the high rates of dolomitic limestone required to adequately raise pH will also supply Mg necessary for improved growth and quality of tobacco.

## SOILS AND PLANT NUTRITION

Fine-textured sandy clay loam soils fixed greater quantities of B than coarse-textured sandy loam soils. In general, the B content (total and hot-water soluble) was lowest in sandy loam soils and highest in clay loam and silty clay loam soils. The quantities of B were positively related to the amount of organic matter (2 to 6.5%) in the soil.

A timesaving step in the determination of plant Mn by atomic absorption spectroscopy was developed, which used hydroxylamine hydrochloride to dissolve the manganese oxides in the dry-ashed tissue. Values determined by this method were equivalent to those obtained by boiling dry-ashed samples with 6 N HCl followed by evaporation, or by digesting plant tissue with nitric and perchloric acids.

## MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Daconil 2787	Diamond Alkali Company
Difolatan	Chevron Chemical Company
Fungicide 1991	DuPont of Canada Limited
Kocide 101	Kennecott Copper Corporation
Nabac 25EC	Nationwide Chemical Corporation
Polyram	Niagara Brand Chemicals
RH-90	Rohm and Haas Company (Canada) Limited
RH-893	Rohm and Haas Company (Canada) Limited

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# Research Station Kentville, Nova Scotia

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## VISITING SCIENTIST

ALY H. RASMY, B.Sc., M.Sc., Ph.D. Postdoctorate Fellow of the National Research Council, December 1967 to January 1969	Acarology
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## INTRODUCTION

This station is the main center for horticultural and poultry research in the Atlantic Provinces, a region characterized by a humid temperate climate and Podzol soils. The Experimental Farm at Nappan, 50 miles to the north, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and blueberries, and on the management of livestock.

Our research capability in food technology was increased during the year by

the addition of two professional members of staff and the expansion of laboratory facilities.

In addition to this report the Station publishes an annual report to provide extension specialists, agricultural representatives, and progressive farmers with up-to-date information on new developments in our research program.

J. R. Wright  
Director

## BREEDING, NUTRITION, AND CULTURE OF CROPS

### Lowbush Blueberry

Rhizome development was stimulated and shoot growth increased following a foliage spray of Amchem 66-329. Similar effects were found with the material applied in lanolin to serial and terminal buds. The effective concentration ranged from 50 to 1000 ppm.

With the exception of Al, the amounts of inorganic constituents were found to be higher in the leaves than in the rhizomes. Determinations were made for K, Ca, Mg, P, Mn, Fe, and Al, as well as sucrose, reducing sugars, and starch. Sucrose and reducing sugars were much lower in the rhizomes than in the leaves, but the reverse was true of starch.

Temperature had no significant effect on blossom set or ultimate berry size, but the higher temperature significantly shortened the time to fruit maturity. This experiment was carried out in a growth chamber with a 16-hr light period. One temperature regime was 21 C in the light and 16 C in the dark and the other 16 C with light and 10 C in the dark.

The intermediate depth was the most satisfactory of three depths used for planting lowbush blueberry clones in peat pots. The depths were just below the soil surface, 7 cm below, and 14 cm below. The 7 cm planting depth resulted in the least

winter heaving of the plants and the largest yield of fruit.

The two most frequently occurring species found in a survey of two blueberry barrens, one approximately 10 acres in Halifax County and the other about 25 acres in Cumberland County, were *Kalmia angustifolia* and *Vaccinium angustifolium*. Other prevalent species were *Pteridium aquilinum*, *Spiraea latifolia*, *S. tomentosa*, *Cornus canadensis*, and *Rhododendron canadense*. The survey was part of a study of the ecology of *Vaccinium* in Eastern Canada.

The new plant growth regulator 2-chloroethane phosphonic acid at 100 ppm was up to 10 times more effective than *p*-chlorophenoxyacetic acid,  $\alpha$ -naphthaleneacetic acid, and 2,4-dichlorophenoxyacetic acid in stimulating ethylene production of detached lowbush blueberry flowers. Kinetin, 3-indolebutyric acid, 2,3,5-triiodobenzoic acid, gibberellic acid, 2-chloroethyltrimethylammonium chloride, and *N*-dimethylaminosuccinamic acid were without effect.

### Highbush Blueberry

The pollination of commercial highbush blueberry in Nova Scotia is satisfactory and equal to that in areas where honey bees are used to obtain adequate fruit set. In Nova Scotia, pollination is entirely de-

pendent on wild bees and other native insects. This information was obtained from a study in the three main highbush plantations in the province.

### **Cranberry**

Cranberry plants growing alone had shorter shoots, a significantly greater number of leaves per 10 cm of terminal growth, and a smaller angle between the leaves and the stem than did plants growing in weedy areas. The density of cranberry shoots was greatly reduced in weedy areas and there was a smaller percentage of blooming shoots and flowers per blooming shoot. In the early part of the growing season the rate of photosynthesis in cranberry leaves was significantly higher in weedy areas than in pure stands. This was not the case as the season progressed.

### **Strawberry**

Seedlings of a diallel cross of seven strawberry inbreds, omitting reciprocals, were fruited in matted rows. Fruit yields were comparable with leading cultivars, but berry appearance and quality of the hybrids were poor. Differences in resistance to powdery mildew reflected the values of the cultivars from which the inbreds were derived. All four characters studied showed significant general combining ability values. The results indicate the existence of substantial nonadditive genetic variation in the strawberry.

In a uniformity trial with plants grown in a matted square system, two replicates of 10 plants were sufficient to provide standard errors within 10% of the mean for the characters: flowers per stalk, vigor rating, berry weight, daughter plants per mother plant, and average picking date. Six replicates of 10 plants each were required to measure the number of runners per mother plant in the 1st year, the flower stalks per plot, and the number of berries per plant. The standard error for total yield was more than 12% of the mean with six replicates of 10 plants.

In an experiment to determine the effect of soil pH on simazine phytotoxicity, there was no significant difference in mother plant survival between none and a rate of 4 lb of simazine per acre at

pH 4.2. At pH 5.6 and 6.5, there was a significant reduction in the number of survivors with a 2-lb application. The 4-lb rate reduced the number of runner plants per surviving mother plant and foliar injury was increased markedly, particularly at pH 6.5.

### **Peas**

In a fertilizer trial with canning peas conducted at 15 locations over a 4-year period, no general or consistent yield response was obtained by increasing rates of N, P, or K. Leaf N increased at the higher rates of fertilizer N. Leaf K increased and leaf Ca and Mg decreased with increasing rates of fertilizer K. The results of the tests indicated that 25 kg/ha of fertilizer N and K plus 50 kg/ha of P were adequate for commercial production of peas.

### **Apples**

The number of elongated McIntosh apples often presents an economic problem to the industry. Nine years data from 52 trees showed that normal-shaped apples are produced from lateral buds, whereas the misshapen ones come from terminal buds in the cluster.

Low-volume sprays of  $MgSO_4$  were concentrated eight times from the usual dilution of 20 lb per 100 gal without increasing leaf or fruit injury and without seriously reducing absorption efficiency. The sprays were applied to mature McIntosh trees at the calyx stage with a conventional air-blast sprayer. The Mg content of the leaves was increased by 0.067% of dry weight at one times concentration and by 0.051% at eight times. The two and four times concentrations produced intermediate increases.

### **Forage**

In a 5-year experiment with herbage production on dykeland soil at pH 5.7, surface applications of 20% superphosphate produced increases in soil acidity, soil P, and exchangeable Ca, but a decrease in exchangeable K. Surface application of dolomitic limestone decreased soil acidity and exchangeable K and increased exchangeable Ca. Exchangeable



Mg was not changed by the superphosphate or limestone treatments. Herbage yield was increased by application of superphosphate, but not by dolomitic limestone.

In a test of four varieties of timothy, the variety Climax maintained a uniform advantage over Clair in *in vitro* digestibility throughout the growing season. Climax made a slight gain over Bounty as the season progressed. Drummond decreased in digestibility at a slower rate than the other varieties and was almost identical with Climax at the late seed stage of development. Clair had the highest protein content at the early stages of development, but decreased more rapidly than the other varieties as the season progressed.

Birdsfoot trefoil cut twice per season at the 75–100% bloom stage produced more forage than four cuts at the prebud stage, three cuts at 10%, or two cuts at 50% bloom. The birdsfoot trefoil was grown in mixtures with timothy in a 2-year test. Trefoil root weights were generally more for the two-cut systems of management. The percentage of available carbohydrate did not vary between Empire and Viking,

the two varieties used in the test. Frequent harvesting reduced the amount of K removed from the soil by the plants.

Small pulses of alternating current were found to be conducted chiefly in the channels of the cell walls of tubers of potato, *Solanum tuberosum* L., the roots and stems of alfalfa, *Medicago sativa* L., and similar plant tissue. Impedance measurements may usefully detect the state of water relations in these channels when the frequency of the measuring alternating current is around 60 Hertz when chloridized silver probes are used and when the geometry of the sample is appropriate. Over the temperature and soil moisture ranges investigated, the log impedance was found to be approximately linear with the reciprocal of these parameters. Impedance changes have also been found to accompany endogenous and other changes in the plant. In particular, pulses of light or heat caused changes of impedance to occur, which reflect a change of internal water relations and possibly transport. Suitable light and K fertilizer treatments at temperatures around 4 C enhanced the impedance of alfalfa and its apparent resistance to frost.

## PROTECTION OF CROPS AGAINST PESTS

### Biology and Integrated Control

When the number of European red mites, *Panonychus ulmi* (Koch), the common food of predacious insects in orchards has been depleted, the apple rust mite, *Aculus schlechtendali* (Nal.), becomes their food. This ensures the survival of enough predators to prevent resurgence of the red mite in the same season. Depletion of the red mite may result from the use of selective chemicals or excessive activity of predators.

In a study of methods of sampling apple trees for predators and their prey, the number of European red mites on randomly chosen clusters from a limb was found to be representative of the total mite population on the limb. Samples of relatively uniform clusters of good vigor tended to overestimate mite populations. In these experiments, the test prey species

was the red mite and the predator species were largely *Diaphnocoris pellucida* (Uhler) and *Anthocoris musculus* (Say). A 2-year orchard test showed that it was feasible to estimate both mite and predator numbers on a common basis and obtain a measure of their ratio in the sampling universe.

The proportion of fruiting to nonfruiting clusters on apple trees was found to influence the distribution of predators within and between trees. The mirids *Atractotomus mali* (Meyer), *Campylomma verbasci* (Meyer), *Hyaliodes harti* Knight, *Diaphnocoris pellucida* (Uhler), and *Pilophorus perplexus* Douglas & Scott, and the anthocorid *Anthocoris musculus* (Say), all showed greater preference for limbs (or trees) bearing a high proportion of fruiting clusters. The predacious mite *Anystis agilis* Banks exhibited no preference.

## Insect Pathology

The amount of nuclear-polyhedrosis virus of the cabbage looper, *Trichoplusia ni* (Hübner), near the surface of soil in field plots did not decline significantly in 231 weeks after the application of polyhedra to the soil surface. Very little virus was detected at depths greater than 7.5 cm. The concentration of virus detected within 2.5 cm of the top of columns of soil or vermiculite remained nearly constant when leached with the equivalent of about 90 m of water.

A dose of  $3 \times 10^5$  rad of gamma radiation reduced the activity of the nuclear polyhedrosis virus by 90%. More than  $1 \times 10^7$  rad completely inactivated the virus when exposed in aqueous suspension. It was more readily inactivated when exposed dry than as an aqueous suspension. Bacteria contaminating suspensions were more sensitive to gamma radiation than was the virus, but the virus was the more sensitive to ultraviolet light.

The entomogenous fungus *Metarsizium anisopliae* was a more effective pathogen than the fungus *Beauveria bassiana* or the nematode DD136 against the pale apple leaf roller, *Pseudexentera mali* Freeman, and the winter moth, *Operophtera brumata* (Linnaeus). Pupae of both insects were treated in soil and in vermiculite. In most of the tests *M. anisopliae* reduced survival to less than 5%.

## Miscellaneous Insects

Fifty-six species were recognized among 6,886 aphids identified in 312 collections taken from strawberry plantings in Nova Scotia during 1961–66. Forty-nine species were errants and seven were colonizers on strawberry. The most numerous colonizers were *Rhodobium porosum* (Sanderson) and *Macrosiphum euphorbia* (Thomas), averaging 71 and 18.5% of all the aphids identified. The other colonizers were *Aphis forbesi* Weed, 1.4%; *Aulacorthum solani* (Kaltenbach), 1%; *Myzus persicae* (Sulzer), 1%; *Chaetosiphon fragaefolii* (Cockerell) and other *Chaetosiphon* species, 0.4%.

## Plant Diseases

Of 23 varieties of strawberry examined in a single field, none was found to be

immune to red stele, a disease caused by *Phytophthora fragariae* Hickman. All plants of Redcoat and of Sparkle, two of the most commonly grown commercial varieties, were killed. Guardsman and Sunrise showed more tolerance of red stele than any other of the varieties examined.

In an experiment to control fruit rot caused by *Botrytis cinerea* Pers., the yield of marketable fruit of the strawberry varieties Gorella, Midway, Redcoat, and Sparkle was increased by applications of the fungicides dichlofluanid and thiram. Captan and captan-thiram combinations had no effect on yield. All the treated plants had significantly less fruit rot than the untreated plants. The different fungicides gave about the same control of the disease.

In a survey carried out in Nova Scotia between 1945 and 1955, end rot caused by *Godronia cassandrae* Pk. f. *vaccinii* Groves was found to be the most important rot of cranberry fruit. Rots seldom occurred until after the fruit was harvested, and sterile breakdown, which occurred most often in refrigerated and immature fruit, was the second most important cause of fruit loss in storage. Black rot, caused by *Ceuthospora lunata* Shear, and ripe rot, by *Sporonema oxycocci* Shear, were isolated more often from infected fruits from a well-managed bog than from fruit from neglected or wild bogs. Early rot, caused by *Guignardia vaccinii* Shear, was the most abundant fungus on the skin of healthy fruit, but this organism seldom caused fruit rot. Latent infections of *G. cassandrae* f. *vaccinii* on the calyx may be the main source of inoculum for the initiation of this storage rot of cranberry.

In 1967, 10 acres of snap beans in Nova Scotia had a severe infection of leaves, pods, and stems caused by *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. The most likely source of inoculum was an adjacent field of infected oats. The symptoms of the disease differed from those previously described for *B. sorokiniana* on beans in New Brunswick. Lesions on leaves, petioles, and stems were similar to those described for *Bipolaris victoriae* (Meehan & Murphy)

Shoem. on beans in North Carolina, but pod lesions were distinctive in the Nova Scotia material. The fungus failed to sporulate on diseased beans in the field.

Polygalacturonase, pectin methylesterase, and cellulase were obtained from liquid cultures of *Mycosphaerella citrullina* (C.O. Sm.) Gross. and also extracted from infected squash fruit tissue. The pH optima for polygalacturonase, pectin methylesterase, and cellulase were 4, 7, and 5. Newly rotted squash tissue from the lesion margin was high in polygalacturonase activity and low in cellulase and pectin methylesterase. Older infected tissue was low in polygalacturonase and pectin methylesterase, but had cellulase activity almost three times that from the lesion margin. Infected tissue from the center of the lesion had 18–39% as much pectin as healthy tissue and tissue from the lesion margin had 25–63% as much pectin.

The development of *Gleospirium album* Osterw. in McIntosh apples in an atmosphere of zero CO<sub>2</sub> and 3% O<sub>2</sub> was reduced when ethylene was maintained at high levels in the storage atmosphere. This effect was found at both room temperature and at 3.3 C. The same reduction in rots was obtained by raising the CO<sub>2</sub> level to 5%, but at this level raising the concentration of ethylene did not affect rot development. In these experiments, ethylene significantly reduced the growth of *G. album* in vitro in the presence of 5% CO<sub>2</sub> at 3.3 C, but not in the absence of CO<sub>2</sub> or in either combination at room temperature.

The growth of *Fusarium oxysporum sensu* Snyder & Hans. in synthetic liquid medium was reduced by decreasing O<sub>2</sub> concentration, but stimulated when the reduced oxygen atmosphere was supplemented with 2.5 to 15% CO<sub>2</sub>. *F. oxysporum* grew better in air than in any of the artificial atmospheres.

Maximum sporulation of *Venturia inaequalis* (Cke.) Wint. occurred as soon as good mycelial growth was established, but amino acids suitable for growth were not always good N sources for sporulation. In this experiment, 19 amino acids were compared in synthetic culture media as N sources for conidial production by isolates 1096 and 365-4 of *V. inaequalis* and 10

were rated with isolate K-100. With isolate 1096 only L-histidine supported appreciable conidia production and with 365-4 it was an excellent source of N for sporulation. Sporulation by isolates 365-4 and K-100 was generally excellent with DL ( $\alpha$ ) alanine and fair with DL ( $\beta$ ) phenylalanine and DL-asparagine. DL ( $\alpha$ ) aminobutyric acid, L-proline, and glycine were good N sources for isolate 365-4. Few or no conidia were produced with the amino acids DL-aspartic, DL-glutamic, DL-glutamine, DL-methionine, DL-threonine, and DL-leucine.

Two isolates of *Stemphylium radicinum* (Meier, Drechs. & Eddy) Neerg. in a liquid medium made the best growth on organic N compounds and grew poorly on ammonium N. Potassium nitrate was a good source of N for one of the isolates but not the other. Xylose, sucrose, and glucose were the best sources of C although one of the isolates produced more mycelium on pectin. Arabinose and cellulose were poor sources of C. One isolate showed a deficiency of thiamine, whereas the other did not need a vitamin for normal growth. Both isolates produced cellulase, polygalacturonase, and a small amount of pectin methylesterase. Polygalacturonate transeliminase was not produced. Polygalacturonase activity of culture filtrates reached a maximum, growth occurred and declined rapidly when maximum growth was reached. Loss of enzyme activity was accompanied by a sharp rise in the pH of the culture filtrates.

### Pesticide Residues

Cadmium was translocated to the fruit of apple trees that had received one early cover spray of CdCl<sub>2</sub>. Foliage residues declined slowly throughout the season. The experiments were conducted over a 3-year period.

Microcrystalline cellulose without binder was successfully used in the thin-layer chromatographic separation of chlorinated and organophosphorus pesticides. The results obtained suggest that many chromogenic agents and solvent systems used in the paper and thin-layer chromatographic separation of pesticides may also be used with this material.

## STORAGE

In a 5-year survey of strawberry plant storages, losses due to mold were found to be caused mainly by *Typhula* sp., with occasional outbreaks of *Cylindricarpon radicola* Wr., *Fusarium* sp., and *Sporotrichum* sp. Less mold developed on fall-dug plants cooled to  $-1.1$  C within 15 days of digging than on those left for longer periods. The plants were kept at  $-1.1$  C for the entire storage period. Adequate air movement around the storage crates aided mold control.

Greening of Sebago variety white potatoes was reduced when the potatoes were stored in 15% CO<sub>2</sub> and was prevented by 20 and 30% CO<sub>2</sub> during a 5-day continuous exposure, through 1 mil

Mylar (DuPont of Canada Ltd.) film, to 210 ft-c of fluorescent lighting at 21–25 C. During the same period potatoes in air developed enough greening to lower the grade below Canada No. 1. When the CO<sub>2</sub> treated potatoes were boiled, no off-flavors were detected.

Brussels sprouts held in a 200 ppm aqueous solution of benzimidazole in an atmosphere of 7% CO<sub>2</sub> in the light at 21 C for 6 days retained their original color and maintained relatively high rates of respiration and photosynthesis after removal to air. Chlorophyll retention was greatest in oxygen-free atmospheres in both light and dark, but undesirable odors developed.

## FOOD TECHNOLOGY

### Anthocyanin in Fruit and Vegetables

A large number of previously unnoticed anthocyanins was shown to be present in strawberry, rhubarb, radish, and onion. A quantitative rather than a qualitative difference was found in the anthocyanin patterns of the varieties examined in the survey. The examination was carried out by using paper chromatography on Whatman No. 3 MM paper with two new solvents of high resolving power, namely 1-butanol – benzene – formic acid – water (100:19:10:25) and 1-butanol – formic acid – water (100:25:60).

### Broiler Flavor

Highly significant differences in flavor were detected in the meat from broiler chickens fed different levels of fish meal. The tests were carried out on four broiler genotypes and involved four levels of fish meal, ranging from 3 to 20% of the diet. There were no significant differences between genotypes or sexes. We concluded that up to 1.3% fish fat and 15% fish meal may be safely included in a broiler diet with little risk of producing off-flavored meat.

## POULTRY SCIENCE

No significant effects on body weight or feed conversion efficiency of chickens at 9 weeks of age were found between sexes reared separately and those intermingled. The chickens were the progeny of three commercial meat type strains of hens mated to a single strain of male. They were hatched in the same incubator on the same day and reared in windowless pens.

Pre-warming eggs, stored for more than 2 weeks at 11–12 C, at 23 C for 18 hr prior to setting improved hatchability. A

relative humidity of 80–88% during storage was optimum. Enclosing hatching eggs in sealed low-permeable or impermeable plastic enhanced hatchability when pre-incubation holding temperatures were high or the storage period exceeded 10–14 days. When eggs were stored for more than 3 weeks, hatchability decline was reduced by packing eggs in a gas-impermeable sealed plastic enclosure and by flushing it with nitrogen gas. Packing eggs in the small-end-up position resulted in improved embryo survival at all stages of

storage time. Eggs with limited shell fractures were satisfactory for hatching when patched with plastic adhesive tape, and eggs with blood and meat spots hatched as well as normal eggs. There is evidence

that storage methods that resulted in improved hatchability also reduced or eliminated detrimental effects of prolonged egg storage on the subsequent performance of the progeny.

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# Research Station

## Fredericton, New Brunswick

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## INTRODUCTION

This report summarizes research that has been completed and progress that has been made on other projects during 1968. Results from continuing projects reported in 1967 are not included. As in previous years, the main emphasis at the Station

was given to research on all aspects of potato production, animal nutrition, soils, plant pests, and agricultural engineering.

F. Whiting  
Director

## ANIMAL NUTRITION

### Ruminant Nutrition

When high-moisture grass silage is fed to ruminants, the result is usually low dry-matter consumption, which is believed to be caused in part by poor utilization or toxicity of the nonprotein nitrogen. Several supplements designed to overcome the appetite suppression factors were studied on normal and cannulated sheep. The addition of urea, either to the ration or infused into the duodenum, reduced silage consumption. When an equivalent amount of nitrogen as casein was added to the diet, the intake was slightly depressed, but the addition of soybean meal or casein infused into the duodenum had no effect on silage consumption. Cornstarch and urea in the ration resulted in slightly higher silage consumption. In a second experiment with normal sheep, the addition of diethylstilbestrol or a mixture of L-lysine and DL-methionine to grass silage did not increase the amount of silage consumed.

When 0, 150, 300, or 450 ml of a fish oil was fed daily to lactating cows, a greater depression of milk-fat content was obtained from cows fed a low-fiber ration than from those fed rations of medium- or high-fiber content. The fat percentage in milk from cows fed the low-fiber ration averaged 3.5, 2.8, 2.3, and 2.3; for the medium-fiber 3.9, 3.7, 3.2, and 2.6; and for the high-fiber 4.0, 3.7, 3.3, and 2.5 for the four levels of oil.

Immature corn silage (25.8% dry matter) was supplemented with 0 and 0.5% urea at ensiling time, and it was fed as the sole forage to 16 Holstein and Ayrshire cows for 120 days. The cows also received a grain mixture, the amount depending on daily milk production. Daily silage consumption per cow was 36.1 and 38.3 kg, and fat-corrected milk production averaged 13.9 and 15.0 kg for the 0 and 0.5% urea rations. Nitrogen balance after 120 days was +15.0 and -11.9 g/day per cow. The reason for the negative N balance when fed corn silage containing urea is unknown.

### Calf Nutrition

Average daily gains of calves (eight Holstein and two Ayrshire per treatment) from 5 days of age to weaning at 7 weeks and from 7 to 15 weeks of age were 453 and 672 g when fed whole milk, 485 and 626 g when fed an all-milk protein milk replacer, and 476 and 600 g when fed a milk-soybean protein milk replacer (70% of total protein was from a soybean concentrate).

Several sources of bulk added to a liquid milk replacer were fed to calves to compare their effect on diarrhea and performance when fed at 3% of the dry milk replacer. Sawdust or solka floc had no effect on growth rate or rumen development, whereas oat hulls tended to increase growth and to stimulate rumen development. The added bulk did not reduce diarrhea.

## **Pig Nutrition**

In an experiment on self-selection of energy, protein, and mineral concentrates and water, 10 gilts have completed a full reproductive cycle. Most sows consumed mainly high-energy feed up to 4 weeks before farrowing, followed by increased protein intake, which continued through

lactation. Records of feed intake are being collected for subsequent reproductive cycles.

A metabolism cage design suitable for gilts and pregnant sows is under development, and it shows considerable practicality and efficiency for the separate collection of feces and urine.

# **AGRICULTURAL ENGINEERING AND FIELD CROPS**

## **Drying Rates of Hay**

Hourly drying rates of conditioned and unconditioned hay in the field were correlated to moisture content of the hay when data were grouped on the basis of hourly latent evaporation losses from a Bellani plate atmometer. The grouping employed was 0-2, 2-4, and 4-6 cc/hr. Correlation coefficients of 0.53 to 0.93 were obtained for the 2-4 and 4-6 groups with significant regression coefficients when an exponential form of an equation was employed. Work will be continued to obtain a general equation for drying curves and for values of constants as affected by species, maturity, and treatment of the hay material.

## **Potato Harvesting Combines**

During harvesting by combines, potato samples were taken to investigate mechanical injury to potatoes. Preharvesting samples were also taken to obtain yield, stone population and size distribution, and soil moisture data. Records included speed of operations, combine losses, and amount of stones appearing among the harvested potatoes.

Minor damages (skinning) were significantly increased by hauling and bin filling, whereas major damages (bruises) were not increased by these operations. Skinning caused by harvesters ranged from 5.2 to 8.6% of the potato surface. Three harvesters equipped with air separation devices for separating potatoes from stones gave ratings of 2, 4, and 5 (1 is the lowest value of damage). Bruises ranged from 1.1 to 2.7% of the potato surface, and the air harvesters gave ratings of 3, 7, and 9.

The correlation coefficient between skinning and total stone population was 0.51, and between skinning and stones greater than 1.5 inches in diameter was 0.58. The correlation between crack rating and total stone population was 0.46. Stone population did not adversely affect bruising, field losses, or amount of stones in the harvested potatoes. The correlation coefficients expressing the relationship between speed of operation and bruises, field losses, and stones among harvested potatoes were 0.36, 0.32, and 0.38.

## **Effects of Aluminum on Corn Growth**

In previous work in the greenhouse and in the growth chamber, the early growth of corn on acid soils was severely restricted. Aluminum toxicity was suspected. In a field study 450 lb/acre of aluminum sulfate applied to an acid soil did not affect the pH, but caused a 50% reduction in corn grain yield. Application of 2 tons of ground limestone per acre or 1 ton of limestone plus 45 lb P/acre banded near the seed restored corn yields to original levels.

## **Fertilization of Cereals on Low-fertility Soil**

Without fertilization Selkirk wheat and Impala barley yielded 8.8 and 12.9 bu/acre on a Riverbank sandy loam soil, which was very low in readily soluble P and K and had a pH of 5.6. Yields were markedly increased by various rates and placements of N, P, and K. Highest yields (53 bu/acre of wheat and 122 bu/acre of barley) in 1968 were obtained from 500 lb of 10-20-10 broadcast before seeding and another 500 lb with the seed.

# ENTOMOLOGY

## Grain Aphids

Aphid populations on oats (Fundy and Stormont) and barley (Charlottetown 80) were studied in the field, and grain yields under different levels of aphid populations were examined. Two species of aphid, *Rhopalosiphum padi* (L.) and *Macrosiphum avenae* (Fab.), occurred. Greater populations developed on barley (155,234 aphids on 700 tillers) than on oats (71,522 aphids on 700 tillers). Even higher populations occurred when 2,4-D amine was applied to these crops.

One malathion treatment when aphids were dispersing into the field reduced aphid numbers on oats by 29% and on barley by 64%. When malathion and 2,4-D amine were applied together, results were erratic. Malathion increased oat and barley yields by 47% and 32%, but the addition of herbicide confused the results.

In all treatments aphid populations decreased abruptly once the panicle of the grain emerged, and aphids did not persist longer than 10 weeks on either grain.

## Aphid Salivary Enzymes

Salivary glands from leaf-feeding, twig- or bark-feeding, gall-making, and root-feeding aphids showed considerable differences in the structure of their principal lobes. The lobes from bark or root feeders were twice as large as those from leaf-feeding forms. The functional significance of a deeply staining area in these lobes is under study.

## Blueberry Pollination

Significant differences in fruit set were obtained during 1968 between blueberry fields with honey bees added and those with only native pollinators. In most years honey bees contribute little to the level of fruit set. However, in 1968, an early spring in New Brunswick provided excellent conditions for pollination. Most competitive plants, particularly apples, were less responsive to the higher spring temperatures, and bloomed later than blueberries. This forced the honey bees to remain on the blueberries, and as a result twice as much fruit was set in the fields with honey bees as was set in the other fields.

## Blueberry Casebeetle

Populations of the blueberry casebeetle, *Chlamisus cribripennis* (LeConte), showed marked increases in Nova Scotia in 1968, and a new center of infestation was discovered in New Brunswick. The capacity of this species to return to a high population density within 2 years of an intensive spray program emphasizes the need for detailed biological study and alternative methods of control.

## Wireworm Control in Potatoes

Zinophos (American Cyanamid) 10% granular at 3 lb/acre active ingredient was the best treatment for control of wireworms on Nettet Gem potatoes. Thimet (American Cyanamid) at 3 lb/acre active ingredient or chlordane at 5 lb active ingredient were almost as effective. Bromophos (Cela) at 5 lb/acre active ingredient and Dyfonate (Stauffer Chemicals) at 4 lb active ingredient gave good early and mid-season control, but not late season. C10015 (Ciba Co. Ltd.) gave no control. All treatments except chlordane increased yield.

## Potato Flea Beetle Control

Potato flea beetles were controlled with endosulfan 4 emulsifiable concentrate at 3/4 qt/acre and with 25% DDT emulsion at 2 qt/acre. DDT at 1 qt, azinphos-methyl at 5/6 qt, or carbaryl at 2 lb/acre gave some control.

## Apple Maggots

Hour-degree soil temperatures above 42 F at the depth of the apple maggot pupae (0.75 to 1 inch) were recorded from late April to completion of adult emergence in August 1964, 1965, 1967, and 1968. Good agreement was shown in temperature summations at first adult emergence of 24,620 hr-deg in 1964 and 23,706 in 1965. Temperature summations at time of mean peak emergence were 32,256 in 1964 (August) and 32,202 in 1965 (July). Corresponding data for 1967 and 1968 were 25,548 and 26,641 hr-deg. Dates of bloom of McIntosh apples were not related to temperature summations.

Periods of adult emergence from carry-over of pupae from 8 Lobo, 8 Cort-

land, and 8 McIntosh trees showed that since 1963 there were 14 carry-overs to the second season, 11 carry-overs to the third season, 6 carry-overs to the fourth season, and 3 carry-overs to the fifth season.

## PLANT PATHOLOGY

### A Plant Virus Inhibitor

An inhibitor of potato virus X has been isolated from mycelium of *Phytophthora infestans* (Mont.) de Bary. The inhibitor is a polysaccharide of about 100 glucose molecules. When it was added at 500 ppm to potato virus X inoculum and the mixture was rubbed on tobacco leaves, no local lesions developed, in contrast with many lesions in the untreated inoculum. At concentrations of 60 ppm the polysaccharide partly inhibited potato virus X.

### Potato Spindle Tuber Virus

One hundred and sixty potato varieties and 40 seedlings were evaluated for resistance to potato spindle tuber virus during 4 years of field and greenhouse

trials. None of these was entirely resistant to infection, but several, notably the variety Norland, were more resistant than the others.

A new indicator plant, *Solanum rostratum* Dunal, commonly known as buffalo-bur, has been found for spindle tuber virus. When healthy young plants were mechanically inoculated with the virus and maintained in a greenhouse at 27–31 C, they developed veinal necrosis, followed by puckering of the leaves and stunting of the plants. These symptoms are caused by strains of the virus that also cause symptoms in tomatoes. But, as in tomatoes, when *S. rostratum* is infected with mild strains of spindle tuber virus, the plant does not develop visible symptoms.

trials. None of these was entirely resistant to infection, but several, notably the variety Norland, were more resistant than the others.

## PLANT PHYSIOLOGY

### Fruit Development in Native Blueberries

Previous work with the lowbush blueberry, *Vaccinium angustifolium* Ait., showed that auxin is produced in flower buds formed under short-day (8 hr) conditions; and that such buds, removed to long days, develop normal flower clusters, which form parthenocarpic fruit if sprayed with gibberellic acid.

The effect of allowing similar flower buds to complete their development under short-day rather than long-day conditions was investigated. Under continuing short days each bud developed a single flower on an abnormally long stem, rather than the normal flower cluster. These single flowers developed into naturally parthenocarpic fruit as the short days were continued. Occasionally fasciated fruit was produced.

### Growth Regulators For Spinach

Coumarin, chlorogenic acid, CCC (Eastman Organic Chemicals) and Naringenin (Mann Research Laboratories) solutions of 60 and 180 ppm reduced the incidence of bolting in Virginia savoy spinach, but not in Wintra or Hybrid 424. These materials were only effective if applied about 4 days before normal harvesting stages of growth.

### Preharvest Drop of Apples

A spray of Alar 85 (Uniroyal (1966) Ltd.) at 1,000 ppm applied on July 21 to 10-year-old Red Melba apple trees on EM VII rootstocks greatly reduced preharvest drop of fruit, and prolonged the harvest season 4 to 9 days. The delayed harvest caused no significant difference in the storage life of the fruits.

## **Fiddlehead Ferns**

Field experiments have shown that the ostrich fern, *Pteretis pensylvanica* (Willd.), can be grown for its fiddleheads if plant-

ings are made on fertile, well-drained sandy soils. Both upland and interval plantings have been successful. Yields of 1,300 lb/acre have been obtained.

# **POTATO BREEDING**

## **Stem Thinning**

In evaluating early varieties of potatoes, the chief criterion is their ability to size early rather than to mature early. In a potato breeding program it is easy to find seedlings that have a very early maturity, but these usually produce low yields of small tubers. When screening potato seedlings for earliness it is therefore necessary to consider their ability to produce tubers of marketable size within 80 to 90 days from planting. Previous work at Fredericton with the Netted Gem variety showed that a reduction in number of stems per plant increased the number of marketable tubers. Since one of the chief faults of this variety in Eastern Canada is lack of size, this discovery was significant.

Stem thinning was tested over a 3-year period on a collection of early seedlings and varieties to determine if an increase in tuber size could be induced. Four replicates were thinned to one stem for 2 years and to two stems the third year. Thirteen seedlings and varieties were planted each year during the latter part of April, and harvested 85 to 90 days later. In only one case did a seedling or variety that had been reduced to one stem exceed the check for yield of marketable tubers. When reduced to two stems, four varieties gave greater yields than the checks.

## **York, a New Variety**

The new potato variety York was introduced in 1968 by the University of Guelph and the Canada Department of Agriculture. The original selection was made in the field at the Bradford Muck

Research Station, Ont., from an unselected population received from the Research Station, Fredericton. York is an early, smooth, slightly netted potato of high cooking quality, especially adapted to the organic soils of Ontario.

## **Topkilling by Undercutting**

Undercutting is the process of drawing a horizontal steel blade under potato plants before harvest to severely prune the roots and to induce a slow death of the plant, thereby duplicating some of the features of chemical topkill. A comparison of undercutting and chemical topkilling over a 3-year period with the Netted Gem variety showed an increase of 0.003 in specific gravity with the undercut treatment, and no adverse effects on yield or on skinning and bruising. Costs of the two treatments were similar. Undercutting must be investigated in relation to possible induced field frost damage before it can be recommended as an alternate to topkilling.

## **Information Retrieval**

An information retrieval program for advanced-generation seedlings within the potato breeding program has been developed in cooperation with the Statistical Research Service, Ottawa, Ont. At present 425 seedlings have been entered in the system. The program carries 4 years' data on 77 characteristics plus an expanded parentage and 80 characters of comment. Running averages and relative yields are calculated where applicable. The program printout shows this information and can be used as the current year's field book. A series of subroutines ranks and sorts all the characteristics including parentage.

## SOILS

### Effect of Drying on Extractable Manganese and Aluminum

Surface soil from seven sites previously planted to potatoes was stored for 4 months under four conditions: air-dried at 70 F, and moist soil enclosed in plastic bags at 70 F, 40 F, and 10 F. Storage conditions greatly influenced 1 N KCl extractable Mn. Air-dried soils released 10 to 20 times as much Mn as soils stored at 40 F. The influence of storage conditions on 1 N KCl extractable Al was less pronounced. Soils stored at 70 F released slightly more Al than soils stored at 10 F.

### Effect of Particle Size of Limestone on Availability of Calcium and Magnesium

The use of coarse limestone as a filler in the bulk-blending fertilizer industry has created an interest in the effect of particle size on the availability of Ca and Mg to plants.

In a greenhouse experiment, dolomite was separated into seven sizes of particles (300, 100, 60, 32, 16, 9, and 3.6 mesh) and applied to a Riverbank sandy loam at 200 lb/acre. A crop of buckwheat planted immediately after treatment had a higher Mg content, provided the dolomite was 32 mesh or finer. Mesh sizes of 32, 60, 100, and 300 gave similar results. Coarser particles did not increase the Mg content unless the treated soil was incubated for 3 months before cropping. In the latter case, a small but significant increase resulted from 9- and 16-mesh limestone.

Dolomite at this rate of application had no effect on Ca concentration in the plant, regardless of particle size.

### Effect of Stones on Potato Yield

Results obtained from three potato-growing soils, Holmesville, Monquart, and Caribou, showed that potato yields declined when stones were removed. Moisture and temperature were lower in plots from which stones had been removed.

## WEED CONTROL

The rates of herbicides in the following summary are given in active ingredient or acid equivalent per acre.

### Weeds in Lowbush Blueberries

Results of a number of experiments for control of lambkill, *Kalmia angustifolia* L., showed that the age of the lambkill when treated is not a factor in the amount of control obtained with 2,4-D or dicamba. Dicamba at 3 lb was superior to 2,4-D ester at 3 lb for control of lambkill, sweet fern, and bracken fern. In the Maritime Provinces dicamba should be applied to blueberries early in October, because late fall applications may reduce the stand. For control of lambkill, dicamba or 2,4-D should be applied again in the fall, before the second burn.

### Quackgrass in Potatoes

Several herbicides, combinations of herbicides, and cultivations were evaluated for control of quackgrass, *Agropyron re-*

*pens* (L.) Beauv., in potatoes. Cultivation throughout the growing season has been recommended for control of this weed. However, experiments in New Brunswick showed that excessive cultivation reduces potato yields. Variable results have been obtained with herbicides. In certain years, dalapon and EPTC have provided satisfactory control, but in other years they have been quite ineffective. When applied after emergence and before the crop reached a height of 4 inches, paraquat partly controlled quackgrass and most other weeds.

### Eradication of Quackgrass

Single treatments of a number of herbicides applied to quackgrass did not eradicate this weed. However, certain combinations of treatments applied in the same year were more successful. Atrazine at 2 lb or amitrole-T at 4 lb applied in mid-July followed by paraquat at 0.8 lb or by cultivation or a crop of buckwheat de-



stroyed quackgrass. EPTC (7 lb) incorporated into the soil in mid-July followed by two cultivations or by the paraquat

treatment also destroyed quackgrass. Combinations with dalapon gave variable control.

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# Ferme expérimentale L'Assomption, Québec

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Génétique et amélioration  
du tabac à cigare

### **Grande culture**

J. GENEST, B.S.A.

Céréales et plantes  
fourragères

## INTRODUCTION

Ce rapport n'est qu'un bref résumé des travaux de recherches poursuivis à la Ferme expérimentale de L'Assomption en 1968. À la date où ce rapport fut présenté, nous n'avions en main qu'une partie des résultats. Dans le cas des expériences sur les tabacs les résultats ne seront connus qu'à la fin de l'hiver. Ces derniers seront publiés dans divers articles et dans les prochains rapports.

Quelques travaux de recherches sur la culture de la fraise ont été faits à L'Assomption sous la direction de la Station de recherches de St-Jean. Ces travaux se terminent avec l'année 1968.

J. Richard  
Le directeur

## GRANDE CULTURE

### Plantes fourragères

*Effets des plantes-abri sur l'établissement.* L'objet de ce projet est l'étude de l'influence des céréales: avoine (Dorval), blé (Selkirk) et orge (Champlain) sur l'environnement et le comportement de nouveaux semis de luzerne (Vernal), lotier (Empire), brome (Saratoga) et mil (Climax).

Les résultats des trois dernières années démontrent que les conditions d'établissement (énergie lumineuse, humidité) des diverses espèces fourragères ensemencées sans céréale-abri sont les plus favorables au développement des jeunes plantules, même s'il se produit de grandes infestations de mauvaises herbes. Jusqu'à la première semaine de juillet, les semis effectués sans plante-abri bénéficient d'une quantité d'énergie lumineuse nettement supérieure à celle que reçoivent les semis effectués sans plante-abri. De plus, ils profitent d'une plus grande quantité d'eau du sol.

L'amélioration de l'environnement ne cause pas l'établissement d'une plus grande population de légumineuses; toutefois un meilleur tallage augmente considérablement celle des graminées. On constate qu'un milieu propice au semis l'est aussi pour les mauvaises herbes durant la pre-

mière année de l'ensemencement. Dans un semis bien établi les mauvaises herbes sont rares.

Lors de la première récolte de foin faite l'année suivant le semis, le rendement de la luzerne a été peu affecté par l'utilisation de céréales-abri. Par contre, la production des autres semis sans plante-abri, a augmenté d'environ 100 p. 100 par rapport aux semis effectués avec plante-abri. Parmi ces derniers, le blé permit l'obtention de rendements fourragers supérieurs à ceux des semis effectués en compagnie d'avoine ou d'orge.

Le comportement du mil a été très spectaculaire; les semis sans plante-abri permirent l'obtention de 4,506 kg/ha de matière sèche, tandis que ceux effectués avec blé, avoine et orge rapportèrent respectivement 3,300, 876 et 636 kg/ha de matière sèche.

### Céréales

*Blé.* En 1966, on a repris les travaux de recherches sur l'évaluation des cultivars de blé. On a constaté que la productivité des nouveaux cultivars Pitic 62, Wb 8874 et Opal s'est avérée tout à fait exceptionnelle. On a obtenu des rendements de 28 à 51 p. 100 plus élevés que ceux du cultivar Selkirk actuellement recommandé.

# TABAC

## Tabac à cigare

*Génétique.* On a complété la première phase des recherches sur les influences maternelles, au moyen de matériel homozygote. Les résultats obtenus indiquent que la contribution maternelle ressort davantage dans les croisements réunissant des tabacs de types différents, et particulièrement dans les croisements entre les tabacs à cigare et à pipe.

*Séchage.* En 1968, nous avons utilisé le cultivar commercial Ottawa 705. Le tabac séché selon la méthode naturelle a été le plus endommagé, alors que le tabac séché à l'aide de chauffage et de ventilation supplémentaires a été le moins endommagé. Le tabac séché avec ventilation supplémentaire seulement a été légèrement plus atteint que le tabac séché avec ventilation et chauffage supplémentaires.

*Sélection, évaluation préliminaires et finales.* Les observations préliminaires effectuées au champ sur 277 lignées hybrides et 25 cultivars connus ont permis d'éliminer un peu plus de 20 p. 100 des lignées hybrides. Un second triage se fera sur les lignées non éliminées dès que seront connus les résultats du séchage.

Cent trente-neuf des lignées étaient issues du cultivar commercial Ottawa 705, variété appréciée des fabricants de cigares pour la qualité de son tabac. Cependant, le séchage a provoqué quelques difficultés, attribuables à la susceptibilité plus prononcée du cultivar aux maladies des feuilles et des tiges en cours de séchage. Les travaux de sélection sur les lignées issues d'Ottawa 705 ont pour objectif d'améliorer la force de la feuille et la résistance de la tige aux mauvaises conditions météorologiques ou de séchage.

Lors d'essais préliminaires, six lignées hybrides avaient plus de feuilles par plant qu'Ottawa 705 et quinze en avaient plus que R.H. 211. Aucune différence significative n'a été constatée entre les deux cultivars commerciaux. Le sort de quelques-unes des lignées ne sera décidé qu'après le classement de toutes les lignées; toutefois, les observations au champ indiquent qu'au moins 15 p. 100 des hybrides

ont surpassé les cultivars commerciaux par six des caractères à l'étude.

Les essais d'évaluation finale portaient sur 10 lignées répétées quatre fois. La lignée hybride 839 a eu le plus grand nombre de feuilles récoltables et la 250 × 705 le plus petit. On n'a relevé aucune différence significative pour le nombre de feuilles récoltables entre la 839 et les deux cultivars commerciaux. On ne possède pas encore les résultats complets sur les feuilles séchées, le classement n'étant pas encore terminé.

*Essais de dégustation.* Avec la collaboration d'un grand fabricant de cigares de Montréal, un jury de 25 fumeurs-dégustateurs s'est chargé d'évaluer les qualités de plusieurs lignées hybrides et cultivars commerciaux. Les résultats des six épreuves de dégustation réalisées jusqu'à présent font ressortir la nécessité de porter l'effectif du jury au moins à 50 membres.

## Tabac jaune

*Évaluation des variétés.* Trois variétés et un hybride ont fourni des rendements supérieurs à 2,000 livres, à savoir 205 (2,231 livres), Virginia 115 (2,090 livres), Speight G-7 (2,022 livres) et L7 × Speight G-7 (2,020 livres). Dix-sept variétés et lignées ont rapporté \$1,000 et plus à l'acre entre autres Virginia 115 (\$1,318) et Speight G-7 (\$1,267). Onze variétés ont un indice de qualité supérieure à 60 cents entre autres L67 × 138 P.X (64.9 cents) et Delcrest (64 cents). La variété 205 a produit le tabac le plus haut (42.2 pouces) et ayant le plus de feuilles (18.5). La variété Yellow Gold a produit des feuilles de 14.3 pouces de largeur et de 25.4 pouces de longueur.

*Méthodes culturales.* Pour la troisième année consécutive, nous avons étudié le comportement de trois variétés de tabac jaune soumises à trois degrés de compacité et trois taux de fertilisation. Nous avons constaté qu'une majoration de la quantité de fertilisant augmente légèrement le rendement et le revenu brut. Aucune variété n'a été particulièrement sensible aux différentes méthodes culturales.

*Répression des nématodes.* Nous avons constaté que la population des nématodes, dans les parcelles d'expérimentation, était beaucoup plus dense et beaucoup plus variée que dans les sols non cultivés et engazonnés que dans les sols soumis à la rotation seigle-tabac. Nous avons constaté lors de travaux préliminaires que certains nématicides retardaient significativement la maturation du tabac. La population a régressé durant le mois qui suivit les traitements, après quoi elle a augmenté ou est demeurée stable selon le produit.

*Répression des mauvaises herbes.* Lors d'études préliminaires sur l'éradication des mauvaises herbes à l'aide d'herbicides, nous avons constaté que dans les parcelles où aucun désherbage n'a été fait, le rendement et le revenu brut ont diminué de près de 50 p. 100. Les résultats obtenus cette année indiquent qu'un sol préparé à l'aide d'une bêcheuse rotative assure un rendement et un revenu brut supérieurs à un sol préparé à l'aide d'une herse à disques. Des différents herbicides utilisés, soit en pré-émergence soit en post-émergence, l'herbicide R-7465 (Stauffer Chemi-

cal Co.) a retenu particulièrement notre attention.

*Répression des drageons du tabac.* En 1968, nous avons comparé quatre produits, Penar (Pennsalt Chemicals of Canada Ltd.), Emgard (Emery Chemical Co. Ltd.), Off-Shoot-T (Proctor and Gamble Ltd.), TSC 350 (Pfizer Company Ltd.), et nous avons obtenu un arrêt satisfaisant de la croissance des drageons. Le revenu brut à l'acre est le seul critère agronomique où nous avons constaté une différence significative entre les traitements et le produit TSC 350 s'est avéré le meilleur sous ce rapport.

*L'effet du pH sur la croissance du tabac.* Les travaux effectués en plein champ en 1967 et en serres en 1968 nous ont permis d'établir un barème pour modifier le pH original du sol en vue d'atteindre le pH désiré. Les résultats obtenus au champ en 1968 indiquent que seul l'indice de qualité a répondu significativement. L'analyse de tabac en laboratoire n'étant pas terminée nous ignorons l'effet du pH sur les constituants chimiques et sur la combustibilité de la feuille.

## AVICULTURE<sup>1</sup>

### Volailles à chair

*Études de sélection.* Nos essais de sélection enregistrent des progrès constants pour le poids des poulettes jusqu'à 56 jours. Dans la dernière série d'essais, la lignée la plus fortement sélectionnée a donné un gain de 49 p. 100 sur la population dont elle était issue. Rien ne semble indiquer un plafonnement des progrès

génétiques réalisés dans les lignées sélectionnées.

Le taux considérable de mortalité dans les parquets de poudeuses demeure une source d'inquiétude. Le taux de consanguinité actuel n'étant pas élevé, on commence à soupçonner que cette mortalité excessive peut être reliée à la sélection faite en vue de l'accroissement du poids vif.

## PUBLICATIONS

### Divers

ALLARD, J. 1968. Le bilan d'eau du sol adapté à l'irrigation du tabac jaune. *The Lighter*, 38(3):9-14.

LUKOSVICIUS, P. P. 1968. Dehydration during curing of cigar tobacco. *The Lighter*, 38(1):9-15.

<sup>1</sup> Les travaux de génétique avicole sont sous la direction du Dr E. S. Merritt et ceux de nutrition sous la direction du Dr J. R. Aitken, Animal Research Institute, Ottawa, Ont.

# Station de recherches Lennoxville, Québec

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## INTRODUCTION

La Station de recherches de Lennoxville est le principal centre fédéral de recherches en zootechnie au Québec. Le programme porte sur l'amélioration génétique, l'alimentation, et la régie des bovins, des porcs et des moutons. Il se complète par des études en productions végétales ayant pour but l'exploitation plus rationnelle des plantes et la fertilisation plus appropriée des sols.

Les recherches en zootechnie sont effectuées en collaboration avec les fermes expérimentales de La Pocatière et de Normandin, lesquelles relèvent de la Station de Sainte-Foy. Les recherches en productions végétales se poursuivent à la Station de même qu'à 6 autres postes d'essais situés dans un rayon de 80 milles de Lennoxville.

Au cours de l'année, plusieurs changements se sont produits parmi le person-

nel. En mai, monsieur P. E. Sylvestre termine sa carrière après 33 années en recherches zootechniques et 6 années au poste de directeur de la Station. Monsieur Omer Allard, officier de recherches, et autrefois surveillant des fermes de démonstration, prend sa retraite en février. Par contre, le Dr M. Fahmy se joint au personnel professionnel tandis que messieurs J. Dufour et A. Pesant entreprennent des études en vue de l'obtention de leur doctorat.

Ce rapport contient les résultats de quelques essais en cours ou terminés en 1968. S'il est très succinct, c'est que l'ensemble des programmes et des projets d'expérience sont publiés dans une autre brochure que l'on peut se procurer sur demande.

C. Bernard  
Le directeur

## ZOOTECHNIE

### Efficacité de la sélection chez les porcs

Au cours d'une décennie, trois lignées de porcs Yorkshire ont été sélectionnées pour les fins suivantes: première lignée, efficacité alimentaire; deuxième lignée, qualité de la carcasse; troisième lignée, efficacité alimentaire et qualité de la carcasse. La qualité de la carcasse a été vérifiée par le dépeçage selon le procédé d'épreuve de la Direction de Production et des Marchés.

Les deux premières lignées ont donné respectivement 94 et 25 p. 100 de l'amélioration génétique prévue théoriquement. La troisième lignée a atteint 136 et 10 p. 100 des taux d'amélioration anticipés. Les corrélations génotypiques et phénotypiques entre les deux caractères étaient négatives et relativement élevées.

La sélection de la troisième lignée a été basée sur la combinaison des deux premiers critères. On a remarqué une augmentation de l'efficacité alimentaire. Ce-

pendant, c'est dans la deuxième lignée qu'on a obtenu une amélioration maximale pour la qualité de la carcasse.

### Influence du régime alimentaire d'hiver sur les gains subséquents de veaux de boucherie

On a hiverné des veaux Hereford et Angus avec une ration qui, d'une part, était de 14 p. 100 supérieure aux recommandations du Conseil National des Recherches des États-Unis et, d'autre part, 2, 8, 14 et 22 p. 100 inférieure à ces normes.

Les bêtes du premier groupe pesaient plus que les autres, même après une période de 100 jours de paissance l'été suivant. Les poids des autres groupes différaient très peu entre eux.

Le niveau alimentaire n'a pas beaucoup influencé la digestibilité de la ration, sauf celle de la cellulose brute. Celle-ci était



plus digestible lorsque les quantités d'aliments ingérées augmentaient.

Les veaux, dont la ration contenait du gras animal à raison de 115 gr/tête par jour, ont fait un usage plus efficace de leurs aliments.

### **La maturité des graminées et leur valeur alimentaire**

La valeur alimentaire du dactyle, du brome et du mil, en semis purs, diminuait au fur et à mesure que le stade de maturité avançait. Chaque espèce était récoltée à trois stades définis: début-épiaison, début-floraison et mi-floraison. Les fourrages ont été servis à des agneaux dont le poids moyen était de 22.7 kg au début de l'expérience.

Les gains quotidiens pendant la période alimentaire de 63 jours, aux mêmes stades de maturité, étaient de 100, 64, et 54 gr pour le dactyle; de 110, 54 et 27 gr pour le brome; de 73, 23 et 14 gr pour le mil.

En général, la digestibilité de la matière sèche des fourrages diminuait à mesure que la maturité se développait, mais elle augmentait dans les regains récoltés deux mois plus tard.

### **Fertilisation azotée sur un pâturage de dactyle**

Pendant trois années consécutives, un pâturage de dactyle a été fertilisé avec 100 kg de N/ha et pacagé par des agneaux. Le rendement en herbe, les gains de poids vif et le chargement à l'hectare ont augmenté de 21, 47 et 40 p. 100 respectivement par rapport à un pâturage témoin non fertilisé.

### **Finition de bouvillons au pâturage sans moulée**

On a mis en marché des bouvillons antenais finis sur des pâturages de gra-

minées ou de légumineuses dont les chargements étaient respectivement de 1.8 ou 3.7 têtes à l'hectare. Cette expérience, d'une durée de trois ans, comprenait 144 bouvillons.

*Graminées vs légumineuses.* La durée moyenne de la période de paissance était de 155 et 142 jours. Les gains par bouvillon ont été de 126 et 111 kg, le poids final des bêtes de 462 et 448 kg et les gains de poids vif à l'hectare de 348 et 299 kg, respectivement. Par contre, le classement des carcasses a démontré que les légumineuses étaient supérieures aux graminées. Le poids des carcasses était de 232 kg pour les bouvillons finis sur graminées et de 233 kg sur légumineuses, soit un rendement moyen de 51.8 et 53.3 p. 100, respectivement. Parmi les carcasses du premier groupe, 26.4 p. 100 ont été classées «Canada Choix» et «Bon» comparativement à 43.7 p. 100 pour le deuxième groupe.

*Chargement à l'hectare 1.8 tête vs 3.7 têtes.* Les résultats variaient selon les gazons. En doublant le chargement sur les pacages de graminées, on a augmenté les gains de poids vif de 90.7 p. 100, soit de 236 kg/ha à 457 kg/ha, tandis que sur les légumineuses on a enregistré une augmentation de 66.7 p. 100, soit de 223 kg/ha à 371 kg/ha. L'augmentation du chargement n'a pas influencé la durée de la période de paissance dans le cas des graminées, mais elle l'a réduite de 12 jours dans le cas des légumineuses. Le rendement des carcasses est passé de 52.3 à 51.5 p. 100 en augmentant la charge de paissance sur les graminées, et de 52.4 à 53.5 p. 100 sur les légumineuses. L'augmentation du chargement sur les graminées n'a pas favorisé la classification des carcasses, mais elle a influencé avantageusement celle des légumineuses.

## **PRODUCTION VÉGÉTALE**

### **Courbe de productivité de trois graminées fourragères**

On a prélevé le mil Climax, le brome Saratoga et le dactyle Hercules à dix dates différentes s'échelonnant, à une semaine d'intervalle, du 24 mai au 26 juil-

let. Ces coupes ont été suivies, au cours de la saison, d'autres coupes à intervalles réguliers.

*Rendements.* Chez le mil Climax, l'accroissement de la matière sèche lors du premier cycle de végétation a été, chaque

année, constant et rapide. Ainsi, en 63 jours, les rendements moyens en matière sèche sont passés de 1,014 à 6,695 kg/ha. Lors de la deuxième exploitation, c'est-à-dire 42 jours après la première coupe, les rendements variaient de 623 à 3,019 kg/ha, selon la date de la première coupe. Les coupes, avant le 31 mai, donnaient plus de regain que celles effectuées après le 7 juin.

Chez le brome Saratoga, les rendements au cours des 63 jours du premier cycle sont passés de 1,210 à 6,538 kg/ha. L'accroissement a été très rapide du 24 mai au 23 juin et plus lent après cette date. À la deuxième coupe 42 jours plus tard, le regain, suivant la coupe du 24 mai, a donné 2,019 kg en regard de 1,624 et de 1,091 à la suite des coupes du 31 mai et du 7 juin respectivement. À partir du traitement du 21 juin, les repousses ont été semblables.

Chez le dactyle Hercules, la croissance a été constante du 24 mai au 21 juin. Après cette date, elle a été lente. Lors du deuxième cycle, les rendements des traitements des 7 et 14 juin ont été légèrement plus faibles que ceux des autres traitements, soit 1,062 kg/ha (le 14 juin) en regard de 1,826 kg/ha (le 24 mai) et 1,804 kg/ha (le 12 juillet).

*La composition chimique.* Au cours du premier cycle, les teneurs en protéines variaient de 16 à 20 p. 100 dans les jeunes herbes des 24 et 31 mai, tandis qu'à maturité, entre le 5 et le 26 juillet, les teneurs variaient de 3 à 8 p. 100 selon la graminée. Au deuxième cycle, les teneurs ont été plus faibles chez les plantes récoltées jeunes lors de la première coupe, alors qu'elles dépassaient 15 p. 100 chez les autres. Au troisième cycle, les teneurs ont été très élevées chez les trois graminées. Les teneurs en cellulose brute ont varié à l'inverse des teneurs en protéines. Les dosages en phosphore et en potasse ont été légèrement plus élevés chez les plantes jeunes. Le dactyle contenait légèrement plus de phosphore dans ses tissus que le mil ou le brome, tandis que le brome était un peu plus riche en potasse que les deux autres.

## Rénovation de pâturage à l'aide d'herbicides et de méthodes culturales

Traiter un gazon naturel à base de fétuque rouge et de pâturin du Kentucky avec 281 ou 1,123 cc/ha de paraquat pour ensuite l'ensemencer avec deux mélanges à pâturage, semble être un bon moyen d'améliorer des pâturages peu productifs, surtout si on emploie une herse à disques avant le semis. C'est ce qui ressort d'une étude entreprise en vue de déterminer les possibilités de rénover des pâturages peu accessibles et peu rentables. En septembre 1966, on a arrosé un pâturage naturel avec du paraquat à raison de 281 et 1,123 cc/ha pour le comparer à des parcelles témoins. En 1967, ces mêmes parcelles ont été soit hersées, disquées ou laissées telles quelles et ensuite ensemencées avec un mélange mil-ladino ou mil-lotier.

Le mélange mil-ladino a contribué régulièrement plus au rendement que le mil-lotier, même si en 1968 la contribution de l'une ou de l'autre légumineuse était minime (13 p. 100). Le pourcentage des espèces semées dans les parcelles traitées avec 1,123 cc de paraquat a été respectivement de 70.4, 56.7, 38.9 p. 100 pour l'année du semis et les années de récolte 1967 et 1968. Les rendements totaux de ces mêmes années ont été respectivement de 1,022 kg/ha, 5,369 kg/ha et 3,372 kg/ha dans les parcelles traitées avec 1,123 cc de paraquat et de 1,030 kg/ha, 5,443 kg/ha et 2,912 kg/ha dans les parcelles témoins.

Pour la période 1966-68, on peut conclure que le fait d'ameublir le sol à l'aide d'une herse à disques avant le semis a semblé donner un meilleur résultat que de passer une herse à dents rigides ou de ne pas cultiver. Même qu'en 1966 on a aussi pu observer une interaction significative entre les façons culturales et les mélanges. Ainsi, là où nous avons passé avec une herse à disques, le rendement total des parcelles semées avec du mil-ladino a été de 1,469 kg/ha comparé à 900 kg/ha pour le mil-lotier et 940 kg/ha pour le témoin. La proportion des espèces semées était respectivement de 80.4, 54.2 et 41.8 p. 100.

## Herbicides pour le chou fourrager

Les herbicides de préémergence C 7019 (Ciba) et C 6989 (Ciba), employés à raison de 2.24 kg/ha, ont tenu en échec les mauvaises herbes et permis d'augmenter les rendements en matière sèche de façon significative. Le 6 juin, on a semé du chou fourrager de la variété Maris Kestrel et on a appliqué deux herbicides de préémergence: C 7019 (2-azido-4-isoprophlamino-6-méthylmercapto-s-triazine) et C 6989 (2,4-dinitro-4-trifluorométhyl-diphényl-ether). Les doses étaient de 2.24, 3.36 et 4.48 kg/ha dans 700 litres d'eau. Le 16 août on a évalué les mauvaises herbes présentes. On les a estimées à 3,121 kg/ha dans la parcelle témoin et à moins de 500 kg/ha dans les parcelles traitées. Parmi les 53 espèces de mauvaises herbes identifiées on retrouvait surtout le chénopode blanc, résistant au C 6989 et que seul contrôlait parfaitement 3.36 ou 4.48 kg/ha de C 7019. L'herbicide C 7019 a aussi détruit d'autres plantes comme les chénopodes, des persicaires, la bourse-à-pasteur, le pied de coq, le pâturin du Canada et plusieurs autres espèces moins abondantes.

## Date de semis du blé d'hiver

Trois variétés ont été mises en terre à quatre dates différentes, les 16 août, 8, 16 et 26 septembre 1967. À l'approche de l'hiver, le développement végétatif du premier semis atteignait de 35 à 45 cm et celui des autres de 12 à 22 cm. Au printemps, le semis hâtif semblait totalement détruit, tandis que les autres présentaient un gazon régulier, sans perte notable.

La différence de rendements, par rapport aux dates de semis, a été hautement significative. La date la plus tardive, le 26 septembre, s'est révélée la plus propice. Sa production a été de 33 p. 100 et 27 p. 100 plus élevée que celles des 8 et 16 septembre respectivement.

## Essais de variétés—plantes fourragères

*Lotier.* La variété Viking est celle qui a donné le meilleur peuplement et permis d'obtenir les plus hauts rendements en matière sèche. Ces résultats proviennent de 5 semis, dont 3 à Lennoxville et 2 à Thetford Mines, exploités en régime de fenaison

(2 à 3 coupes) ou de pâturage (3 à 4 coupes). À Thetford Mines, pendant quatre ans, la variété Viking a donné en moyenne 5,990 kg/ha et Léo, 5,653 kg/ha. Dans un autre semis, en association avec le mil Drummond, le lotier a fourni sa meilleure contribution, autant en régime de fenaison que de pâturage.

*Luzerne.* Même si les variétés Narragansett et Rhizoma doivent être abandonnées, la première à cause d'une faible production de semence et la deuxième à cause de sa susceptibilité à la flétrissure bactérienne, ces variétés sont encore les meilleures productrices d'herbe. C'est ce qui ressort d'un essai qui contenait encore une population de 51 et 55 p. 100 de luzerne après 4 ans. Parmi les 21 variétés de luzerne qui ont été comparées en parcelles et les 30 autres, en rang d'observation, il est évident que Iroquois, Warrior et Saranac pourront remplacer Narragansett et Rhizoma. Quant à Titan et WL-305 elles sont très prometteuses pour la région.

## Nouvelles variétés de céréales

Deux variétés, homologuées en 1968, ont été incluses dans les essais.

L'avoine Yamaska, qui provient des croisements (MC233 × Acton) × Shefford, a donné un rendement légèrement inférieur à celui de Dorval, mais elle avait une maturité plus hâtive de 4 à 6 jours. Ceci devrait favoriser son emploi en zone à courte saison de végétation. Sa paille offrait une bonne résistance à la verse et son pourcentage d'écales était relativement bas.

Le blé d'hiver Yorkstar s'est révélé rustique et productif, et à ces titres, il s'ajoute aux variétés Talbot, Richmond et Genesee. Au cours de 1967-68 son rendement a presque doublé celui du témoin Kharkov. Il a été de 13 p. 100 plus élevé que celui de Talbot, son plus proche rival. Sa maturité est semblable à celle de Genesee. Sa paille est très rigide et aucune verse n'a été observée en deux ans.

## Action de l'azote, du phosphore et du potassium sur les prairies et sur le contenu en éléments nutritifs des sols

On a étudié, depuis 1956, l'influence que pouvait avoir une fumure en N, P

et K sur l'avoine et les plantes fourragères cultivées, dans une rotation de 4 ans.

*Composition botanique.* Le pourcentage de légumineuses dans le foin de première année est passé de 37 p. 100 à 54 p. 100 à la suite de l'application de 26.9 kg de N/ha et 134.5 kg/ha de  $P_2O_5$  et de  $K_2O$ . Le potassium a été l'élément responsable de cette augmentation en légumineuses. Cependant, ces plantes n'ont pas persisté, et l'année suivante on n'en retrouvait plus que 7 p. 100, même dans les parcelles fertilisées à la dose maximum.

*Composition chimique.* L'application d'azote a augmenté les teneurs en protéines de l'avoine et du foin de deuxième année. Ce sont d'ailleurs ces récoltes qui recevaient une fumure azotée au début de la saison de végétation. La dose de 107.6 kg de N/ha a augmenté de 74 p. 100 la quantité de protéines pendant les quatre années de la rotation. Elle s'est accrue de 671 kg/ha à 1,168 kg/ha.

Les teneurs en P et K ont légèrement augmenté avec les doses de  $P_2O_5$  et  $K_2O$ . La teneur en P dans les plantes s'est maintenue à un niveau satisfaisant, mais celle en K est demeurée nettement insuffisante. La luzerne, par exemple, n'a jamais atteint le seuil critique de 1.4 p. 100 même en dépit d'application de 134.5 kg de  $K_2O$  à l'hectare. Elle n'a donc pu s'établir et encore moins survivre.

*Bilan du phosphore et du potassium.* Le P assimilable s'est accru dans le sol à mesure qu'on augmentait les doses de  $P_2O_5$ . Le bilan du P a été négatif à la dose de 269 kg de  $P_2O_5$  à l'hectare, indiquant qu'il s'était produit une fixation de cet élément dans le sol. À cette dose, le coefficient d'utilisation du P ne s'est d'ailleurs chiffré qu'à 15 p. 100.

Les quantités de K dans le sol à la fin de la rotation n'ont accusé qu'un léger accroissement à la suite d'apport de  $K_2O$  à doses croissantes. Les récoltes ont effectué des prélèvements de potassium allant jusqu'à 336 kg/ha. Le bilan du potassium a été positif, indiquant que le sol a dû libérer du K au lieu d'en fixer. En conséquence, le coefficient d'utilisation des engrais potassiques a été élevé, se chiffrant à plus de 75 p. 100. Il n'est pas étonnant

que la réserve de K n'ait pu s'accroître dans le sol. Tout ceci indique que les doses d'engrais potassiques utilisées se sont révélées insuffisantes même à raison de 269 kg/ha pour l'ensemble des récoltes de la rotation. Le loam de Coaticook, comme bien d'autres sols des Cantons de l'Est, est pauvre en potasse, et il en exige de fortes quantités pour maintenir les prairies en bon état de production.

### L'eau dans la production de la luzerne et du trèfle Ladino

Le degré de sécheresse atteint par un sol affecte considérablement la croissance, le comportement et parfois le rendement des plantes.

Ainsi les rendements en luzerne et en trèfle Ladino cultivés en serre ont diminué de 60 p. 100 lorsqu'on laissait le sol se dessécher près du point de flétrissement avant de l'irriguer. Si on ne permettait pas à la réserve d'eau disponible du sol de baisser en bas de 40 p. 100, on n'avait qu'une diminution de production de 27 p. 100. Si l'eau disponible du sol n'atteignait pas moins que 70 p. 100, les rendements n'étaient réduits que de 7 p. 100.

Le trèfle Ladino a beaucoup plus souffert du manque d'eau que ne l'a fait la luzerne. Le «stress» dû à la sécheresse était beaucoup plus dommageable aux légumineuses croissant sur l'argile Sainte-Rosalie qu'à celles cultivées sur le sable Saint-Jude. L'application d'engrais n'a donné une production maximum de légumineuses que lorsque le sol était maintenu à sa pleine capacité de rétention d'eau.

L'état d'humidité du sol a influencé le développement des racines. La luzerne cultivée en argile de Sainte-Rosalie a développé un système racinaire beaucoup plus abondant en sol tenu continuellement à sa capacité de rétention d'eau. On a remarqué le même phénomène, mais à un degré beaucoup moindre, chez le Ladino croissant dans le même type de sol. Les racines des légumineuses cultivées en sable Saint-Jude n'ont pas été tellement influencées par le régime hydrique. Elles se sont même moins bien développées lorsqu'on a maintenu le pourcentage d'eau à «la capacité du champ» soit environ 13 p. 100.

L'apport de fertilisant a permis une meilleure utilisation de l'eau. Il a fallu en moyenne 1,503 cc d'eau pour produire 1 gr de matière sèche avec une fumure faible tandis qu'il en a fallu que 911 cc en sol fertilisé à dose massive (150 kg de P/ha et 300 kg de K/ha).

En conclusion, une production maximum de trèfle et de luzerne s'obtient sur sol fertilisé à la dose de 75 kg de P/ha et 50 kg de K/ha pourvu qu'on ne laisse pas la réserve d'eau utile atteindre un niveau inférieur à 40 p. 100 de sa valeur maximum.

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# Station de recherches Sainte-Foy, Québec

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M. HUGHES	Préposé
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## INTRODUCTION

En 1968, la décision finale de construire l'édifice devant loger la Station de Sainte-Foy a été prise. Je tiens à rendre hommage à mon prédécesseur le Dr J. C. Perrault pour son grand dévouement dans la réalisation de ce projet. Durant l'année, certains de nos chercheurs ont participé à l'enseignement aux élèves post-gradués de la Faculté d'Agriculture de l'Université Laval.

Mes remerciements sincères vont à messieurs les professeurs F. M. Gauthier, J. P. Lemay et G. J. Ouellette de l'Université Laval qui, même s'ils n'ont pas fait partie de la Direction de la Recherche en 1968, ont apporté leur collaboration empressée à la préparation de ce rapport.

S. J. Bourget  
Le directeur

## LES PLANTES

### La pomme de terre

*Nutrition aminée de Corynebacterium sepedonicum.* Quatre isolats de *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh. ont été repiqués à tous les trois ou quatre jours dans un milieu basique identique contenant 2 p.p.m. de méthionine et 30 p.p.m. d'asparagine (calculée d'après la teneur en azote). Ces repiquages ont été exécutés avec succès pendant plus de 7 mois, ce qui prouve une fois de plus, que l'organisme pathogène peut vivre sur un milieu peu diversifié en acides aminés. Des intervalles plus longs que 4 jours entre les repiquages ralentissent considérablement la reprise de l'organisme. L'essai de filtrats sur de jeunes cultures a prouvé que l'organisme perd rapidement le pouvoir de se multiplier et qu'il ne s'accumule pas de produits toxiques dans les cultures âgées.

### Résistance de la luzerne à la gelée

*Méthodes.* Les racines des plantes sont groupées dans des sacs de polyéthylène et sont soumises à une congélation à taux de refroidissement contrôlé. Après avoir atteint une température minimum choisie, on ramène les racines à 1.5° C pour une nuit. Leur pourcentage de survivance est établi 20 jours après les avoir replantées. On peut également déterminer leur seuil de résistance, i.e. la température qui permet 50 p. 100 de survie. Un programme satisfaisant d'endurcissement a été mis

au point. À l'âge de cinq semaines, les plantes sont transférées en chambre de croissance. En neuf jours, la température diurne est ramenée de 20 à 1.5° C, la durée du jour est réduite de 12 à 8 heures, et l'intensité lumineuse est diminuée des deux tiers. Pendant les 19 jours qui suivent, la température est maintenue à 1.5° C et les jours sont limités à huit heures de faible intensité lumineuse.

*Endurcissement.* Alors que des plantes non endurcies des variétés Vernal et Rambler résistent à une température de -5° C et sont toutes détruites à -8° C, les seuils de résistance de variétés Caliverde (tendre), Vernal (intermédiaire) et Rambler (rustique) sont abaissés par l'endurcissement jusqu'aux valeurs approximatives de -9, -11.5 et -13° C. L'effet de l'endurcissement n'apparaît pas avant le 18<sup>e</sup> jour du programme.

*Induction chimique de la résistance.* Le chlorure de 2-chloroéthyl triméthyl ammonium ou chlorure de chlorocholine (CCC), un retardant de croissance, augmente la résistance à la gelée de plusieurs espèces. Les plantes ont été traitées avec du CCC dès l'âge de trois semaines, à intervalles de cinq jours, jusqu'à la fin de la première semaine de l'endurcissement, par arrosage du sol. Le CCC, appliqué à diverses concentrations inférieures à 1 p. 100 à des plantes non endurcies de la variété Vernal, n'augmente pas leur taux



de survivance à une gelée de  $-11^{\circ}$  C; le CCC, appliqué aux mêmes concentrations à des plantes des variétés Caliverde (tendre) et Rambler (rustique) avant et pendant le programme d'endurcissement, ne stimule pas leur taux de survivance à une gelée de  $-11^{\circ}$  C; le CCC, appliqué à une concentration de 0.2 p. 100 à des plantes des deux mêmes variétés avant et pendant le programme d'endurcissement, n'a pas affecté leur seuil de résistance. Cependant, au cours de ces expériences, le CCC a eu des effets physiologiques caractéristiques des retardants de croissance: raccourcissement des tiges, et diminution du poids de la matière fraîche.

### Pourriture des graines de luzerne

Des essais poursuivis en serres avec *Trichoderma viride* Pers. ex Fr. et *Gliocladium roseum* (Link) Bainier ont démontré que ces champignons, lorsqu'introduits dans le sol en même temps que les graines de luzerne en diminuaient le pourcentage de germination. De plus, ces champignons, contrairement à ce qui a été avancé par d'autres chercheurs, stimulent la pathogénicité de *Rhizoctonia solani* Kühn et de *Pyrenochaeta terrestris* (Hansen) Gorenz, Walker & Larson et diminuent l'efficacité de *Rhizobium meliloti* Dangeard.

### Pathogénicité des champignons du sol envers la luzerne

*Importance du substratum.* Des essais de pathogénicité ont démontré que des

champignons phytopathogènes tels que *Fusarium oxysporum* var. *redolens* (Wr.) Gordon, *Rhizoctonia solani* Kühn, *Pythium debaryanum* Hesse et *Trichoderma viride* Pers. ex Fr. agissaient différemment sur la luzerne suivant que celle-ci croissait dans différents substrats. Il semble qu'un substratum composé de vermiculite et de perlite favorise l'attaque de la racine de luzerne par les champignons ci-haut mentionnés en comparaison des tests faits dans des sols stérilisés et non stérilisés.

### Morphologie des espèces de *Verticillium*

*Influence des facteurs environnants.* L'étude des facteurs environnants capables d'influencer la morphologie de *Verticillium* spp. a démontré que les milieux qui favorisent la croissance mycélienne comme le gélose des pommes de terre et des carottes, le font au détriment de l'uniformité des dimensions des conidies. Par contre ce milieu est le plus propice à la production de spores des espèces de *Verticillium*. La meilleure température pour la sporulation des espèces de *Verticillium* de Québec se situe à  $22^{\circ}$  C. Le milieu de croissance a un effet marqué sur la formation des structures de réserve, comme les microsclérotés, les chlamydo-spores et le mycélium noir, de sorte que les milieux riches ou qui favorisent une croissance mycélienne rapide ne sont pas bons pour la formation de structures de réserves typiques.

## LES SOLS

### Étude physicochimique des horizons indurés

Le premier type à être analysé est le fragipan. L'échantillonnage a été fait à St-Adalbert, dans le comté de L'Islet. Il est intéressant de noter que dans la couche supérieure de la caténa, série Arago, c'est à 8 pieds de profondeur seulement qu'on a décelé la présence de carbonates. Ainsi, malgré la présence d'un horizon imperméable plusieurs mois par année, le déve-

loppement du profil est considérable. On entreprend actuellement l'étude quantitative de la fraction argileuse pour déterminer les phases migrant dans le profil.

D'autre part, on a poursuivi cette année une collaboration à des études de pédogénèse avec la Station de recherches des Antilles, de l'ORSTOM, en vue d'étudier le processus de formation des minéraux argileux. On a contribué à une étude sur les sols dérivés de cendrées volcaniques en Équateur et au Nicaragua.

# FERME EXPÉRIMENTALE, LA POCATIÈRE

## Les animaux

En collaboration avec l'Institut de recherches animales à Ottawa, nous poursuivons des études concernant l'hérédité des bovins laitiers, les performances reproductrices des oies et l'importance de l'interaction génotype-milieu sur la ponte de plusieurs lignées de poules.

### Les moutons

*Influence de la photopériodicité sur la reproduction des brebis.* La possibilité de régulariser artificiellement la période d'activité sexuelle de la brebis, par la modification de l'éclairement diurne, a été étudiée à La Pocatière de 1965 à 1968. Quatre cents brebis âgées de 3 à 5 ans ont été accouplées dès le 1<sup>er</sup> juillet à des béliers Dorset Horn. La moitié de ces brebis ont été gardées à l'extérieur, tandis que l'autre moitié étaient envoyées à l'intérieur seulement de 4 heures PM à 7 heures AM et le reste du temps gardées à la noirceur à l'intérieur.

La réduction de la durée d'éclairement a permis d'avancer considérablement la période de saillie des brebis. En effet, 50 p. 100 des brebis ayant reçu seulement 8 heures de lumière par jour ont agnelé en décembre et janvier, tandis que seulement 16 p. 100 de celles gardées dans les conditions normales ont agnelé durant cette même période.

### Les oies

On a comparé les performances des races Pilgrim, Hongroise et Chinoise pendant deux ans. Au cours de la deuxième année, la production d'œufs des oies Pilgrim a augmenté comparée à celle de la première année. La race Hongroise a maintenu sa production tandis que dans le cas de la race Chinoise il y eut diminution. Nous observons également une augmentation considérable du pourcentage d'éclosion, sauf pour la race Chinoise. Les différences obtenues sont significatives et elles revêtent une importance particulière pour les producteurs d'oies.

## Les plantes

### Écologie

*Étude agro-écologique.* Cette étude a été commencée dans le comté de Rivière-du-Loup en 1968, dans le but de définir les critères qui déterminent les relations sol-végétation-climat. Ceci permettra de délimiter des zones agro-écologiques et leur potentiel agricole. Le tout sera synthétisé sous forme de carte agro-écologique à très grande échelle.

### Les céréales

*L'avoine.* L'amélioration de l'avoine a porté surtout sur la résistance à la verse. Les variétés génitrices Milford, Holmberg et Q.O. 23.5 (une sœur de Stormont) ont été utilisées pour incorporer les facteurs de résistance à la verse dans nos meilleures variétés. Le succès obtenu a varié selon les parents. La variété Milford a semblé la plus efficace si l'on en juge par le comportement de deux lignées éprouvées par l'essai de tamisage. Holmberg et Q.O. 23.5 ont amélioré la résistance à la verse mais, en général, aux dépens de la productivité.

Plus récemment, les introductions Weibull 16387 et 16511, de même que la variété américaine Orbit ont servi à de nombreux croisements afin de concentrer dans une même lignée un grand nombre de facteurs de résistance à la verse d'origine aussi disparate que possible. La variété Yamaska provenant du croisement MC 233 × Acton 2 × Shefford a été homologuée à la suite de son excellente performance.

*Le blé.* La magnifique performance de la variété de blé de printemps Opal, d'origine allemande, a marqué une étape dans les épreuves de variétés et d'espèces. Opal s'est révélée de beaucoup supérieure à la variété recommandée Selkirk au point de vue productivité. Dans les habitats favorables au blé, Opal a même produit des rendements (en livres à l'acre) comparable à ceux des meilleures variétés d'avoine et d'orge, en plus d'exhiber une résistance à la verse supérieure à celle des avoines et des orges les plus résistantes. D'autres variétés de blé de printemps, dont

Pitic 62, une variété mexicaine semi-naine et Weibull 8874 ont donné d'excellents résultats et ont déclassé la variété Selkirk.

*L'orge.* La variété d'orge de provende a continué de dominer par ses rendements élevés. La variété Conquest à paille forte a eu un comportement semblable à Parkland tandis que Paragon a semblé un peu plus productive tout en démontrant une meilleure résistance à la verse.

### Les plantes oléagineuses

*Le lin.* Après sept ans d'essai, les variétés Redwood et Norland demeurent les plus productives en graine et en huile. Leur rendement en huile a été respectivement de 980 et 928 kg/ha. Parmi les variétés hâtives, la Linott est supérieure à la Marine par 85 kg/ha. En 1968, quelques variétés non homologuées se sont avérées prometteuses au point de vue rendement et pourcentage d'huile.

*Le colza.* De 1962 à 1968, la variété Tanka s'est montrée supérieure aux autres variétés du type *B. napus*. La variété Arlo, plus précoce, a donné un rendement supérieur à l'Echo et à la Polish. Son pourcentage d'huile est également plus élevé.

### Les légumes

*Le rutabaga.* Durant sept ans, la variété Angus d'origine écossaise a donné un rendement de 10 p. 100 supérieur à la moyenne des huit autres variétés. Bien qu'elle soit comparable au point de vue rendement à la Ditmars, la variété Laurentien est toutefois préférable à cette dernière au point de vue apparence et résistance à l'éclatement des racines. Comme variété pour la table, dans un essai de trois ans, sur quatre types de sol, la variété Laurentien a donné un rendement supérieur de 12 p. 100 à la York. Depuis 3 ans un essai des dates suivantes: 18 mai, 6 et 20 juin, pour le semis des rutabagas a donné les rendements de 42.7, 32.5 et 18.1 tonnes/acre respectivement. Les rendements moyens furent de 31.5 tonnes/acre pour l'espacement de 20 pouces entre les rangs et de 30.6 tonnes/acre pour celui de 27 pouces.

*La pomme de terre.* On a poursuivi des travaux sur les maladies suivantes: (a) Dartrose, *Colletotrichum coccodes* (Wallr.) Hughes. On a pu l'isoler sur PDA après

8 ans de conservation dans des échantillons de terreau et de loam sableux ou argileux partiellement stérilisés. Ce champignon semble donc pouvoir subsister dans le sol plus longtemps qu'on ne le croyait jusqu'à ce jour; (b) Tache argentée, *Helminthosporium atrovirens* (Harz) Mason & Hughes. Les premiers examens au microscope des tissus de stolons provenant de boutures de pommes de terre, dont on a, au préalable, détaché l'éclat de semence infecté de tache argentée, ont révélé la présence d'hyphe répondant bien à la description que Schultz a déjà faite du mycélium de ce champignon; (c) Flétrissure bactérienne, *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh. L'empreinte faite au point d'attache des tiges est le meilleur critère pour diagnostiquer la flétrissure bactérienne d'une plantation de pommes de terre après 100 jours de croissance. La décontamination du couteau par trempage rapide dans Kem-Germ dilué à 5 onces par gallon a donné une récolte pratiquement saine. La désinfection des contenants en bois à l'aide de SCL 210 et SCL 310 dilués à 500 p.p.m. et de Kem-Germ a été efficace pour combattre la flétrissure bactérienne.

### Désherbage chimique des cultures

Le vernolate et la trifluraline employés en pré-semis (6 jours) et incorporés aux taux respectifs de 4.5 et 1.1 kg/ha se sont avérés les plus efficaces en détruisant 88 et 78 p. 100 des mauvaises herbes sans affecter la récolte de rutabagas depuis 5 ans. Le cycloate en pré-semis et le nitrofen en pré-levée, tous deux au taux de 4.5 kg/ha ont réprimé respectivement depuis deux ans 77 et 64 p. 100 des mauvaises herbes dans les champs de rutabagas. Pour la pomme de terre l'ordre décroissant d'efficacité durant cinq ans a été le suivant: EPTC et vernolate, prométryne et métrobromuron alors que pour les pois secs il était: trifluraline, benefin, vernolate et prométryne durant une période de trois ans. Le bromoxynil, l'EPTC et la trifluraline ont détruit respectivement 86, 84 et 70 p. 100 des mauvaises herbes dans le lin à graine. Dans le cas de la luzerne et du lotier, l'EPTC, la trifluraline et le benefin ont détruit environ 66 p. 100 des mauvaises herbes alors que le nitrofen n'en détruisait que 48 p. 100.

## Les sols

### Influence de la hauteur de la nappe phréatique

Les cinq traitements suivants ont été appliqués sur le sol de l'Anse: drainage naturel, drainage souterrain et nappe phréatique maintenue aux profondeurs de 48, 30 et 18 pouces dans le sol. Dans le cas du drainage souterrain, la hauteur de la nappe a varié de 9 à 28 pouces.

*Activité biologique.* Un test de déshydrogénase fait à l'automne indique que l'activité microbienne tend à s'accroître à mesure que la nappe phréatique s'abaisse. Ce même phénomène se reproduit chez les mites, dont la population a presque triplé pour le traitement de 48 pouces comparé à celui de 18 pouces.

*Rendements des cultures.* Les rendements du brome, du mil et de la luzerne ont été légèrement supérieurs dans les parcelles moins humides alors que le lo-

tier, l'alpiste roseau et le trèfle rouge ont bénéficié de la nappe phréatique élevée. La betterave à sucre a eu un rendement légèrement plus élevé dans les sols plus humides; par contre, l'avoine, tout comme l'orge au cours des années précédentes, a montré une corrélation positive entre le rendement et la faible humidité du sol.

### Fertilisation des sols à pomme de terre

Ce travail est fait en collaboration avec le Département des Sols de l'Université Laval. Après avoir complété des travaux sur les séries St-André et St-Pacôme, on a poursuivi une étude factorielle de trois niveaux des éléments N, P et K sur les séries Achigan, Bourget et Lanoraie. Les résultats obtenus indiquent qu'il faut entre 175 et 200 livres/acre de N sur les séries Achigan et Lanoraie et seulement 125 sur la série Bourget.

## Les abeilles

### Méthodes de production du miel

Trois groupes de 15 colonies ont été mises en production en mai 1968 selon trois techniques différentes, soit le système à deux reines, le procédé

Démarée et le contrôle d'essaimage en une seule opération ou l'essaimage artificiel. Ces méthodes ont produit 164, 133 et 120 livres de miel respectivement.

## FERME EXPÉRIMENTALE, NORMANDIN

### Les animaux

#### Les bovins

Des études sur l'hérédité des bovins laitiers sont faites en collaboration avec l'Institut de recherches animales à Ottawa et certaines Stations à travers le Canada.

*Épreuve de progéniture.* Nous avons prélevé régulièrement la semence de 6 taureaux et 14 taureaux sont gardés en attendant des données sur la lactation de leurs filles. Un taureau a complété l'épreuve de progéniture de façon satisfaisante en 1968. Sur 112 saillies artificielles effectuées, 60 p. 100 des vaches ont été fécondées à la première saillie, 23 p. 100

ont nécessité une deuxième saillie, 10 p. 100 une troisième et 7 p. 100 une quatrième.

*Composition du lait.* L'analyse de plus de 150 échantillons de lait prélevés à chaque 60 jours de la première lactation révèle une augmentation de 1.22 p. 100 de la protéine du lait entre le début et la fin de la lactation. Le taux de protéine du lait est de 2.9 p. 100 de protéine après les premiers 60 jours de la lactation, 3.3 p. 100 à 120 jours, 3.4 p. 100 à 180 jours, 3.6 p. 100 à 240 jours et 4.2 p. 100 à 300 jours.

## Les plantes

### Les céréales

*Avoine.* Quelques lignées dont Q.O. 115.1.2, Q.O. 117.5 et O.T. 716 sont supérieures à nos variétés standards tant pour le rendement que pour la qualité du grain, la résistance à la rayure des feuilles *Helminthosporium avenae* Eidam et la tache des feuilles *Septoria avenae* Frank.

*Orge.* Les meilleurs rendements ont été obtenus avec les variétés Paragon, Champlain et Galt, et la longueur de végétation de ces variétés convient à notre région.

### Les plantes fourragères

*Luzerne.* Deux années consécutives de récolte ont démontré que certaines introductions sont prometteuses si on en juge par leur rendement. Les variétés Mega et Progress manquent de rusticité et leur rendement est inférieur. Rhizoma est la plus persistante de nos variétés et fournit un bon rendement.

*Trèfle rouge.* Une nouvelle variété Hungaropoli a donné des rendements vraiment supérieurs à la première année de récolte, cependant, il reste à déterminer sa rusticité. Après deux ans de récolte, Réa est la meilleure tant pour sa densité que pour

le rendement. Alaskland et Illinois I ne sont pas adaptées à notre région.

*Mil.* Clair et Milton sont les variétés qui ont donné le meilleur rendement en foin. Certaines variétés ont démontré de bonnes qualités pour le pâturage tandis que Heidemij a été très inférieure.

### Les fruits et légumes

*Résistance au froid des framboisiers.* L'hiver 1967-68 fut plus dévastateur que la moyenne des 7 dernières années. La variété Boyne et la sélection M-541 ont subi moins de dommage que la variété témoin Newburg. Les sélections K-57-12 et K-57-23 étant beaucoup moins résistantes que la variété témoin seront rejetées.

*Le rutabaga.* La variété Laurentien a donné le rendement le plus élevé avec une racine de belle apparence. Le semis du 15 juin nous a donné un rendement de 41 p. 100 supérieur à celui du 30 juin.

*Pomme de terre.* Parmi les variétés hâtives, Irish Cobbler, F-6117 et Norland ont donné les rendements les plus forts. Des variétés tardives, Montagne Verte, Sebago et Kennebec ont donné les meilleurs rendements.

## FERME EXPÉRIMENTALE, CAPLAN

### Les plantes

#### Les plantes fourragères

*Le mil.* Après 3 années d'essai avec 7 variétés, la sélection Wisc. T-1 s'est classée bonne première avec une moyenne de 7.7 tonnes métriques de matière sèche/hectare. La nouvelle variété Bounty s'est classée deuxième pour la production d'herbage alors que les variétés Drummond et Milton ont été légèrement inférieures à cette dernière. Le mil Climax a produit 500 kg/ha de moins que la moyenne pour l'essai et a été surpassé par toutes les variétés, y compris Champ et Clair. Dans un essai d'élimination comportant 8 variétés, le mil Itasca a été constamment supérieur aux autres variétés au cours de 3 années d'observation, suivi de la nouvelle variété

Champ. Les variétés Climax, Omnia et Labelle ont produit une quantité comparable de matière sèche, surpassant le mil Drummond par quelques 400 kg/ha. Les variétés propre au pâturage, Heidemij et King, n'ont pas donné les résultats anticipés et ne semblent pas devoir remplacer les variétés propres à la fenaison pour la production de matière sèche.

*La luzerne.* Le comportement de la variété Glacier a été remarquable dans un essai d'une durée de 4 ans; elle a cependant perdu quelque peu de sa vigueur après la première année d'exploitation. La luzerne Narragansett a été très comparable à la Rhizoma durant cette période. La va-

riété Alfa a fourni un bon rendement au début de l'essai; elle n'a cependant pas démontré le même degré de persistance que les variétés mentionnées précédemment. La production d'herbage des variétés Vernal et Cayuga a été relativement faible.

*Le lotier corniculé.* Cinq variétés de lotier exploitées pour la fenaison ont été comparées durant 3 ans. À la troisième année, les variétés Viking et Empire ont produit respectivement trois et quatre fois moins de matière sèche que les sélections L-6725 et M.C.H.-64, et que le lotier Léo.

## LES NOMS COMMERCIAUX ET LES FABRICANTS DES PRODUITS MENTIONNÉS DANS LE TEXTE

### Nom commercial

Benefin  
Bromoxynil  
CCC  
Cycloate  
EPTC  
Kem-Germ  
Méto-bromuron  
Nitrofen  
Prométryne  
SCL 210, 310  
Trifluraline  
Vernolate

### Fabricant

Elanco Products Division, Eli Lilly and Co. (Canada) Ltd.  
Amchem Products Inc.  
Cyanamid of Canada Ltd.  
Stauffer Chemical Co.  
Stauffer Chemical Co.  
Kem-San Products Ltd.  
Ciba Company Ltd.  
Rohm & Hass Co. (Canada) Ltd.  
Fisons (Canada) Ltd.  
Standard Chemical Ltd.  
Elanco Products Division, Eli Lilly and Co. (Canada) Ltd.  
Stauffer Chemical Co.

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## INTRODUCTION

Ce rapport sommaire ne traite que des principaux résultats obtenus de travaux à long ou à court terme poursuivis en 1968. On trouvera des exposés plus détaillés de certains de ces travaux dans les publications mentionnées à la fin de ce rapport;

on peut obtenir des exemplaires de ces publications en adressant sa demande directement aux auteurs ou à la Station.

A. A. Beaulieu  
Le directeur

## SOLS ET NUTRITION DES PLANTES

### Fertilisants

*Légumes sur sol organique vierge.* La pomme de terre est le légume qui répond le mieux au chaulage et à la fertilisation d'un sol organique vierge, acide et nouvellement défriché. La production d'oignons et de carottes est presque nulle dans un tel sol la première année. Les années suivantes, les oignons et surtout les carottes réagissent mieux que la pomme de terre au chaulage et à l'application de fertilisants. Le comportement des différentes récoltes dépendrait plus des changements physiques que chimiques dans le sol.

*La réaction des légumes aux fertilisants.* Des travaux poursuivis depuis 1965 démontrent que dans un sol organique bien décomposé, les légumes les plus susceptibles d'en épuiser les éléments nutritifs se classifient comme suit: carotte > céleri > laitue > oignon. Le premier élément trouvé déficitaire fut le potassium, tandis que la laitue fut la première récolte à démontrer une déficience des trois éléments nutritifs majeurs.

### Carotte

*Effets de la température du sol et du cuivre.* En serre, une élévation de la température du sol a augmenté considérablement

le rendement de la carotte ainsi que l'absorption du cuivre déjà présent dans un sol organique, vierge et acide. Les concentrations de cuivre dans les feuilles de carottes, à la température du sol de 8°, 12°, 16° et 20° C, étaient de 6.6, 6.6, 11.6 et 23 p.p.m. respectivement; après une application de cuivre sous forme de  $\text{CuSO}_4$  au taux de 20 p.p.m. de sol, ces concentrations étaient de 6.6, 15.0, 22.5 et 23.0 p.p.m.

*Rendement et pH du sol.* En serre, un sol organique recevant du carbonate de sodium au taux de 4, 8, 12 et 16 gr/kg de sol a donné des rendements respectifs de 9.8, 79.1, 166.8 et 189.6 gr de carottes. Cette augmentation considérable des rendements correspondait à des variations respectives du pH (0.01 M  $\text{CaCl}_2$ ) de 3.73, 3.89, 4.06 et 4.35.

Lorsque le  $\text{Ca(OH)}_2$  était employé comme équivalent du  $\text{CaCO}_3$ , les carottes n'ont pas survécu à un taux de chaulage de moins de 4 gr/kg de sol à moins d'y ajouter un fertilisant complet. D'autre part, avec ou sans fertilisants, les rendements n'ont pas suivi une projection linéaire proportionnelle au pH du sol. Cela indiquerait que l'augmentation du pH du sol occasionne des variations chez les éléments nutritifs assimilables.

## ENTOMOLOGIE

### Bio-écologie

*Mouche de la pomme.* Des balles ou des pommes artificielles en polyéthylène

recouvertes d'une substance gluante (Stickem) et suspendues aux branches des arbres dans un verger se sont avérées très



efficaces pour la capture des adultes de la mouche de la pomme, *Rhagoletis pomonella* (Walsh). L'emploi de ces pièges a permis de déterminer la période d'activité des mouches et de suivre le mouvement de leurs populations au cours de l'été.

*Chalcis de la pomme.* L'apparition des adultes du chalcis de la pomme, *Torymus varians* (Wlk.), dans des cages d'émergence placées sous des pommiers s'est échelonnée du 13 juin au 16 juillet, soit sur une période d'un peu plus d'un mois.

*Cérèse buffle.* L'éclosion des œufs de la cérèse buffle, *Stictocephala bubalus* (F.), a débuté le 28 mai, a atteint son maximum d'intensité du 3 au 10 juin et s'est terminée le 17 juin. Le développement postembryonnaire a nécessité en moyenne 43 jours et les adultes ont fait leur apparition principalement du 13 au 25 juillet. La période d'oviposition a débuté le 3 août pour se terminer le 12 septembre.

*Mouche de l'oignon.* Des expériences de plein champ ont démontré que la densité des semis d'oignon peut affecter sensiblement la survie des pupes de *Hylemya antiqua* (Meigen). Ainsi, en augmentant la densité de 5 à 20 plants par pied de rang, les pupes parasitées ont augmenté dans une proportion de 9.3 à 21.8 p. 100, celles atteintes de maladie, de 3.9 à 12.6 p. 100, tandis que le taux de pupes normales a diminué de 86.8 à 65.6 p. 100.

*Pyrale du maïs.* Les recherches sur la dynamique des populations naturelles d'*Ostrinia nubilalis* (Hübner) ont révélé en 1968 une augmentation de 80 p. 100 de la population par rapport à 1967. Le taux total de mortalité à la fin de la génération 1967-68 a été de 97.7 p. 100, ce qui laisse prévoir une diminution de population, en 1969, puisque le taux de mortalité susceptible de maintenir la population à un niveau constant s'établit à 98.6 p. 100. Les réductions de population les plus importantes ont été enregistrées chez les larves du printemps (stade compris entre l'hibernation et la nymphose) où la mortalité a atteint 24 p. 100 et chez les adultes qui ont émigré de la parcelle dans une proportion de 35 p. 100.

## Aphidologie

*Nutrition.* Dans des tests à choix multiples, le puceron du pois, *Acyrtosiphon pisum* (Harr.), et le puceron de la pomme de terre, *Macrosiphum euphorbiae* (Thos.), ont pu localiser les concentrations optimales d'homosérine DL associées à des teneurs minimales en ions sodium et éviter l'homosérine L associé à des teneurs élevées d'ions sodium. Le puceron du haricot, *Aphis fabae* Scop., a démontré un pouvoir de sélection moindre tandis que le puceron vert du pêcher, *Myzus persicae* (Sulz.), est demeuré tout à fait indifférent aux formes L ou DL de l'homosérine de même qu'à de fortes concentrations en ions potassium et sodium.

*Comportement.* Le piégeage des pucerons dans la nature à l'aide de plats-filtres réfléchissant des longueurs d'ondes bien définies a démontré que les radiations bleues monochromatiques ou masquées dans des teintes jaunes dans une proportion de plus de 10 p. 100 repoussaient les pucerons.

## Lutte chimique<sup>1</sup>

*Mouche de la pomme.* Les produits bromophos, carbaryl, Cidial, diméthoate formothion, carbofuran, Supracide, Imidan et phosalone, mis à l'essai contre la mouche de la pomme, *Rhagoletis pomonella* (Walsh), ont fourni une récolte de 95 à 100 p. 100 de pommes saines. L'excellence de la répression serait due en partie à la très faible densité de la population initiale du ravageur dans les parcelles expérimentales.

*Tordeuse pâle du pommier.* Les produits Cidial, carbofuran et Gardona, appliqués le 1<sup>er</sup> mai sur de jeunes pommiers Cortland, ont réduit les populations larvaires de *Pseudexentera mali* Free. dans une proportion de 94 à 96 p. 100. Par ailleurs avec C-8353, malathion et phosalone, les taux de répression ont été respectivement de 88, 73 et 60 p. 100.

*Tétranyque rouge du pommier.* Parmi les traitements préventifs appliqués avant la floraison contre *Panonychus ulmi* (Koch), l'endosulfan-huile supérieure 70

<sup>1</sup> Les noms des fabricants des produits dont la marque de commerce est mentionnée dans ce rapport sont colligés à la fin de ce rapport.

sec. et le Lambrol se sont avérés plus efficaces que l'éthion-huile supérieure 70 sec.; et parmi les traitements appliqués à deux reprises après la floraison, le déméton a été plus efficace que le Supracide ou le formothion. Des traitements curatifs, effectués en juillet sur pommiers McIntosh, ont démontré que l'oxythioquinox et le chlorfenamidine étaient plus efficaces que le dicofol ou le phosalone.

*Cochenille virgule du pommier.* Parmi les traitements appliqués avant la floraison contre *Lepidosaphes ulmi* (L.), l'éthion-huile supérieure 70 sec. s'est montré plus efficace que le Lambrol ou l'endosulfan-huile supérieure 70 sec.; après la floraison, le Supracide et le formothion ont été plus efficaces que le déméton. En fait, la Supracide, en deux applications à 5 jours d'intervalle, a donné les meilleurs résultats.

*Phytopte du pommier.* Parmi les traitements préventifs appliqués avant la floraison contre le phytopte du pommier, *Aculus schlechtendali* Nal., le Lambrol et l'endosulfan-huile supérieure 70 sec. ont été plus efficaces que l'éthion-huile supérieure 70 sec. Après la floraison, le déméton et le formothion ont été plus efficaces que le Supracide. Dans des traitements curatifs effectués en juillet, le chlorfenamidine s'est avéré supérieur au carbaryl et au dicofol, deux produits déjà recommandés pour la répression de ce phytopte.

*Taupins.* Les traitements insecticides, effectués en sol organique contre les larves des Elatéridés infestant les pommes de terre, ont été appliqués en octobre 1967 et leur efficacité, évaluée en novembre 1968. Les produits ont été incorporés aux 6 premiers pouces de sol à raison de 5 livres de matière active à l'acre. Les in-

secticides aldrine, dieldrine et bromophos, sous forme d'émulsion ou de poudre mouillable, ainsi que Dyfonate et SD-9098, sous forme granulée, se sont avérés les plus efficaces, assurant de 90 à 96 p. 100 de tubercules vendables.

*Mouche de l'oignon.* D'après les résultats obtenus en 1968, les pertes de plants d'oignon, dans des parcelles non traitées en sol organique, peuvent s'élever jusqu'à 57 p. 100 dont 10 p. 100 seulement sont attribuables à la mouche de l'oignon, *Hylemya antiqua* (Meigen). Dans les parcelles traitées au diazinon ou au Dyfonate, ces pertes sont de l'ordre de 3.7 p. 100 dont 1.9 p. 100, causées par la mouche de l'oignon. Il s'ensuit que les pertes résultant d'une mauvaise germination, des maladies et de causes physiques sont définitivement les plus importantes et que le pourcentage d'oignons comestibles à la récolte ne peut pas être considéré comme le seul critère d'efficacité des traitements insecticides.

*Pyrale du maïs.* Les essais de lutte chimique de plein champ contre *Ostrinia nubilalis* (Hübner) sur une variété précoce et une variété tardive de maïs sucré ont révélé que l'infestation de la pyrale s'est maintenue très élevée dans la région de l'Acadie, que la plupart des traitements ont sensiblement réduit la population des larves dans les plants. Tous les critères biologiques mis à l'essai pour le déclenchement de la première application insecticide ont donné de très bons résultats chez la variété tardive. D'autres essais ont démontré, que le carbaryl a été inférieur au DDT chez les deux variétés et que, chez la variété précoce, l'augmentation d'épis sains a été proportionnelle au nombre d'applications faites au DDT.

## PHYTOPATHOLOGIE

### Écologie

*La racine noire des betteraves.* Chez les betteraves potagères et sucrières, la température et le coefficient de saturation en eau du sol ont une influence considérable sur la durée et le pourcentage de germination, le degré de sévérité de la maladie et la valeur protectrice des traitements de semence. La germination lente favorise la susceptibilité du semis au *Rhizoctonia*

*solani* Kühn et à l'*Aphanomyces cochlioides* Drechsl., deux parasites responsables de la pourriture du semis. Une attaque prolongée en 1968 abaissa considérablement le taux de germination qui ne dépassa pas 40.2 p. 100 dans le sol inoculé avec *R. solani* et 32.4 p. 100 avec *A. cochlioides* chez quatre variétés potagères non traitées. Chez cinq variétés sucrières en présence des mêmes agents pathogènes, le

taux de germination fut de 49.0 p. 100 et 50.3 p. 100 respectivement. Ces conditions microclimatiques défavorables ont prolongé la germination et augmenté la susceptibilité des plantules au stade de préémergence. De plus, l'action protectrice des fongicides fut amoindrie d'une façon telle que, dans la majorité des cas, il n'y avait pas de différences significatives entre les semis traités et ceux non traités. Le Dexon semble avoir perdu plus d'efficacité que le Polyrame et particulièrement chez les betteraves sucrières.

### Lutte chimique

*Effets du DMSO.* L'incubation du diméthyl sulfoxyde (DMSO) dans un sol minéral et un sol organique a produit les effets suivants: augmentation de l'acidité dans les deux types de sol et des quantités de soufre sous forme de sulfates solubles dans l'acétate d'ammoniaque;

diminution plus marquée de l'azote sous forme de nitrates en sol minéral qu'en sol organique et de la quantité d'azote sous forme ammoniacale en sol organique à 32.2° C, mais aucune influence en sol minéral.

L'application de fortes doses de DMSO (966 mg/1740 gr de sol minéral et de 458 mg/825 gr de sol organique) augmenta la croissance des plants de fèves, mais diminua la quantité d'azote dans les parties aériennes des plants en empêchant la formation de nodules sur les racines. Les quantités de soufre et de manganèse dans les plants augmentèrent proportionnellement aux doses de DMSO.

À cause de la dégradation du DMSO dans le sol et de ses effets secondaires sur les plantes, l'emploi de ce produit comme herbicide ou véhiculant de pesticides dans le sol est discutable surtout dans les sols acides.

## AMÉLIORATION DES PLANTES

### Pommier

*Nouvelle technique pour la multiplication du Malus robusta 5.* On utilise des treillis métalliques de 5 mailles au pouce et de 2 pieds de largeur étendus sur des souches de plants-mères ou sur de jeunes pommiers couchés sur le sol. À mesure que les jeunes pousses émergent à travers le treillis, elles grossissent en diamètre et finissent par s'étrangler à leur base dans le sol ajouté par dessus le treillis. Comparés à la multiplication conventionnelle de pommiers en cépée, cette méthode favorise définitivement l'enracinement et aide au sevrage des jeunes plants de *M. robusta 5*.

*Essai de lignées de pommiers résistantes à la tavelure.* Depuis la plantation en 1964, on n'a observé aucun symptôme d'infection par la tavelure sur les 24 lignées de pommiers résistantes et greffées sur *Malus robusta 5*, alors que la variété McIntosh témoin en est gravement atteinte.

### Chou

*Résistance à la hernie des crucifères.* Les lignées 8-41 et 5-38 à choux verts et la

lignée 2-11 à choux rouges sont les plus résistantes des sélections faites en 1968 contre la race 6A de l'agent pathogène de la hernie, *Plasmodiophora brassicae* Wor.

*Hétérose.* Cinq lignées modérément consanguines de chou furent croisées dans toutes les combinaisons possibles et on observa une hétérose favorable dans les hybrides à la F<sub>1</sub> de (B.H. × V5). Ces hybrides à la F<sub>1</sub> parvinrent à maturité 10 jours plus tôt que leurs lignées ascendantes et donnèrent des rendements 55 p. 100 supérieures à ceux de leurs parents.

*Transmission des caractères quantitatifs.* Les analyses des croisements diallèles 5 × 5 ont révélé que la transmission des caractères additifs du chou se fait surtout sentir sur la longueur du trognon et sur le nombre de jours requis du semis à la maturité. On observa des phénomènes d'additivité et de dominance de même importance quant aux diamètres polaire et équatorial des pommes de chou. La dominance favorisa grandement la variation génétique des rendements tandis que le nombre de feuilles enveloppées a varié selon l'environnement.

## Régulateurs de croissance

*Sur pommiers.* Le composé Ethrel, appliqué à 200 et 400 p.p.m., sur des pommiers en pleine floraison des variétés Duchesse, Jaune transparente, Melba et McIntosh, ne s'est pas montré efficace comme «éclaircisseur» de fruits; appliqué à la mi-octobre sur la variété Spy, à raison de 1,000 p.p.m., il n'a pas hâté la tombée des fruits.

Les applications de Alar-85 ont, à l'encontre des deux années précédentes, réduit d'une façon appréciable la grosseur des pommes, particulièrement chez la variété Melba.

*Sur fraisiers.* Le composé Ethrel, appliqué à 200 et 300 p.p.m., favorisa d'une façon évidente l'abscission des fleurs et la formation des coulants chez la variété Redcoat; à 100 p.p.m., son effet fut moins prononcé.

*Sur framboisiers.* Le composé Alar-85, appliqué aux plants de framboisiers de première année, a réduit la longueur totale des tiges et celle des entre-noeuds chez les variétés Latham et Comet. Par contre, le diamètre des tiges et le nombre de branches par tige n'ont pas été affectés. De plus, le dessèchement (dieback) des tiges par les froids de l'hiver a été réduit de moitié par l'application d'un traitement

de Alar-85 et ce, tant chez la Latham, une variété résistante au froid, que chez la Comet, une variété susceptible. Ce traitement a augmenté le rendement de primeurs l'année suivante, mais a réduit le rendement total, surtout chez la variété Latham.

*Sur tomates.* Le composé Ethrel, appliqué à la fin d'août, à 1,000 et 4,000 p.p.m., hâta grandement la maturité des tomates en plein champs.

L'usage d'un paillis de plastique clair a augmenté d'environ 25 p. 100 les rendements, la production de primeurs et la grosseur des fruits chez la variété de tomate New Yorker.

Le produit Alar-85 a aussi augmenté les rendements durant la période où la récolte était à son maximum. Par contre, il retarda le mûrissement des fruits tandis que le rendement total, avec ou sans paillis de plastique, ne fut pas significativement plus élevé que chez les témoins respectifs.

Le Cycocel (CCC) accéléra légèrement le mûrissement mais il réduisit aussi le rendement de 15 à 20 p. 100 sans toutefois affecter la grosseur des fruits. Les plants traités au CCC furent nanisés considérablement de sorte que l'on pourrait augmenter d'autant leur nombre à l'acre.

## LES NOMS COMMERCIAUX ET LES FABRICANTS DES PRODUITS MENTIONNÉS DANS LE TEXTE

<i>Nom commercial</i>	<i>Fabricant</i>
Alar-85	UniRoyal Chemical Company
C-8353	Ciba Company Limited
Cidial	Montecatini Edison, S.p.A., Italy
Cycocel	Cyanamid of Canada
Dexon	Chemagro Corporation, Kansas City, Missouri
Dyfonate	Stauffer Chemical Company
Ethrel	Amchem Products, Qué.
Gardona	Shell Chemical Company, Agricultural Chemical Division
Imidan	Stauffer Chemical Company
Lambrol	Montecatini Edison, S.p.A., Italy
Polyrame	Niagara Chemical Division Food Machinery and Chemical Corporation, Middleport, New York
Plictran	Dow Chemical of Canada Limited
SD-9098	Shell Chemical Company, Agricultural Chemical Division
Supracide	Fisons (Canada) Limited

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# Research Station Delhi, Ontario

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## INTRODUCTION

This report presents the main research findings at the Station in 1968. Our main objective is to improve the production of tobacco and to meet the quality requirements of the manufacturers.

Achievements were made in several fields of investigation, but the most significant was the introduction of a new variety, Delhi 34, which is expected to replace over 50% of the regular varieties in 1969. This variety is more tolerant of black root rot than any other known flue-cured tobacco variety, and it produces a higher yield and has better quality than most licensed varieties in Canada. Another

significant finding was that gibberellic acid applied at the time of topping lowered the final level of reducing sugars in the leaves.

The new closely controlled physical laboratory provides suitable facilities to study in greater depth the physical and smoking characteristics of tobacco by testing samples collected from various field treatments. This program is being undertaken to improve certain quality factors desired by the industry.

L. S. Vickery  
Director

## SOIL SCIENCE

### Fertilization

*Potassium.* In a 3-year study, applications of fertilizer K, at 60 to 300 lb/acre in increments of 60 lb, increased the K and decreased the Ca in the cured leaves of flue-cured tobacco. Applied K had a beneficial effect on time of burn. Time of burn tended to be positively correlated with contents of Ca, Cl, and alkalinity of ash, but negatively correlated with K levels and ratios of K/Ca, K/Cl, K/N + Cl, and K/Ca + Cl. Applied K had no effect on levels of Mg, total ash, total N, total alkaloids, reducing sugars, petroleum ether extractives, and the indices of shatter resistance, filling value, grade, and maturity. Yield was not increased by increments of K, but the highest rate of K tended to depress yield and crop index.

*Manganese.* In a greenhouse experiment, with a soil of pH 6.75 from a field where oats had shown severe gray speck, S applied at 1,000 lb/acre raised the level of Mn in oats and tobacco to the same level as was obtained with applications of 60 lb MnSO<sub>4</sub>/acre. Applications of S plus MnSO<sub>4</sub> resulted in a greater uptake of Mn than applications of S or MnSO<sub>4</sub> alone.

The S treatment decreased the pH of the soil to 6.2 whereas the MnSO<sub>4</sub> had little effect on soil pH.

*Nitrogen.* Decreasing the proportion of NO<sub>3</sub><sup>-</sup> nitrogen in a complete fertilizer while increasing the proportion of NH<sub>4</sub><sup>+</sup> nitrogen from 0 to 100% increased the yield, quality, and dollar returns of flue-cured tobacco over a 4-year period. Increasing the rate of applied N from 20 to 36 lb/acre increased the yield and dollar returns, but the highest quality was obtained with 28 lb of N/acre.

### Nutrition

*Minor element survey.* Analyses of soil and tobacco samples taken at 57 locations on 23 flue-cured tobacco farms throughout the tobacco-growing areas of Ontario showed that the Mn in the tobacco leaves was correlated with both exchangeable and easily reducible Mn in the soil. Fe extracted from the soil with EDTA was correlated with the Fe in the tobacco leaves, but there was not a significant correlation between Cu and Zn extracted from the soil and the levels of these elements in the leaves. The mode for Cu in the tobacco leaves was 7 to 10 ppm, Fe 600 to



800 ppm, Mn 105 to 115 ppm, and Zn 20 to 50 ppm.

*Plant tissue analysis.* Mineral constituents, determined as sand-free ash, of samples taken from the 8th and 10th leaves of flue-cured tobacco decreased from 7.5 to 7.3% in the week following

topping, but increased to 8.5% by the time of harvest. The level of sand-free ash in cured leaves harvested on the same date was 11.7%. The apparent increase in minerals was due to the loss of carbon dioxide and other volatile constituents during curing.

## PLANT SCIENCE

### Maturity Studies

Coefficients of partial correlation were obtained among physical characteristics, and between physical and chemical characteristics, in cured tobacco harvested at various stages of maturity. Shatter resistance, grade index, and rag equilibrium moisture were positively related, as were lamina weight and time of burn, and filling value and total chlorophyll. Shatter resistance, grade index, and rag equilibrium moisture were positively related to total sugars, and negatively to total volatile bases, alkalinity of ash, Cl, Mg, Ca, and sand-free ash. In comparison, total chlorophyll and filling value were, in general, reversibly related to the chemical factors. Lamina weight and time of burn were positively related to the nitrogenous constituents, and negatively related to K.

Levels of phenolics in green and cured tobacco harvested at various stages of maturity were related to chlorophyll, lamina weight, stalk position, grade index, and visual lightness. Levels of chlorogenic acids in green and cured leaves varied from 0.1 to 11.9%, and increased 33 to 500% during curing. Chlorogenic acids increased with advance in maturity and

elevation in stalk position, and levels were positively related to grade index. Visual lightness was poorly related to level of chlorogenic acids. Cured leaves contained less than 0.05% caffeic acid; none was detected in uncured leaves. Levels of scopoletin and a glucoside of scopoletin were higher in cured than in green leaves, but always less than 0.03%. Levels of caffeic acid and scopoletin in cured leaves were directly related to time of yellowing, which increased with chlorophyll and lamina weight; levels of scopoletin in green leaves increased with advance in maturity and elevation in stalk position.

### Sucker Inhibitors

Most chemicals tested to reduce sucker growth on tobacco were less effective in 1968 than in previous years due to excessive growth 2 to 3 weeks after the plants were topped. The fatty alcohols continued to produce results comparable with the other chemicals, with slight improvement in quality. The 1968 results on chemical sucker controls showed that a second application within 10 days of the first may be required in some seasons to prevent the growth of second suckers.

## PLANT PHYSIOLOGY

### Chemical Aspects of Plant Growth

*Gibberellic acid.* Gibberellic acid increased specific and total  $\alpha$ -amylase activities and reduced the starch present in the leaf, thereby lowering the level of reducing sugars in cured leaves. The response of increased  $\alpha$ -amylase activity to gibberellic acid treatment was maintained for a period greater than 4 weeks after application of the growth regulator. Hydrolysis of starch during curing contributed very substantially to the final level of reducing sugars.

Reducing sugar level in the cured leaf is one of the criteria for quality evaluation, and the use of gibberellic acid may be adapted to maintain reducing sugars within an acceptable range.

*Removal of inflorescence.* Topping the tobacco plant resulted in increased alkaloid accumulation in the leaf. The rate of accumulation was lowered when the tops were removed a week before and 2 weeks after three to five flowers were fully open, but during the intervening period alkaloid accumulation was at its maximum.

Topping had little effect on starch accumulation in the leaf. Throughout growth, the starch content of the leaf tissue increased to a maximum at leaf maturity and remained at this level until harvest. At any one time, starch content was highest in leaves that had attained maximum expansion.

*Plant development.* Peat pots lowered yields of cured tobacco mainly because the plants matured earlier and had fewer leaves per plant than seedbed plants. This effect was more evident as the peat pot size increased from 4.5 to 7.5 cm. The advantages of using peat pots to maintain tobacco seedlings for replanting depend on seasonal variations.

## GENETICS AND PLANT BREEDING

### Varieties

*Delhi 34.* A new flue-cured tobacco variety, Delhi 34, developed in the breeding program from a cross of Hicks Broadleaf and Virginia 21, was licensed for commercial production in 1968. It has the highest tolerance to black root rot of all the flue-cured varieties grown in Canada. Yield and quality are superior to previously licensed varieties, and over a 4-year testing period crop returns have shown an increase of \$180/acre. Chemically, Delhi 34 contains a smaller amount of petroleum ether extractives than other commercial varieties, but is similar to them in total alkaloids and reducing sugars. It exhibits a relatively high filling value and has leaf characteristics of color, body, and texture that have been rated favorably by buying companies. Although Delhi 34 flowers 2-3 days later than the standard variety Hicks Broadleaf, it produces one more leaf on a much taller plant resulting in wider spaced leaves, which should facilitate hand or machine harvesting.

*Virginia 115.* A new later-flowering variety of flue-cured tobacco was licensed as a result of 3 years of intensive testing. It is a compact, short-stalked plant, and because it has two to three more leaves than the standard Hicks Broadleaf, it gives a much higher yield. It produces less sucker growth than Hicks Broadleaf, owing to its late flowering habit. Sand leaves are often primed before topping. It is moderately tolerant to weather fleck and black root rot. Chemically, Virginia 115 is distinctly lower in total alkaloids and higher in reducing sugars than all other licensed varieties, but quality ratings as measured by color, body, and texture are above average. It produces a heavier-bodied tobacco than Delhi 34, but is slightly lower

in filling value. Leaf tobacco buying companies have rated this variety as superior to the commercially acceptable variety Hicks Broadleaf. However, under certain environmental conditions, leaves in the upper-mid-stalk position lack uniformity of color.

### Mutations

*Progressive veinbanding.* A new mutation for chlorophyll deficiency was found in the flue-cured tobacco variety Hicks Broadleaf and was called "progressive veinbanding." This mutation cannot be recognized at the cotyledon stage, but the first true leaves of the mutant develop chlorophyll-deficient areas along their margins. In the larger seedling leaves the deficient areas are irregularly distributed over the whole surface. In a fully expanded leaf the whole lamina may become chlorotic. Narrow strips along the veins remain green, clearly exhibiting the reticulate venations of the leaves. The mutant follows monogenic inheritance of a single recessive gene upon which the normal allele exhibits complete dominance. There was a definite association of the mutant type with the M-chromosome of the *sylvestris* genome in tests against the monosomic series.

### Inheritance of Quantitative Characters

*Mammoth character.* The effects of the mammoth gene, which causes a short-day photoperiodic response in a mutant, were studied in the cross between Mammoth Delcrest, a short-day mutation of the flue-cured tobacco variety Delcrest, and Praecox, a day-neutral pipe tobacco. The data showed monofactorial segregation of day-neutral against short-day plants, the latter being recessive. Considerable amount

of positive heterosis was observed for leaf width. In the inheritance of days to flower, in addition to the pair of alleles determining the short-day response, one to two gene groups are indicated, operating probably in an additive way. Two and three gene

groups are indicated for leaf width and leaf length, respectively. Parameters describing additive gene effects were important for all the characters tested, but none of the parameters for dominance and digenic epistatic effects were significant.

## PLANT PATHOLOGY

### Black Root Rot

*Fungal virulence studies.* Virulence studies of an Ontario isolate of *Thielaviopsis basicola* (Berk & Br.) Ferr. during an 8-month storage period showed that pathogenicity was most severe when the fungus was maintained on rose bengal medium compared to P.D.A. (potato-dextrose agar) under paraffin; virulence was rated on the basis of root disease symptoms, fresh weight of roots, and total dry weight of seedlings of the susceptible White Mammoth variety. Seedlings were grown for 6 weeks in a silica-perlite mixture fed by Hoaglands nutrient media and inoculated at the rate of 100,000 endoconidia per plant. Virulence was also affected by the media used to propagate the fungal isolate from the storage media. The endoconidia propagated on P.D.A. were much less virulent than those produced on carrot or potato slices.

*Control.* The necrotic action of *T. basicola* on leaves of the tolerant tobacco varieties Hicks Broadleaf, Delcrest 66, and Yellow Gold was similar in severity and fell in the range between that of the immune and susceptible varieties. The severity of the necrotic action increased as the temperature increased from 20 to 30 C.

For the biological assessment of black root rot in the soil under greenhouse conditions, seedlings of cowpea, *Vigna sinensis* (L.) Endl., raised in sandy soil inoculated with *T. basicola* at 0, 1,000, 5,000, 25,000, and 100,000 endoconidia per gram soil were a better indicator for the level of soil inoculum than those of bean, sweet pea, or portulaca.

Black craft paper coated with clear plastic placed on the row after planting induced a significant reduction of black root rot infection in a highly infested field. In the same field, benomyl (DuPont

1991) rototilled in the row at 2.8 lb active/acre checked infection considerably. In culture, 1 ppm of benomyl was fungistatic to *T. basicola*, and 10 ppm was fungicidal. Significant reduction of black root rot infection in the field was obtained by fumigation with Vorlex or Vorlex 201 (Morton Chemical Company) or chloropicrin at 15, 12, or 3 gal/acre in the row respectively. Highly significant reduction was due to chloropicrin at 6 and 9 gal/acre.

In the greenhouse, fumigation with dazomet at 2 lb/100 ft<sup>2</sup>, Vorlex, Vorlex 201, or chloropicrin at 60 gal/acre reduced black root rot infection and weed population. Soil drenching with allyl alcohol at 3 gal/1,000 ft<sup>2</sup> had a similar effect. None of these chemicals was as effective as steaming, which eradicated black root rot.

### Pole Rot

*Cultural studies.* The organism that causes the common fungal pole rot during curing was isolated and identified as *Rhizopus arrhizus* Fischer. The combined effect of temperature and humidity on the growth and sporulation of the fungus was studied. The fungus grew best in a saturated atmosphere at a temperature of 30–35 C; sporulation was best at the same temperature range but at a relative humidity around 75%.

*Control.* Dipping the butt ends, up to 6 inches, of harvested tobacco leaves tied to laths, in a suspension of 2 lb of dichloran in 46 gal of water was more effective in preventing pole rot during curing than spraying the leaves in the field or on the laths. In culture, dichloran at concentrations of 25 to 1,000 ppm gradually reduced the growth of *R. arrhizus*, whereas concentrations of 1,000 to 5,000 ppm were fungistatic.

# ENTOMOLOGY

## Cutworms

By means of light traps, 24 species of cutworms were found to be present in the tobacco-growing area during the growing seasons of 1967 and 1968. Five species were found to feed on untreated tobacco under natural conditions, but only the dark-sided cutworm, *Euxoa messoria* (Harris), is of economic importance to tobacco at the present time.

*Estimated tobacco crop loss.* To assess the economic importance of the dark-sided cutworm, tobacco crop losses due to the pest were estimated in 1967 and 1968. The severity of damage to tobacco plants depended on the stage of development of the larvae as well as on the population density in the field. A low population level was capable of destroying extensive plantings of this crop. Population dynamic studies showed that a mean population of less than two and a half cutworms per five-plant sample (covering 35 ft<sup>2</sup>) was sufficient to destroy a field of young tobacco. The yield was much

lower in the unsprayed plots than in the plots sprayed with DDT at 4 lb/acre. From the 2-year data, it was estimated that the dark-sided cutworm caused an average loss of 350 lb/acre, or 21.5% of marketable tobacco, at endemic population levels during 1967 and 1968. The results also showed that the cutworm reduces the value of the tobacco crop in two ways: (i) it reduces the yield by destroying or feeding on the plants directly, and (ii) by affecting the uniformity of the plants it indirectly makes the crop much lower in quality and more difficult to process.

*Virus control of cutworm.* In field tests, nuclear polyhedrosis virus gave good control of the dark-sided cutworm. The virus was sprayed on the green rye at nonvirus, low, medium, and high doses. Results of analyses of variance showed no significant differences between nonvirus and low, or between medium and high doses, but showed significance at the 1% level between nonvirus and medium, and between low and high doses.

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



## INTRODUCTION

This report summarizes the principal findings in 1968. Detailed reports of completed research will be found in journals or reports listed under publications. Reprints are available from the authors.

In a continuance of the policy of extending the efforts of the Station to all agricultural types in southwestern Ontario, a test site was established in Lambton County where an important regional problem persists on Brookston clay.

Some adjustment in entomological programs was effected to cope with new

problems posed by the alfalfa weevil and the cereal leaf beetle.

The weed science program was expanded to strengthen scientific support for the application of herbicides to the numerous crops in southwestern Ontario.

A new laboratory-office building is being constructed and will be completed in 1969.

L. W. Koch  
Director

## FIELD CROPS

### Alfalfa

*Insects.* The alfalfa weevil reached epidemic proportions in Essex County. Our studies showed that this species lays eggs in the fall as well as in the spring in this county.

### Burley Tobacco

*Harvesting and curing.* The highest yields of primed Burley tobacco leaf, 3,100 and 3,400 lb/acre, were obtained when the mean vapor-pressure deficit of the curing atmosphere was maintained at 0.25 and 0.27 inches of mercury in the last two curing seasons. These yields exceeded those of comparably cured stalk-cut Burley tobacco by about 30%. Lower mean vapor-pressure deficit levels than those above, or the occurrence of humidity above 84% for at least 24 hr during curing, tended to depress both the yield and quality of primed Burley tobacco leaf.

### Corn

*Breeding.* As a result of Ontario Corn Tests, the Ontario Corn Committee in 1968 recommended that four corn hybrids (three single crosses and one three-way cross) developed at Harrow be declared eligible for license and the Recommended List. All four hybrids have exhibited good

resistance to stalk rot and moderate tolerance to the European corn borer.

*Corn leaf aphid.* When moderate to severe infestations of aphids developed in the plant whorl before tasseling, there was a substantial decrease in yield when rainfall was low. Loss of yield for similarly infested plants was greatly reduced when the plants were irrigated until tasseling time. There was a further, but smaller, decrease in yield loss when plants were irrigated all season. The degree of aphid injury appeared to be closely correlated with the amount of water stress.

*Kernel red streak.* There was less kernel red streak in 1968 in the area than in any year since 1964. This is its first decline since it became widespread in 1964. Typical kernel red streak was found recently when seeds of inbreds grown at Harrow in 1962 were closely examined. Thus its widespread occurrence in 1964 and later could be ascribed to "epidemics" of mites, but this occurrence would not necessarily involve the sudden very wide dispersal of mites that was thought to have occurred in only one season. In tests of inheritance of resistance, some resistant inbreds produced resistant progeny when crossed with susceptible inbreds, but others did not.

*Root and stalk rot.* A strong relationship was found between the growth vigor of resistant and susceptible plants and stalk rot incidence. In evaluations of the contributions to yield and stalk rot resistance made by leaves in different positions on the plant, removal of the leaves from the top quarter of a susceptible hybrid doubled stalk rot, whereas removal of leaves from the top half of the plant trebled stalk rot. A resistant hybrid was considerably less affected by removal of the corresponding upper leaves. The resistant hybrid showed a marked reduction in stalk rot when competition for light and moisture was reduced 3 weeks after mid silk, whereas the susceptible hybrid responded very slightly. Pith taken from the lower internodes of resistant plants shortly before physiological maturity stained more brightly with tetrazolium chloride than pith from susceptible inbreds. The two types of inbreds could not be differentiated before mid silk by this test.

*Viruses of corn and cereals.* Mites were found to persist in winter wheat heads until about a week before harvest, and to transfer wheat streak mosaic from infected wheat plants to corn during this period. At the end of the corn season, mites transferred the virus from infected corn kernels back to wheat until November 5, when the corn was harvested. These results established that the virus can pass from corn to winter wheat in the autumn and back to corn during the following spring.

### Oats and Winter Wheat

*Insects.* The cereal leaf beetle has now reached Elgin and Middlesex counties and is well established in Essex, Kent, and

Lambton counties, but is not yet of economic importance. This species was reared successfully under controlled and insectary environments.

### Soybeans

*Peroxide in seed coats.* Two main groups of soybean varieties that differ in the level of peroxidase activity in their seed coats have been identified. Quantitative determinations showed that there was at least 70 times more peroxidase in the seed coat of the high-activity group than in the low-activity group. Separation of the seed coat extracts by acrylamide gel electrophoresis resulted in one main and two minor isoperoxidase bands in the high-activity types. The same bands appeared to be present in the low-activity varieties, but in a much reduced quantity. A biochemical spot test was developed, which has proved useful in testing genotypes, varieties, putative hybrids, and offtypes. The inheritance of peroxidase activity was studied in  $F_2$ ,  $F_3$ , and  $F_4$  progenies of Blackhawk (low)  $\times$  Harosoy 63 (high). The results indicated a single main gene with alleles *Ep* and *ep* controlling high and low activity. Genetic control resides in the maternal tissue and not in the endosperm or in the embryo.

*Weed control in soybeans.* Under conditions of abnormally high rainfall and a heavy ragweed population, single applications of chloramben and linuron outperformed any other herbicide used alone or in multiple applications of different herbicides. Vernolate with chloroxuron, linuron, or metobromuron gave better weed control than when trifluralin replaced vernolate.

## HORTICULTURAL CROPS

### Field Vegetables

#### Muskmelon

*Fusarium wilt.* Under conditions highly favorable to wilt in the greenhouse pot culture of melons, four fungi and one bacterium, strongly antagonistic in vitro to the wilt fungus *Fusarium oxysporum* Schlecht. f. *melonis* Snyder & Hansen, suc-

cessfully reduced wilt. This result was achieved for a growth period of 35 to 45 days, after which protection diminished. Under field conditions satisfactory control of wilt was achieved in Colwood loam and Fox sandy loam soils by using a fungal antagonist.

Significant reductions in size of populations of the wilt *F. oxysporum* f. *melonis* were obtained with benomyl and dazomet.

### Peppers

*Effect of disulfoton on yield.* Research elsewhere has shown that certain soil pesticides, including disulfoton, have produced increases in fresh weight and yield of some crops and changes in the macro- and micro-element levels. Our studies showed that disulfoton did not stimulate fruit production or influence nutrient levels in field-grown peppers when an adequate level of fertility was provided for the plants.

### Potatoes

*Aphids on early potatoes.* A project was started to relate aphid populations to yields and virus diseases of potato crops and the need for control measures. In early July the populations of aphids in 28 fields of Irish Cobbler potatoes treated by growers were compared with those on untreated potatoes at the Station. From 0 to 453 green peach aphids per 50 leaves

were found in commercial fields, but half the fields had fewer than 5 per 50 leaves. This compares with 1,900 per 50 leaves on untreated potatoes at the Station. Potato aphids ranged from 0 to 27 per 50 leaves in the commercial fields, but all except one field had less than 5. Untreated potatoes had 325 potato aphids per 50 leaves. The green peach aphid was harder to control than the potato aphid, perhaps because the former was mainly on the lower leaves of the plant, which are sheltered from sprays.

*Effect of soil type on specific gravity.* Eleven potato varieties were grown on both Fox sandy loam at the Station and on a peaty muck at Point Pelee. The average specific gravity on the muck was 1.064, whereas on sand it was 1.077. From the processing standpoint, varieties such as Lenape, Grand Falls, and Kennebec were of excellent quality and yield. Kennebec and Grand Falls yielded well on sand and processed well. Avon, a high dry-matter variety on sand, yielded well on muck, but had a very low specific gravity.

## Greenhouse Vegetables

### Cucumbers

*Chemical control of the two-spotted spider mite.* The comparative toxicities and modes of action of 31 materials were established, and the better compounds were tested on cucumbers in the greenhouse.

Persistence of residues of acaricides on cucumber leaves was measured in terms of two-spotted spider mite population suppression on leaf discs taken at frequent intervals. Twelve acaricides were evaluated with three sprays of 0.025% active ingredient, applied at weekly intervals. Acaricidal action increased with successive sprays, and persisted for 9 to 30 days, depending on the materials.

*Biological control of the two-spotted spider mite.* The predacious mite *Phytoseiulus persimilis* Athias-Henriot was used to control populations of two-spotted spider mites on detached bean leaves. At a ratio of one female predator to 10 adult

female two-spotted spider mites, prey egg accumulation was 32% slower than with two-spotted spider mites alone. Prey nymphs were eaten almost as fast as they hatched. All prey were gone in 10 days, and then the predators died for lack of food.

On large cucumber plants the predators dispersed more slowly than on bean discs and the populations were difficult to measure. However, plants with both prey and predator were much less damaged than those with the two-spotted spider mite alone.

Five acaricides were found that did not harm the predacious mite *P. persimilis* at concentrations that gave good control of the two-spotted spider mite. The rate of predator oviposition was not significantly affected by tetradifon, Animert V-101 (Philips Duphar), Milbex (Ihara Chemical Company), or Bay 58733 (Chemagro Corporation).

*Integrated control of the greenhouse whitefly.* Laboratory toxicity tests showed that only oxythioquinox was inactive against the whitefly parasite, *Encarsia formosa* Gahan, at the concentration that killed whiteflies. Integrated control was achieved in a small greenhouse section with a release of *E. formosa* and two applications of oxythioquinox at 0.01% active. This program also controlled powdery mildew for 6 weeks.

*Seedless cucumbers.* Recently developed varieties of the European-type parthenocarpic cucumber are finding increased acceptance on the Canadian market. A Dutch variety M60 (Pinup) that was grown responded favorably to the cultural practices and feeding schedule used for the more commonly grown Burpee hybrid. When severe blossom thinning was practiced, this variety produced a profusion of female blossoms and gave a greatly increased fruit yield.

## Tomatoes

*Bacterial canker.* A bioassay technique was developed using tomato as the test plant that was suitable for qualitative and quantitative studies with *Corynebacterium michiganense* (E. F. Sm.) Jensen, the causal agent of bacterial canker of tomato. The technique was valuable for rapid identification of the pathogen, useful for qualitative and quantitative studies on persistence, and effective in evaluating chemicals and antibiotics for its control.

No bacterial canker transmission occurred when healthy tomato seeds were

seeded directly into severely contaminated soil. When healthy tomato seedlings were transplanted into the same soil, 15% of the plants became infected. Symptoms were not evident until 23 days after transplanting.

Of various plant introductions only *L. esculentum* cv. Cheyenne 146 had sufficient resistance, suitable plant type, and fruit size to be useful in breeding.

*Light.* Beneficial effects and increased yields were obtained by improving the light conditions in the following ways: supplementary artificial illumination to increase the photoperiod to 18 hr, supplementary artificial illumination directed to the sides of the plants instead of from above, and a white plastic mulch for light reflection.

*Magnesium deficiency.* In a sand-culture experiment showing a wide range of Mg-deficiency symptoms it was shown that a tissue level of 0.30% Mg was associated with incipient deficiency and the beginning of symptom expression, and a level of 0.15% Mg or less was associated with severe deficiency symptoms.

*Single-cluster culture.* In a further investigation of the English single-cluster method of production, plants were grown in an artificial medium in tiered troughs at planting rates up to 95,000 plants/acre. Three crops were grown in 1 year and six varieties were tested. Campbell 1327, a processing variety, gave the best results with a yield of 32 tons/acre per crop at a spacing rate of 67,000 plants/acre. The size and quality of the fruit were good.

## Tree Fruits

### Apricots

*Breeding.* Further crosses were made to improve fruit size and quality, to increase cropping dependability, and to study the inheritance of resistance to *Xanthomonas pruni* (E. F. Sm.) Dowson, the causal agent of bacterial spot.

Intensive selection of 3- and 4-year-old seedlings that fruited in 1968 resulted in the selection of 17 individuals for propagation in 1969 and widespread second testing in 1970. Two Harrow selections

exceeded the best varieties and selections under second test at Harrow.

*Microsporogenesis.* Four apricot and four peach cultivars were compared for the rate of microsporogenesis at 7 C and for the sensitivity of their flower buds to the same freezing stress at different stages of microsporogenesis. Meiotic induction occurred sooner in peaches and proceeded at a faster rate at 7 C than in apricots. The four peach cultivars and one apricot were progressively more sensitive to cold

injury from meiosis I to the mature pollen grain stage. Three apricot cultivars had maximum sensitivity at the meiosis II and mature pollen grain stages, but reduced sensitivity at the meiosis I, tetrad, and uninucleate pollen grain stages.

## Peaches

*Controlled freezing of dormant scions to assess winterhardiness.* A laboratory-scale apparatus was developed that permitted freezing of dormant scions and control of the rate of temperature decrease at  $\pm 1$  C to 2 C/hr. Good differentiation was obtained between cultivars known to differ in their level of winterhardiness where liquid nitrogen was used as the refrigerant at cooling rates of 4.5 C/hr and lower.

Sequential freezing of representative winter-hardy and tender cultivars to minimum temperatures of  $-20$  and  $-30$  C from October through January at weekly intervals showed that cold tolerance is accumulated at a much faster rate in the hardy than in tender cultivars. Blossom bud hardening proceeded more rapidly than wood hardening and the loss of cold tolerance was most pronounced in blossom buds, particularly under the influence of the heavy rains that occurred in the dormant period. Hardy and tender cultivars displayed similar sigmoidal damage responses when exposed to decreasing temperatures. However, the  $LD_{50}$  for blossom-bud mortality varies as much as 3 C (10 F) depending upon the relative winterhardiness of the particular cultivar.

*Stages of overwintering in relation to winterhardiness.* The rate of progression through several critical stages of overwintering was studied on 19 representative hardy and tender cultivars of peach in relation to cumulative natural blossom-bud mortality at the end of the dormant period. In this manner, the relative importance of such stages as selection criteria in breeding winter-hardy peaches was established. Measurements were carried out on rates of defoliation, time of microspore meiosis, and blossom season and correlated with blossom-bud mortality. Correlation coefficients were  $+0.6901$ ,  $-0.3003$ , and  $-0.2948$ , which confirms

that low bud mortality was generally associated with early fall defoliation, delayed microsporogenesis, and delayed blossom season. Of these several stages, rate of fall maturation and hardening had the greatest impact on the overwintering of blossom buds.

*New improved winter-hardy cultivars.* Two improved peach cultivars were named and released in 1968 for commercial production. Harbelle is early maturing, ripening just ahead of Sunhaven. Fruits are large, firm, and freestone; they have an attractive bright red overcolor on a rich yellow flesh free of red pigment and good flavor characteristics. The tree is compact in growth habit and productive in relation to its size. Blossom buds showed 8 F additional cold tolerance when compared with moderately hardy Redhaven. Harmony matures with Loring in the mid-season harvest period. Fruits are larger than Harbelle, firm, and freestone and have an exceptional red overcolor for this season. The flesh is yellow with some red pigmentation at the pit and is of good quality. The tree is vigorous in growth habit and its blossom buds are hardier than Redhaven but less hardy than Harbelle.

*Green peach aphid.* Colonies of the green peach aphid, derived from overwintering eggs, had about 10 wingless forms occurring in each. Some colonies were destroyed by predators. The predator most often found feeding in the colonies was *Adalia bipunctata* (L.), although *Ceratomegilla maculata* (Deg.) was more common in the orchards. From each colony that survived, about 360 alatae migrated at the end of May.

Trapping of alatae showed that migration from peaches lasted 15–21 days in 1968 compared with 20–28 days in 1967. The appearance dates and measurements of trapped alatae and those invading a potato plot suggested that most of them came from peach trees. Although shepherdspurse and other weeds in peach orchards were often infested with this aphid in the fall, these aphids did not survive the winter, and so they were not among the winged migrants in the spring flights.

*Peach canker.* Eradication of established cankers caused by *Leucostoma cincta* (Fr.) v. Höhn. (*Valsa cincta* Fr.) and *L. persoonii* (Nits.) v. Höhn. (*V. leucostoma* (Pers.) Fr.) on trunks and larger branches of 7-year-old Redhaven peach trees was attempted by surgical removal of cankered tissue followed by application of canker paints in which the following chemicals were tested: (I) Bacticin (UpJohn Company), a mixture of 56 g dichlone 50% WP, 0.25 lb Kolo-100, and 4 g mercuric chloride in 2 pints water and asphalt base, (II) 25 g quinolinol sulfate in linseed oil, (III) 25 g quinolinol benzoate in linseed oil, (IV) 25 g quinolinol zinc salt in linseed oil, (V) 2 g cycloheximide semicarbazone in 1 pint water and asphalt base, (VI) 1 fluid oz Morsodren (Morton Chemical Company) in 2 pints of water. II, III, and VI were superior in promoting cessation of canker activity and formation of callus tissue. Efficient removal of cankered tissue seemed to be important.

*Translocation of organophosphorus systemics in peaches.* Dimethoate was applied to the stems of peach trees. Analysis of leaf samples showed that the translocation of the insecticide followed the general principles that regulate the movements of nutritive materials towards regions where intense metabolic activity is taking place, which results in concentration of the insecticide in the upper and younger leaves. Phosphamidon penetrated rapidly into the

living tissue where it was degraded rapidly by enzymatic hydrolysis.

*Weed control.* Results from a 3-year study on the integration of herbicides with soil management systems for young peach orchards showed that peach trees can be successfully established and maintained under a zero tillage system. A 6-ft-wide herbicide-treated strip with the tree row in the middle of the strip combined with a mowed creeping red fescue sod was the most efficient and effective system used.

Sinbar (DuPont of Canada Ltd.), a newly developed herbicide, showed considerable promise for selective weed control in orchards. No accumulation of the herbicide in soil has been found. In all instances residues were below 0.1 ppm and well within the safety limits.

### Pears

*Breeding.* A total of 8,409 pear seedlings representing 39 progenies from controlled hybridizations and six from open pollination were screened in a plastic greenhouse for resistance to fire blight caused by *Erwinia amylovora* (Burr.) Winslow et al. An average infection based on all inoculations was 98.6%. Twelve combinations were good to outstanding in terms of the percentage of offspring in the most resistant classes. Parents that appeared to be exceptionally efficient in transmitting resistance to their offspring included NJ 484338262, NJ 505008071, Mericourt, Magness, and Maxine.

## INSECT PATHOLOGY

### Viruses

A field study on the occurrence of viruses of the cabbage looper showed that the concentration of a virus in soil in nontreated plots was related to the concentration of the virus on foliage of plants grown in the plots and to the occurrence of the disease in the population of the host insect. This finding increased the evidence that virus in soil is a source of pathogen for the initiation of epizootics of virus disease.

Three viruses of the cabbage looper were found in soil: the typical nuclear-polyhedrosis virus, an atypical nuclear-polyhedrosis virus that produces large

polyhedral inclusion bodies in the host, and a typical granulosis virus. The last two viruses had not been found previously in Canada and the virus that produced atypically large polyhedral inclusion bodies may be a new disease.

The typical nuclear-polyhedrosis virus of the cabbage looper persisted for longer periods on foliage and in soil than did the granulosis virus in preliminary plot tests. Laboratory tests showed that the LD<sub>50</sub> and LT<sub>50</sub> for the granulosis virus are greater than for the nuclear-polyhedrosis virus. For these reasons the polyhedrosis virus is considered to be the better biological control agent.

## SOIL SCIENCE

### Soil Physics

**Irrigation.** A 4-year study of the interrelationships of soil moisture supply, plant population, and row spacing in relation to the yield of corn has shown that the optimum plant population and row spacing depend upon the soil moisture supply. Under moisture-stress conditions there was no advantage in using more than 16,000 plants/acre. At this planting rate 20- and 40-inch rows were equally effective in both wet and dry seasons. However, with adequate supplies of soil moisture, maximum yield was obtained where 22,000 plants/acre were grown in 20-inch row spacings.

**Root growth.** Measurements showed that roots of corn, tomatoes, and potatoes extend beyond 120 cm deep. More than half of the roots of full-grown tomato and potato plants were located in the top 60 cm of soil. Surprisingly, corn roots appeared to be somewhat more shallow with

more than half the roots located in the top 50 cm of soil. In spite of these extensive root systems 2 atm of soil moisture tension at 15 cm constituted stress conditions for potatoes.

### Soil Fertility

Fertilizer trials on sandy loam showed little effect of P fertilization on the yields of tomatoes, cucumbers, and tobacco when the soil test levels were above 126, 143, and 110 ppm P for each crop. Although a soil level of 94 ppm K appeared adequate for cucumbers, the yield and quality of tobacco was improved by K fertilization at all soil levels between 29 and 128 ppm K.

During the past 2 years corn has responded to fertilization with P and K where soil-fertility levels had declined to 44 ppm P and 65 ppm K. The effects of fertilization have not been evident on more fertile soil.

## MISCELLANEOUS

### Selected Phytotoxicity of Dyrene to Varieties of Canada Thistle

Excavation of root systems 1 year after treatment showed that Dyrene (Chemagro Corporation) almost eradicated the *mite* variety of Canada thistle. Little response was noted with the *horridum* variety. Surfactants at 10% v/v with Dyrene altered this selective action, but also severely damaged tomato, cucumber, and lima bean plants.

### Diseases of Tree Fruit

From 1966 to 1968 isolations were made from small cankers on 1-year-old shoots of peach and sweet cherry trees that showed a range of symptoms including gumming cankers on trunk, branches, and at spurs, and round and irregular leaf spots and shot holes. Plum trees with similar symptoms yielded pathogenic pseudomonads, most of which resembled *Pseudomonas mors-prunorum*

Wormald. Others were identified as *P. syringae* van Hall. For the first time it was found that bacterial canker of sweet cherry and plum was widespread in the Niagara peninsula, Kent, Essex, and Lambton counties.

*P. syringae* was also isolated from dark-purple fruit spots at lenticels with blistered brown centers on "Matsu" apples and proved to be pathogenic. Occasionally, tan-colored cankers measuring 15–43 × 3–6 mm occurred on smaller twigs from which *P. syringae* was isolated. This is the first report of bacterial blister spot of apple in Canada.

### Chromatography

A two-dimensional thin-layer chromatography method was developed to separate and determine the uracil herbicides (terbacil, bromacil, and 3-butyl-6 methyl-uracil).

## Entomology

A taxonomic review of the Nearctic species of the chalcidoid genera *Pnigalio* Schrank and *Sympiesis* Forster was completed. Five species of *Pnigalio* and thirteen species of *Sympiesis* were recognized as biological entities. Eighteen of the nominal species and two subspecies were

placed in synonymy and nine nominal species remain unrecognized.

Cocoons and last-instar larval mouthparts of hymenopterous parasitoids reared from armyworm in Ontario were studied. The research correlates significant, ecological notes with a key and illustrative material so that these stages of the parasitoids can be identified easily.

## SOIL SUBSTATION, WOODSLEE, ONTARIO

### Effect of Nitrogen on Soil pH

High rates of N applied annually for 15 years reduced the pH of Brookston clay soil to very low levels in comparison with pH values on treatments that received no N fertilizer. Nitrogen applied alone at 270 lb/acre appeared to reduce soil pH to the same level as N combined with P and K fertilizers. Alfalfa sod, which appeared every 2 years in a 4-year rotation treatment, also reduced soil pH in comparison with the unfertilized check.

### Cultivation for Corn

During the 6 years of this experiment conducted for corn on clay soil, the yield was increased by cultivation on six locations. Weeds were eliminated in the experiments by hand or chemical methods. The consistency and the amount of yield increase pointed to the necessity of combining cultivation with chemical weed control to obtain maximum corn yield on clay soil.

Soil moisture was increased by cultivation over that in the uncultivated check. Greater soil moisture appeared to be the main factor in improving corn yield.

### Soybean Genetics

A genetic analysis was made of 10 characters measured in populations from two soybean crosses.

The parental differences and progeny variances were larger in populations from cross 1 than cross 2 and in a nonstress environment compared with a stress environment. This was reflected in the higher genotypic variances, heritabilities, and expected genetic advance in progenies from cross 1 and in the nonstress environment.

Selection for yield in  $F_3$  single plants and  $F_4$  single progeny rows failed to increase the population means of the  $F_5$  and  $F_6$ . However, there was a shift towards a later, taller, and larger plant, particularly in populations from cross 1 and in populations selected in the nonstress environment. Thus, selection for yield was considered to be random and the changes in maturity and plant size to be owing to natural selection pressure in bulked progeny lines.

Both phenotypic and genotypic correlations of seed yield with plant height, total plant weight, and pod number were much higher in the stress environment than the nonstress environment. Moreover, in the stress environment, the genotypic correlations for these characters were larger in most cases than the phenotypic correlations. These results suggest the possible use of plant height and pod number as selection criteria for yield under stress conditions.

Heritability estimates were high in both environments for date of leaf yellow, date of leaf fall, maturity date, and seed weight, but were moderate for plant height and height of branching. Heritabilities were moderate for total plant weight, seed yield, and pod number in the nonstress environment, but low in the stress environment indicating that selection for yield would be more effective on the nonstress site. Although actual advance measured in  $F_6$  was lower in the stress environment, the values in both environments were in good agreement with expected genetic advance calculated in  $F_6$  for all characters except total plant weight and seed yield. These were higher in the nonstress site than expected.



Genotype  $\times$  year interactions were higher than genotype  $\times$  location interactions for plant height, height of branching, pod number, and seed weight. The genotype  $\times$  location interactions were larger than the genotype  $\times$  year interactions for date of leaf yellow, date of leaf fall, maturity date,

and total plant weight. The two types of interactions were approximately equal for seed yield. The genotype  $\times$  environment interactions for total plant weight and seed yield were higher in populations selected in the stress environment, which shows that these lines may have limited adaptation.

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# Research Station Ottawa, Ontario

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## INTRODUCTION

The Research Station, Ottawa, and the associated experimental farms at Fort William, Kapuskasing, and Smithfield are concerned with the improvement, protection, and culture of cereal, forage, and horticultural crops in eastern and north-western Ontario. At Kapuskasing research is also being done on beef cattle housing and nutrition.

In 1968, three new grain corn hybrids were licensed. Three apple varieties were released for grower evaluation. A sweet corn hybrid and a hardy everblooming shrub rose were named, and three potato varieties were licensed for Ontario. In-

creasing attention is being given to physiology in relation to efficiency of production and, at Smithfield, to the control of growth processes in fruit and vegetables.

A new controlled-environment building, housing 22 self-contained growth cabinets, is nearing completion at Ottawa. A large growth room was constructed for the Agronomy Section. Two new greenhouses were built, and the lighting systems in two older ranges were brought up to modern standards.

A. W. S. Hunter  
Director

## CEREAL CROPS

### Winter Wheat

Ottawa hybrid 7453-4-3-3, a derivative from a Norin dwarf combined with Genesee and an introduced hybrid, has proved to be superior to the newly licensed Cornell variety Yorkstar in combined agronomic and quality characteristics. It is more resistant to lodging, mildew, and leaf rust than Yorkstar and Genesee. Resistance to the loose smut races that attack Genesee and Avon was transferred to F<sub>4</sub> hybrid lines.

Vernalization at 35 and 50 F for the length of time required to complete the low-temperature phase, followed by exposure to long days at 70 F, made it possible to distinguish between hardy and nonhardy lines. The heading date of nonhardy lines coincided at both vernalization temperatures; hardy lines tended to show retarded heading when vernalized at the low temperature.

### Hybrid Wheat

The conversion of varieties of winter wheat into male-sterile and pollen-restorer

lines is proceeding, but the backcross program must be interrupted occasionally by a progeny test to ensure satisfactory inclusion of these characters. The *Triticum timopheevi* pollen-restorer factors have not operated the same in all varieties. The F<sub>2</sub> ratios for pollen restoration varied from 9:7 to 15:1. Different varieties apparently have different modifying factors that tend to increase or decrease the effectiveness of the main factors in the hemizygous condition. The single gene from Primépi has not been fully effective as a pollen restorer in all combinations.

### Quality Evaluation

A digitizer was added to the electronic recording line of the flour rheology laboratory. This new instrument records torque measurements of a mixing dough in energy units, and gives a precise measurement of the strength potential of Canadian wheats.

## Oats

*Dormoats.* Dormoats, carrying seed dormancy from *Avena fatua* L., raised the yield potential of oats by early spring growth and by reduced losses from rust and septoria infection through early maturity. Low spring emergence (1–5%) of fall-sown seed has constituted a barrier to dormoat improvement, but high values (40–60%) were obtained in 1968 with seed that had been placed on the surface of soil outdoors to germinate and exposed to alternating periods of light and darkness, wetness and dryness before planting. When the dry seed was stored in air indoors, some of the seeds afterripened and most of them germinated immediately when planted in the fall. The degree of afterripening and fall germination was found to be a function of time of storage. The rate of afterripening of the remaining seeds in soil was apparently drastically reduced by the gaseous environment in soil (O<sub>2</sub> and CO<sub>2</sub>) and very few seeds were prepared for spring emergence. The new treatment allows more seeds to afterripen properly in air, but germination is blocked by exposure to light and possibly moisture stress. When the seeds were planted in late fall, these stresses were released, but low soil temperature imposed a new block to germination. In the spring the temperature block was removed and a high percentage of the seeds emerged. This new method of handling seed is now being used on newly created large pools of segregating plant material to improve dormoat survival and commercial acceptability.

*Genetics of strong straw.* The main thrust of the oat genetics program has been directed towards combining short, stout straw with yielding capacity to overcome the inability of present oat varieties to utilize high levels of fertilizer without lodging. Fourteen short-strawed breeder's lines or varieties from the USA and Europe were evaluated in the field in 1968. Nine of these along with two Ottawa selections were crossed, in a combining ability test, to the three adapted varieties Stormont, Kelsey, and Dorval. This new program has two objectives: (i) to locate the best sources of genes for yield and lodging resistance and (ii) to develop bulk populations from which varieties can be selected.

*Short-day tolerance.* With the ultimate objective of breeding daylength-insensitive and consequently widely adapted oats for Canada, the flowering response of many species and varieties was tested under controlled day lengths. Two entries, *A. byzantina* C. Koch (Med. 147) and the California variety Rapida, both showed the desired early heading under short days. Progenies from Med. 147 crossed with Canadian varieties are being screened under controlled environmental conditions and in California for daylength insensitive segregates to be used in further breeding. Early flowering under short days is a dominant characteristic, but the number of genes involved has not been determined.

## Barley

*Breeding.* The feed barley OB 66-23 (Nord × Br. M57-754) continued to perform well. On the basis of 32 station-year tests in Eastern Canada, OB 66-23 outyielded Champlain, the highest-yielding check variety, by an average of 151 lb and York by an average of 347 lb/acre. OB 66-23 was found to be resistant to powdery mildew and loose smut and to have a high kernel weight.

Winter survival, high yield, and disease resistance are combined in winter-hardy selections from the cross *Hordeum murinum* L. (4x) × *H. vulgare* L. (2x) in the 1967–68 Eastern Cooperative Winter Barley Test at Ottawa. More lodging resistance must be added before these selections can be released to farmers. Fertile hardy tetraploid selections are also under trial.

## Triticale

Fertile winter triticale strains, with  $2n = 42, 44,$  and  $56$  chromosomes, were obtained in the  $C_4$  generation from Kent winter wheat  $\times$  Sangaste winter rye. These

have wheat or speltoid type heads and have large, plump, wheat-type seeds. The plants are robust, winter-hardy, and productive.

## Field Peas

A large-seeded pea, CD6474, selected from an introduction from Hungary, out-yielded Stirling by an average of  $21.3$  bu/acre in a five-station test in Ontario and Manitoba in 1967 and 1968. The seed is

larger than Stirling, of better quality, and earlier in maturity. It may have a place as a large-seeded, special-purpose pea to complement the Ottawa-developed Century, the predominant variety in Canada.

## Pathology

*Septoria disease of oats.* Approximately 500 entries from the world oat collection, selected in 1967 for freedom from septoria, were further selected at Ottawa and Kapuskasing in 1968 on the basis of septoria and yield data. This group will be replanted in 1969 to identify the most septoria-tolerant varieties.

*Seed infection of Herta barley.* Seed 100% infected with *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur showed a 30% lower emergence than 3% infected seed. Treatment of the seed with mercurial fungicides increased the emergence of all samples, and the 100% infected seed by approximately 40%. There was only a 10% difference in yield between the 3 and 100% infected untreated seed and no significant increase in yield because of treatment of the seed. It was found that reductions in yield were due to the level of seed infection and number of plants

per row, but the latter had to be reduced to less than half of the original number before significant yield reductions occurred. Greenhouse trials substantiated emergence data and under high-humidity conditions mercury seed treatment controlled the buildup of the fungus on the developing plants.

*Continuous cropping of barley.* Tests in 1968 with three varieties showed a consistent 11% reduction in seed yield and 15% reduction in green yield on land that had grown barley for 2 years compared with land producing its first crop. Two levels of fertilizer gave no increase in seed yields, but did give proportionate increases in green yields. There were no obvious changes in disease development, but there appeared to be some differences in the numbers of *C. sativus* spores in the soil from the various plots.

## FORAGE CROPS

### Grass Breeding

#### Timothy

The variety Bounty, recommended for the Maritime Provinces, continues to be impressive because of its 10-day delay in maturity. This lateness is not advantageous in Ontario and Quebec where timothy is used mainly in mixtures with alfalfa and cut at the correct alfalfa maturity.

#### Orchardgrass

Seed increase in Canada has stimulated interest in the late-maturing variety

Rideau. A good supply of certified seed is available for 1969. The 1968 data confirmed the adaptability, vigor, and winter-hardiness of Strain K in northern Ontario, Quebec, and the Maritime Provinces. Licensing will be recommended in 1969. The variety Bumper has not lived up to expectations in yield. It is leafy and late, but does not equal Rideau in total acre yield of dry matter.

## Alfalfa Breeding and Genetics

*Bacterial wilt resistance.* Six Rhizoma and five DuPuits synthetics were increased to the Syn-2 and one DuPuits synthetic to the Syn-3 generation. All Syn-2 increases were produced in greenhouses and growth rooms with honey bees as pollinators and will be used to establish yield trials in 1969.

*Heterosis in autotetraploid alfalfa.* The effect of inbreeding on vigor, as measured

by fertility, was investigated in two alfalfa clones. Results were consistent with the assumption of multiple alleles in an autotetraploid genetic system, where maximum vigor in a single-cross hybrid between two inbred or partially inbred lines does not occur in the  $F_1$  but in a subsequent generation of panmixis. Further data will be collected on vegetative vigor.

## Corn Breeding

Three new Ottawa hybrids qualified for licensing in Ontario Corn Committee trials. Seed production rights will be allotted to commercial companies.

Incorporation of the Opaque-2 and Floury-2 genes in selected inbred lines continued. In three of 19 inbreds genetic background prevented full expression of the character, making classification difficult.

Top cross tests to measure the general combining ability of 118 European introductions have identified 54 lines worth further study. These will be tested in three-way combinations in 1969. Development of tillered hybrids for silage continued. Several Swiss flints in combination with North American dents are currently under test.

## Soybean Breeding

Breeding nurseries were grown at Ottawa and at Grassy Lake, Alta., in cooperation with the research stations at Lethbridge and Morden. The Ottawa nursery consisted principally of 267 lines, group OO maturity or earlier, involved in the development of high-oil (20% plus) varieties and 17 lines involved in the development of high-protein (50% plus) varieties. Of the high-oil material 60 lines

are in the  $F_7$  generation and ready for testing in yield trials in 1969.

The Ottawa section of the Alberta nursery consisted of 103 lines, mostly from the high-oil program. Hail damage and abnormally low temperatures and high rainfall in August and September resulted in generally poor development, particularly in seed size. Response to these conditions showed a wide range of variability, providing considerable room for selection.

## Pathology

### Host-Pathogen Relations

*Influence of the carbohydrate fraction of alfalfa root exudate on Fusarium.* Alfalfa roots exude fructose, glucose, galactose, raffinose, and sucrose. Three additional compounds with low Rgl values that could not be hydrolyzed were frequently observed, but remain unidentified. Glucose, fructose, and galactose stimulated the germination of the macrospores and chlamydospores of both *Fusarium solani* (Mart.) App. & Wr. and *F. oxysporum* Schlecht. Raffinose and sucrose were effect-

ive in stimulating the germination of the chlamydospores of *F. solani* only when applied in the soil in amounts similar to those actually released by roots of young alfalfa plants. Both *Fusarium* spp. were able to use the root exudate sugars as a carbon source for growth when tested in shake culture.

*Chemical changes in the mycelium of Fusarium during autolysis.* Autolysis set in between the 11th and 15th day of incubation. By the 106th day of incubation, *F. solani* mycelium lost 57.8% of its maxi-



mum initial (10th day incubation) dry weight and *F. oxysporum* 49.5%. The total amount of reducing substances decreased considerably as autolysis set in. Sixteen amino acids were detected in the autolyzing mycelium of both *Fusarium* spp. The general picture was one of a decreasing amount of free amino acids as autolysis proceeded. The culture filtrates stayed at pH 4.7 during the initial stage of growth and then shifted to 8.0–8.5 at the 9th day and remained in that neigh-

borhood through the whole period of incubation.

*The effects of nitrogenous amendments on the germinability of Fusarium spores in soil.* A decrease in germinability of chlamydospores of *Fusarium* spp. was observed in soil amended with 0.2% (w/w) of the following compounds: ammonia,  $\text{NH}_4\text{NO}_3$ , chitin,  $\text{Ca}(\text{NO}_3)_2$ , and  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$ .  $\text{NH}_4\text{HCO}_3$  and  $(\text{NH}_4)_2\text{SO}_4$  had no evident effect.

## Introductions

The most interesting new introductions observed in 1968 were: an alfalfa from Leningrad that yielded 40% and one from Turkey that yielded 28% more green forage than the highest Vernal check; a Hungarian clover, *Trifolium pannonicum* Jacq., from Romania that yielded as much green forage as the alfalfa check and had 100% stand the second season; a hairy vetch, *Vicia villosa* Roth, from Prague that shows good possibilities as a very high protein forage producer even when sown in early summer.

Zigzag clover, *T. medium* L., and crown vetch, *Coronilla varia* L., compared favorably with Vernal alfalfa at the same ma-

turity stage in 1968 palatability and digestibility trials with sheep at the Animal Research Institute.

Sainfoin, *Onobrychis viciaefolia* Scop., may become important because of the weevil threat to alfalfa. A late Russian and an early English strain with good persistence were selected for further breeding and increasing. Sainfoin starts growth a week earlier in the spring than alfalfa. It often outyields alfalfa at the first cut, but total yield for all cuts is only about 65–75% of alfalfa. For high aftermath production, the first cut must be made when the plants are at the bud stage.

## HORTICULTURAL CROPS

### Fruits

#### Apples

*Breeding for late harvest.* The program involving crosses between parents that are susceptible to apple scab, *Venturia inaequalis* (Cke.) Wint., has been discontinued. An elite selection from this program, seedling T-397 (Red Delicious × Linda), is promising. Its fruit is of good commercial size with an average of 75% red overcolor. It has low acidity and good flavor, is ready for harvest in mid-October, 3 weeks after McIntosh, and keeps at 31 F until mid-February. T-397 is being recommended for testing in areas where McIntosh is grown.

*Breeding for scab resistance.* Nineteen scab-resistant seedlings selected during the period 1961–67 are being evaluated as

potential new varieties in Ontario and Quebec orchards. O-541 and O-544, not previously reported, are promising. Both are from crosses of McIntosh with derivatives of *Malus floribunda* Sieb. Some difficulty has been experienced in getting good fruit size on O-541, but size was acceptable in 1968, indicating that the trees are developing a good growth pattern. Both have acceptable flavor. Their shelf life is shorter than that of McIntosh; O-544 would have to be marketed by mid-November and O-541 by late December.

*Rootstocks.* A quarter diallel for crosses between size-controlling root stocks subjected to artificial stresses using a portable low-temperature chamber indicated that

genetic advance is possible for winter-hardiness by selecting and mating the best phenotypes. Electric impedance recorded in the fall and early winter was not useful in predicting winter damage. There was some correlation (0.33) between damage and impedance recorded in the spring, but this was much lower than that for morphological ratings of damage (0.87).

### Strawberry

*Genetics.* Data on resistance to powdery mildew, *Sphaerotheca macularis* (Wallr. ex Fr.) Magn. (*S. humuli* (DC.) Burr.), were collected from four quarter-diallel experiments conducted in 1966 and 1967. Thirty-two clones selected from the cultivated varieties grown in Canada and the United States were employed as parents. Preliminary analyses suggest that powdery mildew development may be controlled by two additive genes for resistance and one epistatic gene for susceptibility.

*Breeding for processing.* Ease of calyx removal is important in processing varieties and for mechanical harvesting. Two promising easy-capping, high-yielding selections are 55-01-01, midseason in maturity, and 55-02-04, late ripening. Both are from the progeny of Sparkle × (Louise × Elgin).

### Raspberry

*Components of yield.* Dynamometer readings were in good agreement with empirical ratings of ease of picking, related to mechanical harvesting. Winter damage over the years was clearly related to annual yield, but the relationship was obscured in some years by the ability of damaged canes to compensate by producing longer laterals from the undamaged buds. Electric impedance helped to establish the order of dormancy among cultivars, especially in years when leaf fall could not be studied because of early frosts. Ascorbic acid content of leaves was found to be very high and negatively correlated with ascorbic acid content of the fruit.

### Pathology

*Leaf curl of raspberry.* No definite pattern of spread of leaf curl virus of red raspberry was observed within an experimental plantation over a 6-year period. When infected canes were located at the ends of six 150-ft rows, the virus spread to approximately 50% of the healthy plants in 6 years. The virus did not follow along the rows, but became scattered throughout the plantation. Despite a definite increase in the vector population, *Aphis rubicola* Oestl., the number of newly infected plants each year remained constant.

## Vegetables

### Genetics and Breeding

*Cucumber breeding for disease resistance.* Ottawa 68, a new breeding line, resists field infection with the present strains or races of powdery mildew, *Erysiphe cichoracearum* DC. ex Mérat, but exhibits an unexplained leaf necrosis. It was selected from Marketer × Ottawa 41. The latter was derived from a single resistant plant found at Ottawa in a population of PI 227208, a U.S. Department of Agriculture introduction from Japan.

*Pea breeding for multipoddedness and resistance to Fusarium diseases.* A single plant, found in 468 F<sub>2</sub> greenhouse inoculated seedlings from Ottawa 12 × M-129,

has recessive genes for the desirable agronomic traits of suitable height, white flower, multipoddedness, and green, wrinkled seed, as well as two or more genes from M-129 for tolerance to *Fusarium solani* (Mart.) App. & Wr. f. *pisi* (F. R. Jones) Snyder & Hansen, which causes root rot and basal stem disease.

*Inheritance of blossom-end split of fruit in Solanum melongena L.* Segregation in F<sub>2</sub> and B<sub>1</sub> populations from Black Beauty × PI 105347 showed that blossom-end split of fruit is monogenic and recessive. We have assigned the gene symbol *bes*. This trait makes eggplant unmarketable and was found at Ottawa in PI 105347 from the U.S. Department of Agriculture.

*Tomatoes for preservation by freezing.* Tests by the Food Research Institute showed that fruit slices of our breeding line Ottawa 48 can be preserved by liquid nitrogen freezing to give an acceptable product after storage. It carries the "high pigment" gene (*hp*) that intensifies pigmentation and is associated with firm thick central flesh, allowing the fruit to be sliced easily and to retain its structure after freezing and thawing.

*Summertreat sweet corn.* Summertreat, a second early, market-garden hybrid, was released in 1968. It has excellent eating quality and good yield and is 5 days earlier than Tastyvee and 9 days earlier than Seneca Chief. The ears are easily picked, 12-rowed, 7.6 inches long when husked, and slender, permitting fast cooling for better quality preservation.

### Pathology

*Wilt, near wilt, and root rot of peas.* Variants of the fungi *F. oxysporum* f. *pisi* (Linford) Snyder & Hansen and *F. solani* f. *pisi* occurred in culture and within the host. Increases and decreases in pathogenicity were represented in these variants when produced within pea plants. Most variants that occurred in culture were less pathogenic than the original. Some variants of *F. solani* f. *pisi* produced symptoms of wilt generally attributed to infection by *F. oxysporum* f. *pisi*.

*Cucumber mosaic virus.* Tests with the 1966 Ottawa isolate of cucumber mosaic virus indicated that it was not the same as the strain designated as virus 1. This isolate was different from a strain of the virus found in cucumbers in the Ottawa area in 1962 and from a strain obtained from Beltsville, Md., in 1963. In all tests, the "Ottawa 66" isolate caused more severe stunting in cucumbers than the other three strains and was present in inoculated cucumber plants in much higher concentrations, as shown by the cowpea assay.

### Seed Irradiation

*Low dose gamma irradiation of vegetable seeds.* Research was started in 1967, in cooperation with Atomic Energy of Canada Limited, to observe the effect of low dose (100, 300, and 1,000 rad) gamma irradiation of seeds on yields of tomato, sweet corn, pea, cucumber, lettuce, pumpkin, and eggplant. The response varied with the crop, but was positive at the 100-rad level in all crops except cucumber, which responded negatively to all dose levels. In 1968, sweet corn responded to the same treatments with significant increases in the number of ears. In both years, at least one level of irradiation induced earlier flowering in sweet corn, lettuce, pumpkin, and eggplant and in 1968 the earlier flowering resulted in earlier maturity and greater concentration of yield.

## Potatoes

*Breeding and evaluation for Ontario.* The variety York was recommended for licensing in 1968 by the Ontario Regional Potato Committee. Lenape and Wauseon will be recommended for licensing in 1969. Seeding F5570 and Chieftain, reported in 1967, will be subjected to further grower trials in 1969.

*York*—a white-skinned, medium-early variety with good tablestock quality; especially adapted for growing on organic soils; originated at the Research Station, Fredericton, N.B.

*Lenape*—a white-skinned, medium-late variety, has very high total solids and is quite promising for processing as chips and French fries; originated at the USDA (Maine).

*Wauseon*—a white-skinned, medium-early variety that has multiple disease resistance and has shown good promise for heat processed products as well as very good tablestock potential; originated at the USDA (Maine).

## Roses

*Breeding.* Selection FO6, an open-pollinated seedling of the *Rosa rugosa* Thunb. hybrid Schneezwerg, was named Martin Frobisher. It is an upright, well-formed shrub that attains a height of 1.5 to 1.8 m. The flowers are fragrant, double, 4–6 cm in diameter, and of a soft pink color shading to darker at the base of the petals. The upper parts of the branches are spineless. This rose flowers from June until frost and is resistant to powdery mildew, *Sphaerotheca pannosa* (Wallr. ex

Fr.) Lév., and probably immune to black-spot, *Diplocarpon rosae* Wolf.

*Winterhardiness.* Further observations failed to show any relationship between winterhardiness in roses and the magnitude of electric impedance of woody tissue measured during the growing season until the end of October before frost injuries occurred. Previous observations, that the magnitude of the electric impedance is characteristic of certain plants, were confirmed.

## Agronomy

*Alfalfa establishment.* The establishment and first-year growth of Vernal and Du-Puits alfalfa were not affected by seeding method (conventional seed drill vs. Brillion seeder). Plant number and yield increased with seeding rate (6 to 36 lb/acre without a companion crop), but the yield increase did not compensate for the cost of extra seed over 12 lb. Weeds were practically eliminated by herbicides.

*Nitrogen on reed canarygrass.* Results from a 3-year study on Grove (late), Frontier (early), and two medium-maturity strains corroborated previous findings that 80 and 160 lb of N/acre and 160 lb in a split application did not increase yields in the first crop year, but increased yields in the order of 1,500–2,000 lb dry matter (DM)/acre in the two subsequent years. The 160-lb rate consistently led to higher yields than the 80 lb, but the increase was not sufficient to justify the added cost of the fertilizer.

*Yield and maturity of timothy varieties.* In a comparison of first-cut yields of 17 varieties in two tests over two harvest years, the medium-maturity varieties (e.g. Climax and Bounty; harvested July 3) outyielded the early varieties (e.g. Astra and Champ; harvested June 15) by over 500 lb DM/acre, which in turn outyielded the late varieties (e.g. Essex and Drummond; harvested July 9) by 300 lb DM/acre. Harvesting timothy varieties according to physiological maturity provides a much better measure of first-cut potential than subjecting all varieties to the same management regime.

*Mixed grain production.* To obtain information on the performance of varieties of oats and barley in mixtures between and within species, Russell and Garry oats and Herta and Champlain barley were compared in 1967 and 1968 at Ottawa and Verner in varietal combinations for the production of forage, grain, and straw. The effect of underseeding with an alfalfa-brome mixture was assessed.

At both locations grain yields were higher each year for barley than for oats, with Herta higher than Champlain and Russell slightly higher than Garry. Grain yield for mixtures equaled the average of the components grown alone. Doubling the seeding rate had no effect.

Straw yield of barley alone or in mixtures averaged about 1,000 lb/acre, or nearly 25% less than oats. Oat variety mixtures and oats seeded at twice the rate yielded 10% more straw than the same varieties alone. Straw yields of oats and barley mixtures averaged slightly more than either alone. Green chop yields were 14% higher for barley than for oats, with Herta much better than Champlain. Mixtures of barley varieties or of oats and barley produced the best yields of green chop.

Underseeding had a variable effect on the yields of grain, straw, and green chop. On the average, underseeding increased grain yields slightly, increased straw yields considerably, but tended to depress green chop yields.

*Bird damage in corn.* An assessment of bird damage in corn has shown that al-

though grain loss is substantial it may not be as extensive as visual observations indicate. In a field of eight early grain varieties visual examination indicated damage in excess of 23%, with no significant differences between varieties. When quantitative values were obtained, the damage averaged about 11%.

The upper quarter, the tip portion of the ear, of these varieties yielded only 16% of the total grain so that the entire removal by birds of the grain from this part would give a loss in the same order. Although damage is not always confined to the upper part of the ear, it is necessary to keep this factor in mind if a good visual assessment is to be made.

## CYTOGENETICS

### *Avena*

*Cytogenetic architecture.* The pairing behavior of the chromosomes of the recently discovered tetraploid *A. magna* Murphy et Terrell and the tetraploid *A. abyssinica* Hochst. was compared in triploid and pentaploid hybrids. On the basis of chromosome morphology, cross-compatibility, and pairing behavior, it is probable that *A. magna* has the genomes AADD and that it is the ancestral tetraploid of the hexaploid species. Experiments to synthesize hexaploid *Avena* have been started.

*Chromosome polymorphy.* *A. hirtula* Lag., a diploid, and *A. barbata* Pott. ex Link, a tetraploid, cannot be separated with certainty without chromosome counts. In 222 collections of these species made by the Canada-Wales expedition, 14.4% were diploids, 83.7% tetraploids, and 1.8% mixed diploid and tetraploid. Nineteen geographic populations of *A. hirtula* and 46 of *A. barbata* were crossed to a standard diploid and tetraploid respectively. No interchange differences were detected in the diploid hybrids, but a reduction of chiasmata was observed in 58% of the hybrids. This may have been caused either by cryptic structural differences or by outbreeding. In contrast, only 20% of the tetraploid hybrids formed exclusively bivalents, 54% had one, and 26% had two associations of four chromosomes.

*Monosomic series.* Forty-eight monosomic lines, including five genotypes, were classified by chromosome morphology; 20 of the potential 21 were tentatively identified. A backcross program, to establish the monosomic lines in a common genotype, has been started.

### Medicago

In the study of marker gene segregation in trisomic hybrids between trisomics and disomics, to aid identification of the primary trisomics, one disomic was homozygous recessive for the C locus, which produces white seed, and another was homozygous recessive for a yellow growing-point character.

### Mutation Cytogenetics

A curled-leaf (*Cu*) mutation in *Chenopodium rubrum* L. was found to be influenced by nonchromosomal determinants. Studies of *Cu* stem tissue disclosed anomalous deposition of secondary wall thickenings in primary xylem and excessive enlargement of parenchymatous cells. Because orientation of wall microfibrils is thought to be cytoplasmically controlled, this is further evidence for nonchromosomal inheritance in *Cu*.

Ultrastructure studies confirmed the absence of any known viruslike particles in *Cu* plants.

## EXPERIMENTAL FARM, FORT WILLIAM, ONT.

### Crop Management

*Forage crop establishment.* In the establishment year, forages sown without a companion crop of oats or barley were more productive owing to reduced plant

competition and improved light interception by developing seedlings. In 1968, red clover and Climax timothy, seeded at 6 lb each/acre, were highest yielding in the

first year followed by DuPuits alfalfa at 12 lb/acre in pure stand or in a mixture with Saratoga bromegrass at 10 and 8 lb/acre respectively. Although Keystone barley and Russell oats at 4 and 6 pk/acre depressed forage yields in the year of establishment, satisfactory grain yields were obtained. Keystone barley sown at 6 pk/acre and removed as grain silage during the third week of August produced over 6,000 lb/acre. Although the growth of forages was depressed by a companion crop in the year of seeding, their performance in subsequent years compared favorably with forages established as a pure stand.

*Chemical fertilizers for oats and barley.* The production of Kelsey oats and Herta barley on light-textured soils was significantly increased by adding large amounts of N, P, and K in the ratio of 1.5:2:1. Phosphates were the first limiting element restricting grain production and there was a significant interaction between N and P. In 1968, the highest grain yields were secured from 120 lb N, 160 lb P, and 80 lb K/acre.

*Yield and feed value of mixed grains.* In a comparison of wheat, oats, and barley sown singly and in mixtures using a basic seeding rate of 80 lb/acre, the highest yields were from  $\frac{3}{4}$  oats and  $\frac{1}{4}$  barley (3,243 lb/acre) followed by  $\frac{1}{2}$  oats and  $\frac{1}{2}$  barley. Wheat, sown singly or in a mixture with oats or barley, was inferior in yield. In terms of total feed value per acre, pure barley was highest with 369.4 lb protein and 2,404 lb total digestible nutrients/acre. Oats mixed with barley was superior in feed value to oats in a pure stand or with wheat.

*Alfalfa variety management.* Differences in flowering maturity were substantially reduced in alfalfa under conditions of a long daily photoperiod. When harvested at the same maturity stage (first flower) yield differences between Saranac (early), Vernal (midseason), and Norseman (late) disappeared. Significant differences were observed in forage regrowth harvested July 23; the midseason Vernal exceeded both Saranac and Norseman.

## EXPERIMENTAL FARM, KAPUSKASING, ONT.

### Crops

*Fertilizer requirements of grasses.* In 1967, yield responses were obtained from N applications up to 240 lb/acre on timothy, bromegrass, orchardgrass, and reed canarygrass, but only bromegrass responded to P (22 lb/acre). There was a significant positive NP interaction in timothy, bromegrass, and orchardgrass, and there were no significant plant growth responses from K. Responses to both P and K began to appear in these plots in 1968, suggesting that with high levels of N fertilization, P and K do eventually become limiting on the heavy clay soils at Kapuskasing.

*Cereal crop management.* The effect of the rate of N application (0, 75, and 150 lb/acre), dates (May 3, 21, and June 7), and rates (100, 150, and 200 lb/acre) of seeding and variety are being studied with

oats, barley, and wheat. N at 75 lb/acre significantly increased yield of all varieties. Delayed seeding, May 3 to June 7, reduced oat yields by 58%. Late-maturing Herta barley gave high yields when sown in early May. Midseason York and Keystone yielded better when seeded in mid-May. All barleys sown June 7 responded to a high seeding rate; we found that when sowing early, the seeding rate can be reduced, except with Herta. Selkirk and Pembina wheat must be sown early in May; Manitou did not respond to early planting. Selkirk seeded at 200 lb/acre yielded 29% more than at 100 lb at all seeding dates. Manitou responded to an increased seeding rate (150 vs. 100 lb/acre) when sown May 21 and June 7. Pembina responded only when sown June 7.

## Animals

*Mineral intake in relation to plane of nutrition and forage preservation.* The plane of nutrition and method of storing feed affected mineral intake. Beef cows on hay rations consumed 76 g/cow per

day, whereas those on silage ate 172 g/cow per day. Cows on full feed, 75% of full feed, and 50% of full feed consumed 104, 115, and 153 g/cow per day.

## EXPERIMENTAL FARM, SMITHFIELD, ONT.

### Crop Management

*Control of biennial bearing of Kinkead Red Spy.* Trees thinned with carbaryl, or carbaryl plus naphthaleneacetic acid (NAA) had biennial bearing indexes of 0.403 and 0.381 respectively, compared with 0.756 for untreated trees. Supplemental N as a soil application of  $\text{NH}_4\text{NO}_3$  or foliar urea sprays gave an index of 0.492.

Carbaryl plus supplemental  $\text{NH}_4\text{NO}_3$  was the most effective treatment for the first 2 years, but third year data showed that yields increased each season when thinning with carbaryl during the "on-year" was combined with extra N as urea sprays applied 10 days after petal fall; marketable yields were increased 27% over the control.

*Thinning apples in eastern Ontario.* In 1967 it was suggested that desirable thinning would be expected annually by using specific mean diameter values to time thinning spray applications to each variety. In tests in 1966-68 NAA thinned McIntosh, Spy, and Delicious maximally when applied at average diameters of 9-10, 11-12, and 7-8 mm.

*Effect of Alar on young apple trees.* Alar-treated 1-year Delicious trees in the greenhouse showed reduced terminal growth and increased dry weight of 2-year wood, bark, and root system, 102 days after treatment. Trees treated with 1,000 and 2,000 ppm produced more total growth than the controls, whereas those treated with 3,000 and 4,000 ppm showed marked reduction in shoot, root, and total growth 182 days after treatment.

Treated trees had lower levels of K in leaves and new wood 30 and 52 days after treatment, indicating an interference with

K translocation to new growth. Alar at 1,000 and 2,000 ppm reduced and at 3,000 and 4,000 ppm increased the level of soluble amino nitrogen without altering total N in the leaves. At all treatment levels soluble amino nitrogen increased after 102 days in new wood and bark. Although Ca, P, and Zn levels were higher in treated trees, the increases were probably due to growth inhibition.

*Alar delays McIntosh maturity.* Alar (*N*-dimethylaminosuccinamic acid) at 0.75 to 1.5 lb/100 gal applied 50 days before harvest delayed onset of preclimateric minimum by at least 7 days, and ethylene detection by at least 10 days. The starch index and the pressure test for optimum maturity were delayed 14 and 9 to 14 days respectively.

*Chemical weed control in strawberries.* One-half or 0.75 lb of Terbacil (DuPont) applied 4 weeks after planting in 1967 produced 1.6 to 2.0 tons/acre more than hand-weeded plots even though Terbacil caused some injury, and some weeds, particularly pigweed, were not controlled. In 1968 plantings, Terbacil at 0.25 lb/acre preplant, incorporated, followed by 0.75 lb 4 weeks after planting gave over 90% weed control with no significant crop injury. The early incorporated application showed considerable promise in the control of pigweed. Excellent quackgrass control in a renovated strawberry planting was obtained by application of 1.0 lb/acre of Terbacil to frozen ground in late November.

*Virus-indexed raspberries.* Indexing tests in the greenhouse in 1967-68 on sample plants from a trial of 12 virus-indexed va-

ieties established in 1963 showed that all varieties were infected with virus (mainly mosaic) in varying degrees, accounting in part for moderate yields recorded in 1967 and 1968. Thus, even with a normal spray program to control insect vectors, virus infection may reduce yields in 4 to 5 years.

*Zinc in relation to frost resistance.* Zinc sprays applied in May 1964 to a McIntosh orchard K trial raised the foliar Zn levels in July 1964 from an average of 15 to 55 ppm dry weight basis (DWB). On May 22, 1965, immediately before full bloom, temperatures in this orchard dropped to 30 F. On trees with foliage K levels in July 1964 of 1.25–1.40, 1.40–1.50, and 1.50–1.70% (DWB) the blossom kill due to frost was 100.0, 85.2, and 35.2% respectively when Zn was not applied and 80.2, 50.3, and 9.8% when supplementary Zn sprays were

applied. These data suggest that raising Zn levels in the foliage increased blossom survival by 20 to 35%.

*Populations of canning tomatoes.* Significant yield increases were obtained from the Heinz and Fireball varieties with populations up to 10,000 plants, and from Trent up to 15,000 plants/acre. Of greater significance than total yield in 1968, a late season, was the advancement of the date by which 20 tons/acre of ripe fruit were produced. This yield was achieved 7, 10, and 12 days earlier as the population was increased from 5,000 to 10,000, 15,000, and 20,000 plants/acre, suggesting that although populations above 10,000 plants usually do not increase total yield, they do permit removal of the crop under better conditions of color development and with less risk of frost.

## Vegetable Breeding

*Cold tolerance of tomatoes.* In a test of the ability of approximately 500 breeding lines and varieties to germinate at low temperatures, and of the frost resistance of the seedlings, it was found that although most seed will not germinate below 50 F, some

lines germinated satisfactorily at 45 F. Varietal differences were found in seedling resistance to several degrees of frost. There is no indication that cold germination is linked to frost resistance or low temperature fruit set.

## Food Processing

*Ultrastructural study of freeze-thaw damage to fruit and vegetable tissue.* In an electron microscope study it was shown that the effects of freezing and thawing on the structure of edible plant tissues at the subcellular level are due largely to the rupture and disarray of protoplasmic membranes, with consequent loss in the moisture-retaining capacity of the cells. Intermediate rates of freezing and thawing caused less damage than slower or faster rates by allowing the removal of some cellular water, by extracellular ice growth, before freezing solidification occurred. The protective effect of this "dehydrefreezing" was confirmed by using plasmolyzing agents to remove some cellular water before freezing. Studies of ice crystal pat-

terns formed during freezing suggested that intracellular ice formation is probably not as damaging as has been assumed, but that the size of ice crystals formed within the protoplasmic layer could be a critical factor.

Different fruit and vegetable tissues responded differently to freezing and thawing. The minimal "textural" change that certain nonvacuolated, high starch tissues (e.g., immature pea seeds) undergo appeared to be due to the protective effect of large starch granules that filled most of the cellular contents not occupied by protoplasmic structure, thereby preventing collapse and rupture of membranes during freezing and thawing.



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# Research Station

## Vineland Station, Ontario

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## INTRODUCTION

Research at this station emphasizes chemical and biological approaches to pest management in horticultural crops.

The first commercial trial of an integrated control program for peach was encouraging in that a single insecticide application, properly timed, was as effective as the standard four applications in the current recommendations. Research on the application of pesticides indicates that present rates may be reduced substantially in certain regions of the province. Field surveys were carried out on virus

diseases in vegetable crops and on nematodes in forage legumes. A simplified method for detecting resistance to acaricides in the European red mite will form the basis for monitoring field resistance of this pest in Ontario orchards. Research on the ecology of apple insects is being strengthened.

The new laboratory-greenhouse complex was officially opened by the Minister of Agriculture on May 24, 1968.

W. B. Mountain  
Director

## VERTEBRATE PESTS

### Bird Damage to Fruit

Dr. R. G. B. Brown, Canadian Wildlife Service, was based on the Station during the summer while he continued his research on bird damage to fruit. He paid particular attention to the importance of fruit in the birds' diet as a whole, compar-

ing the intensity of damage to the availability of various animal foods. He also ran food-choice trials with caged birds to investigate what stimulates fruit eating. A number of "protective" devices were evaluated; shotgun patrols still seem to be the most effective system.

## CONTROL OF PESTS

### Integrated Control

*Modified spray program for peach pests.* Tests with phosmet in a minimum spray program for control of the oriental fruit moth on peaches indicated that this insecticide may be useful in an integrated program for peach pests. A single application in early August in two successive years failed to induce an increase in the population of the European red mite. In a commercial orchard of the cultivar Elberta one spray of phosmet 12 days before harvest gave better control of the fruit moth than four insecticidal sprays applied according to spray calendar recommendations. Conspicuous early injury was higher in the phosmet block, but total fruit injury was less. An acaricide was included in four sprays in the fully sprayed block and none in the phosmet block, but numbers

of the red mite remained low in both blocks till mid-September when they increased somewhat in the fully sprayed block.

### Chemical Control of Fruit Pests

*Evaluation of insecticides and acaricides.* Good progress was made in the orchard and greenhouse trials of experimental compounds and spray programs against the main orchard pests. Of the 48 compounds tested, 35 were unregistered and 9 of these were carbamates.

Partly as a result of our trials in 1968 and earlier, Omite, phosalone, and menazon (Sayfos) have recently been registered for sale in Canada and recommended for use in Ontario apple orchards against mites, general orchard pests, and aphids, respectively. Further trials of

menazon on cherries showed it to be much more effective than diazinon against the black cherry aphid, giving almost perfect control for 3 weeks compared with 3 days for diazinon.

Two soil applications (July 24 and August 9) of 10% aldicarb granular to 1-year-old McIntosh apple trees at rates of 0.5, 1.0, 1.5, and 2.0 oz per inch of trunk diameter gave excellent control of a heavy infestation of the apple aphid. The three higher rates also gave fair control of the European red mite. The two higher rates of aldicarb caused some stunting of the terminal growth of the trees compared with the checks, whereas the two lower rates appeared to stimulate the terminal growth.

In trials to improve the control of the European red mite, the best results on apple were by 2% superior oil at the half-inch green stage followed by either chinometonat or Animert in the prebloom and calyx periods. Promising materials for the control of the European red mite on Italian prunes were Carzol (E.P. 332), tetradifon, chlorphenamide, and G. S. 19851. The last material also controlled the plum rust mite.

When used in seasonal protection programs in bearing apple orchards, very good control of most apple pests except the European red mite was given by the organophosphorus compounds bromophos, phenthoate, fenitrothion, Gardona, and phosalone and the carbamates Bay 37344, methomyl, and carbofuran.

In the search for safe and effective compounds to replace DDT in the grape spray program, in case its use is restricted, the two most promising materials tested in 1968 were the carbamate methomyl and the organophosphorus compound C-9491. The latter is of special interest because of its low mammalian toxicity (2,000 mg/kg). Other compounds that gave as good as or better control than DDT for the grape berry moth were phosmet, carbaryl, Gardona, Bay 77488, and phenthoate.

*High- and low-volume spraying of grapes with reduced amounts of pesticides.* In vineyards, a general trend is toward light-weight low-volume concentrate sprayers that are cheaper and cover larger acreages per tank than the conventional high-volume hooded-boom sprayer. Because de-

posits on foliage from concentrated sprays are often greater than from dilute sprays, reductions in rates per acre are being suggested by manufacturers.

To find ways to improve the performance of both dilute and concentrate sprayers and to reduce rates per acre, a cooperative experiment was conducted with Bright's Wines Ltd. Three rates of pesticides per acre were each applied by three spray machines to Agawam grapes for each of the recommended summer sprays, namely, prebloom, postbloom, and first cover. High-volume sprays of 75-125 gal/acre (larger amounts in later sprays) were applied with a Friend hooded-boom sprayer to both sides of each row. In contrast, very low volume sprays of 5.0-8.5 gal/acre were applied to one side only of each row by two air-blast, concentrate sprayers, the Marlow 'Econ-o-mist' (compressed air atomization) and the Rittenhouse 'Conjet' (air shear atomization). For economic reasons the driving distance per acre had to be the same for each machine. The fungicide folpet, the insecticide carbaryl, and the acaricide tetradifon were applied at the recommended rates per acre and at  $\frac{1}{2}$  and  $\frac{1}{4}$  of these amounts. Water-sprayed and unsprayed checks were included in the test, which was laid out in a randomized triplicate block design.

Spray coverage of foliage was observed with a fluorescent green dye, Phosphor 2283, and recorded as an index of distribution. Additional information was obtained from the chemical analysis of carbaryl residues on the foliage by a colorimetric method. Both of these methods showed that the hooded-boom sprayer gave a very uniform, high deposit on both sides of the row. The air-blast machines gave a lower deposit and variable coverage on the side of the row facing the sprayer and poor to fair coverage with low carbaryl deposits on the side away from the sprayer.

The populations of the European red mite and the two-spotted spider mite in early August, and the severity of downy and powdery mildew infections were measured. The grape berry moth was too scarce to be measured. Mite control was generally inadequate, but was better with the hooded-boom sprayer than with the Econ-o-mist and Conjet. The full and  $\frac{1}{2}$  rates of pesticide applied by all three

sprayers and the  $\frac{1}{4}$  rate applied by the hooded-boom were about equally effective, whereas the control at the  $\frac{1}{4}$  rate applied by the air-blast machines was markedly inferior. These trends were confirmed by the severity of powdery mildew infections. Powdery mildew control was significantly better with the hooded-boom sprayer than with the concentrate sprayers with which the full recommended rate of folpet was used. Even with the  $\frac{1}{2}$  and  $\frac{1}{4}$  rates the hooded-boom sprayer controlled mildew as well as did the Conjet and Econ-o-mist applying the full rate.

The poor control of mites and powdery mildew obtained with the concentrate sprayer was largely explained by the uneven spray coverage and low pesticide residues on the sides of the vines away from the sprayer. The air-blast concentrate sprayers would undoubtedly have given very much better results if they had been used to spray both sides of each row. However, the driving distance would then have been twice that of the hooded-boom sprayer. Further cooperative trials will follow to find the optimum way to operate each of these sprayers under grower conditions.

*Protectant and eradicant spray programs for apple scab control.* Three fungicides, benomyl, Bay 33172, and dodine, all at 0.5, 0.25, and 0.12 lb active ingredient per 100 gal were compared in a 14-spray protectant program (May 2 to September 10) and a 10-spray eradicant program (May 13 to September 3) on McIntosh apple trees. Intervals between consecutive protectant sprays were 7 days in May and 12 days in the remainder of the season. Consecutive eradicant sprays were not applied at intervals shorter than those used in the protectant program. Each of the eradicant sprays was applied at the equivalent of 40 hr at 55 F after the beginning of the infection period.

In the protectant program, all rates of the three fungicides gave good control of scab on the fruit. Control of leaf scab was fair with dodine and benomyl but poor with Bay 33172. In the eradicant program, benomyl effectively controlled both fruit and leaf scab and also showed distinct acaricidal activity. The other materials gave inadequate control of scab and no control of the European red mite.

*Tree shape vs. spray coverage and mite control.* Large mature Northern Spy apple trees were photographed and measured in June, July, August, and September to illustrate their changing shape as developing fruit depressed the ends of the branches. By August the middle branches had dropped, thus thickening the lower portion of the canopy and exposing the top branches. A fluorescent dye tracer added to an acaricide spray showed that the outside bottom of the canopy had the heaviest deposits, the top somewhat less, and the center, bottom, and skirt inside very poor coverage. Mite populations bore a direct relationship to the number of poorly sprayed leaves.

*The detection and measurement of dicofol resistance in the European red mite.* Dicofol is still one of the best acaricides available to Ontario fruit growers though resistance of the European red mite to it has been suspected in some orchards. To determine if reported mite control failures following applications of difocol were caused by resistance or by other factors such as poor spray coverage, a simple leaf-disc method was standardized at the Station. By comparing resistant and susceptible laboratory colonies, it was possible with one concentration of dicofol to confirm resistance as the cause of control failure in five out of eight orchards where resistance was suspected in 1968. The method was sensitive enough to measure the early stage of resistance development and thus to indicate when an alternative acaricide should be used.

A rapid method for analyzing dicofol deposits, developed at the Station, was very useful in devising the test for resistance by mites and in studying the distribution and degradation of dicofol deposits on foliage.

*Nematode control in established orchards.* Application of the nematicide 1,2-dibromo-3-chloropropane (DBCP) at the rate of 4.5 gal active ingredient per acre reduced the number of a root-lesion nematode, *Pratylenchus penetrans* (Cobb), by as much as 80% in the soil around established peach and sweet cherry trees. The nematicide was injected 6-7 inches deep on two sides of the tree with a tractor-drawn spring-tooth applicator. The chemi-

cal was applied as close to the trees as possible with negligible damage to feeder roots. The tests show that DBCP will reduce root-lesion nematode populations around established orchards without any

phytotoxic effects. However, it has not been determined whether or not the resulting growth and yield increases will be sufficient to make such a practice acceptable.

## ECOLOGY OF INSECTS AND MITES

### Factors Affecting the Population Dynamics of the European Red Mite in Peach Orchards

Artificial introduction of a virus disease quickly reduced experimental populations of the European red mite on orchard trees, and the infection also spread to nearby trees. A high density of the mites appears to be necessary for the maintenance and spread of the infection. Instability of the virus, especially its inactivation by water, may limit its use for practical control of the mite.

### Behavior and Ecology of the Oriental Fruit Moth

*Host preference of females.* When given a choice of branches of apple, peach, pear, or quince on which to oviposit, on a slowly revolving stage in an open insectary, females of the oriental fruit moth laid the fewest eggs on apple foliage either with or without fruit on the branches. Approximately the same numbers of eggs were laid on peach branches with or without green or ripening fruit as on pear or quince branches with both foliage and fruit. On quince the eggs on leaves tended to be clustered close to the fruit; numerous eggs were laid on both pear and quince fruit, whereas very few were laid on peach fruit. There was no indication that the females were attracted to ripening fruit, which newly hatched larvae penetrate most easily.

*Artificial diets.* The codling moth diet used in British Columbia failed to support oriental fruit moths for more than four generations and necessitated a further investigation of artificial diets. A relatively simple diet containing alfalfa meal, vitaminized apple juice, brewers' yeast, and agar gave a good yield of moths for three successive generations. Waxing the surface

of the diet and puncturing the wax with pin holes is necessary to start feeding by newly hatched larvae.

### Ecology of the Codling Moth

*Survey of codling moth populations in Ontario.* The density of overwintering populations of the codling moth in abandoned orchards in eastern, central, and southern Ontario (1.5–2.1 insects per tree trunk) was found to be somewhat higher than that at Georgian Bay and in southwestern Ontario (0.8–1.2 insects per tree trunk). On all trees, populations were highest on the first foot of trunk above ground level irrespective of tree trunk height. Natural mortality varied between 56% and 88%, and appeared to be higher in the northern than in the southern parts of an orchard. Bird predation seemed to be the most important biotic factor, accounting for 48–93% of the observed mortality. Disease, with the exception of orchards at Georgian Bay (34%) and southwestern Ontario (47.6%), as well as parasitism (0.6–9%) and freezing (0.4–3.1%), appeared to be generally of minor importance.

### Grape Phylloxera

Investigation of the occurrence of different strains of the grape phylloxera did not show evidence of additional strains. Strain I and isolates from *Vitis riparia* Michx. and cultivar Clinton produced mainly necrosis on the leaves of the cultivar Foch and the rootstock *Vitis riparia* × *rupestris* 3309 in both field and laboratory. Strain II, originally collected from Foch, and isolates from '3309' produced galls on both Foch and '3309'. In the field, Strains I and II incited many aborted galls on Delaware and produced neither galls nor necrosis on Concord and Niagara.



# PLANT DISEASES

## Fungus Diseases of Vegetables

*Susceptibility of cabbage varieties to Ontario isolates of Fusarium oxysporum f. conglutinans.* Early Marvel, Chieftain Savoy, and Mammoth Red Rock cabbages grown at a soil temperature of 26 C were killed or severely injured within 4 weeks of inoculation with a mixture of eight Ontario isolates of *Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyder & Hans. Supposedly yellows-resistant Marion Market Autumn Marvel, Greenback YR, and Badger Market YR were moderately or slightly infected; whereas Market Prize and Golden Acre YR had only traces of infection. Vascular discoloration was common in the stem tissues of both susceptible and resistant varieties. However, fungus isolation was easier from tissues of severely affected varieties than from those with a trace of infection.

*Carrot "rusty root."* This disease was observed in the Bradford Marsh of Ontario in 1968. Symptoms on mature plants included forking of tap root 2-3 inches below the soil line and "rusting" (necrosis) of lateral roots. Forking appeared to be due to tap root abortion, which apparently started during the seedling stage. *Rhizoctonia solani* Kühn, *Fusarium* sp., and *Alternaria* sp. were isolated from necrotic tap roots; *R. solani* and an unidentified fungus were isolated from lateral, rusty roots. Seedling emergence was 100% in steamed muck soil, whereas seed decay and severe postemergence damping-off occurred within 25 days of seeding in untreated soil. *Pythium* sp., *Penicillium* sp., *Fusarium* sp., and an unidentified fungus were recovered from infected roots.

## Virus Diseases of Vegetables

*Survey of virus diseases of vegetable crops in Ontario.* Fifteen of 31 vegetable crops examined between May and October 1968 contained viruses or showed virus-like symptoms. Viruses tentatively identified were: cucumber mosaic (CMV), tobacco mosaic (TMV), turnip mosaic, cauliflower mosaic, bean yellow mosaic, common bean mosaic, squash mosaic, lettuce big vein, and lettuce mosaic. The

incidence of infection was below 2% of the plants examined in all but a few crops. Symptoms of field-infected plants, particularly tomatoes and peppers, were difficult to correlate with the presence of specific viruses. A CMV-TMV virus complex seriously reduced the growth and yield of the pepper cultivar Romanian in Lincoln County. Big vein of lettuce, previously reported from Essex County, was detected in Lincoln, Welland, and Norfolk counties. At one location the incidence of this virus reached about 38%, but most of the infected plants produced marketable heads.

*Viruses in imported rhubarb.* Indexing of rhubarb clones (cultivar Timperley Early) from England detected turnip mosaic, arabis mosaic, and two unidentified sap-transmissible viruses. Monthly indexing showed that transmission failures are common, particularly in the late summer. Arabis mosaic has not been reported in Canada; neither has its known nematode vector. Many isolates of this virus differed widely in biological activity and their identity required serological confirmation.

*Studies of mode of transmission and control of Canadian cucumber necrosis virus.* Zoospores released into cucumber necrosis virus (CNV) antiserum from roots of cucumber, naturally infected with virus and *Olpidium cucurbitacearum*, failed to transmit CNV; whereas zoospores released into water or normal serum did so. Identical results were obtained with systemically infected cucumbers that were exposed to virus-free zoospores. These results and those previously reported from this station show that the zoospores are virus-free when released from infected roots and subsequently become infective by contact with released virus. Control of the fungus in the soil was attempted with several fungicides of which quintozene and ferbam proved to be the most effective. Adequate and nonphytotoxic rates for these materials are being determined.

## Virus Diseases of Fruit

*A sap-transmissible virus associated with diseases of peach and grape.* Isolates of peach rosette mosaic virus (PRMV) trans-

mitted to *Chenopodium quinoa* from peach and grape have both been returned to peach and recently to grape. Symptoms in peach and grape only partly represented those seen under field conditions. PRMV was detected in 80–90% of the seedlings from inoculated *C. quinoa*; only 2–4% of the seedlings showed symptoms. The infectivity of partially purified PRMV was increased by passage through a column of Sephadex-200. Electron micrographs of isolates from peach and grape showed similar 28 m $\mu$  particles. Comparative serology with serum to peach and grape isolates indicated a close strain relationship.

### Serological Studies

*Characteristics of the immune response.* The development of cross-reactivity has been studied in over 40 rabbits given both primary and several anamnestic stimulations with a plant virus. Test periods ranged from 92 to 151 days post primary stimulation. All rabbits exhibited a similar development of cross-reactivity; that of the

3–7 day serum was always greater than that of serum taken several weeks later. The average occurrences of minimum cross-reactivity and maximum antibody titer (primary response) were 21 and 23 days. The time of occurrence and the duration of minimum cross-reactivity appeared only slightly if at all affected by the total dosage (4–500  $\mu$ g), schedule of injection (day 0; 0, 7, 14; 0, 7, 14, 21, 28; 0, 14, 28; 0, 14, 28, 42; and 0, 28), route of injection (intramuscular or intravenous), or the virus vehicle (water, 10% and 50% Freund adjuvant, or 0.7–8% agar). Anamnestic responses were inducible as early as 27 days and were induced as late as 109 days post primary stimulation. During anamnestic responses (25–56 day test periods), the percent cross-reactivity either remained unchanged or increased, whereas antibody titers in all cases increased. Averages of cross-reactivities for early and late (inclusive of anamnestic period) serum were 10.6% and 22%; the average minimum cross-reactivity was 5.8%.

## NEMATODES

### Ecology of Nematodes

*Influence of the soil environment on penetration of root-lesion nematodes.* The penetration of the roots of corn by *Pratylenchus penetrans* (Cobb) and *P. neglectus* (Rensch) was studied in three soil types, at two bulk densities, at six moisture tensions, and at three temperatures. Fox loamy sand, Vineland silt loam, and Jeddo loam were the soil types. The time allowed for penetration was 72 hr. Adults and larvae of both species responded to the physical factors.

Penetration of corn roots by both species was always greater in all three soils at low bulk density when moisture tension was optimal. This was most pronounced in Jeddo and Vineland soils.

In Fox soil maximum penetration of roots by *P. penetrans* occurred while the soil was draining and by *P. neglectus* just as the soil began to drain. In Jeddo and Vineland soils maximum penetration by *P. penetrans* occurred just as the soils began to drain and by *P. neglectus* before the soil began to drain. At field capacity,

penetration by both species fell off drastically.

The optimum temperature for penetration was 20 C for *P. penetrans* and 30 C for *P. neglectus*.

Adults and fourth-stage larvae of *P. penetrans* always penetrated roots in greater numbers than second- and third-stage larvae, whereas second- and third-stage larvae of *P. neglectus* in Jeddo and Vineland soils at 20 and 30 C penetrated roots in equal and often in greater numbers than adults and fourth-stage larvae.

*Distribution of cyst and root-knot nematodes.* Forage legume crops in 31 counties of southwestern, central, and eastern Ontario were sampled in 1968 for root-knot and cyst nematodes. The northern root-knot nematode, *Meoidogyne hapla* Chitwood, was present in 30 of 130 samples at an average of 370 larvae/lb of soil. The clover cyst nematode, *Heterodera trifolii* Goffart, and the oat cyst nematode, *H. avenae* Wollenweber, were found in 35 samples averaging 1,122 larvae/lb of soil. The root-knot and cyst

nematodes were found together in 14 samples. Clover cyst and root-knot nematodes appeared to be common over the whole region sampled.

*Pin nematode on rhubarb.* In 1968 the pin nematode, *Paratylenchus projectus* Jenkins, was found in all of the 18 samples taken from rhubarb-forcing sheds of 14 growers. Ten of these growers re-

ported less than average yields of forced winter rhubarb.

Yields of grade 1 and 2 stems were significantly reduced when roots of rhubarb, cultivar Victoria, were inoculated with 10 or 20 thousand pin nematodes per root in a forcing room (12 C, 85% relative humidity, and constant darkness).

## MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

### Trade name

Animert  
Bay 33172  
Bay 37344  
Bay 77488  
Carzol (E.P. 332)  
C-9491  
Gardonia  
G.S. 19851  
Omite

### Manufacturer

Green Cross Company  
Chemagro Corporation  
Chemagro Corporation  
Chemagro Corporation  
Morton Chemical Company  
CIBA Company Ltd.  
Shell Chemical Company  
Geigy Chemical Corporation  
UniRoyal Limited

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# Animal Research Institute

## Ottawa, Ontario

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F. A. VANDENHEUVEL, B.Sc., M.Sc., Ph.D.	Steroids, lipoproteins, and biological membranes

## VISITING SCIENTISTS

C. R. DICKSON, B.Sc., Ph.D. National Research Council postdoctorate fellow 1968-69	Selenium metabolism
A. K. MOSI, B.S.A., M.Sc. External Aid trainee, September 1967-68	Palatability and digestibility of forages

## INTRODUCTION

The rebuilding program, wherein the Animal Research Institute is constructing all new animal facilities at its 2,800-acre "A.R.I. Greenbelt Farm," took an enormous effort from the scientific and operational staff during 1968. By early 1969 all the buildings for dairy cattle and poultry will be completed, and projects using these species will be conducted at the new farm. One sheep barn was completed in 1968 and two others will be completed in 1969.

The new animal accommodation has permitted the development of a more extensive program on the nutrition of dairy calves, heifers, and milking cows. The dairy cattle breeding program is under review and will likely be redesigned in order to use the new facilities more effectively in 1969. Studies on the nutritional requirements of adult egg- and meat-type fowl are now possible since the completion of the new poultry buildings.

The reproductive physiology program utilizing sheep as laboratory animals has been started. Emphasis is being placed on the mechanisms that control estrus and ovulation and the identification of the related steroids in blood.

An attempt is being made to develop a sheep that is adapted to intensive housing throughout its life, that lambs twice a year, and that has twins or triplets at each lambing. Geneticists, nutritionists, and physiologists are cooperating in this program. If such a sheep can be developed, it might make lamb a more economical meat product for Canada, despite the year-round housing requirements.

Considerable progress has been made in unraveling the causes of ketosis in ruminants, and the metabolism of selenium in relation to White Muscle Disease.

R. S. Gowe  
Director

## BIOCHEMISTRY

### **Etiology of Nutritional Muscular Dystrophy in Farm Animals**

Studies were continued on the mechanisms by which selenium (Se) is converted to organo-Se compounds in animal tissues and functions in the prevention of muscular dystrophy.  $\text{Se}^{75}\text{O}_3$  incubated with chick or guinea pig liver homogenates (phosphate buffer, pH 7.0; 20 C) was bound nonenzymatically to the liver proteins within 30 sec. Selenocystine, selenomethionine, and selenate were inactive. Oxidation of the protein sulfhydryls with peroxide or alkylation with iodoacetamide prevented selenite uptake, which suggests that the Se is bound as protein-selenotrisulfide (protein-S-Se-S-protein). Liver cell fractionation studies showed that all subcellular structures are able to fix  $\text{Se}^{75}$  in proteins. On a  $\text{N}_2$  basis, the microsomes were the principal site of  $\text{Se}^{75}$  uptake, fol-

lowed by the soluble, mitochondrial, and nuclear fractions.

Selenite and selenomethionine, orally administered to pregnant and lactating ewes, were carried by the  $\alpha_2$ - and  $\gamma$ -globulins. For both Se treatments, more than 80% of the milk Se was found in the caseins. The ratio of blood serum Se concentrations for the lambs and their dams ranged from 0.4 to 0.5, and 0.7 to 0.9 for the selenite and selenomethionine treatments, which demonstrated a higher transfer efficiency for organically bound Se. The results showed that less than 50% of the Se in the serum proteins was protein-selenotrisulfide, the predominant form in monogastric animals.

### **Studies on Energy Utilization in Animals**

Recent findings have demonstrated the presence of a contractile principle in the membrane of skeletal muscle mitochon-

dria, which acts as a regulator of the extent to which generated high-energy bonds are exposed to hydrolysis and thus appears to constitute a basis for metabolic control. The findings show that this  $Mg^{++}$ -controlled swelling mechanism involves the operation of either a specific  $Na^+$ -activated adenosine triphosphatase or an uncoupled respiration. Support of swelling by uncoupled respiration also shows a requirement for alkali metal cation, although this requirement shows no cation specificity. The findings suggest that proton release is the rate-limiting factor involved in facilitated diffusion and that exchange diffusion is the basis for ion translocation after the establishment of a proton gradient.  $Mg^{++}$  imposes control of respiration by phosphorylation and prevents ATP- as well as substrate-supported exchange diffusion.

Facilitated diffusion is also promoted by thyroxine, added in the form of a soluble albumin complex. However, it is apparent that thyroxine does not promote swelling simply because it chelates  $Mg^{++}$ , since each kind of facilitated diffusion has its own specific requirements. In contrast to the  $Na^+$ -specificity for ATP-supported swelling in the absence of  $Mg^{++}$ , thyroxine in the presence of  $Mg^{++}$  promotes ATP-facilitated diffusion in the presence of  $K^+$ -salts only.

In contrast to the observed  $Na^+$ -adenosine triphosphatase in the absence of  $Mg^{++}$ , a thyroxine-stimulable  $K^+$ -adenosine triphosphatase or  $K^+$ -pyrophosphatase has not been found under swelling conditions. As with swelling in the absence of  $Mg^{++}$ , respiratory substrates support a thyroxine-induced swelling that shows no alkali metal cation specificity. This substrate-supported swelling is rotenone-sensitive, but fails to respond to cyanide. Although respiratory substrates support swelling in the presence of thyroxine, they fail to support respiration under the same circumstances. The findings suggest that thyroxine acts to promote an electron bypass.

### **Studies on the Mechanism of Hormone Action**

One striking difference was observed among different species of experimental animals in regard to their response to hormone action on gluconeogenesis. Tri-

aminolone diacetate, which elevates the blood glucose level, hepatic glycogen, and total RNA contents, and causes marked increases in the activities of aspartate and alanine aminotransferases, phosphoenolpyruvate carboxykinase, glucose-6-phosphatase, and fructose-1,6-diphosphatase in the livers of fasting or fed rats, did not produce any such changes in the livers of chickens or guinea pigs. The increased gluconeogenesis (measured from blood-glucose level) from alanine, aspartate, glutamate, and pyruvate was not noticed in chickens, although it was observed in rats. Marked increases in the activities of the key enzymes associated with the gluconeogenic pathway were observed in hormone-treated rats and were believed to be caused by the induction of these enzymes. This latter process depends on the concentration of cellular RNA, particularly mRNA, and, as expected, an inverse relationship between gluconeogenesis (glucose production) and the activities of RNA-degrading enzymes was found in rats after treatment with the hormone. The ribonuclease inhibitor activity, however, was not affected.

After hormone treatment, a significant reduction in the concentrations of free alanine, serine (plus threonine), and aspartate and a significant increase in glutamate concentration were noted in the liver of fasting rats, but in the liver of the fasted rat the concentration of serine only was significantly reduced. A significant increase over the control was found in the rate of autolysis of muscle proteins from fasting and hormone-treated fasting rats, which suggests a relationship between the rate of autolysis of muscle proteins and the release of amino acids *in vivo*.

### **A Study of the Metabolism of Ruminant Ketosis and the Utilization of Volatile Fatty Acids**

Studies have led to the conclusion that animal ketosis is primarily the result of fatty-acid mobilization and transport to the liver and not directly related to lack of gluconeogenic precursors. Although lack of glucose may be the stimulus required to initiate fat mobilization (and ketosis), it may not per se be the primary cause of ketosis. Ketotic cows were infused (via a jugular vein catheter) at the rate of 20



mmoles/hr with DL-carnitine, propionylcarnitine, sodium propionate, sodium acetate, sodium aspartate, or glucose. The glucogenic precursors (propionylcarnitine, propionate, and aspartate) and acetate were not effective in reversing the symptoms of ketosis (i.e., elevated blood ketone bodies and depressed glucose). The infusion of DL-carnitine successfully reversed ketosis in two of three animals treated. Blood ketones (acetoacetate plus  $\beta$ -hydroxybutyrate) fell from levels of 35–60 mg/100 ml whole blood to normal values of 5–20 during a 24-hr period of infusion. Blood-glucose values rose during the same period of infusion from 25–35 mg/100 ml whole blood to normal values of 50–65 mg/100 ml.

The possible inhibitory role of long-chain fatty acids on some key enzymes of the tricarboxylic acid cycle was investigated.

A model reaction was discovered, which involved the catalytic cleavage of 5,5'-dithio-bis(2-nitrobenzoic acid) (DTNB) by the  $\alpha$ -ketoglutarate dehydrogenase complex. This reaction was used to demonstrate that long-chain ( $C_{14}$ – $C_{22}$ ) acyl-CoA esters inhibit the overall reaction by irreversible binding to the CoASH site (irreversibility results from an interaction between the acyl-CoA side chain and the hydrophobic regions in the enzyme); short-chain acyl-CoA esters ( $C_2$ – $C_6$ ) are inhibitory as a result of competition for the CoASH site as well as by transacylation to the lipoic acid residues in the enzymes. Comparison of pyruvate and  $\alpha$ -keto-glutarate dehydrogenases demonstrated that the former enzyme is more readily subject to control by the acyl-CoA:CoASH ratio than is the latter. This is further evidence of the importance of fatty-acid esters in controlling metabolic rates.

## GENETICS

### Biochemical Polymorphisms

*Serum esterases in poultry.* A polymorphic system of nonspecific serum esterases that exhibited genetically controlled differences in electrophoretic mobility on a tris-HCl pH 7.0 starch gel was reinvestigated using a tris-citrate pH 8.95 starch gel. This new system showed one esterase zone per allele rather than the two to three zones per allele shown on the pH 7.0 system, and showed a new zone controlled by a third allele. Investigations of these esterases with neuraminidase showed that each zone is probably composed of esterase molecules with two sialic acid residues attached.

Sera from about 1,400 meat-strain hens were assayed for activity of the nonspecific esterases previously mentioned. About 15% of these hens had already laid their first egg when they were bled at 160 days of age. The correlation between the age when the first egg was laid and the nonspecific esterase activity was +0.5. A plot of the optical density (reflecting esterase activity) against the age when the first egg was laid for 160 hens showed that the optical density was less than 0.26 for all hens that had laid their first egg by 160

days of age, whereas those that laid their first egg after 160 days had optical density readings of 0.11 to 1.47.

*Cholinesterase in chickens.* A cholinesterase polymorphism has recently been elucidated in chicken sera. All sera exhibit a pattern with one zone of this esterase, whereas other serum patterns exhibit an additional faster migrating zone. The presence of this fast zone is caused by a dominant gene.

### Egg Quality

*Variation and selection for egg quality.* Measurements of specific gravity, egg weight, and albumen height of eggs from three consecutive trap days were taken at approximately 225, 350, and 450 days of age, for 3 years, from three strains of Leghorns. Haugh units were calculated for each egg.

Pooled estimates within the 27 strain-period-year subclasses for heritability of single-egg records from sire components were 0.36, 0.48, 0.46, and 0.45, and for repeatability were 0.68, 0.74, 0.76, and 0.74, for the four traits—specific gravity, egg weight, albumen height, and Haugh units. The intraclass correlations between

period-means of the same hen, expressed in standard deviation units for each subclass, were 0.58, 0.71, 0.74, and 0.69. Heritability from sire components for pullet means over the three periods (annual performance) averaged 0.57, 0.66, 0.65, and 0.64.

Using a generalized formula to express the effect of varying the number of periods ( $N$ ) and of eggs per period ( $n$ ) on the accuracy in predicting breeding values for annual performance, it was concluded that sampling three eggs from each hen in each of three or four periods throughout the laying year was nearly optimal. Sampling two or three eggs from each hen in only two periods before the hens were 10 months old should be 95% as accurate; this procedure permits a generation interval of 1 instead of 2 years.

### **Meat Production, Poultry**

*Egg size and growth.* Numerous research investigations have clearly established that the weight of the chick at hatching is closely related to the size of the egg from which it hatched. A similar positive relationship has been shown also between the size of the hatching egg and the subsequent post-embryonic growth of the chick. It has been commonly inferred, as attested by commercial practices, that the relationship between hatching-egg size and postembryonic growth is an extension of the effect of egg-size environment on embryonic growth. An alternative hypothesis for such an observed association is the genetic relationship between a maternal trait (hatching-egg weight) and a trait of the progeny (body weight at a given age).

Experiments were carried out to test these two alternate hypotheses. The evidence for a direct (environmental) carry-over effect of maternal egg size, as related to parental age, on postembryonic juvenile growth to 56 days of age was not entirely consistent, but was primarily negative. However, deviations (environmental) from an individual dam's mean egg weight showed a very small but consistent positive relationship with 56-day body weight of male progeny, but a negative relationship with female progeny. The principal basis for the observed relationship between hatching-egg size and postembryonic growth appeared to be due to the genetic relationship between the maternal trait

(egg weight) and the progeny trait (body weight).

*Growth pattern and correlated responses.* In each of two lines, one selected for high 63-day and one for high 147-day body weight, direct and correlated responses up to the seventh generation were in good agreement with predictions, based on genetic parameter estimates on the base population (Ottawa Meat Control Strain). The primary trait increase in each line was slightly over 30%, whereas reproductive fitness (hen housed egg numbers  $\times$  fertility  $\times$  hatchability) decreased 25% and 47% in the 63-day and 147-day lines.

A concurrent experimental line from the same base population, selected on a rank index for high 63-day and low 147-day weight and with approximately the same intensity as the other lines, showed an increase of about 15% in 63-day but no change in 147-day body weight and a loss in reproductive fitness less than 3%.

Inbreeding was less than 1% per generation in each of the lines. All traits showed some inbreeding depression.

### **Dairy Cattle**

*Age adjustment of milk records.* A new method of adjusting milk-yield records for differences in age at calving has been devised. It is called the Prediction Method, because it is based on a regression equation that relates yield to age of the cow at calving, herd average yield, and average calving age in the herd. It is at least 15% more accurate than the presently used Contemporary Comparison or Herd Mate methods, as judged by the similarity of ranking of bull progeny groups in different seasons of calving.

*Genetic adaptation.* Genetic adaptation in teat shape and size has been observed in three breeds on a selection experiment. In 13 years of selection for high milk yield, the length and diameter of teats have decreased in Holsteins and Ayrshires and increased in Jerseys. The phenotypic relationship between these measurements and the yield was in the same direction as the genetic correlated response in teat shape to selection for yield. These relationships were more pronounced in herds with high production. This selection experiment suggests that cows with teats

deviating from optimum size cannot express their true genotypic potential for milk production and that this effect is more pronounced in high-producing herds than in low-producing herds.

*Weight loss and level of production.* Recent studies have shown that twice as much of the variation in milk yield is accounted for by differences in the weight loss of cows during the first 180 days after calving as is accounted for by differences in weights of cows at 180 days after calving. It is presumed that the weight loss represents mainly loss of fat. The correlation between weight loss and milk production was less for second and later lac-

tations, presumably because the dry periods do not allow as much variation in fatness as does the growth period for heifers. These relationships also suggest that the different yield-age relationships for spring and fall fresheners may be due to more restricted feeding during the winter season (spring fresheners). This would lead to lower production for younger and less competitive heifers freshening in the spring. Although overfatness may be harmful, the time of breeding should be determined by the degree of fatness in order to minimize the cost of rearing heifers in relation to future yield.

## NUTRITION

### Available Energy from Forages and Wood

Relatively simple processes, such as steam heating or simple chemical treatment, have resulted in substantial increases in the *in vitro* dry-matter digestibility (DMD) of the woods of poplar (up to 50% DMD, from 23% for untreated) and birch (up to 40% DMD, from 15% for untreated). Similar attempts with the conifers lodgepole pine, black spruce, and eastern hemlock have been unsuccessful. These woods have shown an almost complete lack of *in vitro* fermentation after a wide variety of chemical or physical treatments, or both, except for chemical pulping, which yielded various fractions of purified cellulose and hemicellulose. Work on hardwoods and softwoods is continuing and will be extended to animal feeding trials.

### Selenium and Tocopherol Metabolism in Sheep

Se<sup>75</sup> given orally was incorporated rapidly into the tissues. The highest concentrations occurred in kidneys, liver, and adrenals. Elimination was also rapid; over 80% of the dose was excreted in the feces within 3 days and all but traces of the remainder in the urine within 10 days. Absorbed Se was passed effectively to the fetus in pregnant ewes.

Following oral administration of  $\alpha$ -tocopherol-H<sup>3</sup>, most of the subsequent radioactivity at 4, 24, and 48 hr was in

the abomasum, duodenum, and liver. Adrenal tissue lipids reached the highest specific activity; the spleen reached somewhat lower levels.

### High-concentrate Feeding of Lactating Cows

After parturition, 36 cows were fed either (A) a grain mixture *ad lib.* plus 3.6 kg hay/day, or (B) hay *ad lib.* plus grain mixture rationed to 1 kg/3 kg milk produced. Comparative results for groups A and B respectively were: daily milk yield, 20.6 and 18.4 kg; daily digestible energy (DE) intake, 27.6 and 28.7 Mcal; plasma glucose, 25.7 and 30.1 mg/100 ml; and plasma ketones, 3.20 and 4.15 mg/100 ml. One cow in group A and five in group B were treated for clinical ketosis. In a further experiment, 48 cows were divided into four groups and fed: (A) a concentrate with 2% tallow *ad lib.* plus 2.7 kg hay/day; (B) a concentrate with 6% tallow *ad lib.* plus 3.7 kg hay/day; (C) the 2% tallow concentrate rationed to 1 kg/4 kg milk plus hay *ad lib.*; or (D) the 6% tallow concentrate rationed to 1 kg/4 kg milk plus hay *ad lib.* All cows produced similar milk yields (mean 17.7 kg/day), but those fed restricted concentrates had higher butterfat percentages (3.70 vs. 3.1), milked for 12 days longer on the average, and gained less weight (45 vs. 79 kg) than those fed concentrates *ad lib.* Cows fed the high-

fat diets produced milk with 3.34% fat, compared with a 3.46% for those fed low-fat diets. The milk from the cows fed the high-fat diets contained higher levels of Mg, K, and Ca than that from the cows fed the low-fat diets.

### Ground Roughages in High-concentrate Diets for Beef Cattle

In concentrate diets based either on barley or corn, the inclusion of 40% ground oat straw, barley straw, or low-quality hay depressed growth and efficiency of feed conversion, compared to roughage-free diets, in Holstein-Friesian steers. Rate of gain differed little with type of roughage or fineness of grinding. Efficiency of feed conversion was best with hay diets and poorest with those containing barley straw. Coarse-ground straw was utilized more efficiently than fine-ground, but the degree of fineness had little effect on hay. DE values, determined with sheep, declined with increase in fineness and were lowest for the hay-containing diet.

### Uptake and Utilization of Sodium Bicarbonate by the Laying Hen

The addition of 0.5% NaHCO<sub>3</sub> to the diet of the laying hen had no effect on the pH of the proventriculus, gizzard, duodenum, small intestine, or large intestine. The addition of 5.25% CaCO<sub>3</sub> to the basal diet increased significantly the pH in the proventriculus, gizzard, and large intestine. There was no interaction between the two salts on the pH of the digestive tract.

The introduction of C<sup>14</sup>-labeled NaHCO<sub>3</sub> into the crop showed that total expulsion as CO<sub>2</sub> in expired air was complete in 1.5 hr. Following ligation of the digestive tract 1 hr after administration of the tracer, only 0.7% of the dose was present in the tract and 84% in the crop. When tracer was administered 4 to 6 hr before oviposition, 3.4% and 2.7% of the total dose for low and normal chloride diets respectively was found in the shell, a non-significant difference.

## PHYSIOLOGY

### Reproduction

*Growth and development of the ovarian follicle in sheep.* In contrast with the cow, in which two successive waves of ovarian follicular development occur, the evidence in sheep suggests that the follicle that grows during the first few days of the estrous cycle is the one destined to ovulate. Experiments in which the largest follicle present in the ovaries on the 5th to 8th day of the cycle were marked have confirmed that only one wave of follicular growth occurs in the ovaries of sheep. A number of different procedures have verified that this follicle is ripe for ovulation early in the cycle. It is of interest that in the absence of a corpus luteum, follicular development and ovulation in the sheep

may have a time span very similar to the rat, i.e. 4-5 days.

*Steroid hormones and their metabolites.* In view of a projected systematic investigation of the levels of steroid hormones and their metabolites in farm animals, analytical methods applicable to the estimation of very low concentrations of these compounds in tissues and body fluids have been investigated for some time in these laboratories. Considerable improvement in efficiency, sensitivity, and accuracy has recently been achieved with a combined thin-layer and gas-liquid chromatography method of analysis. New methods of identification, applicable at the nanogram level, based on a systematic study of the TLC and GLC behavior of over 200 standard steroids, have been developed.

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# Cell Biology Research Institute Ottawa, Ontario

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Z. POLAK, Prom.Biol., C.Sc., R.N.Dr., 1968-69	Virology
E. STRZELCZYK, B.Sc., M.Sc., Ph.D., 1967-68	Soil microbiology



## INTRODUCTION

The highlights of research progress made by the scientists on our staff during 1968 are recorded briefly in this report. Detailed accounts are available in the published papers, listed at the end of the report. Reprints are available from this Institute.

During the year, a new emphasis has emerged in the phytopathology program. A National Crop Loss Assessment Program has been initiated on a small scale. It is designed to provide accurate and reliable data on crop losses in Canada, caused by infectious diseases. More precise knowledge of the factors that cause crop losses should be of considerable practical value to Canadian agriculture. Although

many cooperative arrangements still have to be worked out, it is expected that this program will be in full operation by the end of 1969.

Plans are under way for the further development of the Electron Microscope Center. It is intended to become the focal point in the support of numerous studies in a wide variety of biological disciplines in the Research Branch.

Our research on foams for the protective insulation of plants against frost damage has aroused gratifying world-wide interest.

R. M. Hochster  
Director

## BIOCHEMISTRY

### Mode of Action of Myxin on Bacterial Cells

Although the antibiotic myxin inhibits the synthesis of new DNA in bacteria, host cells can support the synthesis of T<sub>4</sub> phage (DNA phage) even when cell DNA synthesis is blocked.

Myxin exerts bactericidal effects on *Escherichia coli* cells at a significant kill rate, which becomes logarithmic after exposure for 12 min. However, if myxin is removed from cultures, cells recover an appreciable portion of their metabolic activity, even after exposure for 20 min to myxin concentrations that are optimum for bactericidal action.

The enzymes DNA polymerase, RNA polymerase, and the nucleoside kinases are not affected by the addition of myxin to their assay systems in vitro. Even the enzymes isolated from cells that have been exposed to myxin for 15 min did not show any lowered activity.

Although many important facts have been established, the precise locus of myxin action in intracellular terms remains a fascinating mystery.

### Mode of Action of Gibberellic Acid

Gibberellic acid (GA<sub>3</sub>) was shown to be incorporated as tritium-labeled GA<sub>3</sub> into the transfer-RNA fraction of *Azotobacter chroococcum* during growth. Also, GA<sub>3</sub> was shown to stimulate growth of this organism in a linear manner. Transfer-RNA was isolated from cells grown in the presence of tritium-labeled GA<sub>3</sub>, and, after hydrolysis under mild alkaline conditions, labeled GA<sub>3</sub> was recovered. These results as well as data obtained previously (Lin, J. Y. 1967. Ph.D. thesis, McGill University) suggest that gibberellic acid may play an amino acidlike role in the regulation of RNA and of protein synthesis in vivo. This work establishes for the first time a precise locus of intracellular action by gibberellic acid.

### In Vivo Uncoating of Tobacco Mosaic Virus Protein

Intact virus protein subunits were released from parental tobacco mosaic virus

(TMV) from 10 min to 4 hr after inoculation of tobacco leaves. The reaction occurred in two stages. The initial removal of one-quarter of the virus protein, which occurred within 10 min, was unaffected by low temperature or by inhibition of protein synthesis in the leaves by cycloheximide. Thus the initial disruption of the virus immediately after inoculation does not appear to depend on the activities of induced or preexisting enzymes. This lends support to the idea that uncoating of TMV-RNA begins in a hydrophobic environment by a physical disruption of the bonds that bind protein subunits together and to the nucleic acid. The second stage, lasting to 4 or 5 hr during which another 25% of the protein was removed, was inhibited by both low temperature and cycloheximide.

The reaction was found to be nonhost-specific, since at least the earliest stages occurred in plants that are not considered to be hosts of TMV.

## Biochemical and Serological Taxonomy of the Fungi

Eighteen electrophoretically different DL-dihydroxyphenylalanine-catalytic forms of tyrosinase were demonstrated among six species of fungi in the Hymenomycetes. Eleven molecular forms were found in one species—*Agaricus hortensis* Cke. A comparison of the six species examined showed great variability in the electrophoretic patterns of the tyrosinase isoenzymes. The multiplicity of tyrosinase isoforms was demonstrated also by gradient fractionation on hydroxyapatite columns and by immunochemical techniques. A new theory based on molecular size and subunit structure is being proposed to explain the molecular heterogeneity and catalytic variability observed in the fungal tyrosinases.

A dopachrome staining technique specific for precipitin lines in agar and an immunological monitoring method for identifying proteins separated and collected in fractions were developed during the course of this work.

## CRYBIOLOGY

### Frost Hardiness

Continuing studies of the biochemical mechanisms that occur in the frost-hardening of plants received new impetus with the discovery of the involvement of apparent replication of cell membranes. The role of replication was deduced from metabolic, analytical, and ultrastructural studies, which show that microsomes, mitochondria, and membranous strands and structures increase with hardening. In addition, the lipoproteins and polar lipids, especially the phospholipids, increase significantly. It is believed that such replication has a protective effect by enabling the

cell to withstand the dehydrative stresses during freezing.

Work is also continuing on the use of protein-based fire-fighting foams for the protective insulation of plants against frost. Considerable increase in stability of the new foams was achieved by the cooperating manufacturing company during 1968. The new foams are nontoxic. Machine application has been proven to be practicable. As a result of these most encouraging results, commercial development of a foam applicator machine is under way. Both the chemical mixture and the machine will be available commercially by the spring of 1969.

## CYTOLOGY

### Cytological Effects of Myxin on Bacteria

To supplement previous data on the effects of myxin on macromolecular bio-

synthesis (Lesley S. M., and R. M. Behki. 1967. *J. Bacteriol.* 94:1837-1845), electron microscopic studies were undertaken to determine the effect of the antibiotic on the

development and fine structure of *E. coli* 15T-. The cytological changes produced by myxin varied, depending on the concentration.

At low concentrations (1  $\mu\text{g}/\text{ml}$ ) the action was bacteriostatic. Cytokinesis was inhibited, but there was no apparent effect on macromolecular synthesis as shown by the formation of filamentous cells. Except for the lack of septation during the first 60-min exposure, the filamentous forms appeared normal with well-defined nuclear bodies distributed throughout the cell. At higher concentrations (3 and 5  $\mu\text{g}/\text{ml}$ ), myxin was bactericidal and the cells soon appeared vacuolated. Examination of ultrathin sections of such cells showed intracellular ramifications of the plasma membrane. Membrane intrusions appeared both laterally and terminally at the sites where mesosomes normally occur in the

cell. The degree of infiltrated plasma membrane appears to be the result of stimulated membrane synthesis rather than the relaxation and unfolding of preexisting mesosomes. Further evidence of the effect of myxin on membrane synthesis was obtained from protoplast studies. Cells treated with lysozyme and ethylenediaminetetraacetic acid after exposure to myxin (5  $\mu\text{g}/\text{ml}$ ) for only 15 min produced protoplasts that were enlarged and fragile. When protoplasts of untreated cells were exposed to the antibiotic, they remained stable, which indicated that myxin had little or no effect on preformed membranes. This effect of myxin on membrane synthesis, particularly at low levels where macromolecular synthesis is unaffected, may prove to be a useful tool in studying the potential role of cell membranes in nuclear replication and cytokinesis.

## MICROBIAL ECOLOGY

### Rhizosphere Bacteria

Protein patterns of a number of coryneform bacterial isolates from rhizosphere and control soil of wheat were compared by means of the disc electrophoresis technique with those of coryneform organisms of culture collection origin such as species of *Arthrobacter*, *Nocardia*, *Mycobacterium*, and *Brevibacterium*. Results with the culture collection organisms show that the patterns are similar within a species and dissimilar among species and genera. The major bands were present consistently in extracts from organisms of each particular species. There were indications also that most of the soil isolates are quite similar in pattern to species of the genus *Arthrobacter*; most of them resemble *A. globiformis*. The consistency and reproducibility of the protein patterns from isolates of any one species show that they may give more precise information for the study on the ecology of microorganisms.

The incidence of organisms of the genus *Bacillus* was found to be greatly suppressed in the root zone of both wheat and soybeans. Numbers varied from 0.07% to 0.7% of the total, depending on the stage

of development of the plant, although in root-free soil they accounted for 20% of the total count. Strains of *B. megaterium* and *B. cereus* predominated over all other species of bacilli in both environments. *B. circulans* and *B. laterosporus* were more abundant in the root zone than in root-free soil in later stages of plant development. Strains of *B. mycoides* and *B. subtilis*, abundant in root-free soil, were never found in the root zone of either crop.

### Fungi

The microbial content (actinomycetes, bacteria, fungi, yeasts) of 10 soil samples from Baffin Island, N.W.T., was found to be low in comparison with that of most temperate zone soils. Nevertheless, seven distinct groups of actinomycetes belonging to the genus *Streptomyces* were found: *S. albus*, *S. antibioticus*, *S. flavus*, *S. fradiae*, *S. griseus*, *S. lavendulae*, and *S. ruber*. Many of these isolates proved to be antagonistic to other microorganisms (bacteria, fungi, yeasts). Although 26 genera of fungi were recognized, only species of *Penicillium* were common to all samples. Other genera that were dominant in one or more of the soils

were *Mortierella*, *Mucor*, *Phoma*, *Pyrenochaeta*, *Pseudogymnoascus*, *Chrysosporium*, *Oidiodendron*, *Phialophora*, *Cladosporium*, and *Cylindrocephalum*. Nematode-trapping fungi were not found in the samples.

### Numerical Taxonomy and DNA Composition of Soil Microorganisms

A two-stage principal component (P.C.) procedure was applied in a comparison of the nature and properties of 19 named cultures of *Arthrobacter* and 77 arthrobacter-coryneform soil isolates; cultures of *Brevibacterium linens*, *Nocardia cellulans*, *Corynebacterium michiganense*, and *Jensenia canicruria* were also studied. These cultures were characterized in terms of their reaction to 98 tests. DNA was isolated from 50 of the cultures, and the percentage of guanosine plus cytosine (GC) was determined by thermal denaturation ( $T_m$ ) and ultracentrifugation methods. The P.C. analysis resulted in the recognition of 13 groups of cultures. Twelve of the *Arthrobacter* cultures (representing nine species) were contained in two groups, one of which contained only *Arthrobacter* cultures. *Arthrobacter citreus*, *A. duodecadis*, *A. flavescens*, and

*A. terregens* were contained in another group with 13 soil isolates. *A. simplex* and *A. tumescens* were located in separate groups, which also included *B. linens* and *N. cellulans* respectively; otherwise these groups contained soil isolates. *C. michiganense* was located in a group of four soil isolates, which was spatially related to the two groups of *Arthrobacter* clusters. Twenty-five characteristics were considered important for differentiating the groups of cultures, and they were concerned with nutritional requirements, utilization of carbon compounds, catalase production, nitrate reduction, antibiotic sensitivity, and the Gram reaction. Because most of the named *Arthrobacter* cultures were located in a test space some distance away from most of the soil isolates, it was concluded that the named cultures were not sufficiently indicative of the diversity found among the soil isolates. The DNA of the 50 cultures examined contained 40% to 70% GC; for 29 of these cultures the GC content of DNA was between 56% and 64%. In general, the GC results were consistent with those of the numerical analysis, but there were some exceptions.

## PHYSIOLOGY

### Host-specific Toxins

Isolation and purification of the host-specific toxins of *Helminthosporium carbonum* Ullstrup and *Periconia circinata* (Mangin) Sacc. were mentioned in the Research Report for 1967. The toxin from *H. victoriae* may now be added. Although these toxins are among the most powerful biologically active substances known, establishment of their structures has been most difficult owing to their instabilities and because so little material can be produced in the laboratory. Recently developed techniques of analysis for microquantities applied in cooperation with other laboratories have given results that suggest new types of chemical structures.

Studies of the kinetics of host-specific toxin uptake by susceptible plants and the effect of these substances on cell organelles, apparent free space, plasmolytic

activity, and active uptake of solutes of susceptible and resistant plants show that the primary site of action of *H. carbonum* toxin has quite a novel action. This hypothesis is being investigated with tissue cultures and with protoplasts prepared from susceptible and resistant plants.

### Growth Control—The Rest Period

Comparative analyses of growth regulators involved in the rest period of higher plants have been performed on predormant, dormant, and postdormant *Rhododendron* flower buds. Growth promoters, specifically indoleacetic acid and gibberellic acid, are present in much higher concentration in predormant than in dormant buds. An indoleacetic acid inhibitor is prominent in dormant buds but absent in postdormant bud tissue. In predormant buds an ether-soluble acidic substance was

found to have a synergistic effect on the indoleacetic acid growth-promoting action on *Avena* coleoptile segments. Possible direct implication of these growth regulators in the phenomenon of dormancy is, thereby, suggested.

The rest period of *Rhododendron* flower buds was also studied cytologically and biochemically. Flower petal cells were

found to accumulate a reserve supply of protein and starch during the preresting condition. During rest and on resumption of flower growth, the reserve food supply was depleted.

In tissue culture, gibberellic acid, indoleacetic acid, and kinetin did not affect the rest period, but promoted flower growth after the rest period.

## PHYTOPATHOLOGY

### Pathogen Survival in Soil

*Ascochyta spp. of field peas.* In 1967 it was shown that *Ascochyta pinodes* L.K. Jones, the cause of blight, and *Ascochyta pinodella* L.K. Jones, the cause of foot rot, were soil-borne. Further studies have revealed that these organisms can survive over a 12-month period at temperatures from  $-20^{\circ}\text{C}$  to  $25^{\circ}\text{C}$ . Cultures were also pathogenic when reisolated from soil maintained at  $-20^{\circ}\text{C}$  to  $15^{\circ}\text{C}$ , but were more virulent when incubated in soil at  $5^{\circ}\text{C}$  and  $10^{\circ}\text{C}$ . *A. pisi* survived at  $-20^{\circ}\text{C}$  and  $5^{\circ}\text{C}$  over the 12-month period, but only isolates from  $-20^{\circ}\text{C}$  soil were virulent. Chlamyospores were found in soil cultures of *A. pinodes* and *A. pinodella* but not in *A. pisi*. Chlamyospores are regarded as the means of survival of these two important pea pathogens over long periods under adverse conditions. Laboratory studies showed that both *A. pinodes* and *A. pinodella* exerted strong antagonistic influences on *A. pisi* in the soil. Soil cropped to corn contained fewer propagules of *Ascochyta* than did soil cropped to beans, peas, or turnips.

*Corynebacterium michiganense (E.F. Sm.) Jensen.* This organism survived and retained its pathogenicity (causal agent of bacterial canker of tomatoes) for 8 months in soil at  $-20^{\circ}\text{C}$ . At  $25-27^{\circ}\text{C}$  the pathogen did not survive for more than 3 weeks in either sterile or unsterile soil.

Inoculation of tomato plants during the flowering stage caused a reduction in total fruit production of 12–14% compared

with uninoculated controls, but the time of ripening was not altered by infection.

### Bacteriophage

A numerical analysis of the relationships among phytopathogenic bacteria, incorporating data on phage sensitivity of strains of the genus *Xanthomonas*, showed that related bacteriophage isolates may be determined by the same procedures described to demonstrate the interrelationships among clusters of bacteria based on their character frequencies. A new temperate phage isolate, lytic to strains of *Xanthomonas phaseoli* (E.F.Sm.) Dowson var. *sojensis* (Hedges) Starr & Burk., has been isolated and used to identify lysotypes of this "species."

### Remote Sensing for the Detection of Bean Diseases

It was possible to detect common blight, *X. phaseoli*, and fuscans blight *X. phaseoli* var. *fuscans* (Burkh.) Starr & Burk., by tonal and geographic patterns with color infrared aerial photography taken at scales of 1:3,600 (height of 4,500 ft) and 1:8,400 (9,600 ft) with a 12-inch focal length camera. The importance of using blight-free bean seed was clearly demonstrated by this method. Imported disease-free Idaho seed produced plots of deep pink in contrast with the clearly defined blue infection foci in bean fields, which had been produced from seed grown in southwestern Ontario for a number of years. The various crops grown in the area were identifiable by their color, characteristic pattern, and land use.

# VIROLOGY

## Viruses Affecting Cereals and Other Grasses

*A soil-borne virus of wheat in Ontario.* A disease of fall-sown wheat, first recorded in 1957 in southern Ontario and found to be caused by a previously undescribed soil-borne virus, has been prevalent in some years in areas of Ontario where wheat is grown. The disease, designated wheat spindle-spotted mosaic, appeared to have only mild effects on yield in most years, but caused major damage in a number of fields during 1968. Evidence from experiments and from observation of farm fields showed that the mosaic may develop anywhere in southern Ontario if winter wheat is grown repeatedly in the same field. Wheat grown in infested soil developed the disease when kept in growth rooms at 5–13 C, but not when kept at 15 C or higher. An examination of temperature records for various years showed that there were more days during the fall and spring with mean temperatures of 5–13 C in crop years when the disease was prevalent than when it was scarce.

The infectivity of soil can be reduced or eliminated by treatment with fumigants or by the addition of some amendments including sucrose, uric acid, urea, ammonium nitrate, and poultry manure.

The virus, which is a rod-shaped particle, was concentrated by differential centrifugation of butanol–chloroform-treated juice from diseased plants.

## Leafhopper-transmitted Virus and Viruslike Plant Diseases

*Aster yellows.* The leafhopper *Elymana virescens* (Fab.) was discovered to be a vector of the aster yellows causal agent (AYCA). When nymphs and adult leafhoppers were caged for 7 days on infected barley plants, 26% and 24% of the exposed insects subsequently transmitted AYCA to barley seedlings. In comparable concurrent experiments with *Macrostelus fascifrons* (Stål), 48% of the nymphal and 78% of the adult group transmitted the virus. An incubation period of 39–46 days was required before 95% of the inoculative *E. virescens* could transmit,

whereas less than 32 days were needed for 85% of the inoculative *M. fascifrons* to transmit. When adult *E. virescens* and *M. fascifrons* were injected with an inoculum containing AYCA, 16% and 55% of the injected insects became inoculative, respectively. Although *E. virescens* proved to be a relatively inefficient vector species, those individual insects that did transmit, did so as efficiently as did comparable *M. fascifrons*. Furthermore, the concentration of AYCA in extracts in inoculative *E. virescens* was equal to that in extracts of inoculative *M. fascifrons* when extracts were prepared on a weight basis.

*Clover proliferation.* Female leafhoppers of the species *M. fascifrons* were much more efficient in acquiring the clover proliferation causal agent (CPrCA) from aster than were male leafhoppers, whether they were allowed acquisition access feeds as nymphs or as adults. Maximum transmission by males and by females fed as nymphs was 35% and 10% respectively, and fed as adults was 34% and 5% respectively.

## Vector – Virus – Host Plant Transmission Studies

Particles of wheat striate mosaic virus (WSMV) are easily deformed during purification of the virus from infected plants. Virus morphology was stabilized by infiltrating the infected wheat leaves with glutaraldehyde before they were used for virus extraction. Such preparations revealed the presence of uniform bullet-shaped virus particles of about 250 m $\mu$   $\times$  70 m $\mu$ . Studies on the growth curves of WSMV in the internal organs showed that the virus multiplies in the alimentary canal, hemocytes, and salivary glands of viruliferous leafhoppers. The virus is carried to various tissues of the insects through their hemolymph.

Examination of ultrathin sections of aster plants infected with clover phyllody disease showed the presence of mycoplasma-like organisms in phloem cells of the leaves and in different parts of phyllod flowers. The size of such organisms

varied from 80  $\mu$  to 500  $\mu$  in diam, depending on their developmental stage in the cell.

Clover phyllody causal agent (CPCA) was detected in susceptible tissues of *M. fascifrons* before the insects were able to transmit the disease to plants. The alimentary canal and the salivary glands were the main sites of CPCA multiplication. The concentration of the causal agent in salivary glands must increase to a certain level before an insect can transmit the disease to plants.

### Aphid- and Thrip-transmitted Viruses

*Barley yellow dwarf virus (BYDV)*. An antiserum developed against a strain of BYDV specifically transmitted by the aphid *Macrosiphum avenae* (Fabricius) showed a titer of 1/320 (ring interface test) against extracts from virus-infected plants, but showed no reaction against extracts of inoculative aphids. Hemolymph preparations and extracts of whole aphids (from aphids fed for 5 days on virus-infected plants) were infective. No virus increase was detected in the aphids by infectivity bioassay during the period following a 24-hr virus acquisition feed, al-

though most of these aphids transmitted the virus throughout a 2-week test period. This suggests a very limited multiplication, or an accumulation of the ingested virus in the aphids. Electron microscopy of ultrathin sections of virus-infected oat leaves showed the presence of BYDV virions in high concentration in the phloem cells, but not in any other leaf tissue. This suggests translocation and probable synthesis of the virus only in this tissue. BYDV virions were not observed in thin sections of any of the internal organs of viruliferous aphids.

*Tomato spotted wilt virus (TSWV)*. A virus causing a severe disease in dahlias and geraniums at the Central Experimental Farm, Ottawa, was isolated and identified as TSWV. Of the four Ontario isolates of *Thrips tabaci* Lindeman tested, only the one from western Ontario transmitted the virus. In ultrathin sections of virus-infected tobacco and tomato leaves, spherical virions (80–100  $\mu$  in diam) of TSWV were found in large numbers in the mesophyll cells, but not in vascular or other leaf tissues. The virions, either solitary or in groups of 2 to 5, were characteristically bound by a thin membrane.

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## INTRODUCTION

The Entomology Research Institute is responsible for a national program in bi-systematics and, as custodian of the Canadian National Collections of Insects, Arachnids, and Nematodes, is responsible for providing identifications for government departments, universities, and the public. Research is conducted on the taxonomy and evolution of these organisms and also on their bionomics and physiology with the aim of describing and understanding the content, origin, and biological significance of the fauna of Canada.

New activities undertaken include the energetics of root maggots, *Hylemyia* spp., and the consideration of cold hardiness, diapause, and winter survival, factors most appropriate in view of the severe Canadian winter.

The Insect Taxonomy and Administration sections of the Institute as well as the Entomology Library moved into freshly renovated and more spacious quarters during the year.

G. P. Holland  
Director

## TAXONOMY

### Surveys and Collections

Nineteen scientists devoted about 109 man-weeks to field collecting. The work included surveys in Western Canada and Northwestern United States for Coleoptera and Diptera; in southern Alberta for Cretaceous amber with insect inclusions; in Newfoundland for Lepidoptera; in the Maritimes for mites; on Banks Island for general collecting; from the Canadian Prairies to Texas for Noctuidae; in Northern Europe for nematodes; and in the Dakotas, Colorado, and Utah for Coleoptera, Siphonaptera, and general collecting. Approximately 180,000 insects, mites, and nematodes were added to the Canadian National Collections during the year.

Two important collections of Tachinidae (Diptera) were purchased. The Reinhard collection contains over 25,000 specimens and about 1,460 species; it also has 450 species of Sarcophagidae and Calliphoridae. Most of this material is from North and South America, and some is from Europe. The Thompson collection contains about 4,000 specimens, mostly from Trinidad; it also includes over 2,500 microscope slides, mainly of immature stages. Both collections are extremely rich in type material.

The Moore collection of about 50,000 beetles and library was purchased. This collection is mostly of Staphylinidae and is rich in intertidal species from California and Baja California.

### Identification and Information Services

During the year, 833 shipments of insects and other arthropods with a total of over 33,700 specimens were received for identification. The Department of Agriculture submitted 284 shipments (34%) with 10,240 specimens (30%) and the Department of Fisheries and Forestry submitted 188 shipments (23%) with 8,540 specimens (25%).

During the year, over 43,500 specimens were identified and returned. The accompanying table shows the number of specimens identified, their various sources, and the distribution within the insects and other arthropods.

A total of 420 soil and plant samples were submitted for identification of nematodes. Approximately 80% of these were submitted by the Plant Protection Division and the remainder were from other sources including the public and scientists in other institutions.

NUMBER OF SPECIMENS IDENTIFIED DURING 1968

	<i>Coleoptera</i>	<i>Diptera</i>	<i>Hemiptera</i>	<i>Hymenoptera</i>	<i>Lepidoptera</i>	<i>Siphonaptera</i>	<i>Trichoptera</i>	Other insects	<i>Acarina</i>	Other arthropods	Totals
<b>Canada</b>											
Department of Agriculture.....	747	4,761	821	968	1,066	6	6	2,239	936	65	11,615
Department of Fisheries and Forestry	3,286	3,290	2,316	6,240	2,010	-	-	61	276	17	17,496
National Museum.....	2	356	-	5	49	104	25	-	29	6	576
Other federal departments.....	-	36	-	-	1	-	3	78	40	-	158
Provincial departments.....	71	78	7	10	9	4	9	5	-	-	193
Industry.....	34	17	-	-	3	-	-	1	-	1	56
Universities.....	72	485	115	414	16	-	-	79	-	3	1,184
Private inquiries.....	133	122	17	22	492	14	-	33	33	42	908
<b>United States</b>											
Government departments.....	112	880	15	36	413	139	-	-	16	-	1,611
Universities.....	6,080	1,171	18	649	107	138	2	-	8	-	8,173
Private inquiries.....	148	545	-	-	525	-	-	-	-	-	1,218
<b>Others</b>											
Mostly European.....	-	261	1	47	56	17	-	-	6	-	388
<b>Total.....</b>	<b>10,685</b>	<b>12,002</b>	<b>3,310</b>	<b>8,391</b>	<b>4,747</b>	<b>422</b>	<b>45</b>	<b>2,496</b>	<b>1,344</b>	<b>134</b>	<b>43,576</b>

**Taxonomic Investigations**

*Acarina.* A review of the holarctic tarsonemid mites that parasitize eggs of the ipine bark beetles was completed. These mites are extremely host specific on the eggs of various species of bark beetles. The present classification of *Ips* is substantiated by the study of these mites.

*Coleoptera.* The North American species in the tribe Xyleborini and in the genus *Leiparthrum* in the Scolytidae were reviewed. In the Alleculidae, the Mexican and Central American species of *Isomira* were revised. Two New World subfamilies of Staphylinidae (Micropeplinae and Oxyporinae) were revised. In the Scarabaeidae, the North and Central American species of the subfamily Trichiinae were reviewed, as were the relationships of five genera of Melolonthini. Notes affecting the classification of North American Bruchidae, a list of all the species found north of Mexico, and a list of world genera and their type-species were published.

*Diptera.* Work on the new Manual on the Genera of North American Diptera continued. Drawings for 10 families have been completed, over 200 wing mounts are

ready, and manuscripts for 26 families are finished. Editing of the important Muscidae manuscript is nearly done, and the glossary is complete.

An annotated key to some drosophilid genera and a revision of the *Paracacoxenus* were published. Four large papers are in press: a revision of the *Prosimulium* of Canada and Alaska; a revision of the genera of world Syrphini; descriptions of the larvae and pupae of some eastern North American Tabanidae; and descriptions of new genera and species of Acalyptratae.

Aerial swarming of 16 species (3 genera) of Lonchaeidae was reported for the first time, and it was related to the occurrence, nature, and evolutionary significance of insect swarming in general. The theory that aerial swarming is basic to the two-winged condition in Diptera was proposed. Evidence was presented to show that various swarming habits and associated morphological adaptations were primitive features of not only Lonchaeidae, but of all Diptera.

*Hemiptera.* The North American species of the mirid genus *Slaterocoris* were revised, and descriptions of *Scalponotatus*

are in press. Notes of the Saldidae types in the Provancher collection were published and a paper on the other Heteroptera in the same collection was completed.

In the Aphididae the nearctic species of *Neosymydobius* and the world species of *Tuberculatus* and *Myzocallis* were revised; a review of the holarctic genus *Roepkea* was completed.

*Hymenoptera*. Several new Canadian species of Braconidae and Cryptinae (Ichneumonidae) were described. A revision of the nearctic species of the eulophid genus *Pnigalio* was completed, as well as a bibliography of the nearctic bumblebees.

*Lepidoptera*. In the Pyralidae, four of a series of papers on the Pyraustinae of temperate east Asia were published; these contained mostly descriptive material. A revision of the species of *Ostrinia* allied to the European corn borer was completed, and also a revision of the Western Canadian species of two groups of *Dioryctria*.

A revision of about one-fifth of the large genus *Euxoa* (Noctuidae) containing all of the subgenera except *Euxoa* (*Euxoa*) was completed.

Descriptions of the larvae of the North American Aegeriidae were published. As a result of this study several new groupings were suggested.

*Siphonaptera*. A revision of the fleas of New Guinea is in press. Several new genera and many new species are described. The relationships of the flea fauna with that of the Oriental Region and of the Australian Region are discussed.

*Trichoptera*. Several comprehensive revisionary papers dealing mainly with the Himalayan caddisflies were published; these included the Arctopsychidae, the Apataniinae, *Gunungiella*, and *Poecilopsyche*. Two other papers on *Rhyacophila* and the Stenopsychidae were completed.

*Nematoda*. A study of phenotypic variation in diagnostic characters of a species of *Acrobeloides* revealed hitherto unrecognized extremes. By altering environmental conditions, extensive variation that bridged species, genera, and subfamilies was induced in the head and tail shape, position of the excretory pore, nerve ring, and deirids. Reevaluation of the status of the nominal species in this genus and reclassification of the Cephalobidae is under way.

Morphological studies of *Cryptonchus* and of *Periplectus labiosus* Sanwal helped to clarify their affinities with other closely related taxa. Emendations of the diagnoses of Plectoidea, Plectidae, and *Cryptonchus* were based on these observations.

A tylenchid, *Dactylotylenchus crassaticulus* Wu, was named and described from the Rocky Mountain area of Alberta.

*Actarjania splendens* Hopper, a marine nematode, and *Paraplectonema canadinum* Hopper, a freshwater nematode, were described and the genus *Paraplectonema* emended. New information gained from a study of the male of *Laimella longicauda* Cobb necessitated emendation of the diagnosis of this genus and the transfer of several species to other genera. *Bathylaimus hamatus* Hopper and *Hypodontolaimus reversus* Hopper, marine species from the coast of Prince Edward Island, were named and described.

*Meyersia* Hopper, from Biscayne Bay, Florida, and five new species of oncholaimids were described. A taxonomic review of the mononchids of Oregon revealed 25 species, of which 5 are new. Fourteen soil-inhabiting species of the orders Araeolaimida, Chromadorida, Enoplida, and Monhysterida from the Lake Hazen area, N.W.T., including two new species, were described. Several genera were revised.

Collation of information and material for a reevaluation of the cyst-forming genus *Heterodera* is well under way.

## BIONOMICS AND PHYSIOLOGY

### Ecology of Crop and Grassland Insects

In the population (life-table) studies, special attention was given to the adult

stage of the imported cabbageworm, *Pieris rapae* (L.). The females spend much less time in the crop than the males, and after

mating they leave the field and reenter only to lay eggs. Multiple matings are common, but not essential for fertility. The female lives rather longer than the male and lays 174 to 578 eggs (average 239).

Analysis of life tables for eight generations of the Colorado potato beetles showed that food supply, acting on larvae and summer adults, is the principal factor regulating the numbers of the species on potatoes. Other important causes of death include cannibalism (eggs) and frost (adults). On tomatoes, mortality is higher and the adults are smaller and lay fewer eggs.

The cabbage root maggot, *Hylemya brassicae* (Bouché), has been found to have only two generations annually in eastern Ontario, with approximately the same initial density. Most second-generation pupae hibernate, and the few that emerge die without laying eggs. In southwestern Ontario, in contrast, there were three generations in 1967 and the initial population increased with each generation. Heavy mortality occurs in the egg and pupal stages in both areas, but in the former it is due to desiccation and infertility, and in the latter to parasitism.

The white grubs, *Phyllophaga* spp., have a synchronized 3-year life cycle in the Ottawa area, and two generations have now been followed. The 1965-68 generation started with fewer eggs but later mortality was about 60% compared with 80% for the 1962-65 generation, so the number of beetles that emerged from the soil was similar in the two cases.

### Ecology and Biology of Nematodes

Studies of *Anguina calamagrostis* Wu, based in part on electron microscopy, suggested that synthesis of proteins, which may be utilized in egg-shell formation, takes place within the crustaformeria (a newly described part of the reproductive tract).

Examination of the benthic nematodes of soft surface sediment from beds of turtle grass in Biscayne Bay, Miami, Fla., showed a high degree of homogeneity by the dominance of four species out of approximately 100 taxa. Population densities reached a maximum during November-December and February-March.

### Bionomics of Bees

*Nosema apis* Zander, a parasite of the honey bee, cannot be grown in artificial culture, so indirect studies are required. Its reproduction in the bee was not repressed when myxin up to 400 mg/liter of syrup was fed to inoculated bees; the lytic enzyme from the myxin organism did not lyse *N. apis* spores. *N. apis* spores extracted with water at 55 C released a number of carbohydrates into the medium without loss of integrity or infectivity.

Combs containing larvae infected with European foulbrood disease were irradiated with 0 to 0.8 Mrad in the pneumatic chamber at the Commercial Products Division of the Atomic Energy Commission of Canada, Tunney's Pasture, Ottawa, Ont. Infectivity was reduced but not eliminated at the 0.8-Mrad level; viable cultures of *Streptococcus pluton* Bailey were obtained from all levels. This pathogen thus appears more resistant to radiation than *Bacillus larvae* White. A culture of the latter with a microscopically visible morphological character reproduced the marker in experimentally infected larvae.

Tetracyclines were found in biologically detectable quantities in treated syrups stored in the combs of wintering colonies of honey bees in British Columbia until late February, when a fresh nectar flow ended the tests.

A substance extracted from pollen by several organic solvents attracts foraging honey bees; chemical separation combined with bioassay showed that the attractants are a lutein ester and a rather unusual 18-carbon fatty acid.

### Diversity in Insect Communities

Faunal studies on the bracket fungus *Polyporus betulinus* (Bulliard) have centered around DDT-sprayed and DDT-free forest areas in New Brunswick. More than 250 species of arthropods have been recorded. Unlike a typical "pest" situation, the fauna is rich in species but poor in individuals, perhaps because of the discreteness and the low food content of the sporophores. In the study of the distribution of arthropod occurrences, a distinction has been made between *nonsegregative association*, in which the species, although mutually independent, are apparently crowded into fewer brackets than are

present, and *segregative association*, in which recurrent groups of species are formed. Nonsegregative association is common, and perhaps is controlled by the site and exposure of the brackets, whereas segregative association is rare.

### Bionomics of Diptera

A review of the mating behavior of Diptera showed that assembly in flight at a visually recognized swarm marker is a widely diffused habit in the order, and probably the primitive one. At the assembly station a short-range recognition takes place, mediated by the specialized upper facets of the male eye, as in black flies, or by the plumose antennae, which function as directional auditory organs, as in mosquitoes. The halteres, the modified hind wings that are specialized as proprioceptive organs sensitive to angular accelerations, may have evolved in relation to the habit of mating in flight, which obviously requires rapid and intricate changes of direction.

Many modifications of the swarming and mating flight are found. In some Empididae the male catches insect prey, flies with it to the swarming station, and uses it in an aerial courtship. The prey is transferred and the female feeds on it during mating. The females do not hunt prey for themselves, but the mating flight may be repeated frequently and supplies the food that is necessary for maturation of the eggs.

*Aedes atropalpus* (Coquillett) has been found to be an autogenous mosquito in which egg maturation begins when the adult emerges from the pupa. Females, whether unfed or supplied with sugar, mature about 130 eggs in the first gonotrophic cycle. Some unfed females survive to lay eggs, but they all die within 5 days when the blood carbohydrate is almost depleted. The sugar-fed females live for a much longer time and gradually lay their whole complement. When males are present, females are more active and lay their eggs within a shorter period, and the carbohydrate reserve appears to decrease more rapidly. After oviposition a blood meal is taken, but often less than 50% survive to oviposit a second time. It seems that the ability to utilize blood may be somewhat reduced in this species.

### Arctic Insects

The Chironomidae taken in two emergence traps at Hazen Camp over 6 years have been identified and studied. Twelve species were encountered. The abundance and the emergence period varied from year to year, and in some species emergence did not take place in every year. Two pairs of closely related species occurred, but their emergence periods were separate or overlapped only slightly.

Taxonomic and life-history studies of the chironomids in Char Lake, Cornwallis Island, were begun, to provide information for the freshwater productivity studies of the International Biological Program. There are at least 11 species, one of which is parthenogenetic and another is dimorphic in the male, the forms differing in the structure of the antennae.

One of the four high-arctic species of Empididae catches its prey and mates on the ground rather than in flight, and in the male the structure of the eye is considerably simplified. These characteristic adaptations to cold and windy environments had not previously been recognized in this family.

### Organ and Tissue Physiology

The carbohydrates and amino acids in the larval hemolymph of *Hylemya anti-qua* (Meig.), *Agria affinis* (Fall.), and *Musca domestica* L. are being examined to determine if the composition of the blood affects the survival of the braconid parasite *Aphaereta pallipes* (Say). The arctic blow fly *Boreellus atriceps* (Zett.) has recently been found to be an excellent host for *A. pallipes* and has been included in this study.

The use of egg-protein patterns as a taxonomic aid is being examined. Electrophoretic separation of the proteins from individual eggs has shown remarkably constant and specific patterns.

Blood cells of eight species of cockroaches were studied in vivo and in stained films. The four categories of cells (prohemocyte, plasmatocyte, granular hemocyte, and spherule cell) recognized in *Blaberus giganteus* L. occur in all species, but with specific distinctions in the size and inclusions of the granular hemocytes. In some species the protein frac-

tion of the carbohydrate-protein inclusions is predominant, and in others the carbohydrate portion.

### Regulation of Sex in Parasitic Hymenoptera

An electron microscope study of the spermatheca of *Dahlbominus fuscipennis* (Zett.) has shown a folding of the inner wall of the duct through which the spermatozoa pass from the spermathecal capsule to the vagina during oviposition. This folding causes the spermatozoa to descend in single file. A sinistrally coiled spermatozoon, however, blocks the micropyle of the egg and prevents the dextral form from entering. The sex of the offspring is thus determined, in random order, in proportion to the numbers of the two types of spermatozoa received by the female.

### Insect Morphology

A comprehensive study of the morphology and evolution of the insect thorax, the second part of a projected series on the structural evolution of insects, is nearly completed. This study establishes homologies of the external structures and the muscles throughout all orders of insects, and sets up a uniform system of designation. Three kinds of muscles, palaeogenetic muscles (inherited from the wingless ancestors), neogenetic muscles (arising in winged insects), and cenogenetic muscles (confined to the larval stage), have been distinguished for the first time in insect morphology, and their evolution is discussed. Another general principle brought forward is that of Anlagen replacement, the evolutionary substitution of one morphogenetic route for another in the production of homologous structures.

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## VISITING SCIENTISTS

### *National Research Council postdoctorate fellows*

V. L. N. MURTY, B.Sc., M.Sc., Ph.D., 1968-69	Physico-chemical studies of polysaccharides
W. WATANABE, Ph.D., 1967-68	Application of microwave energy to food processing

## CHEESE QUALITY

### Milk-clotting Enzymes

An experiment was completed comparing the use of rennet with a 50:50 mixture of rennet and pepsin in the manufacture of Canadian Cheddar cheese. Eight pairs of vats were made in each of four factories. There was no significant difference in flavor quality as determined by federal graders at 3 weeks or at 6 and 12 months of age. At 3 weeks of age, the texture of cheese made with the mixture was slightly poorer than that of cheese made with rennet only; there was no significant difference at 6 and 12 months of age. Taste panels disclosed no significant differences at 12 months of age in intensity of Cheddar flavor or of bitter flavor between pairs of cheeses made with the mixture or with rennet. In one factory there was a significant difference between the coagulants in their effect on pH and salt content of the cheese at 3 weeks of age; there was no significant difference in pH of the cheese at 6 and 12 months. Similarly, protein hydrolysis was significantly less in cheese made with the mixture than in that made with rennet in some factories. Cheese made with the mixture was significantly firmer at 6 and 12 months than cheese made with rennet only. The overall quality of cheese made with the mixture was judged to be equal to that of the cheese made with rennet.

### Milk Enzymes

Two new milk enzymes,  $\alpha$ -mannosidase and an amino acid arylamidase, have been found in milk and their properties investigated.

$\alpha$ -Mannosidase is associated with the  $\beta$ -casein fraction following polyacrylamide electrophoresis. It was separated from milk by ammonium sulfate precipitation in the presence of 10% (v/v) ethanol.  $Zn^{2+}$  or  $Mn^{2+}$  were required for maximum activity and the enzyme was very labile. The optimum pH for hydrolysis of *p*-nitrophenyl- $\alpha$ -mannosidase was about 3. High

concentrations of the substrate were inhibitory and the apparent  $K_m$  for this hydrolysis was 1.2 mM. The enzyme was inhibited in amino acid buffers, apparently by zwitterions.

An amino acid arylamidase is associated with the microsomes of the milk fat globule membrane. It was purified by DEAE cellulose chromatography of a 0.1 M NaCl extract of milk microsomes. There were three peaks of arylamidase activity after chromatography. Specific activity was 12,700 times that in milk. Substrates, inhibitors, and activators were determined; optimum pH for hydrolysis of lysyl  $\beta$ -naphthylamide was 7.7.

### Cheddar Cheese Flavor

*Volatile flavor components.* Material recovered as effluent, when vapor or concentrated solvent extract samples of a cheese distillate were gas-liquid chromatographed, did not have a characteristic cheese aroma. However, when the effluents from vapor and concentrated solvent extract samples were combined, an aroma similar to that of cheese distillate was observed. It would appear that the columns adsorb traces of less volatile compounds from the vapor sample, whereas the concentrated solvent extract sample is deficient in the more volatile compounds.

*Bitter and astringent flavor components.* Extracts containing the bitter components of Cheddar cheese were separated on Sephadex columns. The isolated fractions were found to be heterogeneous, as determined by thin-layer chromatography and high-voltage electrophoresis. An astringent component isolated from the bitter extract of cheese was shown to be homogeneous by polyacrylamide and cellulose acetate electrophoresis. The astringent component had a high extinction coefficient at 280 m $\mu$ , and a low sedimentation velocity. Its estimated molecular weight was 40,000 to 50,000.

# MICROBIOLOGY

## *Byssochlamys nivea*

Implication of *Byssochlamys* sp. in a confirmed case of fruit juice spoilage supports the suggestion that this organism may be important in fruit processing. An analysis of soil samples (75) taken randomly in southern Ontario did not disclose the presence of *Byssochlamys* sp. although it was found in a sample of grapes from Vineland, Ont. Isolations have been made from Central Experimental Farm soil by using selective techniques, but the organism was present only in small numbers.

Respiration studies confirmed that acetate ion and heat shock stimulates the germination of *B. nivea* ascospores. Oxygen uptake increased rapidly 3–4 hr after heat shock in the presence of acetate, and the rate of uptake reached a peak in 14–16 hr.  $\text{Cu}^{2+}$ ,  $\text{Al}^{3+}$ , and  $\text{Fe}^{2+}$  appeared to inhibit germination, but further study is needed to confirm and clarify the influence of ion concentration.

## Pediococci

The pediococci produce at least three kinds of antigens, which may be useful in identification and classification. One of these, an antigen released from the cell

walls of some pediococci by the action of lysozyme and trypsin, was not homogeneous. The antigenic determinant was detected at the end of the void volume and in subsequent samples up to several void volumes following gel filtration on Sephadex. The same antigen gave extended streaks after immunoelectrophoresis. These phenomena suggest that the antigenic determinant occurs in polymer fragments of different sizes and does not constitute a molecular species per se.

## Lactic Streptococci

A method for determining the activity of lactic cultures in milk was developed. Differences between cultures and the effects of storage can now be evaluated.

## Bacteriology of Frozen Vegetables

A study of the effect of three freezing rates on the microbial population of snap beans, broccoli, Brussels sprouts, cauliflower, corn, and spinach did not disclose any differences attributable to freezing rate. All freezing methods significantly reduced the microbial population of spinach and broccoli, but little change in microbial numbers due to freezing occurred in the other vegetables.

# SENESCENCE OF FRUITS AND VEGETABLES

## Ethylene Production in Apples

McIntosh apples harvested at or near the preclimacteric minimum and stored at 12 C showed a normal respiration pattern accompanied by an increasing ethylene production pattern. Maximum ethylene production—about 70  $\mu\text{l}/\text{kg}$  per hour—was observed at the respiration peak. Apples of similar history stored at 0 C entered a respiration and ethylene production pattern similar to those at 12 C except that (i) ethylene production rates were much depressed, (ii) the onset of the climacteric was delayed, and (iii) the peak level was maintained for a longer period. The ethylene production rate after 4 months at 0 C was about 15  $\mu\text{l}/\text{kg}$  per hour. These results indicate that preclimacteric apples develop a normal climacteric pattern during storage at 0 C.

Since preclimacteric apple fruit showed a normal climacteric pattern in storage, it was not suitable material to use for studying means of inhibiting senescence. We believe that if the initiation of ethylene production can be prevented or delayed, the subsequent climacteric pattern can be delayed.

## Ethylene Production from Bean Hypocotyl Treated with 3-indoleacetic Acid

The plant hormone 3-indoleacetic acid and a number of synthetics are known to stimulate the production of ethylene when absorbed into plant tissues. We have screened various agents that may retard or prevent the production of ethylene in bean hypocotyl treated with 3-indoleacetic acid. None of the agents tested inhibited



ethylene production. Alar (Nauगतuck Chemicals), a compound that delays the whole growth pattern of apples, did not inhibit the ethylene response in the above plant system. Applications of 0.2–10  $\mu\text{g}$  of 3-indoleacetic acid to bean hypocotyl resulted in an ethylene production rate response of about  $8.5 \times 10^{-3}$   $\mu\text{g/g}$  per hour. This rate is about 21 times that of control cuttings. The indoleacetic acid degradation products indole and 3-indolecarboxylic acid did not affect ethylene production.

### Plant Enzymes

*Phloridzin reactions.* Acetone powders and plant extracts were prepared from young apple shoots (new growth) in this laboratory. Phloridzin incubated with acetone powder extracts for 7 hr failed to yield phloretic acid or phloroglucinol as enzymatic products. Phloretin was detected as a product, showing that gluco-

sidases were present in apple tissue. Chromatography of the shoot extracts did not disclose the presence of phloretic acid in the tissues nor of any other free phenolic acid. There is therefore considerable doubt that an enzyme in apple can convert phloridzin to phloretic acid.

*Other enzymes.* (+)Catechin, (–)epicatechin, phloridzin, and chlorogenic acid were found to be substrates for polyphenoloxidase obtained from acetone powders of apple peel. Peroxidase was apparently present, and catechin and phloridzin were good substrates. Phenylalanine ammonia lyase and tyrase of the apple peel could not be detected by the use of phenylalanine and tyrosine as substrates. It is possible that these lyases are induced enzymes as in potato skin. Glucosidases were only detectable in apple stem extracts. Further work is necessary to confirm the presence of most enzymes other than phenoloxidase and peroxidase.

## FOOD PROCESSING

### Microwave Processing of Wieners

The application of microwave energy to the cooking of wiener emulsions was studied using a 2450 MHz, 2kW microwave tunnel with a forced hot-air system. Bursting of the cased emulsion was prevented by emulsion deaeration and a two-stage microwave cooking process. Commercially acceptable emulsions were cooked by microwave energy to yield wieners that had excellent emulsion stability, color, skin, and peelability. Microwave cooking was accomplished in 55–60 sec using a 2kW and 75 C forced air (40 ft<sup>3</sup>/min). Research is continuing on the effect of microwave processing on the microbiological stability of the wieners and the development of a wave guide cooking apparatus.

### Edible Rapeseed Meal

Feasibility studies have shown that a white, bland, defatted, thioglucoside-free flour can be prepared from rapeseed. The thioglucosides, the precursors of toxic principles, present in rapeseed, were removed by aqueous extraction. The key operations, boiling of the seed followed

by wet grinding and aqueous extraction, helped to remove the seed coat from the rapeseed. Although aqueous extraction resulted in a loss of solids, the quality of the end products is good and may offset the loss. The processing of seed to defatted flour involves enzyme inactivation in boiling water, wet grinding in a vertical plate grinder, aqueous extraction of thioglucosides at ambient temperature, drying, flaking, oil extraction, and air classification. Current research is directed towards the determination of product quality (nutritional, functional, and physical) and at optimizing process costs and efficiency.

### Cryogenic Freezing

*Mushrooms.* Preliminary experiments were conducted to determine optimum pretreatment freezing rate and frozen storage temperature for mushroom freezing. Results confirmed that blanching was unnecessary, that liquid-nitrogen freezing resulted in better-quality mushrooms than conventional freezing, and that ultralow

storage temperatures are not necessary for storing nitrogen-frozen mushrooms. More work is being conducted to study the influence of certain chemical treatments on the quality of fresh frozen mushrooms.

*Shrimps.* Liquid-nitrogen freezing of pink shrimps was found to result in less than 1.5% weight loss compared with more than 8% loss in air-blast frozen shrimps.

## FOOD QUALITY AND COMPOSITION

### Eating Quality of Chicken Broilers as Influenced by Age and Sex

The relative eating quality of male and female chicken broilers killed at 6, 7, 8, 9, and 10 weeks was assessed by using a sensory panel and the modified Warner-Bratzler shearing device.

Results of both the panel and the Warner-Bratzler device indicated a trend for meat to decrease in tenderness with increasing age. Males had lower shear values than females. Females had better flavor at 10 weeks than at 6, 7, or 9 weeks. At 9 weeks males had better flavor than females.

When panel evaluations of flavor, tenderness, and juiciness were combined, females appeared to have optimum eating quality at 8 weeks and males at 7 weeks. At both 7 and 8 weeks males seemed to be superior to females in overall eating quality.

### Lipids of the Edible Muscle Tissue of Geese

In general, there was slightly more lipid, and the proportion of neutral to polar lipid was higher, in the leg plus thigh of a goose than in the breast. Over 40% of the fatty acid of the neutral lipids was oleic and more than 45% of the polar lipid fatty acid was arachidonic plus stearic. Phosphatidyl choline and phosphatidyl ethanolamine were the principal phospholipids; the neutral lipid was almost entirely triglyceride.

### Relationship Between Constituents of Apple Leaf and Fruit

Further comparisons were made in a collaborative study with the Ottawa Re-

search Station on the possibility of using leaf analysis for early selection of apple seedlings that would eventually bear high-quality fruit. Work with mature leaves and fruit disclosed many interesting correlations. Those reported last year between contents of fruit phenols and leaf phenols, and between fruit phenol and leaf free acid were confirmed. In addition, there were correlations between fruit phenol and leaf sugar; fruit acid and leaf acid; fruit ascorbic acid and leaf pH (negative correlation); and fruit pH and leaf acid (negative) and pH.

There were also several relationships between fruit characteristics and leaf analysis. The main ones were: negative correlations between fruit size (diameter and depth) and leaf contents of free acid, total acid, and phenols, and a positive correlation between leaf pH and intensity and extent of red skin coloration.

### Synthesis of New Methyl Ethers

The occurrence of 3,5-di-*O*-methyl-D-mannose in the methylated cleavage products of the glycopeptide from royal jelly, which was based on a previous misidentification of this methylated sugar (Urbas, B., et al. 1964. *Can. J. Chem.* 42:2093) has been corrected to 2,4-di-*O*-methyl-D-mannose by the synthesis of both these sugars.

The two methyl sugars have been synthesized respectively from methyl- $\alpha$ -D-mannofuranoside and methyl- $\alpha$ -D-mannopyranoside, by successive tritylation, toluene-*p*-sulfonylation, methylation followed by successive desulfonylation, detriylation, and hydrolysis.

# POTATO QUALITY

## Potato Tuber Analysis and French Fry Texture

Highly significant positive correlations were found between French fry texture as measured by an expert sensory panel or by a mechanical test and the dry-matter content of the tubers (Netted Gem variety). Values for dry matter, specific gravity, and starch content are very closely related, and therefore data from the measurement of these last two were also highly correlated with texture ratings. The percentage of large-sized starch granules was well correlated with the mechanical puncture test. There were no relationships between texture and the ratios among the weights of the five size ranges into which the starch granules were sieved.

## Potato Cell-wall Polysaccharides

Previously reported work on potatoes which showed no significant factors to account for textural variations in frozen French fries focused attention on the cell-wall material. Preliminary work on potato cell-wall polysaccharides of the Netted Gem variety from two locations, New Brunswick and Alberta, showed that (i) the Alberta potatoes gave solids (80% ethanol-insoluble) that were 31.5% higher than in the New Brunswick potatoes; (ii) the cell-wall polysaccharides from the Alberta potatoes were 36.8% higher than those from the New Brunswick potatoes; (iii) the cold-water-soluble cell-wall polysaccharides from the New Brunswick potatoes were 31.2% higher than those from the Alberta potatoes.

Based on these results, it would appear that good texture in potatoes could be re-

lated to: (i) high solids (80% ethanol-insoluble); (ii) high content of cell-wall polysaccharides; (iii) low content of water-soluble cell-wall polysaccharides.

## Maleic Hydrazide in Potato Tubers

A disorder that caused excessive shrinkage and disfigurement of cold-stored Kennebec potatoes has been traced to the presence of abnormally high amounts of maleic hydrazide. Affected tubers were found to have average contents of 125 and 93 ppm in the peel and central tissues, whereas the concentrations in the respective tissues of normal tubers from the same field averaged 45 and 36 ppm maleic hydrazide.

## Frozen French Fry Texture

The effect of storage and growing location on frozen French fry texture was studied. Netted Gem potatoes were grown in 10 locations in Canada, stored at the Food Research Institute, processed to frozen French fries, and evaluated for texture by an expert taste panel and an objective method (puncture test). The study was conducted over a 2-year period (two growing seasons).

The expert taste panel found no change in texture due to storage, but found significant differences between growing locations. On the assumption that mealy internal texture is best, Western potatoes produced better-textured French fries than Eastern potatoes. Two characteristics of the puncture test curve were found to relate with the results of the expert taste panel.

# PROTEINS

## The Multiple Myoglobins of Beef Muscle

Repeated two-dimensional polyacrylamide gel electrophoresis has demonstrated the myoglobins to be interconvertible forms of one molecule. The electrophoretic difference among the myoglobins, and also among their heme-free derivatives, per-

sists in 8 M urea. The difference was shown to be one of charge rather than of size.

## Destruction of Methionine in Proteins

The previously reported work on the preparation of a methionine-reduced casein

product for use in homocystinuric diets has been completed. The product, reduced in methionine content from 2.7 to 0.8% by reaction with cyanogen bromide, has proved nontoxic to rats. Details of reaction rate and specificity, protein recovery, and elimination of side products were obtained. The use of denaturing agents showed the extent of the reaction to be dependent on the degree of polypeptide unfolding. Com-

plete destruction of methionine was obtained in 4 M urea.

### Prerigor Glycolysis of Beef Muscle

Preliminary work has indicated that the rate of postmortem, prerigor glycolysis can be controlled by mild doses of gamma irradiation and that the rate of glycolysis influences ultimate tenderness.

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## INTRODUCTION

One of the highlights of 1968 was the publication of the first two of the three-volume work entitled *Flora of the Queen Charlotte Islands*. These two volumes contain the first detailed systematic and cytological study of a flora of a defined geographical region in North America.

The book *Ornamental Shrubs for Canada*, published in 1968, fulfills a national need for an illustrated factual reference work. It is receiving wide acceptance by nurserymen and the gardening public.

The research on fungal parasites of Scrophulariaceae has shown new aspects of the means of coevolution of hosts and parasites. Valuable life-cycle studies on the Ascomycetes contributed to taxonomic revisions of a number of species parasitic on wheat, balsam, Douglas fir, and other cultivated and wild plants.

A major accomplishment in agrometeorology was the preparation and publication of a series of bulletins that present climatic information from across Canada in a suitable form for making decisions on land use, crop zonation, and agricultural water requirements. These bulletins are the product of several years of research that included the measurement and calculation of evapotranspiration, soil moisture, and freezing temperature hazards, and the computer processing of masses of daily weather data.

Dr. Ruth Macrae retired after 39 years of service. She is an authority on the Polyporaceae and rendered tremendous service to forest pathologists through her competent and dependable identification work.

Allan Chan  
Director

## AGROMETEOROLOGY

### **Model Building and Crop Response to Weather**

Research was concentrated on the development of a crop-weather model, which accounts for the daily contribution of any three weather parameters to the final crop yield. Incorporated in this model were techniques for determining soil water (versatile budget) and rate of development towards maturity (biometeorological time scale).

Soil-water data, both observed and synthesized, from under nonirrigated sod at Ottawa over 10 years were analyzed. It was concluded that water-budgeting models for synthesizing daily soil water from standard climatic data are sufficiently accurate to replace or supplement actual soil-water measurements. The importance of selecting appropriate physical characteristics of soils for these estimator models was demonstrated. Such models

are essential for interpreting weather data for use by farmers, economists, engineers, and others engaged in agricultural planning.

### **Weather and Winter Damage to Forage Crops**

A survey of the winter survival of 75 species and varieties of forage crops was made, and the data were used to determine the winterhardiness indices of several species. They varied from 100 to 94 for smooth brome grass, 92 to 48 for alfalfa, 74 to 55 for red clover, and 67 to 45 for orchardgrass. Evaluation of relative site suitability indices for winter survival of forage crops gave, for example, 100 for Saanichton, B.C., 61 for Ottawa, Ont., 49 for Fort Vermilion, Alta., and 20 for Fort Chimo, Que. The development of a universal model that uses climatic data to determine site suitability of any Canadian area is under way.

## Wheat Production on Virgin Land

By the application of a biometeorological time scale a zonation map showing the varying suitability of climate for maturing wheat over the Canadian Great Plains was prepared. The temperature normals at the time of wheat maturity were computed from the latitudes, longitudes, and elevations of nearly 1,200 locations. The hazards of freezing temperatures can be appraised from these normals.

## Weather Causes Wheat Losses

Wheat production on the Canadian Prairies from 1952 to 1967 was found to be closely related to precipitation and potential evapotranspiration. For example, two-thirds of the billion dollar difference between the values of the crops in 1961, a dry year, and in 1966, an almost ideal year, can be explained by differences in these variables.

## Long-term Weather Records and Farm Planning

Agriculturists, economists, farm loan managers, and engineers depend on a knowledge of weather variability when planning, financing, and designing many farm operations. Long-term records of daily climatic data have been used to estimate irrigation requirements for various levels of probability and to determine dates of critical temperatures near freezing for various risks at research and other selected establishments across the country. Studies using these results are under way to determine relationships that will provide estimates of these derived factors from long-term monthly climatic normals. The 700 stations in Canada for which such normals are available will provide basic data for the preparation of maps showing water deficiencies and dates of critical temperatures near freezing that will be included in the Canada Land Inventory's data bank.

# MYCOLOGY

## Taxonomic Research

*Phycomycetes.* Morphological and physiological comparisons of North American isolates of *Hypochytrium* from such widely scattered locations as the Canadian High Arctic and the Arizona desert have shown they all belong to one species, *H. catenoides* Karling. Studies of physiology, morphology, and fine structure carried out on soil-inhabiting chytrids (Phlyctidiaceae) to develop taxonomic criteria showed that, in addition to morphological characters, pH optimum and differential growth on nitrogen compounds and carbohydrates are useful criteria. Some of these fungi are being tested as vectors of plant-disease viruses. Transmission studies on wheat mosaic virus have been carried out in cooperation with the Plant Virology Section, Cell Biology Research Institute. Although *Polymyxa graminis* Ledingham is a likely vector, other fungi such as *Lagena radicolica* Vanterpool & Ledingham and *Olpidium brassicae* (Wor.) Dang., isolated from wheat roots, are being investigated as possible vectors.

*Basidiomycetes—rusts and smuts.* Three papers on fungal parasites of Scrophulariaceae were published and throw new light on the means of coevolution of hosts and parasites. A note was published on parasitic relationships and the taxonomic disposition of *Filipendula*. A short discussion of morphology and terminology of the spore states of the rusts was published.

The study of the autoecious species of *Puccinia* was extended to include the species on Ambrosiaceae that are included in the Heliantheae. Field observations of *Gymnosporangium* established the effective range of basidiospores at 15 miles, twice the reported range. A new subspecies, *Gymnosporangium gaeumannii* Zogg ssp. *albertense*, was recorded for the first time in North America.

*Basidiomycetes—Hymenomycetes.* On the basis of their cultural characters, 227 species of Polyporaceae were assigned to 42 groups, each considered to represent a taxon of generic or higher rank, and 29 of these groups included one or more species that have been designated as types

of genera. In such groups, evidence from cultural studies confirms the validity of the genera segregated on the basis of fruit-body morphology. In each of the remaining 13 groups, correlated studies of cultures and fruit bodies are required to determine whether the groups merit generic recognition.

*Ascomycetes—Discomycetes.* Studies are under way on the inoperculate Discomycetes of the family Dermateaceae including taxonomy, morphology, life history, and conidial relationships. The conidial state of *Dermea pseudotsugae* Funk has been established. Two new species of *Ascocalyx* that occur on species of *Abies* have been described: *Ascocalyx asiaticus* from Pakistan and *A. tenuisporus* from British Columbia. A new name, *Crumenulopsis*, has been proposed to replace the illegitimate name *Crumenula* Rehm., and the species of this genus have been reviewed. *Peziza viburni* Schw., originally described as on *Viburnum*, has been shown to occur on *Ilex* and to belong in the genus *Eutrybliidiella*. Genera that are being studied include *Encoelia*, *Encoeliopsis*, *Pezicula*, and *Phibalis*.

Extensive cross-fertilization studies using single ascospore cultures of *Streptotinia caulophylli* were conducted. This species is hermaphroditic and self-sterile, and the cultures fall into two sexual groups that are intragroup sterile and intergroup fertile. Apothecia were produced in culture in two isolates of *Lambertella* sp. and in *Lambertiella corni-maritima*.

*Ascomycetes—Pyrenomycetes.* Taxonomic revision of nine species of *Pleospora* was completed. Two parasites of *Lonicera* spp., *Amphisphaerella xylostei* and *A. alpigena*, were distinguished. The taxonomy of *Cucurbitaria pityophila* and some allies occurring on scale insects on conifers is under revision.

*Castanea* seedlings imported from Asia as a source resistance to *Endothia parasitica* were killed by other fungi, including *Cytodiplospora castanea* (a new record in Canada), *Cryptodiaporthe* sp., and six species of Sphaeropsidales.

Ascomycete development and cytological studies are well under way for *Aithalomyces rhododendri* Woron., *Metacapno-*

*dium juniperi* (Phil. & Plowr.) Speg., and *Leptosphaerulina australis* McAlpine, and studies on *Trematosphaeria fallax* Mouton and *Enthallopycnidium gouldiae* Stevens have been started. A paper on the ontogeny of *Platyspora pentamera* (Karst.) Wehm. was published.

*Fungi Imperfecti.* Two fungi occurring on conifer resin, *Strigopodia resiniae* (Sacc. & Bres.) Hughes from Europe and eastern North America and *S. resiniae* Hughes from western North America, were differentiated, illustrated, and described. Both species produce phragmoconidial states of *Hormisciella* Bat. and phialidic states of *Capnophialophora* Hughes, for which descriptions, illustrations, and synonymies were also published.

The generic names *Myxotrichum* Kunze, *Onocladium* Wallr., and *Diploospora* Grove were explained through studies of type or other relevant collections, as were four genera described by Preuss, *Calcarisporium*, *Botryonipha*, *Gongromeriza*, and *Tolypomyria*.

A study of some tropical hyperparasitic hyphomycetes was completed jointly with F. C. Deighton, Commonwealth Mycological Institute. Four species were segregated from *Eriomycopsis* Speg. to the new genus *Chionomyces* Deighton & Pirozynski. *Atractilina* Barth. was adopted for some species of *Arthrobotryum* Ces. Two new genera and one new species of *Calcarisporium* were described, and a number of rare taxa, including *Spermatoloncha maticola* Speg., *Domingella asterinearum* Petr. & Cif., and *Triposporina uredinicola* Höhn., were redescribed.

A new genus, *Cryptophiale* Pirozynski, and two new species, *C. kakombensis* Pirozynski from Tanzania and *C. udagawae* Pirozynski & Ichinoe from Japan, were described.

Research in the taxonomy and nomenclature of *Amblyosporium* Fres. was completed. *A. spongiosum* Fres. was reinstated as the type, and the fungus generally identified as *A. botrytis* was removed to *A. spongiosum* (Pers.) Hughes. *Searchomyces* B.S. & M.P. Mehrotra was treated as a synonym of *Amblyosporium*, and a new species, *A. thaxteri* Pirozynski, was described.

*Arctic fungus flora*. Some general observations on the plants of central Baffin Island were recorded in connection with a study of the fungi of the region. A report on the parasitic fungi collected on Baffin Island in

1967 was prepared. New hosts have been recorded for *Cylindrosporium serabran-kowii* (Bub.) Bub. and *Selenophoma drabae* (Fckl.) Petr. *Puccinia pedicularis* Thuem. is a new record for North America.

## ORNAMENTALS

### Evaluation of Ornamental Plants

New cultivars and seedlings of ornamental plants that have not yet been released for sale were evaluated in 1968; these included 984 woody plants; 846 herbaceous perennials; 353 bulbous, cormous, and tuberous plants; 404 garden annuals and related plants; and 54 outdoor chrysanthemums.

A large number of the woody plants under test during the past 3 years were obtained from the disbanded nurseries of Pierre Lombarts and Sons, Holland, who were well known for their selected clones of rare and unusual ornamental plants.

The groups of annuals selected for intensive testing in 1968 were celosias, marigolds, and verbenas. All of these showed considerable improvement in form and color over those observed a few years ago when they were previously tested.

*Cytisus* × *beanii* 'Golden Carpet' and *Juniperus scopulorum* 'Silver Column' were propagated and distributed to nurserymen through the Canadian Nursery Trades Association during 1968.

### Winterhardness in Nursery Crops

The telemetry system of recording electric resistance readings (e.r.r.) was

extended to include a 10-point multiplexer to study the winterhardness of plants. With this added electronic device electric signals can be transmitted automatically and in consecutive order at any time.

Results have also substantiated previous findings that styrofoam covers aided the winter survival and general plant vigor of rose plants. These covers moderated the extreme effects of maximum and minimum winter temperatures, and had a favorable effect on the overwintering of roses.

### Salt Tolerance of Turfgrasses

Greenhouse experiments have shown that most turfgrasses can withstand considerable foliar sprays of road salt, but they vary in their tolerance to salt. Of 12 strains and species tested, Norlea perennial ryegrass and Kentucky 31 tall fescue were the most salt tolerant. Fine-leaved bentgrasses, annual bluegrass, and creeping red fescue were the least tolerant to chloride ions and salt sprays. Kentucky bluegrass was less tolerant than tall fescue, but more tolerant than bentgrasses and creeping red fescue.

## PLANT GROWTH AND DEVELOPMENT

### Growing Plants in Controlled Environment

The maximum light intensities required for crop plants in growth rooms with atmospheric air at a constant 25 C and 16-hr photoperiod were 2,000 ft-c for beans and tomatoes; 3,000 ft-c for corn, cucumbers, and rape; and 3,800 ft-c or higher for barley, oats, wheat, and peas. These results show that with the exception of cereals 3,000 ft-c is adequate for growing most plants in growth rooms.

The effects of 1.5 hr of twilight before and after the high light period were

observed on Top Crop beans and Michigan Ohio hybrid tomatoes at a constant 25 C and 16-hr photoperiod. There was no difference in the growth of bean plants, but the growth of tomato plants was significantly lower when twilight was added after the photoperiod. Twilight had no effect on the time to flowering of either beans or tomatoes.

Growth and flowering of several seedling ornamental annuals were markedly increased when given a 2-week environment of supplementary CO<sub>2</sub> (1,300 ppm),

high temperatures, and a photoperiod of 16 hr at 3,000 ft-c.

### Growth Efficiency of Cereals

Kinetically true rates of growth for Marquis wheat were obtained as functions of light intensity, CO<sub>2</sub> concentration, and N level. The dependence of the rate of C assimilation on the concentration of CO<sub>2</sub> increased hyperbolically with light intensity, but the reverse occurred for plant growth. Growth at the lower light intensities benefited more from added CO<sub>2</sub>. The calculated maximum growth rate for saturating light intensity at 25 C and in 350 ppm CO<sub>2</sub> with Hoagland's nutrient solution was 36% higher than the highest rate measured. The calculated rate of growth was decreased 10% when the normal CO<sub>2</sub> concentration was doubled. Five times the normal supply of N also lowered growth efficiency at high light intensities.

### Developmental Physiology of the Shoot Apex and Inflorescence in Wheat

A series of studies was started on the growth and morphological development from germination to mature inflorescence of the shoot apex in wheat. When the day length was increased from 8 to 16 hr, the mean daily rate of primordium formation up to the double ridge (DR) stage was unaffected, but the duration between germination and DR stage was reduced from 49 to 17 days in cv. Marquis, and from 50 to 43 days in cv. Pitic 62. In both varieties at both day lengths, the apex stopped primordium formation at approximately the stamen primordia (SP) stage of inflorescence development. Between the DR and SP stages the mean daily rate of primordium formation was affected by day length; it was higher in the long day. The effect was more pronounced on Marquis, which had a lower rate than Pitic in the short day, and a higher rate in the long day (before the DR stage, all four mean rates were similar). The duration between DR and SP stages was decreased from 41 to 16 days in Marquis, and from 16 to 12 days in Pitic with increased day length.

The number of spikelets on the main shoot inflorescence was a function of the differential rates of primordia formation

and of stage development, and of differential distribution of primordial sites between leaf and spikelet initials. Differences among varieties and treatments were also apparent in such characters as: proportion of main shoot spikelets that were fertile; grain numbers per fertile spikelet; number of ears per plant; grain numbers and weight per plant; and distribution of grains among the potential grain sites on the main shoot inflorescence.

### Polar Orientations of Rhizome Buds in *Poa pratensis* L.

The rhizome is oriented in both the vertical and horizontal planes by forces acting under biological control. The angular direction of orientation is primarily determined by the bud scales (cataphylls). Stem elongation of the rhizome does not occur until orientation is complete. The cataphylls, initially dome-shaped with a slightly offset apical pore, are situated one within another. Later they elongate, but growth is disproportionate, the vertical orientation being caused by enhanced growth on the upper side of the cataphyll and early vascularization with pronounced development of sclerenchyma tissue on the outer and ultimately lower side. Collectively the cataphylls form a curved tube through which the young rhizome stem will be directed in its ultimate growth. Simultaneously the plane of bilateral symmetry of the rhizome apex shifts by 90°.

Horizontal orientation occurs when a rhizome bud on a young shoot bends away from the parent plant thus directing the rhizome into an area of new soil. In this case the orientation responses are similar except that the region of vascularization in the cataphylls is on one side of the bud. When both orientations occur simultaneously in the same bud, the region of vascularization shifts to occupy a position midway between the side and the lower positions.

These orientations, originally thought to be geotropic responses, appear to be biologically controlled. On the rotating clinostat, in a multidirectional gravity field, the orientations are identical with those outlined above. Therefore they are probably polar responses, governed by the fore and aft axis of the shoot. Later rhizome growth is gravitationally oriented.

# TAXONOMY OF THE VASCULAR PLANTS

## Floristic Studies

The two-volume work incorporating both systematic and cytological studies of 593 taxa from the Queen Charlotte Islands, British Columbia, was published during July. Documented herbarium material relating to both volumes will be sent out in exchange during 1969.

Further papers containing a floristic treatment of the plants of the Prairie Provinces were published this year. Approximately one-half of the flora has now been published.

A checklist of all the plants known to occur in the continental Northwest Territories was published during 1968, and work on the flora itself was continued.

About 2,000 herbarium specimens were collected in the Gatineau Park this year, and work on the text of a flora of the park was initiated.

A systematic treatment of the milkworts (Polygalaceae) of Canada was published during the year.

## Major Taxonomic Studies

Systematic studies on the *Trifolium longipes* Nutt. polyploid complex were completed. Classification of the various sections of the genus *Trifolium* and systematic studies of the *T. eriocephalum* Nutt. complex are under way. In a co-operative study with the New York Botanic Garden, progress continues on the chromosome number variation in the large legume genus *Dalea*.

Study of the genus *Cirsium* was concentrated on species of eastern North America, mainly those of the Atlantic coastal plain. A manuscript on the cytology, morphology, and probable evolutionary relationships of 10 species of this area was completed. Preparation of a book on the native and introduced members of the tribe Cardueae in Canada was continued.

Evolutionary studies of native North American species of flax, *Linum*, continued with emphasis on their breeding systems, chromosome number and structure, and speciation mechanisms.

A taxonomic study has recently been published on three introduced species of

*Atriplex*: *A. heterosperma* Bunge, *A. oblongifolia* Waldst. & Kit., and *A. hortensis* L. Further studies are being done on other species of the genus, native and introduced, in North America.

A taxonomic study of the Plantagina-ceae of Canada is in manuscript form, and systematic studies of two related species, *Plantago fastigiata* Morris of North America and *P. ovata* Forsk. of Eurasia, are being continued.

The last papers of a series on the cytology of species of *Physaria* were published. Pairing configurations in pollen mother cells of a natural first-generation hybrid between *Rorippa barbareaefolia* (DC.) Kitagawa ( $2n=16$ ) and *R. islandica* (Oeder) Borbas ( $2n=32$ ) suggested that the male parent, *R. islandica*, was an autotetraploid. A population of the amphiatlantic *Draba norvegica* Gunn. was found in the Mackenzie District, N.W.T., nearly a thousand miles west of the nearest plants of the species in northeastern North America. Cytotaxonomic studies are proceeding on North American species of the genus *Draba*.

A delimitation of the oat genus *Avena* was established, and the relationship between cultivated oats, *Avena sativa* L., and wild oats, *Avena fatua* L., was determined from Canadian material. A new technique was found for the detection of the  $F_1$  *A. sativa*-*A. fatua* hybrids that occur to a fairly large extent in cultivated oat material from different parts of the world.

The natural hybrid between two common species of cordgrass of Atlantic coastal marshes, *Spartina pectinata* Link and *S. patens* (Ait.) Muhl., is not aggressive, nor does it pose a threat to navigation as does the *S. townsendii* H. & J. Groves hybrid of Europe.

The illustrations and distributional maps for the publication *Saxifragaceae of Canada and Alaska* are nearly completed. Electron-microscope studies were carried out on the fine structure of the pollen wall of the genera *Mitella*, *Tiarella*, *Tellima*, and *Tolmiea*.

## Weeds

A revision of *Weeds of Canada* was finished. An additional 11 plates of 21 species and text for 25 more taxa are included in the revision. It should be available for distribution by the middle of 1969.

## Air-borne Pollen Surveys

Results from an air-borne pollen station on Sable Island have shown that although ragweed and several trees do not occur on the island their pollen is present in the air. Surveys on air-borne pollen were continued at pollen stations in Eastern

Canada, Alberta, and Saskatchewan. New information on the abundance of ragweed pollen in the air is being added to the publication *Canadian Havens from Hay Fever*.

## Flora-Insect Relationships

The relationships between the spectral qualities of flowers of 200 species and the photoreceptive abilities of their pollinating insects are being studied. Particular attention is being given to the quality and quantity of ultraviolet light emission from petals in daylight. Special instruments are being searched for and developed.

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## VISITING SCIENTIST

### *National Research Council postdoctorate fellow*

E. H. HANSEN, M.Sc., Ph.D., 1967-	Humic acid chemistry
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## INTRODUCTION

This report covers the main research activities and findings in the Soil Research Institute in 1968.

The Soil Research Institute is concerned mainly with basic and applied chemical, physical, and biological studies designed to give a better understanding of the nature and behavior of Canadian soils. This information is of great assistance in determining the cause of many problems associated with the different soils and in developing satisfactory solutions.

The Institute cooperates with provincial institutions in soil survey programs in

Nova Scotia, Ontario, and Alberta. The Cartography Section prepares basic soil maps for publication, and soil capability and computer input maps for the Canada Land Inventory.

Mr. W. E. Bowser, Head, Alberta Soil Survey and Mr. W. E. Nichol of the Physical Chemistry Section of the Institute retired after many years of service.

P. C. Stobbe  
Director

## SOIL FERTILITY

### Soil Temperature

Experiments on the effect of soil temperature on plant growth were continued. A 3-year stand of brome grass in a controlled-temperature experiment in the field showed a much higher quantity of residual roots under cool conditions (about 9 C) than under seasonal or warm soil conditions (about 27 C). Soil from the cool plots gave poorer growth of oats and peas in a pot test than soil previously managed at a higher temperature. Upon incubation, soil from the cool conditions gave much lower amounts of nitrate than did the soil from warmer conditions. This detrimental effect of cool temperature was partly overcome by the addition of N and P in the pot test.

When clones of the parental selections of the new timothy variety, Champ, were grown in the greenhouse at lower soil temperatures, S-5 and S-9 usually produced more herbage than S-2 and S-6 but not more than Climax or Drummond, two registered varieties. Under high nutrition (N + P) and temperature (27 C day and 20 C night), however, S-2 produced the most. After the fourth clipping, the rate of growth for S-6 was near its optimum, whereas that of the others was decreased sharply.

### Soil Moisture

A moisture stress index for wheat was developed in cooperation with the Research Station, Brandon. Analyses of wheat yield data from a fertilizer field-plot experiment for the years 1955 to 1963 showed that the grain yields were closely associated with a plant moisture stress index ( $r = -0.83$ ). The moisture stress (potential evapotranspiration less actual evapotranspiration) was calculated from daily mean air temperature, precipitation, and estimated rate of moisture movement within different layers of the rooting zone for several stages of plant development. The results showed a yield reduction of  $5.91 \pm 1.52$  bu/acre per inch of accumulated moisture deficit to the plant during the growing season. The optimum calculated yield of wheat grown without any moisture stress for the years 1955 to 1963 was 48.9 bu/acre.

### Soil Pollution (Pb and Ni)

Because Pb from industrial wastes, from the exhaust of automobiles, or from other sources may lead to soil contamination, experiments were conducted on its solubility in soils and its uptake by plants. Four sandy loam soils varying in pH and organic matter content were contaminated

by adding  $\text{PbCl}_2$  (0 to 1,000 ppm Pb) and then lime ( $\text{CaCO}_3$ ) and phosphate ( $\text{CaH}_2(\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$ ) treatments were given.

It was found that the solubility of Pb in the soils and its concentration in oats and alfalfa were less when the pH and organic matter content of the soils were high and that the amounts were reduced by phosphate treatment and by lime treatment of the acid soils. For example, where Pb was added to the rate of 1,000 ppm, the amount of Pb soluble in 0.1 M  $\text{CaCl}_2$  was only 0.6 ppm in a slightly alkaline soil (pH 7.6) and only 2.3 ppm in a soil high in organic matter (C 12.3%) as compared with 132.0 ppm in an acid soil low in organic matter (pH 5.7, and C 0.8%). The amount in the latter soil was reduced to 22.1 ppm by lime treatment, to 31.5 ppm by phosphate treatment, and to 10.2 ppm by both treatments. The concentrations of Pb in plants grown in a pot test were in accord with its solubility in the soil. For instance, the concentrations in oat grain grown with the 1,000 ppm rate of Pb in the slightly alkaline soil, the soil high in organic matter, and the acid soil low in organic matter were 8.0, 3.9, and 23.1 ppm respectively. The latter was reduced to 9.1 ppm by lime, to 5.7 by phosphate, and to 4.2 ppm by additions of both.

In a corresponding experiment, where the soils were contaminated with Ni instead of Pb, the results were similar except that phosphate increased the solubility of Ni and its uptake by plants.

## PHYSICAL CHEMISTRY

### Reactions Involving Aluminum

It was pointed out in the previous Research Report that reactions between Al in solution and clays depend on the forms of Al existing in the system. Consequently, it was necessary to determine the forms of Al that exist in solution or in suspensions in aqueous systems as a function of the acidity of the solution. Methods were developed for determining the concentration of mononuclear and polynuclear ions in the liquid phase and the initial amorphous solid phase. These methods were applied to solutions of  $\text{AlCl}_3$  to which vary-

### Selenium

In the Kapuskasing area of Ontario, the forage crops fed to cattle are often deficient (<0.1 ppm) in Se. This deficiency is related to the incidence of white muscle disease in beef cattle. This problem prompted an investigation of Se in the soils of the northern Ontario clay belt. Preliminary results pointed to the low Se contents (<0.4 ppm) of these soils compared with those of a number of other Canadian soils. A close association was found between Se and organic matter, which indicates that most of the Se was either of organic nature or complexed with the organic matter.

### Cesium-137

An experiment designed to show the effects of the fixation and plant recovery of  $\text{Cs}^{137}$  showed that the chlorides of  $\text{NH}_4$  and K leached much more  $\text{Cs}^{137}$  from soils than did those of Mg, Ca, or Al. Yet  $\text{Cs}^{137}$  was taken up by oats from the part of the  $\text{Cs}^{137}$  fixed against the salt leachings, and there was evidence that  $\text{NH}_4$  augmented the absorption of  $\text{Cs}^{137}$  by the crop. The effects of  $\text{NH}_4^+$  versus  $\text{NO}_3^-$  were therefore studied in another experiment. There was a substantial increase in the concentration of  $\text{Cs}^{137}$  in oats grown with applied  $\text{NH}_4$  instead of  $\text{NO}_3$  when no K was added. When K was added to the soils, however, this effect was not consistent. There appeared to be an interaction between  $\text{NH}_4^+$ ,  $\text{K}^+$ , and  $\text{Cs}^+$  competing for fixation sites on the soil particles.

ing amounts of NaOH were added. The results show that where the pH of an  $\text{AlCl}_3$  solution is raised by adding a base, the initial product is a solid phase, which can be represented by the formula  $\text{Al}(\text{OH})_{3-x}\text{Cl}_x$  where the value of x depends on the Cl concentration and pH of the solution. The polynuclear ions form more slowly at the expense of the solid phase. When conditions are such that some of the solid phase remains in the system, gibbsite eventually forms, providing the Cl concentration is not too high and the system is moderately acid.



## Reactions of Sulfate in Aqueous and Aluminum-Clay Systems

The precipitate of aluminum hydroxy sulfate  $[\text{Al}(\text{OH})_{3-x}(\text{SO}_4)_{x/2}]$  formed by the addition of  $\text{Ca}(\text{OH})_2$  to dilute aqueous solutions of aluminum sulfate remained amorphous at 25 C for a reaction time of 1 year. At 50 C the amorphous precipitate, formed over the range of OH/Al molar ratio of 1.6 to 2.5, crystallized after about 5 months to a basic aluminum sulfate of the chemical composition  $\text{Al}_4(\text{OH})_{10}\text{SO}_4 \cdot 5\text{H}_2\text{O}$ , similar to basaluminite. The ion product  $(\text{Al})(\text{OH})^3$  of these systems varied between  $10^{-33.83}$  and  $10^{-33.54}$  and these variations were caused mainly by variations in pH brought about by the different OH/Al ratios. The solubility product  $(\text{Al})^4(\text{OH})^{10}(\text{SO}_4)$  of these compounds was relatively constant ( $10^{-117.30}$ ) at 25 C in close agreement with the solubility product of the crystalline compound basaluminite formed in the presence of clay.

A treatment of the neutralization of dilute  $\text{Al}_2(\text{SO}_4)_3$  solutions with a base was developed and supported by experimental data. These experiments clarified some of the ideas presented in the literature. The formation of the soluble complex,  $\text{AlSO}_4^+$ ; the first stage hydrolysis product,  $\text{AlOH}^{2+}$ ; and the precipitation of amorphous alu-

minium hydroxy sulfate are the reactions controlling the conditions in solution up to 80% neutralization. Beyond 80% neutralization there is slow replacement of  $\text{SO}_4^{2-}$  by  $\text{OH}^-$  in the amorphous precipitate of aluminum hydroxy sulfate.

## Reactions between Orthophosphoric Acid, Aluminum, and Bentonite

Studies of the reactions between orthophosphoric acid, aluminum, and Wyoming bentonite, and of the effect of the products of these reactions on the properties of the bentonite and the activities of  $\text{Al}(\text{OH})_3\text{H}_2\text{PO}_4$  and  $\text{Al}(\text{OH})_3$  in solution at equilibrium with the solid phases, were started. A relatively stable interlayer phase, consisting of Al, P, and probably OH, formed, which increased the  $d(001)$  spacing and decreased the cation exchange capacity of the bentonite. Values of the  $(\text{Al})(\text{OH})^2(\text{H}_2\text{PO}_4)$  ion product were larger than would have been maintained by crystalline variscite, but X-ray diffraction studies showed no evidence for formation of a separate crystalline phase. Values of the  $(\text{Al})(\text{OH})^3$  ion product were smaller than would have been maintained by crystalline gibbsite and they decreased with increasing additions of  $\text{H}_3\text{PO}_4$ .

# MINERALOGY

## The Nature of Clay Minerals

From the analysis of a range of dioctahedral aluminous mica clay minerals it was found that they could be described in terms of the Si/Al ratio of the tetrahedral layer. The ratios of normal muscovites and microcrystalline muscovite fell between 3.0 and 3.4. The ratios for hydromuscovites were mainly 3.4 to 3.6 whereas those for the hydrous micas were concentrated in the range of 4.0 to 5.4. In spite of the structural varieties of hydrous micas, the range in the Si/Al ratio was found to be remarkably narrow. This suggests that not only the amount of Al substitution for Si, but also its distribution pattern in the tetrahedral layers should be taken into account to explain the structural variety.

Unlike the illites, a naturally occurring fine-grained muscovite had the ideal K content, which did not vary with particle size. A detailed study was made in order to compare it with soil clay micas.

## Experimental Alteration of Clay Minerals

Continued studies of the decomposition of orthochlorites in acid solutions showed no preferential dissolution of octahedral rather than tetrahedral cations nor of the hydroxide sheet rather than the 2:1 sheet. The chemical data suggested a diffusion-controlled reaction. However, microscopic observations, X-ray and thermal analyses indicated that the reaction was much more complicated. Acid attack was not exclu-

sively an edge effect, but started at and advanced along such accessible sites as cracks and structural weaknesses, resulting in channels and etch pits as well as frayed edges.

#### **Interlayer Complexes with Montmorillonite**

Reaction of  $Mg(OH)_2$  with excess  $AlCl_3$  in the presence of Wyoming bentonite resulted in the interlayer complexes of montmorillonite with mixed Mg-Al hydroxides and thereby caused a pronounced reduction in the cation exchange capacity of the montmorillonite. There was evidence that the interlayer material consisted of brucite-like layers in which Al has proxied for some of the Mg.

When Al was precipitated with a base from sulfate solutions in the presence of montmorillonite, it entered the interlamellar space initially. Upon aging, the interlayer hydroxide was removed and formed crystalline  $Al_4(OH)_{10}SO_4 \cdot 5H_2O$  similar to the naturally occurring basaluminite.

Thermal analysis of a montmorillonite-fulvic acid complex provided further evidence of interlamellar adsorption of fulvic acid and was consistent with the previous finding that nearly one half of the adsorbed fulvic acid was in the interlamellar spaces of the montmorillonite. Differential thermal analysis could be used for the detection of soil organic-clay complexes.

## **SOIL BIOCHEMISTRY**

#### **Release of Amino Acids in Soils**

Studies on the effect of length of time of acid hydrolysis on the release of amino acids from soils showed that the rate of release is similar to that reported in the literature for proteins. There was a slight increase in the amount of valine and isoleucine, and some loss of serine, threonine, and cystine with long hydrolysis time. In general 16–24 hr seems to be the most suitable time of hydrolysis. This suggests that the amino acids of soils are combined as peptides, polypeptides, or proteins. Some preliminary work with the proteolytic enzyme pronase indicated that its action on a series of soil organic matter parts was similar to its action on soybean meal with respect to the proportions of amino acids released.

#### **Amino Acids in Rhizosphere**

A method of separating asparagine, glutamine, and citrulline from each other and from the other common amino acids was developed. The method showed that more amino acids were present in the aqueous extract of rhizosphere samples than in nonrhizosphere samples. Greater amounts of asparagine, glutamine, and citrulline were found in the rhizosphere of legumes than in the rhizosphere of nonlegumes. Larger quantities of these amides were liberated by fertilized plants than by nonfertilized plants. Increasing the soil

temperature also increased the amount of amides excreted by plant roots. The finding that the rhizosphere contained substantial amounts of citrulline, whereas root tissue contained only trace amounts, suggests that some of the amino acids found in the rhizosphere are liberated by the living plant root instead of being the result of root autolysis.

#### **Polyphenols in Peats**

The application of new preparative, analytical techniques to the extractives from sedge peat has afforded *p*-coumaric acid, ferulic acid, protocatechuic acid, alpha-resorcylic acid, and some polymeric polyphenols that appear to possess appreciable amounts of protocatechuate and resorcinol moieties. Hydrolysis experiments, moreover, showed that the isolable compounds occur predominantly as alkali-labile, acid-stable derivatives.

In appendant experiments the survey of the phenolic composition of the bog plants was extended. The common Labrador tea, *Ledum groenlandicum* Oeder, for example, was found to contain the flavonoid compounds quercetin and cyanidin. The presence of these compounds in association with those previously reported suggests that the refractory and antibacterial properties attributed to certain peats may be related partly to the comparatively acid resistant phenolic constituents of the bog plants.

# HUMIC ACID CHEMISTRY

## Structure of Humic and Fulvic Acids

Investigations of the chemical structure of humic and fulvic acids were continued, using Zn-dust fusion, a somewhat milder procedure than the Zn-dust distillation referred to in last year's Report. The main distillation products were polysubstituted naphthalene, substituted phenanthrene, and substituted and unsubstituted anthracene, pyrene, and perylene. These results point to the occurrence in the "nuclei" of soil humic compounds of significant amounts of polycyclic aromatic ring structures or structures yielding such ring systems under the experimental conditions employed. Recent Zn-dust fusions of methylated humic and fulvic acids indicate, however, that the four- and five-membered ring structures isolated earlier were in all likelihood formed during the fusion procedure. It appears, therefore, that the humic compounds investigated do not contain condensed ring systems in excess of three rings.

## Free Radicals in Humic and Fulvic Acids

Many reactions in soils, involving humic and fulvic acids, are one-electron or free radical reactions. The structures and origins of the free radicals are still a matter of conjecture. To shed light on this problem electron spin resonance spectroscopy was used to determine: (i) the free radical concentration and location in humic and fulvic acids; (ii) the relationship between oxygen-containing functional groups and free radicals; (iii) the effects of forming organic matter—metal and organic matter—clay complexes on the free radical concentration; (iv) the effects of pyrolysis, oxidation, and reduction on the free radical content; and (v) the relationship between free radical content and biological activity as measured by root initiation. The following results have been obtained so far: the free radical concen-

trations of the humic and fulvic acids were 7 and  $4 \times 10^{17}$  spins per g respectively; from the magnitude of the spectroscopic splitting factors,  $g$ , it appeared that the free radicals were associated with O rather than C atoms. The numbers of unpaired electrons decreased by selectively blocking phenolic hydroxyls and carboxyls. Heating of the humic samples to 450 C increased the free radical contents 30 times. The  $g$  values agreed well with those published for coals and semiquinones.

## Biological Degradation of Fulvic Acids

Studies on biological degradation of soil humic compounds were continued with Podzol Bh Fulvic acids (FA) and the *Poria subacida* (Pk.) Sacc. The reliability of decoloration as a measure of FA degradation was confirmed by precipitation of FA by  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  and C analysis of the complex. The role of exocellular enzymes was found to be restricted to oxidation of the products of FA degradation.

A specific combination of cultural and cell disruption techniques yielded an active cell-free preparation of the *P. subacida*. The particulate fraction of the preparation decolorized the FA up to 10% in 4 hr. The soluble fraction, which could not initiate decolorization, extended or facilitated activity of the particulate fraction to exhibit a 20% decoloration. Phenol oxidase activity was inhibited by the addition of sodium diethyldithiocarbamate. Peroxidase activity, absent in cultural filtrates and indistinguishable from oxidase activity in live cells was discovered in cell-free preparations. Its role is under investigation. Attempts are also being made to isolate the FA-cleaving enzymes from cell-free preparations of the *P. subacida* for use in a relatively clean system from which isolation of FA degradation products should be easier.

# SOIL PHYSICS

## Moisture Movement

In recent years, physical phenomena such as infiltration when soils are wetting continuously throughout the profile, or

drainage to a water table when they are drying continuously, have been analyzed fairly satisfactorily. The common situation in which both wetting and drying occur in

the same profile is more complicated because it involves hysteresis in the water content—pressure potential relationships. In 1968, further progress was made in analysis of the first level of difficulty, i.e., in redistribution following infiltration. Such analysis involves only a primary wetting curve and drying scanning curves. The combined situation involving both wetting and drying scanning curves remains one of the outstanding problems in the physics of water conservation and use. The progress made on redistribution and on two approaches to the wetting and drying problem is described.

Comparisons of computed and measured water content profiles following infiltration and subsequent redistribution were carried out for three soils of widely differing texture and structure. The method introduced last year for inferring diffusivity and conductivity data from experimental redistribution profiles was developed further and used for the three soils. Satisfactory agreement was obtained between computed and measured profiles for independent infiltration tests. Besides elucidating water movement processes, this work demonstrated how hysteretic effects contribute to field capacities and available water contents of different soils.

In one approach to the wetting and drying problem, basic studies were continued to relate theories or models of hysteresis to soil-water parameters. The techniques for filling and packing soil columns were developed so that separate levels in the column of soil could be used

interchangeably in measuring hysteretic scanning curves in the water content—pressure potential relationships. A column of Rubicon sandy loam was subjected to a number of wetting and drying cycles. During such changes gamma ray equipment and a pressure transducer were used to measure water content, pressure potential, and hydraulic conductivity. These data showed that the currently available independent domain theory is inadequate for this soil. Work is continuing along these lines attempting on the one hand to find the magnitude of the discrepancy for different soils and conditions, and on the other to find where the theory fails and if possible to correct the failure by modification.

A second approach to this problem was made by rewetting columns of soil after partial drying. The resulting moisture content profiles were compared with those computed with the use of conductivity coefficients and rewetting scanning curves based on the independent domain theory. Thus far the measurements have not been sufficiently accurate for detailed comparison of hysteretic effects, presumably because of consolidation of the soil during the initial drying.

An ionization chamber for gamma ray detection was designed and built to be used with a commercially available electrometer. Preliminary data indicated that the method maintains accuracy while improving the response time of the gamma ray system.

## PEDOLOGY AND GENESIS

### Correlation and Classification

Classification and inventory of Canadian soil resources by the Institute have continued in Nova Scotia, Ontario, and Alberta in cooperation with provincial organizations. Soil correlation studies were made with other provincial soil survey units across Canada with emphasis on capability evaluation. This work included the evaluation of the agricultural potential of Indian Reserve lands in Canada. Significant contributions were made to a revision of the taxonomic classification of soils by the National Soil Survey Committee and a

new classification of organic soils was proposed. In connection with the FAO sponsored program of a Soil Map of the World a draft of the Canadian section of a soil map of North America has been completed. Detailed tables have been developed that permit easy correlation of Canadian, American, and World classification.

### Soil Genesis

Investigations have continued on the development of precise criteria for identifying specific soil horizons to apply in the

classification of soils. Extractable Al, and not Fe, appeared to be the best single criterion for the identification of Podzol B horizons. Thin indurated horizons (pans) in soils of Newfoundland were found to be cemented by Fe-fulvic acid complexes, amorphous Fe and Mn oxides, or Fe oxides. Micromorphological, chemical, and mineralogical data showed that, in spite of thin acid sola, many of the reddish-brown soils of the Atlantic Provinces satisfy the requirements specified for Gray Luvisols and not those for Podzols.

#### **Nova Scotia Soil Survey, Nova Scotia Agricultural College, Truro**

The investigation of the soils in Cumberland County has been continued and special attention has been paid to the nature and occurrence of fragipans. Detailed studies have been made of a section of the Musquodoboit Valley in which a number of flood control dams have been constructed.

#### **Ontario Soil Survey, University of Guelph**

Detailed studies of the soils in Brant and Waterloo counties were continued and the variability of the soils in relation to geomorphological forms was established. In northern Ontario reconnaissance surveys of the soils were continued and this involved considerable air photo interpretation in the more inaccessible areas. An assessment of soil capability was made for an additional 12,500,000 acres, bringing the total so assessed in Ontario to 50,000,000 acres.

#### **Alberta Soil Survey, University of Alberta, Edmonton**

During the past year close to 1,000,000 acres were surveyed on the Sand River Sheet (73L). The field and laboratory studies of the soils in the upper North Saskatchewan River Valley were continued and soil capability maps for agriculture were completed for approximately 17,000,000 acres on sheets 83I, 83B, 82P, 73D, and 73E.

## **CARTOGRAPHY**

During the year, eight basic soil survey maps and 26 soil and land capability maps for the various sectors of the Canada Land Inventory were prepared and

published in color. Over 1,000 detailed land capability maps were prepared for the ARDA computer program of the Inventory.

## **PUBLICATIONS**

### **Research**

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Integrated control of orchard pests

## 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 chemical 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. The processes receiving particular emphasis are: fecundity, mortality or stress imposed by biotic agents or by nutritional imbalance, host selection, and food preference.

During 1968 a collaborative project with the Research Station, Delhi, Ont., has shown that field applications of virus reduce cutworm damage to tobacco. On Vancouver Island, larvae of an introduced moth have effectively controlled a noxious weed over a 50-acre trial area; and, with the cooperation of local farmers, larvae have been transported to other weed-infested parts of the Island. The effects of certain antibiotics used widely in insect diets have been measured, and both safe

and toxic levels have been determined. A surprising discovery is that mosquitoes are attracted to, and will feed on, insect larvae, and as a result will develop eggs. This finding greatly extends the range of animals among which mosquitoes may transmit disease.

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. The Institute also provides liaison with the Commonwealth Institute of Biological Control to sponsor surveys and research needed by Canada in foreign countries.

Mr. H. G. James, a member of the research staff since 1932, retired on December 24, 1968. His work included studies on the predators of biting flies.

This is the sixth report, and the third annual report, to be published from the Institute.

Philip S. Corbet  
Director

## REPRODUCTIVE PHYSIOLOGY AND BEHAVIOR

### Ovary Development and Antimetabolites

Gel electrophoresis revealed 10 different proteins in the fat body, blood, and ovary of the fly, *Pseudosarcophaga affinis*. Two of these are assumed to be incorporated into the egg as yolk proteins, because during follicle growth they are synthesized rapidly and appear in increasing amounts in the blood and follicles. The amino-acid analogues, canavanine, imidazole, and *dl-p*-fluorophenylalanine, fed to flies in the diet, inhibit protein synthesis and prevent ovary development in the second and third cycles.

### Effects of Density on Fecundity

In the mosquito, *Culex tarsalis*, when larval feeding is standardized but adults are maintained at four different densities, preliminary experiments showed that females at the greatest density (2,000/unit

volume) developed fewer eggs than those at the least density (20/unit volume).

### Mosquitoes Feeding on Insects

At least two species of mosquito are attracted to certain insect larvae in the laboratory; they engorge on them and then develop eggs. The number of eggs laid is in proportion to the protein content of the host's blood. This unexpected finding raises the possibility that mosquitoes may sometimes attack insects in nature, and perhaps transmit disease between insects and vertebrates. It also reveals a potentially useful tool for physiological and behavioral studies.

### A Sex Pheromone in Spiders

A contact sex pheromone has been discovered in lycosid spiders. It is secreted by adult females of all ages, and is non-volatile and stable under long exposure to air.

## PHYSICAL AND CHEMICAL CONTROLS

### Silica as an Insecticide

Dry silica, included in the larval foods of the potato beetle, *Leptinotarsa decemlineata*, and the coccinellid, *Coleomegilla maculata lengi*, has been found to prevent molting and to cause 100% mortality. Colloidal silica in water with 5% sucrose, applied to potatoes, was not as effective against *L. decemlineata* as was dry silica.

### Autocidal Control of Mosquitoes

The feasibility of applying the sterile-male technique to mosquitoes that have already been localized by other means is being examined in the field and laboratory.

Fluorescent, date-specific marks (subsequently detected by ultraviolet light) were used to establish when mating occurs in nature. In three species of woodland *Aedes* about 90% of the females were inseminated within 3 days after emergence. Most adults were recaptured within 200 m of the release point, and females of *A. stimu-*

*lans* and *A. fitchii* were recaptured up to 72 days after emergence.

Laboratory experiments have established that ultraviolet irradiation is unsuitable for use in autocidal control. Irradiation of male *Aedes aegypti* with ultraviolet light (2,537 Å) at  $\sim 2,400 \mu\text{w}/\text{cm}^2$  for  $\frac{1}{2}$ , 1, 2, 4, and 8 min resulted in 2, 4, 5, 5, and 45% mortality 24 hr after treatment. Progeny of virgin females paired individually with survivors were reduced by 43, 90, 96, 99, and 100%, but this reduction was due mainly to failure of males to mate. Mortality of females treated similarly was negligible; reduction of their progeny (by 6, 45, 53, 72, and 98%) was caused mainly by failure to take a blood meal.

Two alkylating agents, tepa and apholate, were applied to larvae of *Culex pipiens* at different doses to test their chemosterilant effect. Treated males ceased to be competitive with normal males before complete sterility was induced.

## PREDATORS

### Ants

Field and laboratory studies have shown that *Myrmica americana* is suitable for manipulation as a biological control agent. Because many queens occur in each nest, this species is easily propagated. It is an active predator, adapting to many ecological niches. The foraging area can be modified, depending on the availability of food; and, instead of distinct colony units, there are feeding centers that may combine, move, or divide,

depending on the quantity and distribution of food.

### Coccinellids

Four species of coccinellids are attracted (by odor) to wood of *Juniperus virginiana* for oviposition. If isolated, such an attractant might be used to increase the numbers of coccinellids in places where they are most needed to control aphids.

## PARASITES

### Biosystematics of Mirid Parasites

In the Belleville district the number of mirid species known to be parasitized by braconids is 64, the highest total recorded anywhere. On *Solidago*, braconids attack 6 of about 30 mirid species. Only two of these braconids are host-specific: *Leiophron* sp. A attacks *Polymerus venaticus* in May–June, and *Leiophron* sp. B (with two broods or species) attacks *Slaterocoris*

*atritibialis* in May–June and *S. stygicus* in June–July. In 1968 nymphal (i.e. larval) mortality caused by parasites reached 40% in *P. venaticus* and 29% in *S. atritibialis*.

The two temporally discrete populations previously assigned to *Leiophron pallipes* are distinct species; the earlier one is *L. pallipes* and the other is undescribed.

## Parasite-Host Interactions

In laboratory experiments, additional details of competitive interrelationships were shown among three hymenopterous parasites (*Nasonia vitripennis*, *Muscidifurax raptor*, and *Spalangia cameroni*) when they attacked the same host. Adults of these species devote little time to unsuitable hosts, because they are able to discriminate between unparasitized host pupae and those already attacked by its own species or by the other two. In each species this ability is manifested by a reduction in oviposition on parasitized hosts, and (in *N. vitripennis* only) by a reduction in the percentage of fertilized (i.e.

female) eggs laid. The discrimination is based on changes that occur in host pupae after they have been pierced during oviposition; these changes are detected by the female's ovipositor.

Females of *Nemeritis canescens*, an oligophagous parasite, can be conditioned to attack dishes that contain the odor of geraniol; these females retain the conditioned response whether or not natural hosts are present. The discovery that associative learning can occur in an oligophagous and a polyphagous (*Itopectis conquisitor*) parasite shows that this capability may be more widespread among insects than was previously supposed.

## PATHOGENS

### Cutworms on Tobacco

To test the feasibility of controlling tobacco cutworms with virus diseases, nuclear polyhedrosis virus was applied at three dose levels to the rye cover crop in field plots at Delhi, Ont., in early spring before the rye was plowed and the tobacco seedlings were set out. The two highest levels of virus significantly reduced the number of cutworm larvae in the plots and reduced the damage to young tobacco plants to  $\frac{1}{3}$  to  $\frac{1}{8}$  of that

suffered by untreated plants. Because virus is expensive to produce, further tests are planned to determine if similar control is possible with smaller doses of virus combined with stress factors, such as other diseases or sublethal doses of insecticides. Granulosis virus, applied to the rye in a spot-grid pattern, infested and killed at least 25% of the cutworm larvae, but this reduction in population was not sufficient to protect the tobacco crop from serious damage.

## POPULATION ANALYSES

### Regulatory Effects of Predators

Food requirements and preferences of the mite *Typhlodromus fallacis*, a predator of the mite *Tetranychus urticae* that infests alfalfa, were determined in the laboratory at 75 F. The data for greenhouse populations reared at 75 F were used to estimate predation and to predict maximum values of each fluctuation in prey abundance; minimum values were determined by factors such as prey consumption, sex ratio of predators, relative immunity of adult female prey to predation, and size adjustment of predators to prey scarcity.

As part of a continuing study of the role of spiders in regulating arthropods in grassland, diel (i.e. 24-hourly) patterns of activity were determined by means of time-sort pitfall traps. Activity periods of

all prey groups (e.g. leafhoppers, crickets, and springtails) coincided with those of one or more of the major predators (hunting spiders, ants, and carabid beetles); certain groups of predators had coincident activity periods and so may have been interacting with each other.

Field observations on the apple maggot, *Rhagoletis pomonella*, showed that crickets contribute little to the 29% mortality recorded for puparia in the soil between the first fall frost and the first adult emergence.

### Behavioral and Cultural Control

The feasibility of localizing orchard populations of the apple maggot in order to increase their accessibility for control is being examined. Yellow-board traps with

hydrolyzate bait caught 20 times as many adult maggots as did traps without bait. Such traps placed in prototype "trap-trees" (i.e. decoy trees made exceptionally attractive to adult maggots) caught 25 times as many adults as did traps in well-pruned trees of commercial varieties. Trap-trees also attracted more entomophagous insects than did controls.

Cultural control of the European skipper butterfly, *Thymelicus lineola*, will require knowledge of the factors controlling the time of egg-hatch. In August, eggs in diapause were placed at 34 F, and samples were removed weekly for 21 weeks for incubation at 72 F. These experiments showed that, after 18 weeks of cold, eggs hatch promptly after incubation.

## INSECT-PLANT RELATIONS

### Biological Control of Weeds

Studies continued on the control of noxious weeds by liberating, after screening, weed-feeding insects from abroad.

*Senecio jacobaea*. In British Columbia the moth, *Hypocrita jacobaeae*, increased in numbers nearly 50 times and reached a population of about 500,000. Larvae stripped the tansy ragwort in the 50-acre release site and by means of a "farmers' field day" were distributed throughout the infested area on Vancouver Island. In Nova Scotia a smaller increase of the moth caused local stripping. The moth is now established in Prince Edward Island. An anthomyiid fly, *Hylemya seneciella*, released against the weed in British Co-

lumbia and Prince Edward Island, probably did not become established.

*Cirsium arvense*. The failure of the beetle *Alica carduorum* to thrive in Canada seems to have been caused by predation rather than climate. A colony of the weevil *Ceutorhynchus litura*, released in Ontario in 1967, spread in 1968. Laboratory experiments with the gall-forming trypetid, *Urophora cardui*, showed, in contrast to results reported last year, that galls reduce the biomass of Canada thistle: roots of galled plants weigh about 20%, and stems plus leaves weigh about 40%, as much as plants without galls. Therefore *U. cardui* is promising as a control agent in Canada.

## NUTRITION

### Effects of Antibiotics and Mold Inhibitors in Insects

Eighteen compounds at various concentrations were fed in artificial diets to larvae of *Pseudosarcophaga affinis* reared axenically. Depending on the concentration used, these compounds are toxic and arrest growth or affect the size of larvae, pupae, or adults. The compounds are not equally harmful at moderate levels; and results suggest that the kind of nutrients present or their concentration may affect the potency of an antibiotic.

### Food Selection and Nutrition

To standardize experimental procedure, the temporal pattern of feeding activity in *P. affinis* was determined at a constant

temperature (73.4 F). It was found that larvae feed most actively when 72-120 hr old; they show no evident diel periodicity, but feed slightly more during darkness than during light.

Experiments showed that the preferred, and nutritionally superior, diet is high in amino acids and low in glucose.

### Fat Metabolism of a Parasite on Various Hosts

Results of further experiments with *Exeristes comstockii* reared on a variety of hosts favor the hypothesis that this parasite's duplication of its host's fatty-acid composition is induced by the composition of the host fat rather than by a transfer of regulatory mechanisms.

## INSECT IMPORTS AND EXPORTS

The Institute continued to obtain information and living insects from abroad for research establishments of the departments of Agriculture, and Fisheries and Forestry. Five agricultural, six weed, and six forest-insect projects were serviced. About 130,000 living insects were imported from 11 foreign countries, and 41,500 specimens of beneficial insects

were shipped to eight Canadian provinces for use against the insects *Adelges piceae*, *Coleophora laricella*, *Rhyacionia buoliana*, *Neodiprion sertifer*, *Psylla pyricola*, and *Tipula paludosa*; and these plants *Carduus acanthoides*, *C. nutans*, *Cirsium arvense*, *Euphorbia cyparissias*, *Linaria vulgaris*, and *Senecio jacobaea*. Shipments to six foreign countries totaled 2,600 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>Adelges piceae</i> Ratzeburg	balsam woolly aphid
<i>Aedes aegypti</i> (Linnaeus)	yellow-fever mosquito
<i>Aedes fitchii</i> (Felt and Young)	mosquito
<i>Aedes stimulans</i> (Walker)	mosquito
<i>Altica carduorum</i> (Guérin-Ménéville)	beetle
<i>Carduus nutans</i> Linnaeus	nodding thistle
<i>Ceutorhynchus litura</i> (Fabricius)	weevil
<i>Cirsium arvense</i> (Linnaeus) Scopoli	Canada thistle
<i>Coleomegilla maculata lengi</i> Timberlake	ladybird beetle
<i>Coleophora laricella</i> Hübner	larch casebearer
<i>Culex pipiens</i> Linnaeus	mosquito
<i>Culex tarsalis</i> Coquillett	mosquito
<i>Euphorbia cyparissias</i> Linnaeus	cypress spurge
<i>Euxoa messoria</i> (Harris)	dark-sided cutworm
<i>Exeristes comstockii</i> (Cresson)	parasitic wasp
<i>Hylemya seneciella</i> Meade	anthomyiid fly
<i>Hypocrita jacobaea</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	yellow toadflax
<i>Muscidifurax raptor</i> Girault & Sanders	parasitic wasp
<i>Myrmica americana</i> Weber	ant
<i>Nasonia vitripennis</i> (Walker)	parasitic wasp
<i>Nemeritis canescens</i> Gravenhorst	parasitic wasp
<i>Neodiprion sertifer</i> (Geoffroy)	European pine sawfly
<i>Polymerus venaticus</i> (Uhler)	plant bug
<i>Pseudosarcophaga affinis</i> auct. nec Fallén	parasitic fly
<i>Psylla pyricola</i> Foerster	pear psylla
<i>Rhagoletis pomonella</i> (Walsh)	apple maggot
<i>Rhyacionia buoliana</i> (Schiffmüller)	European pine shoot moth
<i>Senecio jacobaea</i> Linnaeus	tansy ragwort
<i>Slaterocoris atritibialis</i> (Knight)	plant bug
<i>Slaterocoris stygicus</i> (Say)	plant bug
<i>Spalangia cameroni</i> Perkins	parasitic wasp
<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
<i>Typhlodromus fallacis</i> (Garman)	predatory mite
<i>Urophora cardui</i> Linnaeus	fruit fly

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### Research

- ARTHUR, A. P. 1968. Further information on the control of the introduced European skipper, *Thymelicus lineola* with *Bacillus thuringiensis*. Journal of Invertebrate Pathology 10:146-150.
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E. B. ROSLYCKY, B.Sc., M.Sc., Ph.D.	Microbiology and virology

### Chemistry

D. M. MILLER, B.Sc., M.Sc., Ph.D.	Biophysical chemistry
R. M. KRUPKA, B.A., M.A., Ph.D.	Enzyme kinetics
J. R. ROBINSON, B.S.A., M.S.A., Ph.D., F.C.I.C.	Radioactive tracers
A. N. STARRATT, B.Sc., Ph.D.	Natural products: pheromones
A. STOESSL, B.Sc., Ph.D., F.C.I.C.	Natural products: fungal toxins
G. D. THORN, B.Sc., M.A., Ph.D., F.C.I.C.	Organic chemistry and fungicides
A. VARDANIS, B.Sc., M.Sc., Ph.D.	Comparative biochemistry and toxicology

### Entomology

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D. G. R. MCLEOD, B.S.A., M.S., Ph.D.	Physiology
T. NAGAI, M.A., D.Sc.	Neurophysiology

### Fumigation

H. A. U. MONRO, B.S.A., M.Sc., Ph.D.	Fumigation
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T. DUMAS, D.C.E., M.Sc.	Analytical chemistry

## Plant Pathology

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L. T. RICHARDSON, B.A., M.A., Ph.D.	Fungicides
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## Plant Physiology

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T. T. LEE, B.Sc., M.Sc., Ph.D.	Plant biochemistry and herbicides
M. A. VENIS, B.Sc., Ph.D.	Plant biochemistry and growth regulators

## Soil Pesticide Behavior

C. R. HARRIS, B.A., M.A., Ph.D.	Entomological toxicology
J. R. W. MILES, B.Sc.	Analytical chemistry
C. M. TU, B.Sc., M.Sc., Ph.D.	Microbiology

## VISITING SCIENTISTS

### *National Research Council postdoctorate fellows*

K. HELLENBRAND, D.Sc., 1967-68	Enzyme kinetics
I. ISHAAYA, B.Sc., M.Sc., Ph.D., 1966-68	Insect biochemistry
A. R. THOMPSON, M.A., Ph.D., 1968-69	Insect ecology

### *Graduate students*

R. DEJARDIN, B.Sc., 1966-68	Plant pathology
J. WOOD, B.Sc., 1966-68	Plant pathology: fungicides
A. MORELLO, Pharm. Chem., Ph.D., 1964-68	Biochemistry: toxicology
E. D. MURRAY, B.Sc., M.Sc., 1966-68	Biochemistry: toxicology

## INTRODUCTION

The highlights of the Institute's broad research objectives are reported here. In 1968 research continued on the mode of action of toxicants (fungicides, herbicides, and insecticides) and biologically active material such as toxins associated with fungal plant pathogens, insect pheromones, and phytoalexins. To demonstrate,

isolate, and then chemically characterize these active materials requires a multidisciplinary approach and cooperation among members of the staff of the Institute, various research scientists in the Branch, and others.

E. Y. Spencer  
Director

## BACTERIOLOGY

### Structure and Composition of the Insecticidal Parasporal Body of *Bacillus thuringiensis*

An amino acid analysis of crystals from several strains of *Bacillus thuringiensis* with a gradation in toxicity showed no significant differences in composition. These values have been used to calculate minimum molecular weights and hydrophobicity of the protein. In order to examine the possible contribution of polypeptide components to toxic properties, a milder method of protein dispersion at a lower pH was developed.

### Interaction of Herbicides and Soil Microflora

Work has been started on the isolation of organisms in the soil that rapidly degrade the triazine herbicide atrazine. The study also includes the effect of atrazine on the soil population and the response of specific groups.

The interaction of soil microflora and fungicides and insecticides is described in the sections Fungal Physiology and Toxicology and Soil Pesticide Behavior.

## BIOPHYSICS

### The Physical-Chemical Nature and Functioning of the Cytoplasmic Membrane

The kinetic data obtained from a study of the simple transport system of monosaccharides in human erythrocytes were applied in the assessment of three transport mechanisms. They were all found to be unsatisfactory, and therefore the field is open for further speculation.

An attempt is now under way to obtain comparable data on an active transport

system by using galactoside transport in *Escherichia coli* for contrast with the facilitated system.

A method was developed with a non-ionic detergent whereby the red cell membrane is completely dispersed without denaturation so that enzyme systems such as acetylcholinesterase and adenosine triphosphatase maintain full activity. The dissolved membrane consists of spherical lipoprotein structures of uniform size.

## FUMIGATION

### Absorption and Metabolism of Fumigants by Insects

A method has been developed using gas chromatography to measure the ab-

sorption of phosphine by insects during fumigation. Large differences were found in the rate of uptake and in the amount absorbed by different species. In a nitro-

gen atmosphere, phosphine is not absorbed or toxic. The uptake in an atmosphere of varying oxygen composition was determined. These results provide a reasonable explanation for some of the unusual and irregular responses of insects treated with phosphine in commercial use and in experimental investigations. Phosphine has been shown to diffuse readily through rubber stoppers, septa, and ground-glass joints. A method of measuring the rate of diffusion through plastic films is being developed.

In a study of the response of insects to fumigants at reduced pressures, prelim-

inary investigations showed that respiration was lowered under reduced pressure, depending on the level of oxygen tension.

### **Fumigant-resistant Insects**

During the study of the resistance of the granary weevil to phosphine an unusual response was shown: when plotted logarithmically the slope of the toxicity curve was not linear. Thus the resistant: susceptible ratio is, in mg/liter per hr, 500 for LD<sub>50</sub> but only 60 for LD<sub>90</sub>.

## **INSECT PHYSIOLOGY AND TOXICOLOGY**

### **Electrophysiological Studies of Insect Visceral Muscle**

The structure and function of insect visceral muscle was electrophysiologically analyzed. The unusual plateau-type action potential, never before observed in muscle fiber, was found to be myogenic and was followed by a contraction. The relationship between action potential and mechanical activity was studied in detail by the simultaneous recordings of electrical potential and mechanical tension.

### **Pharmacologically Active Substances in Insects**

The neuromuscular transmitter substance isolated from roach guts has been further purified 2,000 times by the application of countercurrent separation and Sephadex. Final purification of stock-piled material should provide enough for chemical identification.

### **Mode of Action of Photoperiod in Determining Growth and Development in Insects**

Diapause termination in the corn borer involves the reactivation of the brain so that it can secrete the activation hormone and is under the control of a photoperiodic light regime. Current studies have shown that there is a cyclic fluctuation in the size of the lateral neurosecretory cells. The cyclic pattern changes that occur under the two experimental conditions, however, do not correspond to the simple

explanation of a cyclic pattern set by either the light-on or light-off signal. The changes appear to be more complex, and data from a number of experiments are being analyzed by the Statistical Research Service to provide a mathematical description of these cyclic variations.

### **Isolation and Identification of Insect-feeding Stimulants and Attractants**

In attempting to isolate feeding stimulants from *Euphorbia* spp. in a cooperative project with the Research Institute, Belleville, Ont., a new triterpenoid monoketone was identified in extracts from *E. cyparissias* Linnaeus. A number of constituents were characterized from *E. polygonifolia* Linnaeus. Some scientists attach considerable chemotaxonomic significance to the occurrence of triterpenoids in *Euphorbia*.

A chemical investigation is under way in collaboration with the Research Station, Winnipeg, Man., to isolate and identify the substances in certain species of stored-grain-borne fungi, which can elicit aggregating and feeding responses of the rusty grain beetle. Among the constituents isolated from the mycelial mat of *Nigrospora sphaerica* (Sacc.) Mason the fraction showing the highest aggregation activity is associated with a monounsaturated triglyceride fraction.

### **Glycogen Synthesis in Insects and Mammals**

During the study of glycogen utilization and synthesis a new process was developed

for the isolation of glycogen-bound enzymes by forming a complex with the plant protein concanavalin. This resulted in greatly increased yields with high enzyme activity. When this new technique was used to isolate liver glycogen synthetase, the enzyme differed significantly from that obtained by the standard, lengthy centrifugal fractionation.

#### Acetylcholinesterase

In a comparative biochemical study of fly-head acetylcholinesterase (AChE) and erythrocyte AChE several differences were found, such as location of the active sites. The mechanism of action is not the same and the fly-head AChE appears to be roomier near the active site. This study will be extended to an examination of the AChE from insects that are resistant to organophosphorus insecticides.

#### The Biochemistry of Insecticide Resistance

Cell-free membrane preparations of *E. coli* were used to study enzyme induction, namely  $\beta$ -galactosidase. Synthetic activity appeared to be dependent on the integrity of the highly organized complex of mem-

branes attached to a meshwork of DNA and ribosomes. The synthetic activity of reconstituted systems was dependent on the presence of membranes.

DDT and, surprisingly, actinomycin D stimulate incorporation of amino acids into the proteins of fly endoplasmic membranes. This action of DDT is in accord with its known property of enzyme synthesis inducer.

#### Mode of Action of Organophosphorus Insecticides

During the study of the detoxication of the geometrical isomers of two vinyl organophosphorus insecticides, mevinphos and Bomyl<sup>B</sup> (Allied Chemical Corporation), the *cis*-isomer of mevinphos was found to be the only one converted to the desmethyl derivative. It was shown to be reduced-glutathione-dependent, and *S*-methyl glutathione was isolated. From the experimental results a possible role of glutathione in the selective degradation of some organophosphorus compounds was postulated. In addition an explanation was offered to account for the different toxicity of the thiono-isomers of mevinphos from the house fly and the mouse.

## FUNGAL PHYSIOLOGY AND TOXICOLOGY

#### The Mode of Action of Dithiocarbamate and Related Fungicides

When sodium dimethyldithiocarbamate, nabam, cycloheximide, Panogen (Morton Chemical Company), Dexon (Chemagro Corporation), and chloramphenicol were applied to the roots of tomato plants a marked reduction in root pressure and in total amino acid synthesis was produced. The systemic fungicides Vitavax (Uni-Royal Limited) and DuPont 1991 had no effect on root pressure, and actually increased the amino acid synthesis in the roots. With the reduction in root pressure, water requirements were greatly reduced.

#### Effects of Fungicides on Soil Microflora

Among the organic mercury fungicides that affect soil microflora, Panogen was found to be nonselective, whereas Ceresan

PL (DuPont) and Emmi (Velsicol Corporation) were tolerated by *Penicillium*, *Aspergillus*, and *Fusarium* spp.

When one variety of pea seed was treated with the systemic fungicide oxathiin, the seeds were decayed by an *Aspergillus* sp., but the control was unaffected, evidently being protected by competitors.

#### Mode of Action of the Toxin from *Bipolaris sorokiniana* and Other Dialdehydes

The sesquiterpenoid dialdehyde, helminthosporal, isolated from the root rot organism *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem., and its monoacid have been shown from respiration studies of various plant tissues and protein synthesis to inhibit amylase synthesis by blocking

the supply of energy (ATP) in cells of the aleurone layer.

Toxic carboxylic dialdehydes from several more fungi including *Penicillium gladioli* McCull. & Thom, *Penicillium cyclopium* Westling, *Aspergillus quadri-lineatus* Thom & Raper, and *Aspergillus flavipes* (Bain. & Sart.) have been isolated. Gladiolic acid, isolated from *P. gladioli*, which attacks gladioli corms, might be considered as a phytotoxin. In mode of action studies, cytochrome *c* was found to be complexed and rendered non-functional, whereas oxidative phosphorylation was strongly inhibited at certain steps.

### Physiology of Plant Pathogenic Psychrophilic Fungi

The change in cell permeability and cell metabolism at growth-inhibitory but non-lethal temperatures was studied for two psychrophilic fungi. Although the proportion varied between the two, leakage of various soluble cell components such as total sugars, nucleic acids, and amino acids increased when the temperature was raised.

None of the fungi collected from a glacier and adjacent soils in Switzerland are as psychrophilic as those under study in Canada. They are typically mesophilic and are adapted to growth at low temperatures.

## PLANT PHYSIOLOGY AND TOXICOLOGY

### Streptomycin, Hordatine, and Protein Synthesis

It was shown earlier that streptomycin and other diguanidines inhibit protein synthesis in peas and this inhibition was overcome by the divalent cations of Mg, Mn, and Ca. This antagonism is remarkably similar to that reported several years ago from this institute between divalent cations and the antifungal agent from barley, hordatine (a diguanidine compound characterized more recently at this institute). This similarity was confirmed when experiments demonstrated that hordatine, like streptomycin, inhibited the

### The Abnormal Metabolite of Rust-inoculated Resistant Wheat

In collaboration with the Research Station, Winnipeg, Man., considerable progress has been made in improving the method of isolation of some of the metabolic products from a rust-resistant inoculated wheat variety. As a result enough material has become available to identify some of the components that include the *cis*- and *trans*-isomers of ferulic acid.

### Antifungal Agents in Plants

Considering phytoalexins as antifungal agents produced by higher plants in response to fungal infections, the toxin produced by the fungus *Ceratocystis fimbriata* Ell. & Halst associated with carrots was examined. Contrary to the suggestion of other investigators that isocoumarin and dihydroisocoumarin are phytoalexins produced by the carrot, it was shown that they are products from the fungus. Among other metabolites isolated, indoleacetic acid (IAA) was found in such large amounts that it might account for some of the phytotoxic properties of the mold. As a by-product of the IAA isolation a reaction was found that produces a specific fluorescent compound that seems to have excellent promise as a basis for an analytical method.

The antifungal agents, hordatines, previously isolated from barley in the dark, have been shown to be produced under conditions approaching those in the field.

incorporation of C<sup>14</sup>-leucine into pea segment protein, and this was overcome by the cations of Mg, Mn, Ca, and Zn. Thus the presence of two guanidine residues is required for high biological activity, and may account for the antifungal action of hordatine through the inhibition of fungal protein synthesis.

### Auxin-induced Conjugation Systems

The conjugate isolated from pea tissue after benzoic acid treatment with 2,4-D as inducer was shown to be *O*-benzoyl-L-malic acid rather than benzoylaspartate, as reported elsewhere. The enzyme in-

volved is induced not only by auxins but also by many aromatic carboxylic acids. This is in contrast with the aspartate synthetase system, where induction is restricted to compounds with auxin activity only.

### **Metabolic Root Pressure and Uptake of Triazine Herbicides**

Although urea stimulates metabolic root pressure and atrazine translocation is in-

creased, plants exposed to light had more than double the concentration of atrazine in their shoots than did those held in the dark. The increased uptake in the light shows that in intact plants transpiration affects the uptake of atrazine. However, even in the dark, the shoots appear to accumulate more atrazine than can be accounted for by metabolic root pressure only. Distribution is not uniform in the tomato shoot.

## **SOIL PESTICIDE BEHAVIOR**

### **Screening and Applied Entomology**

From principles evolved as an outgrowth of the results obtained in defining the factors influencing the behavior of insecticides in soil, screening techniques have been devised for assessing the activity of experimental insecticides against soil and other insect species of economic importance. Of the 20 experimental materials examined, several showed promise as short-residual soil insecticides, and, of these, two were highly toxic to the larvae of the dark-sided cutworm, a serious pest of tobacco. These will be included in the 1969 field experiments. Laboratory tests have shown that the most effective material will provide a similar degree of control at 1-2 oz/acre compared to DDT at 16 oz/acre. The results from laboratory screening tests for the control of the cabbage looper and cabbage aphid show that there are new materials more effective than those now recommended.

Microplots were established on a minimum scale, and so only a fraction of the promising compounds from the laboratory experiments could be evaluated. However, from the microplot studies it will be possible to develop a spray program suitable for controlling the main cruciferous insect pests by using only a fraction of the insecticide presently in use.

### **Soil Pesticide Behavior**

Studies on the absorption and translocation of cyclodiene insecticides by crops were continued. After completion of the studies on dieldrin, heptachlor epoxide was examined. It was found to be most active in moist soils at high temperatures,

and the degree of activity was proportional to the organic content of the soil. The study of the effect of the main factors influencing behavior in soil and biological activity was extended to chlordane and related products in the technical material.

### **Interaction of Soil Microorganisms and Insecticides**

In vitro studies on chemical and soil microbial degradation of heptachlor showed three degradation pathways. The soil microorganisms that oxidize heptachlor to its epoxide were identified. In aqueous media, heptachlor was hydrolyzed to 1-hydroxy-chlordene; and soil microorganisms then epoxidized this, and then converted it to an unknown metabolite. Another degradation pathway involved dechlorination to chlordene by bacteria and subsequent microbial epoxidation. On fungi the insecticide and its by-products were concentrated in the mycelium.

Several organophosphorus insecticides applied to sandy loam at rates to 100 ppm showed a marked effect on bacterial and fungal populations during the first week of incubation. However, they subsequently recovered to the level of the controls, and there were no serious permanent effects on microbial activities related to soil fertility. However, in some cases, there was a depressive effect on nitrification.

### **Development of Radioisotope Techniques**

The development of radioisotope techniques for use in biochemical studies of the action of crop, animal, and food pro-

tection agents has continued. These techniques include counting methods for phosphorus-33, Cerenkov counting of phos-

phorus-32, dual-label counting of P<sup>32</sup>-P<sup>33</sup>, and specialized sample preparations for liquid scintillation counting.

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H. V. MORLEY, B.Sc., Ph.D.	Organochlorines
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## VISITING SCIENTIST

*National Research Council postdoctorate fellow*

J. DOKLÁDALOVÁ (Mrs.), M.Sc., Ph.D., 1968-69	Pesticide residues
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## INTRODUCTION

This report is a summary of the work carried out by Analytical Chemistry Research Service during 1968.

In addition to providing expert knowledge and advice in analytical chemistry for the solution of agriculture problems and cooperative service in analytical chemistry to Branch establishments as required, we have continued to cooperate with Research Branch personnel in many of their projects.

Arrangements have been made for expansion of the work in pesticide residues

by providing a position for a scientist who will concentrate on the analytical chemistry of organophosphorus residues, their metabolites, and their breakdown products.

The acquisition of a precision micro-calorimeter has enabled us to continue studies on the three forms of water (chemically bound, physically bound, and free) that occur in biological systems.

R. B. Carson  
Director

## INORGANIC CHEMISTRY

### Selenium in Biological Materials

A micro method (nanogram range) was developed to measure Se in biological materials and is being used to increase our basic knowledge of the role of Se and to establish optimum benefits from its use. Work was completed on a method for determining the three main forms of Se (Se(IV) or selenite, Se(VI) or selenate, and organically bound Se) that are present in agricultural materials. The procedure can be used to determine the form of Se in water or acid extracts of plant and animal tissues, rumen juices, or any naturally occurring aqueous samples.

A new approach is being taken to determine the need for therapeutic injections in selenium-deficient areas. A simple method is being sought for determining the actual Se status of an animal without interference with its normal activities. Preliminary results embodying the incubation of freshly drawn blood with Se solutions and the resulting uptake of Se by the red cells were highly encouraging.

Analytical work was completed on a study of the distribution of Se between the prenatal fetus and the mother ewe kept on a dystrophogenic diet. One group of ewes was treated at breeding time with Se and

vitamin E, a second group was treated 10 days before slaughter, and a third group was retained as a control. Tissues from both the dam and fetus were analyzed at periods of 2, 3, 4, and 5 months after breeding and when the lambs were 1 day old. Although preliminary evaluation of the data showed that Se is transmissible through the placenta, the pattern of Se distribution is complicated and there was considerable individual variation.

A joint project involving the Canada Department of Agriculture and the Department of National Health and Welfare was started to establish the normal levels of Se in the tissues of farm animals at 11 sites across Canada. The data will be used to establish valid residue tolerances for consumer protection.

### Canada - United States Feed Composition Project

Results for Zn, Fe, Mg, Mn, Cu, and Se as well as proximate constituents were reported for 27 samples of grain prepared by the Grain Research Laboratory, Winnipeg, for the Canada - United States Feed Composition Project. The data provided authoritative information on the mineral contents of various grades of wheat, rye,

buckwheat, oats, barley, corn, and screenings. Screenings proved to be the most variable in composition (especially for Fe, Mn, and Cu). On the basis of its low Se content, corn has been recommended for animal diets designed to produce selenium-deficiency symptoms.

### **Thermogravimetric Studies on Agricultural Materials**

Systematic studies on the applications of thermal methods for agricultural materials were continued.

The cellulose component of organic soils, which is inversely related to the degree of humification, was identified as being responsible for the 280 C differential thermogravimetric (DTG) peak derived during pyrolysis. The holocellulose (total carbohydrate) component gave a more significant correlation with DTG peak height than the cellulose component.

The effect of  $\text{AgNO}_3$  and  $\text{NaNO}_3$  on the ignition temperature of peats, humic acids, coals, and other naturally occurring carbonaceous materials was determined thermogravimetrically. All carbonaceous materials ignited explosively between 150 C and 240 C when admixed with  $\text{AgNO}_3$ .

Ignition with  $\text{NaNO}_3$  (at 220 C) was selective for materials containing over 4% alpha-cellulose. We suggest the latter technique as a novel and useful qualitative test for alpha-cellulose in complex carbonaceous materials.

### **Iodine in Agricultural Materials**

A micro method for the accurate and universally applicable determination of I in agricultural materials is in the preliminary stage of development.

### **Comparison of Methods for Determining Nitrogen**

The Coleman semimicro automated N analyzer was compared with the Kjeldahl method for determining N in fertilizers. Fifteen inorganic and two organic types of fertilizers were analyzed by both methods on 10 different days. Results by the N analyzer were less precise, but, when the operating procedure was modified by the use of tungstic oxide catalyst and an extended combustion at 900 C to ensure complete recovery of nitrate N, the accuracy was well within the tolerance accepted for control determinations of the amount of N in fertilizers.

## **ORGANIC CHEMISTRY**

### **Pheromones of the Honey Bee**

In a joint program with the Entomology Research Institute and Cornell University, queens of the species *Apis dorsata* F. and *A. indica* F. were analyzed for "queen substance." The queens of both species were found to produce 9-oxo-*trans*-dec-2-enoic acid, the same substance as was found in *Apis mellifera* L.

The alarm reaction of honey bees to isopentyl acetate and to extracted sting pheromone and also to 2-heptanone and to mandibular gland pheromone were compared. 2-Heptanone was found to be only

about 1/50th as effective as isopentyl acetate in producing an alarm reaction.

### **Analytical Methods of Determining Amino Acids**

Analysis of amino acids by gas chromatography of their *N*-trifluoroacetyl methyl esters was compared with the analysis by an ion exchange method. With samples of oats the results by the gas chromatographic method were much less satisfactory than with the ion exchange method because of interfering substances.

## **PHYSICAL CHEMISTRY**

### **Maleic Hydrazide Determination**

The third and final part of this work was completed. Photometric measurements confirmed and extended the earlier equilibrium

and solution chemistry results. The application of the ideas and data of this work to the analysis of trace hydrazine concentrations was investigated. (The analysis of

maleic hydrazide proceeds through quantitative decomposition to hydrazine.)

### Moisture in Agricultural Products

An improved cold trap has been designed, built, and tested in collaboration with the Engineering Research Service. Improved gas-liquid scrubbers were built and installed for bringing a N gas stream to a known water content at 25 C.

The moisture retention properties of cured tobacco are probably dominated by the chemical and physical properties of its pectins and proto-pectins, which can form aqueous polyelectrolyte gels. The Na<sup>+</sup> form of carboxylic cation exchange resin is being used as a polyelectrolyte model system. Water loss vs. time plateaus at 25 C and 50 C were obtained for this model material, after equilibration with the water partial vapor pressure of saturated Mg-(NO<sub>3</sub>)<sub>2</sub> solution at 25 C.

### Complexing of Fe<sup>+++</sup> by Soil Organic Matter

An ion exchange reaction suitable for investigating Fe<sup>+++</sup> - fulvic acid complex-

ing has been developed using the H<sup>+</sup> form of the carboxylic ion exchange resin "Bio-Rex 70." Some preliminary complexing experiments were completed, and careful ion exchange complexing measurements are now in progress.

Both zirconium tungstate and zirconium molybdate give measurable, interesting Fe<sup>+++</sup>-Na<sup>+</sup> and Fe<sup>+++</sup>-H equilibria. Although the literature describes these zirconium salts as "insoluble," they were found to have small but finite solubilities. This ruled out their use for complexing studies.

### Complexing of Cu<sup>++</sup> by Soil Organic Matter

A considerable number of Cu<sup>++</sup> - fulvic acid complexing experiments have been executed, together with the necessary Cu<sup>++</sup> - K<sup>+</sup> - Dowex 50W ion exchange calibration experiments. More measurements of this type will be made in an effort to improve the standard deviations through refinement of techniques and by the accumulation of a sufficient amount of data.

## PESTICIDE RESIDUES

### Soils

The first year of the check sample program for pesticide residues in soils was completed in July 1968. During this year, six samples were made up for federal, provincial, private, and industrial laboratories distributed throughout Canada. The object of the check sample program was to realistically appraise the analytical capability for soil pesticide residue analysis in Canada. Only field-treated soils were used in the program because previous work in this laboratory showed that fortification, at best, is a poor criterion of extraction efficiency.

The first year's results showed the value and need for this kind of work and the second year's program is being planned.

### Animal Products

Samples of perianal and omental fat (obtained by biopsy), taken at 0, 19, 39,

and 75 days after treatment, were analyzed for residues of alpha, gamma, and delta isomers of benzene hexachloride (BHC). This was a cooperative project with the Research Station, Kamloops, B.C., to establish levels of BHC isomers present in the fat of animals treated with technical BHC for protection against the paralysis caused by the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles.

Samples of beef fat (loin and caul) from animals treated with technical DDT for horn fly control were analyzed for the *o,p'*- and *p,p'*-isomers of DDT, DDD, and DDE. This work was done in cooperation with the Research Station, Lethbridge, Alta.

Work was started on the development of an electron-capture method for determining trichloroacetic acid residues in cereals, potatoes, soils, and hay fed to animals for fodder.

# HERBICIDES

## Electrophoresis of Herbicides

Further electrophoretic studies were conducted with the following herbicides: 2,4-D, 2,4,5-T, MCPA, 2,4-DP, fenoprop, 2,4-DB, dicamba, amiben, and picloram. High-voltage electrophoresis (HVE) was chosen for its better resolving power and rapidity (about 30 min). A Camag HVE Apparatus was used. Most of the standard herbicides (50  $\mu\text{g}$  samples) showed more than one spot after electrophoresis.

The electrophoretic mobilities of herbicides were determined in five buffer systems (pH 3.7 to 6.5). The relative mobilities (with respect to dicamba) remained fairly constant under different voltage gradients. With the addition of methanol to the buffer the migration rate decreased. The electrophoresis of these herbicides in the presence of wheat extract showed some tailing or retardation. After extraction and a simple clean-up of ground wheat fortified with 2,4-D, it was found that the cleaned 2,4-D sample had the same electrophoretic mobility as the standard 2,4-D sample. This study showed that electrophoresis can be used as an additional detection or identification method for some of the herbicides.

## Effect of 2,4-D on Proteins of Pea Seedlings

From the preliminary results using "Disc" electrophoresis no significant difference in protein pattern could be detected after 2,4-D treatment.

## Effect of 2,4-D on Free Amino Acids of Pea Seedlings

After treatment with 2,4-D at 4 ppm for 48 hr the free amino acids were extracted with 70% ethanol and analyzed by the Beckman Amino Acid Analyzer, Model 120B. The results were calculated on the basis of mg amino acid per g dry weight of the sample. Both root and shoot samples were analyzed (control and treated). After treatment with 2,4-D the basic amino acids

(lysine, arginine, and histidine), the hydroxyamino acids (serine and threonine), glycine, alanine, valine, and cystine (or cysteine) decreased and the acidic amino acids (aspartic and glutamic acids), aromatic amino acids (phenylalanine and tyrosine), isoleucine, and methionine increased in the roots. In the shoots the basic amino acids decreased and acidic amino acids, hydroxy amino acids, aromatic amino acids, alanine, valine, isoleucine, leucine, and methionine increased. The leucine content did not change in roots, nor did glycine in shoots. Cystine (or cysteine) could not be detected in shoots.

## Derivatives of Pesticide-related Amines for Gas Chromatography

Some trifluoroacetyl and dinitrophenyl derivatives of aromatic amines were prepared and preliminary work was completed for the development of sensitive methods for the parent pesticides.

## Monuron Residues in Soil

Monuron residues were determined in plots where soybeans were grown in 1968. The soybean plants showed some toxic effects. The highest monuron residue was 2.71 ppm. The interferences due to organic matter in the soil were removed by adsorption on a cellulose column. Muck soil gave the azo-dye color equivalent to 1.89 ppm.

## Qualitative Screening Method for Maleic Hydrazide on Tobacco

At the request of the Ontario Department of Agriculture and Food, a rapid test that can be used to screen representative samples from an entire tobacco crop was developed. At least 75 samples of tobacco per day can be checked by a single operator and 2 or 3 ppm of maleic hydrazide can be detected with certainty. The method is being used by the enforcement agency at the University of Guelph to analyze and screen the 1968 tobacco crop.

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# Engineering Research Service Ottawa, Ontario

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## INTRODUCTION

Major emphasis in research was related to physical and engineering concepts that have potential utilization in biological and agricultural research. The development of electronic systems, equipment, and instrumentation for the acquisition, recording, and analysis of biological phenomena have been the main contributions to various research programs.

The Canada Farm Building Plan Service was transferred from the University of Guelph to this Service and integrated with the program of developmental engineering in farm structures. The Plan Service is developed and coordinated with the pro-

vincial agricultural engineering extension services and fulfills a national need in this area.

An agricultural engineering periodical, ERDA, was developed and is being issued quarterly. Its main purpose is to disseminate scientific and technical information in agricultural engineering, gathered from around the world, to interested persons.

Liaison and cooperation with university people and extension engineers increased appreciably during the year.

C. G. E. Downing  
Director

## DEVELOPMENT AND ADVISORY

New professional and technical staff added during the year made possible an expanding program of research and development with emphasis on farm structures, water resources and waste disposal, and field mechanization. Three surveys were conducted to determine the most crucial needs for future Canadian research in agricultural engineering. The water resources engineer studied current research and future needs in drainage, irrigation, farm water supply, and animal waste disposal. The storage structures engineer studied vegetable harvesting operations and the commercial storage of fruit and vegetable crops, and the livestock structures engineer studied current trends in swine management and housing. These two investigations were conducted especially for the updating of bulletins and plans of the Canada Farm Building Plan Service, which is a rapid method of getting current research results implemented.

Recent research results were used to update the 1970 edition of Farm Building

Standards (Supplement 6 to the National Building Code of Canada).

Several research projects in cooperation with the Animal Research Institute were started at the Institute's Greenbelt Farm. Preliminary results from this research are now being used for the design of new experimental buildings, for modifications and adjustments of automatic barn ventilation systems, and for development of safe and efficient manure-handling systems.

On request, specialists brought the results of current research to provincial extension engineers, agricultural producer groups, and agribusiness on items such as animal waste processing, dairy cattle housing and management, plastic drain tile manufacture, and experimental land drainage. Engineering design assistance was provided to several Research Branch stations on such problems as burley tobacco conditioning, research remodeling building facilities for research animal housing, irrigation plot design, and drainage research.

## RESEARCH SERVICE

### Equipment for Mechanization of Plot Experiments

Trials of the single-row harvester developed recently for lodged or standing cereal crops were satisfactory and machines are now commercially available.

A commercial concern was assisted in the development of a prototype machine to apply protein foams to horticultural crops for frost protection. A working prototype was assembled so that field operation could be evaluated.

Assistance was provided to the Ontario Department of Lands and Forests in the development of a nursery seedling harvester. A potato-digger type of machine elevates the seedlings and increases harvesting efficiency.

A machine for cleaning small seed samples was completed for the Department of Forestry and Rural Development. An inclined moving belt effectively separates seed and debris.

A single-row spaced-plant seeder for cereal crops was developed. A notched disc picks up seed and carries it to the delivery tube for accurate space planting of wheat, oats, and barley. Commercial manufacture has been arranged. A universal four-row plot seeder, based on the cone principle, was designed for mounting on a light tractor. Either one cone per row or a single cone with a four-way divider of the involute type can be used. Fertilizer attachments were also developed. Seeding rates up to 500 plots/hr are possible.

A thresher was developed for single soybean plants. It is also efficient for threshing cereals, oilseeds, and peas. A rubber face rub-bar cylinder and rubber concave were used. The machine is self-cleaning and easily opened for inspection between samples.

Surveys of plot equipment developed in Canada were completed for the International Association for the Mechanization of Field Experiments and the American Society of Agricultural Engineers to provide data on the machines and instrumentation available to researchers. Several commercial machines were evaluated for harvesting and processing plot material, and their performance was reported.

### Environmental Apparatus

An environmental laboratory  $12 \times 12 \times 8$  ft high was completed for testing instruments under simulated field conditions; range  $-10$  to  $140$  F  $\pm 0.5$  F, relative humidity up to  $95 \pm 5\%$ .

A domestic freezer was modified as a cabinet for winterhardness testing of winter wheat by adding an electronic control and changing the refrigerant circuit; range  $-20$  to  $5$  C  $\pm 0.1$  C. A cabinet was developed for the coldhardness testing of plant material, using liquid nitrogen as the cooling source; range  $-120$  to  $45$  F  $\pm 1.25$  F. Operating economy was comparable to mechanical refrigeration.

### Electronics

A heat flux and temperature integrator was developed to measure rate of heat flow and temperature in soils. A heat flux disc and thermistor were connected to an amplifier driving a new type of digital integrator developed for the purpose.

An automatic spectroradiometer was completed to integrate the radiant energy at 11 wavelengths in the visible spectrum at the sun and shade sides in an apple tree. This will be used to study relationships between light quality and ripening of apples. An integrator was developed to record radiant energy in the field or laboratory up to  $999.99$  cal  $\text{cm}^{-2}$   $\text{min}^{-1}$ .

A telemetry system for the acquisition of physiological data from plants was completed. It automatically transmits and records the temperature and winterhardness of 40 apple trees.

A time control was developed for a meteorological data logging system. Based on integrated circuits the unit uses the line frequency to provide a precise time source.

### Food Process Engineering

A machine was developed for crushing rapeseed. Rollers deform the seed, cracking the pericarp so that it can be removed in a process for producing rapeseed oil.

Temperature controls were developed for vats used in the manufacture of Ched-

dar and cottage cheese. The temperature was regulated precisely, but uniformity was lacking due to the design of the stirring mechanism.

### **Instrumentation**

It was discovered that eggshells were sensitive to rate of strain. The effect was greatest at the slow compression speeds used by most researchers. Much of the data previously published must be used with caution. A nondestructive eggshell tester developed in Holland and adopted by several commercial concerns was evaluated and found to be inaccurate because of design errors. In a cooperative project with the U.S. Department of Agriculture, a nuclear backscatter technique was compared with mechanical measurements. The nuclear method did not predict eggshell strength with precision. It measured eggshell thickness with an accuracy comparable to the determination by specific gravity. Improved apparatus for testing eggshells indicated that the shell behaves as a Hookean element under impact conditions.

Electronic recording dough mixers were completed for the Cereal Quality Laboratories at Winnipeg and Ottawa. It is now possible to study baking quality using only 3.5 g of flour. The mixers were also used to successfully measure the viscosity of honey.

An instrument for measuring the total back fat thickness in hog carcasses at meat-packing plants was developed and commercial manufacture arranged, so that the

Production and Marketing Branch can meet the requirements of a new hog grading system.

A control was developed to program a multichannel temperature recorder to operate at selected times during the day for selected periods. Three timers were used to operate the chart drive and print mechanisms, thus conserving chart paper.

An automatic slide cover was manufactured to study spray distribution in apple trees. The spring-loaded cover has a remote release so that it can be operated immediately the sprayer has passed.

A new sensitive indicator was developed to measure the filling value of tobacco. Tobacco is compressed in a cylinder at 20 cm/min to a selected volume and the force required recorded.

Load links were developed for the Kemptville College of Agricultural Technology to measure towing forces in an experimental vehicle.

Gauges were developed to measure the diameter of spray nozzle orifices. Commercial manufacture has been arranged.

Consultations were made with establishments throughout the Branch, other Government agencies, and universities to solve technical problems. A total of 54 research and development projects were started during the year, of which 38 were at the request of other establishments. The remainder include research into basic engineering problems or the development of new concepts in instrumentation for biological research.

## **TECHNICAL AND SCIENTIFIC INFORMATION**

This section has expanded its collection of information in developing fields so that it is possible to better inform engineers and scientists of the Branch. As part of the operation 90 periodicals are regularly reviewed, and pertinent agricultural and engineering articles are abstracted.

Government departments and foreign agencies were supplied with such information as lists of Canadian manufacturers of farm equipment, technical information on specific farm machines, and engineering properties of farm products.

The periodical ERDA covered a wide range of topics of interest to engineers and other scientists. In addition to informative reports by Engineering Research Service staff, and summaries of published articles, it contained a section on bulletins and articles of interest, including the latest information on research developments in agriculture. Special interest was shown in ERDA Supplement 1, "Post-frame Wall Construction for Farm Buildings." The Research Branch, government organizations, universities, and industry contributed important articles to ERDA.

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# Statistical Research Service

## Ottawa, Ontario

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## INTRODUCTION

Advice and assistance in the planning and design of experiments and surveys, and in the analysis and interpretation of the data collected, continue as important functions of the Statistical Research Service. In this connection, twenty-five visits were made to Research Branch establishments outside Ottawa. Work on general mathematical and statistical problems is also important. Among the problems receiving special attention during the year were optimization procedures, required in many aspects of model-fitting; methods for quantal data, arising from subjective trials or bioassays; and multivariate techniques.

The work has grown in volume, complexity, and scope with the use of the computer, which is now integral to the activities in the Service. The installation in

January of a Univac 1004 computer to give remote access to a Univac 1108 resulted in a marked improvement over the previous truck delivery service. The number of jobs processed increased from an average of about 480 per month to about 1,000 during each of the first 2 months of full operation of the new system. Furthermore, improvements were made in the speed of transmission to and from the terminal, and in each of the last 3 months of the year an average of over 1,500 jobs were run.

The programming courses instituted in 1967 were continued in 1968. There were seven introductory courses, and one 2-week intensive course; a total of about 120 scientists attended.

P. Robinson  
Director

## BIOMETRICS AND COMPUTER SCIENCE

### Mathematical Ecology

Statistical methods for dealing with populations of rare species were examined, and measures of the association among such species in isolated ecological communities were investigated.

Work continued on models of population growth. Some of the properties of the invariants of the Leslie model were examined by simulation on the computer. It was found that the rate of approach to the stable age distribution appears to be approximately proportional to the ratio of the absolute values of the first and second eigenvalues, and independent of the number of age groups.

Further work was carried out on cyclical models involving delayed responses, and the work was extended to cover the interaction between species.

Simulation studies were carried out on the spatial distribution of plants and the dispersal pattern from generation to generation.

### Population Dynamics

Studies relating the numbers of *Aedes vexans* (Meigen) and the numbers of *Euxoa* spp. to environmental factors were carried out. In addition to those factors that are generally recognized as important, it was also found that some, such as photoperiod, which are usually dominated by others, were also of descriptive or predictive value.

Collaborative work on a study of mite populations in apple orchards was started.

### Food Research

The design and analysis of organoleptic experiments present special statistical problems. Collaborative work in this field included experiments on the use of different enzymes in the manufacture of Cheddar cheese; preference for different types of frozen eggs; effect of aging and finish on tenderness of beef; effect of age, sex, and breed of broilers on consumer preference; and a survey of consumer reaction to fortified milk.



A program was written to analyze data from paired-comparison tests with ties, following the Rao-Kupper method; a modified version was applied to insect behavior studies. An examination was made of multivariate problems associated with paired comparisons; different models have been proposed and are under test.

### **Bioassay**

Two problems arising in the analysis of quantal data were investigated: methods were developed for the analysis of data obtained from a mixed population of resistant and susceptible individuals, and methods of handling consecutive observations were studied. Programs were prepared for these situations, and improvements in the iterative procedures are planned.

From tables generated by a program written to evaluate different experimental designs for single-line quantal assays, a scientist can decide how many test subjects, how many dose levels, and what dose ratio may be expected to give the desired precision. The effect of a poor guess of potency, slope, or natural response rate on this precision can be assessed.

Assistance and advice were given on design, analysis, and interpretation of data for a number of bioassay problems, including the application of probit plane methods to preference studies with bees.

### **Quality Control and Inspection Sampling**

Arising from a problem in quality control of apples, programs for developing operating characteristic curves for two-stage samples were developed.

Advice was also given on inspection sampling procedures for potato crops to help maintain high quality for export.

### **Mathematical Methodology**

Several statistical problems arising during the year necessitated further investigation of some of the mathematical techniques associated with their solution.

The properties of fractional or non-integral powers of matrices were investigated. A so-called principal value exists

for these, defined in terms of the eigenvalues and eigenvectors; but in certain cases there exists a series of integral powers of a transformation of the original matrix whose sum converges to the power desired. Conditions for convergence of this series were obtained.

A Monte Carlo investigation of the distribution of eigenvalues of a square matrix, whose elements are independent random normal variates with known means and variance, indicated that under certain conditions the eigenvalues are normally distributed.

A survey was made of existing routines for the automatic optimization of a general function. A computer program is being prepared that combines two of these routines in order to exploit the better features of each. The form of the Nelder-Mead method of optimization was modified for application to linear programming techniques.

The matrix inversion program was improved by adding an iterative procedure to reduce errors caused by rounding, and a subroutine was added for finding a generalized inverse (as defined by Rao) if the matrix is singular.

### **Statistical Methodology**

Programs were developed to handle canonical analysis, canonical correlation, and principal component analysis. These were used in comparing different taxonomic categories, different ecological areas, and different physiological states, and in a population growth study.

Two-stage analogues or extensions of Hald's results on the compound hypergeometric distribution were investigated.

### **Breeding and Quantitative Genetics**

The analysis, reported last year, of data collected for evaluation of the swine carcass grading system resulted in a revision of the system, effective January 1, 1969.

Programs were written to reevaluate data collected during the development of the Lacombe breed of swine. Similar programs were prepared to trace the pedigree of several hundred strains of oats.

An information storage and retrieval system was developed for the potato breeding program in the Maritimes.

Methods for the analysis of data from different types of incomplete diallel cross designs were developed.

### General Statistical Programs

In setting up a library of general statistical programs, started some 3 years ago, particular emphasis has been placed on the ease of use of our programs, on well-labeled output, and on the provision of a good set of user instructions. There was, however, little uniformity in the way in which information for different programs was read into the computer. During the year a system was developed to overcome this deficiency, and programs will be modified to accept information in a common and logical, yet flexible, manner. This system should make our programs easier to use, and should also simplify conversion to a different computer system if necessary.

The general survey and tabulating program (GENTAB) received major modifications to increase its power and versatility, particularly in regard to output. The program is, in effect, a compiler, the user having to write a simple mainline program.

One single simple instruction will automatically accumulate cell totals in a multi-way table, cell frequencies for the same set of data, and marginal totals for both tables. The program has proved to be one of the most useful ones we have prepared, because it allows a scientist to summarize his data in several different ways before he decides on the appropriate statistical analysis.

A general program (MINFAC) to handle uncomplicated split-plot and factorial designs without confounding was developed. This is not as powerful as GENFAC, but the input specifications are more straightforward.

A program to handle correlation problems with missing observations, and sub-routines for producing different types of pictorial output, were also developed.

There are now some 27 fully documented programs, and 7 programs in use but not fully documented, compared with 19 and 8 at the beginning of the year. In addition many of the existing programs were modified and improved.

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# Research Station Brandon, Manitoba

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## INTRODUCTION

Research activities at the Research Station, Brandon, include programs on breeding and physiology in Animal Science; on breeding, physiology, and management in Plant Science; and on soil-plant relationships, soil fertility, cultural practices, crop rotations, and weed control in Soils and Agronomy. In this report only results and new developments in research are described. Details may be found in the scientific papers and reports listed in the publications section. Reprints may be obtained from the authors.

Staff changes involved the replacement of a barley breeder and the addition of two scientists in Soils and Agronomy. These additions permitted expansion of

research on plant nutrition and the initiation of work on the physiology of weeds. Our research in apiculture was discontinued at the end of the 1968 production year. Mr. L. D. Bailey was granted educational leave, and Dr. G. W. Rahnefeld proceeded on a 1-year postdoctorate transfer of work at CSIRO, Sydney, Australia.

At the spring convocation, the University of Manitoba conferred an honorary Doctor of Science degree on W. H. Johnston for his outstanding contribution to cereal breeding, in the development of seven varieties of barley including feed and malting types.

W. N. MacNaughton  
Director

## ANIMAL SCIENCE

### Beef Cattle

Since 1959 the Shorthorn herd has been closed and subdivided into a control and a selected line. After 6 months on a standard performance test, select-line replacements are chosen for superior performance at 1 year of age. Some Shorthorn cows, surplus to the selection project, have produced Brown Swiss crossbreds, which are used for evaluation.

*Response to selection.* In 1968 the differences between control and selected lines were 29 lb for weaning and 82 lb for yearling weight. These are estimates of genetic differences, and they represent average changes of 3.6 lb/year in weaning and 10.2 lb/year in yearling weight.

*Yield of lean meat.* Beef carcasses from the selected line were significantly higher in predicted and actual yield of lean meat than carcasses of animals killed at the same age from the control line. The few available crossbred carcasses had a higher percentage of lean meat than either Shorthorn line. Carcasses from the control line had more fat cover and a greater degree of marbling than those from select-line Shorthorns or crossbreds.

*Tenderness evaluation.* When broiled steaks were subjected to shearing tests on the Warner-Bratzler shear press and to

taste-panel evaluation, samples from control-line carcasses required significantly less force for shearing (18.5 vs. 20.3 lb), and they had a significantly higher sensory tenderness score (6.31 vs. 5.85) than samples from select-line carcasses. Samples from the available crossbred carcasses were intermediate in shear force required and lower than either Shorthorn line in tenderness score.

### Swine

*Stability of a pedigree-bred control population.* A Yorkshire pedigree-bred control (20 males and 40 females per generation) has been maintained since 1963 to evaluate response to selection on average daily rate of gain in Lacombe swine. The analysis of the genetic stability of the control for five generations showed no evidence of significant change in the genetic value of the population as determined by estimates of additive genetic variance, selection differentials, and related parameters.

*Daily sperm production and epididymal reserves.* When 11-month-old boars were placed on a regular 96-hr schedule of semen collection, they averaged  $47.3 \times 10^9$  sperm per ejaculate. Sperm reserves in such boars were depleted by collecting three ejaculates from each within 24 hr. Half of the boars were killed immediately after

the last ejaculate, and the remainder were killed 48 hr later. Sperm reserves in the epididymides of the boars killed after the last ejaculate were  $145.0 \times 10^9$ , whereas the epididymal sperm count from boars where reserves were replenished for 48 hr was  $172.2 \times 10^9$ . Thus  $27.2 \times 10^9$  sperm had been added to the epididymal reserves in 48 hr and the daily sperm production estimated by this method was  $13.6 \times 10^9$ . Total production for 96 hr would be  $54.4 \times 10^9$ , so that 87% of sperm production was being recovered on the 96-hr collection schedule.

On a daily schedule of semen collection, 3-year-old Yorkshire boars averaged  $18.3 \times 10^9$  sperm per ejaculate. When these boars were killed 24 hr after the last ejaculate, the sperm reserves in the epididymides were 39.6, 21.5, and  $34.0 \times 10^9$  in the capita, corpora, and caudae epididymides. When combined, the sperm counts for both epididymides resulted in reserves of  $109.2 \times 10^9$ . This amount divided by the epididymal transit time (10.2 days) yielded  $18.7 \times 10^9$  as an estimate of daily sperm production. Therefore on a daily collection schedule the recovery of sperm production was 98%.

*Semen characteristics as affected by age and sexual experience.* Boars that produced poor-quality semen at 6.5 months of age were assigned to three groups (equal numbers of Lacombe and Yorkshire). One group was placed immediately on a 96-hr schedule of semen collection and the second and third groups were placed on collection schedules at 7.7 and 8.9 months of age, respectively. At 8.9 months no differences were recorded in semen volume, sperm concentration, and total and motile sperm per ejaculate between groups that had been sexually active or inactive. Therefore chronological age rather than sexual activity appears to be the more important factor governing semen characteristics. No differences were found in the semen characteristics of the two breeds.

*Age at puberty.* In Yorkshire and Lacombe gilts the average age at puberty was 197 days. Ten percent of gilts attained puberty between 141 and 174 days, 80% between 174 and 224 days, and 10% between 224 and 254 days of age.

*Length of estrous cycle.* The average estrous cycle for 225 Yorkshire and Lacombe gilts and sows was 21.5 days. The distribution was: short cycles (18 days) 4%, normal cycles (19–23 days) 82.5%, long cycles (24–28 days) 11.5%, and abnormal cycles (28–35 days) 2%. Long or abnormal cycles were equally distributed between gilts and sows.

## Poultry

*The effect of environment on selection.* In the third cycle of selection for rate of egg production to 273 days of age less response to selection was found in the strain on feed restriction during the growing period than in the full-fed strain. A close scrutiny of the data suggests that an outbreak of avian encephalomyelitis when the birds were 10 days old may have masked the real effects of selection. The rate of egg production to 500 days of age for the control strain was 66.8% under full feeding, compared with 73.6% under restriction. The difference was much greater than that usually found here. Also, brooding mortality in the restricted-fed strain was lower during the course of the disease than in either the control or the full-fed strains. This suggests that the weaker pullets in the latter two strains succumbed to the disease, and died before reaching maturity.

*High-fiber rearing diets in confinement.* A normal 16% protein rearing ration and a ration containing 30% finely ground wheat straw and 70% of the rearing ration were fed to several strains of Leghorns during the growing period. The birds raised on the high-fiber ration had slightly higher egg production and net revenue than those reared on the standard ration. Some strains appeared to perform much better than others on the high-fiber diet. Sexual maturity, egg weight, and mortality were not affected by the high-fiber diets.

## Apiculture

*Strain testing of bees.* Strain testing of bees was concluded in 1968, thereby ending 34 years of studies in beekeeping and management. Several hybrid strains, a

commercial Italian, and a Caucasian strain were overwintered and compared on the basis of 2 years' production. One hybrid strain produced more honey than any other strain, and outyielded the Italian check colonies by 15%. The Italian colonies outyielded the Caucasians by 12%.

Most strains overwintered well, although one strain had only half the number of survivors compared with other strains. There was little difference in honey yield between overwintered colonies headed by an overwintered queen and colonies headed by a new young queen from the same source as the initial stock.

## PLANT SCIENCE

### Cereal Crops

*Malting barley improvement.* The newly licensed malting barley Paragon has displayed a yield potential equivalent to that of commonly grown feed varieties by outyielding Keystone and Herta in trials throughout Manitoba. However, Paragon has been excelled by a number of new selections undergoing final testing.

Peeling in malting barley continues to be a problem, but some selections that have good hull adherence and good yield and quality characteristics are under development.

Most of the lines in one breeding project in 1968 matured 4 to 5 days earlier than Conquest and produced 2 to 3 inches shorter straw, but maintained the yield potential of Conquest.

*Feed barley breeding.* Emphasis is on yield, resistance to disease, and strong straw. Most developing lines are in the early generations, but some selections from Keystone × Galt appear outstanding in head and straw characteristics and yield.

### Forage Crops

*Digestibilities in bromegrass evaluation.* First-cut yield of dry matter was similar in two strains of bromegrass, and in vitro analyses showed insignificant differences in the digestibility of leaves and stems. Differences in second-cut dry matter yields of

1,265, 1,277, and 92 lb/acre for N applied at 75, 150, and 225 lb/acre showed a strain - rate of fertilizer interaction.

*Herbarium.* A study of the genus *Melilotus* was completed and prepared for publication. Each species was described from material grown at Brandon and notes were prepared on agronomic characteristics. A taxonomic key based mainly on flowers and immature fruit was developed.

### Horticulture

*Pea breeding.* After two generations of selection for high and low sugar content based on water-absorption capacity, two groups of lines have been isolated averaging 14.7 and 13.3% sugar in immature peas.

*Geum.* Selections from crosses of the variety Mrs. Bradshaw with *G. aleppicum* Jacq. and *G. triflorum* Pursh have shown some degree of fertility, and 260 seedlings have been produced.

*Roses.* The variety Cuthbert Grant [Crimson Glory × (Donald Prior × *Rosa arkansana*)], which was developed at Brandon, has been selected as the Centennial rose for Manitoba. It resembles the Hybrid Tea rose and produces large dark red flowers in mid- to late summer. It is hardier than the Hybrid Tea and floribunda varieties but less hardy than some of the shrub roses.

## SOILS AND AGRONOMY

### Soil Fertility

*Nitrogen fertilizer on flax and rapeseed.* Yield response of flax and rapeseed to high rates of N was restricted by limited sup-

plies of available P on soils in the Pasquia drainage project of northern Manitoba. Significant yield increases of both crops were obtained with 40 lb of N plus 8.7 lb



of P per acre. A further significant yield increase was obtained with the application of 80 lb of N and 17.4 lb of P per acre.

*Bromegrass response to nitrogen.* When 1- to 5-year-old stands of bromegrass were fertilized with N at 75 to 225 lb/acre, hay yields increased with increased rates of fertilizer. When the first- and second-cut yields were combined, the increases varied from 0.73 to 1.74 T/acre; the older stands showed the greatest benefit.

### Soil Management

*Rotations.* After one cycle of production where summerfallow or a summerfallow substitute was followed by two crops of wheat, the highest net returns for the 3 years in the rotation on heavy clay loam were obtained from crop sequences using clover hay, potatoes, and oat hay in place of fallow. Silage corn and flax as fallow substitutes produced lower net returns than conventional summerfallow. Yields of first-crop wheat were greatest after clover hay and black summerfallow.

On light sandy soil only the rotation using flax as a summerfallow substitute gave lower total net returns than that using black summerfallow. Yields of the first crop of wheat were greatest after potatoes, and some beneficial effect carried over into the second crop.

The use of herbicides decreased the total weed population on both soil types. Quackgrass infestations were reduced slightly on all substitute fallows, but wild oats increased when flax was used on a fallow substitute.

### Weed Control

*Control of wild oats in wheat.* Based on 2 years' results triallate at 1 to 2 lb/acre

gave 84 to 95% control of wild oats in wheat seeded on stubble land of a clay loam soil. Yields of wheat were increased by 5.1 to 5.4 bu/acre, in comparison with untreated plots yielding 18 and 30 bu/acre. The herbicide was equally effective when applied in the fall or in the spring after seeding.

*Control of weeds in potatoes.* For the second year, harrow treatments before and after emergence followed by two interrow cultivations controlled a heavy infestation of green foxtail in Norland potatoes. Yields obtained were 90% of the hand-weeded check (245 cwt/acre) compared with 37% on untreated plots. Promising results were obtained also with postemergence applications of the herbicide TCA with prometryne, linuron, or paraquat.

*Control of green foxtail.* TCA at 2, 3, and 4 lb/acre applied in the field effectively suppressed growth of green foxtail in Noralta flax, and reduced production of weed seeds. The yield of flax was not affected by these rates of herbicide application. In greenhouse tests the minimum rates of TCA required for good control of green foxtail were 0.75 to 1 lb/acre at the 2 to 2½ leaf stage of growth. Early application of TCA at or before the two-leaf stage of growth was important for effective control of green foxtail.

*Differential response of crops to TCA.* A study with C<sup>14</sup>-tagged TCA showed that wheat absorbed 14% more TCA than oats; that alcohol extracts from wheat contained two to three times as much C<sup>14</sup> as oats; and that the time required for half the C<sup>14</sup> to disappear was 11 days in wheat and 8 days in oats.

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### Research

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# Research Station Morden, Manitoba

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S. T. ALI-KHAN, B.S.A., M.Sc., Ph.D.	Pea and buckwheat breeding

## INTRODUCTION

This report describes the more significant results of the research activities at the Research Station, Morden, Man., in 1968. This station, located on the western edge of the Red River Valley and 14 miles north of the Canada - United States border, is where much of the research in horticulture and flax and all work on soybeans, field peas, field beans, and sunflowers is done by the Department for the Prairie Provinces.

Achievements of interest include studies of preconditioning potatoes for chipping

prior to placing them in cold storage. Two experimental techniques, developed to evaluate quality of small samples of field peas and chipping potatoes, enable more samples to be tested and save time, labor, and test materials. Three ornamental plant selections and one  $F_1$  sunflower hybrid developed here were named and released for distribution.

C. Walkof  
Acting Director

## VEGETABLES

### Chipping Quality in Potatoes

Processing studies showed that most potatoes chip satisfactorily when harvested, regardless of their maturity. Even Warba, a variety seldom used for chipping, was good until it was subjected to cold storage; thereafter its tubers lost this characteristic permanently despite their high dry-matter content and early maturity which normally result in good chipping quality. Two experimental varieties, F5208 and F5889, had excellent quality coincident with late blight disease resistance.

Tubers harvested 80 days after planting and then stored at 5 C could not be reconditioned later at a higher temperature for satisfactory chipping. Preconditioning, or warming potatoes to 21 C prior to placing them in cold storage, enhanced chipping quality particularly in tubers harvested 115 and 135 days after planting. Such tubers reconditioned satisfactorily after cold storage. The high-quality varieties F5208 and F5889 responded well to preconditioning and chipped satisfactorily without reconditioning after being taken from cold storage. Chipping quality, measured in L values with a Hunter color and

color difference meter, was excellent. The benefits of preconditioning potatoes, in addition to an excellent effect on chipping quality, include a reduction in losses due to respiration and tuber deterioration, which occur often during reconditioning of potatoes from cold storage. The preconditioning of potatoes at harvest still warm from field heat was more economical than reconditioning tubers after cold storage. The preconditioning temperature facilitated suberizing and healing of bruised tuber tissue, and reduced rot development.

The use of filter paper discs in evaluating chipping quality of single tubers resulted in an 8-fold increase in the number of samples tested, saved up to four times the oil required for chipping, and greatly reduced the labor compared with the conventional frying technique. The tubers were cut lengthwise and a filter paper disc was impregnated with juice from the cut surfaces. The color of the fried discs was remarkably similar to that of chips obtained from the same tubers, and the L values from the discs and chips were highly and significantly correlated at  $+ .929$ .

### Rootknot Nematode on Cucumber

The northern rootknot nematode, *Meloidogyne hapla* Chitwood, occurred on plants in a field of pickling cucumbers in 1968. This is the first report of such an infestation in Canada on direct-seeded field-grown plants. Some stunting occurred in early growth, but the plants recovered during subsequent cool and moist weather. The nematode also caused rootknot on wild mustard, wild buckwheat, and cultivated flax in the same field.

### Rhizoctonia on Potatoes

In 10 potato fields in southern Manitoba, *Rhizoctonia solani* Kühn, was found to infect 46% of the stolons examined in September 1968. Infection ranged from light to severe including some characteristic knobby tuber formation. Sclerotial initials of the "black scurf" stage were evident also on tubers. Tests to reduce the incidence of rhizoctonia in

the field with the use of a biocide, potassium azide, applied at rates up to 400 lb/acre gave negative results on eight potato varieties.

### Sweet Corn Germination and Seedling Growth

The percentage germination and vigor of seedling growth of sweet corn grown under controlled soil temperatures and moisture conditions showed large differences between lots of seed from the same variety particularly at low temperatures. Seed germination and seedling emergence were affected more by temperature than by moisture. Early sowings in the field had lower germination than those sown later. A survey of 12 fields of canning corn showed that an average of 18% of the emerged seedlings had brown discoloration at the lower end of the mesocotyl and their weights averaged 1.8 g compared with 2.5 g for normal seedlings.

## WEED CONTROL

Mixtures of benzadox with linuron or prometryne applied at low rates as post-emergence herbicides were promising for controlling green foxtail and broad-leaved weeds in seeded onions. The chemicals caused considerable early-season injury to the onion seedlings, but did not affect yield. Excessive rainfall following application, which may have leached linuron or prometryne into the root zone, did not produce additional injury. Nitrofen at first suppressed growth of green foxtail when applied at the two-leaf to four-leaf stage, but the plants recovered quickly. Injury to the onion plants was minimal.

Low rates of trifluralin, when incorporated into the soil before seeding, success-

fully controlled green foxtail and wild oats and when combined with post-emergence tillage also controlled broad-leaved weeds. Yield increases of 20 to 30% were obtained from plots of sunflowers seeded late in a season when green foxtail and wild oats were controlled by trifluralin. Incorporating the chemical into the soil in a band over the row and using post-emergence inter-row tillage gave promising results. Linuron and prometryne, at rates suitable for control of broad-leaved weeds, caused only minor injury to sunflowers when applied in such a way that the spray did not contact the topmost leaves and growing points.

## ORNAMENTALS AND FRUIT CROPS

### Breeding and Selection of Ornamentals

Three new ornamental plant cultivars were described and named in 1968.

*Tilia cordata* Mill. 'Morden': This is a winter-hardy selection of European little-leaf linden. The original tree, now 25 years old and 30 ft tall, has a densely

compact plant form and a pyramidal to ovoid shape. Its leaves are typical of the species, medium-green and free from leaf spot and gall mites.

*Aster novi-belgii* L. 'Velvet': This is an open-pollinated seedling of *A. n-b.* 'Hilda Ballard' that produces a hardy, vigorous,

spreading plant 3 ft tall that has healthy, broad, dark-green leaves. The flowers measure 1.5 inches, possess supernumerary petals, and have a soft lavender-mauve color. Its season of bloom begins in mid-September.

*Aster novi-belgii* L. 'Marine': This is also an open-pollinated seedling of *A. n-b.* 'Hilda Ballard' quite similar in plant type and hardiness to the cultivar Velvet. The flowers of Marine measure 1.5 inches and they have supernumerary petals of a deep violet-mauve color. It blooms from late September through October.

Two plant introductions from Morden, *Rosa* hybrid 'Prairie Dawn' and *Chrysanthemum* hybrid 'Morden Cameo' will receive "Awards of Merit" in 1969 from the Western Canadian Society for Horticulture.

### Propagation

Carbon dioxide added to water used in a misting system for propagating ornamental plants increased the rooting percentage of cuttings and the length and number of roots, and reduced the time required for rooting by two cultivars of

*Juniperus horizontalis* Moench; namely, 'Dunvegan Blue' and 'Prince of Wales'; three cultivars of *Thuja occidentalis* L.; namely, 'Brandon Pyramidal', 'Globosa', and 'Wareana'; *Potentilla fruticosa* L. 'Coronation Triumph'; *Weigela* hybrid 'Centennial'; *Lonicera tatarica* L. 'Arnold Red'; *Tilia cordata* Mill. 'Morden'; *Elaeagnus angustifolia* L. 6501; and *Chrysanthemum* 6408.

Cultivars of *Amelanchier*, normally difficult to increase by asexual means, rooted in 12 days when etiolated shoots from root cuttings that were grown in flats in a greenhouse were cut and immediately "stuck" in a misting bed.

### Taxonomy of Woody Ornamentals

Taxonomic evaluation of the genus *Populus* with emphasis on morphological studies of species and hybrids native to Manitoba indicated that hybridization occurred between *P. balsamifera* L. and *P. deltoides* Marsh. var. *occidentalis* Rydb. Chemotaxonomic data based on gas chromatography of phenolic glycosides, supported the morphological studies.

## SPECIAL CROPS

### Buckwheat Testing

CD 7274 selected from a Russian introduction yielded more than the standard variety Tokyo and other varieties in 1968. It may soon be named and licensed for distribution.

Tests of seeding rate and row spacing indicated that 0.5 to 1 bu of seed per acre planted in rows 6 inches wide produced an excellent yield of buckwheat.

### Corn Breeding

Promising early maturing versions were selected from Corn Belt inbreds B14, WF9, and B8. Very good yields were obtained from many hybrids that involved these lines. Their seedling vigor, plant height, and lodging resistance were excellent. Some of the inbreds were good seed parents. A single-cross hybrid involving the new inbreds is expected to be released soon. Attempts to develop haploid seed for the production of inbred lines

using embryo and endosperm genetic markers,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $C_1$ ,  $C_2$ , and  $R^{nfeudu}$  basically were unsuccessful. Only two plants from 300 selected seeds with colored endosperm and colorless embryo appeared to be haploid and both plants failed to set seed.

### Flax Breeding and Testing, Flax Rust

F.P. 497, reselected from F.P. 454 for resistance to flax rust, *Melampsora lini* (Ehrenb.) Lév., produced the highest yields in the Cooperative Variety Test. F.P. 497 and F.P. 454 were similar in yield, oil content, and other agronomic characteristics. F.P. 454 matures late and was derived as a high-oil plant selection from the cross Valuta  $\times$  Raja. In 3 years of testing it performed well in all soil zones, particularly in the Brown soil zone.

Before the appearance of rust race 300, the variety Marine was widely grown in the Prairie Provinces. In 1963, a back-

cross program was initiated to transfer the rust resistance genes  $L^a$ ,  $M^a$ ,  $N^1$ , and  $P^a$  to Marine. These condition immunity to all known races of rust in North America. In 1968, 26 backcross lines, each possessing one of the so-called immune genes, were tested at two locations. Nine of the resistant lines were very similar to Marine in yield and other agronomic characteristics.

Dates of seeding flax from April 30 to June 10 were tested over 2 years at Morden and Portage la Prairie to determine their effect on the yield performance of the early variety Noralta. Two other early varieties, Raja and Redwing, and the late variety Redwood were included. The best yields were obtained from the June 3 seeding and the lowest from the first and the last dates. Noralta and Redwood consistently yielded best from all seedings except that of June 10, from which the yield of Redwood was the lowest.

Flax rust, race 300, was again prevalent in southern Manitoba in 1968 when cool and wet growing conditions appeared to be conducive to its development. The continued culture of susceptible varieties is cause for concern because of the opportunity for the pathogen to develop new mutant races to which varieties hitherto resistant may be susceptible.

### Field Pea Breeding

MP 39, a yellow-seeded type of field pea, and MP 46, a green-seeded type, selected from Chancellor  $\times$  Weibulls' 700 are expected to be named and licensed for distribution. In 4 years of cooperative testing in the Prairie Provinces the small-seeded MP 39 was superior in yield and equal in cooking quality to Chancellor, the standard small-seeded variety. MP 46 was superior in yield to the comparable variety Delwiche Scotch Green.

Quality evaluation of small experimental samples of field peas was simplified by a new technique. A pressure cooker and screw top type glass bottles of 50-ml capacity were used to process peas under 15-lb pressure for 60 min, one-half the time of the conventional method. The capacity of the pressure cooker presented the only restriction on the number of samples tested simultaneously. The procedure

allows selection from segregating hybrid generations, which was previously impossible.

### Soybean Breeding and Testing

The Morden soybean strain CM 30 was superior in yield to most other varieties at two locations in Manitoba. It matured earlier and grew taller than the standard variety Altona. Strains CM 21 and CM 61 also performed very well in yield, plant height, and maturity, but showed a high percentage of seed coat and kernel cracking. Strain CM 107 yielded 23% more than the other strains, its seed quality was good, and plant height was acceptable.

Sclerotinia wilt and bacterial blight were observed for the first time on soybeans in 1968. There was a high incidence of both diseases, probably due to wet growing conditions.

The soybean strains Portage, Altona, and CM 30 were each grown at two population levels of 350,000 and 175,000 plants per acre and at row spacings of 12, 24, and 36 inches. The average yields for the three varieties over 2 years and two locations for these row spacings were 34.0, 32.4, and 29.4 bu/acre. The plants in the 12-inch spacing were slightly shorter and lodged less than those in the other spacings. The average yield for the two populations differed by 0.5 bu/acre over the four tests. In 1968 the high population slightly exceeded the lower in yield, whereas in 1967 the reverse situation occurred. The lower yield of individual plants in the high population was due mainly to reduced number of pods and seeds on the branches. The yield of the main stems remained relatively constant at the two populations.

### Sunflower Breeding and Diseases

Valley, an  $F_1$  hybrid of a partially sterile inbred crossed with the variety Peredovik, was licensed in 1968. The Russian variety Majak, which produced high seed yields and oil content, was considered too late for the Prairie Provinces. Krasnodarets has outyielded Armavirec by 15% for 2 years and may be licensed for distribution. A genetic male-sterile hybrid from Dr. M. L. Kinman, United States Department of Agriculture, College Station, Texas, yield-

ed well and matured early in the first year of testing at Morden. A male-sterile strain of sunflower received from France, in which a recessive gene is linked with green hypocotyl, was treated with three concentrations of gibberellic acid (GA3) at several stages starting prior to meiosis. No seed set occurred on 47 treated plants with 26,000 florets nor on nine control plants with 4,250 florets. Aside from precluding this method for propagating the male-sterile strain, the test indicated reliability of the sterility gene.

Headrot, due primarily to *Sclerotinia sclerotiorum* (Lib.) de Bary, but also to *Botrytis cinerea* Pers. ex Fr., was the most important disease in sunflower fields in southern Manitoba in 1968.

Factors for resistance to wilt caused by *Verticillium dahliae* Kleb., found in 1967 in wild sunflower, were confirmed in F<sub>1</sub> and F<sub>2</sub> hybrid plants from crosses involving the highly susceptible inbred CM 162. The

resistance of CM 144 broke down in 1968, possibly due to cool summer temperatures and excessive rainfall. An organism resembling *Verticillium tricorpus* Isaac. was isolated from potatoes in Manitoba in 1967. It was not pathogenic to sunflowers or tomatoes, but caused mild symptoms in potatoes grown in the greenhouse. *Verticillium* sp., isolated from potatoes in 1967, was not pathogenic to sunflowers and only mildly pathogenic to potatoes and tomatoes. This species was characterized by hyaline conidia, brown vegetative mycelium, and chains of chlamydospores, which developed from hyphae lying in a knot and by older conidia and conidiphores that turned brown and developed thick walls. Studies on *V. nubilum* Pethybridge showed that it forms aleuriospores rather than chlamydospores. It may be related to species of *Humicola* or *Mycogone*, which also form aleuriospores as well as a *Verticillium* stage.

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# Research Station Winnipeg, Manitoba

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### VISITING SCIENTISTS

M. A. HAGGAG, B.Sc., M.Sc. Egyptian Government Scholarship, 1967-68	Breeding wheat for rust resistance
D. HARDER, Ph.D. External Aid Trainee, 1968	Cereal rusts

#### *National Research Council postdoctorate fellows*

P. BARTOS, Ph.D., 1966-68	Plant physiology
JOSEF PESEK, Ph.D., 1968	Genetics
W. A. SHIPTON, Ph.D., 1968	Plant pathology

## INTRODUCTION

The Research Station, Winnipeg, is responsible for the development of varieties of wheat, oats, and barley suitable for production in the Prairie Provinces. Studies on diseases and insects attacking cereals comprise significant parts of the total program.

A new variety of durum, Hercules, was licensed in 1968. This variety has large kernels, strong gluten, and good pigment. Six dwarf varieties of common wheat were introduced from Mexico and tested throughout Western Canada. Only one, Pitic 62, showed promise for Canadian conditions.

The results of tests with the confused flour beetle suggest that it may be useful

in assessing feeding quality of small grains.

Two staff members, Dr. G. J. Green and Dr. J. W. Martens, were loaned to the Canadian External Aid program in Kenya to organize and initiate a wheat rust research program in that country. In addition, a postdoctorate student, Dr. D. Harder, was given intensive training in rust research techniques in our laboratory during 1968. He will assume responsibility for the program in Kenya, January 1, 1969.

Six graduate students, enrolled at the University of Manitoba, conducted their research at the Research Station, under the supervision of Station staff.

A. E. Hannah  
Director

## BREEDING, GENETICS, AND CYTOGENETICS

### Plant Breeding Methods

An analysis of N content and total beta-amylase activity in a cross between Vantage and Br 7212-39-1 varieties of spring barley showed that the two traits are highly heritable and positively correlated. Both traits showed a negative correlation with the level of free beta-amylase and no association with aleurone color.

A study of the interrelationships among yield and six quality traits in a cross of Prelude and CT 423 spring wheats showed that the heritabilities of the quality traits were higher than the heritability of yield. Of the quality traits, sedimentation value was the most unstable in response to environmental stress. A high negative correlation was observed between yield and nitrogen content as well as between nitrogen content and starch damage, sedimentation value and tolerance index, and dough development time and tolerance index. Dough development time was positively correlated with sedimentation value.

### Barley Breeding and Genetics

The major goals of the barley breeding program are to improve yields, malting quality, and resistance to several foliage diseases. Sources of resistance to net blotch, *Pyrenophora teres* (Died.) Drechsl., and speckled leaf blotch, *Septoria passerinii* Sacc., were combined with resistance to stem rust, *Puccinia graminis* Pers. f. sp. *tritici* Erikss. & Henn., and loose smut, *Ustilago nuda* (Jens.) Rostr. The early generation material was screened for resistance to all diseases in growth cabinets and the resistant lines were planted in the field for further selection.

The development of high yielding, high energy varieties suitable for livestock feed is receiving greater emphasis. Two-rowed varieties introduced from eastern Europe were found to be superior in agronomic and quality characteristics to present commercial varieties of this type. However, they lack resistance to stem rust, loose smut, net blotch, and speckled leaf blotch.

The confused flour beetle, *Tribolium confusum* Jacquelin du Val, was used as

a bioassay to evaluate the nutritional value of small grains. Four varieties of barley, and one each of wheat, oats, and Triticale were assayed by measuring rates of growth and development for larvae fed each variety. The larval period varied from 21 to 27 days depending on the cereal variety; varietal and species differences in feeding value are apparent.

### Oat Breeding and Genetics

Progress was made towards the goal of obtaining high yielding oats with rust resistance, good straw strength, high fat content, and good kernel appearance.

Heavy rainfall and cool weather during the past season caused severe lodging, and crown rust infections were very heavy. Good selection for straw strength was possible.

Several genes for resistance to crown rust isolated from *Avena sterilis* L. were backcrossed into the variety Pendek. Similarly, two stem rust resistance genes have been backcrossed into Rodney.

### Common Wheat Breeding

Six Mexican semidwarf wheat varieties were tested in the Western Wheat Co-operative Test in 1968. These were Pitic 62, chosen for its wide adaptability and high yield, and Noroeste 66, Inia 66, Tobari 66, Ciano 67, and Norteno 67, chosen because of their reported medium level of baking quality. Only Pitic 62, which has inferior baking quality, was outstanding in yield, averaging 24% higher than Manitou over the 17 tests in the Prairie Provinces. However, Pitic 62 is almost a week later maturing than Manitou, a severe disadvantage, particularly in northern areas. Combining high yield with the required maturity and other necessary attributes such as disease resistance continues to be a major goal.

The development of hybrid wheats has been in progress since 1963. Twenty-one hybrid varieties, which had been produced by natural cross-pollination in the field in 1967, were tested for yield and disease resistance. The resulting grain was subjected to milling and baking tests. Restoration of fertility in the hybrids was inadequate and none of them outyielded

Manitou. However, a few were equal to Manitou, and with better restoration could yield appreciably higher. Ergot continued to be a problem; the most severely infected hybrid yielded 2.6 bu of ergot bodies per acre. Stem rust resistance was adequate in most of the hybrids, but leaf rust readings were high. The quality results were quite variable, even though the six parents all possessed acceptable quality. Selkirk, Pembina, Justin, and Manitou were four of the parents. On the basis of one test, it appears that many of the hybrids may not meet the stringent Canadian quality standards.

### Durum Wheat Breeding

Hercules, an early maturing, short, strong-strawed variety, was licensed for sale in 1968. This variety has good resistance to leaf and stem rust and loose smut. It has a larger kernel, higher yellow pigment content, and greater gluten strength than Mindum or Stewart.

A number of hybrid populations involving dwarf tetraploids were advanced in the breeding program. In addition to being a source of short straw, they are important as a source of divergent germ-plasm.

A hexaploid wheat carrying a translocation for *Agropyron elongatum* stem rust resistance is being used in the breeding program. Attempts to establish homozygous resistant tetraploid lines in the variety Mindum were unsuccessful. The ratios obtained suggested lack of transmission of the resistance factor through the pollen. A study of chromosome number and pollen grains revealed no abnormalities. The difficulty encountered appears to be due to either certation or zygote abortion.

### Cytogenetics of Wheat

Genetic analysis of  $F_2$  and  $F_3$  populations from the hybrid between Canthatch common wheat and a synthetic hexaploid (AABBDD) produced by combining the AABB component extracted from Canthatch with *Aegilops squarrosa* L. R.L. 5289 (DD) showed that each of the following characters, derived from the *squarrosa* parent, was monogenically inherited: purple coleoptile, brown glumes,

nonwaxy foliage, tenacious glumes (non-free threshing), and resistance to leaf rust. One dominant gene provided excellent resistance to all four races of rust used, whereas a second gene gave resistance to one race only. The first resistance gene was found to be linked with the gene for brown glumes with a recombination value of  $3 \pm 1.1\%$ . Linkage was also noted between the gene for nonwaxy foliage and the gene for tenacious glumes; the recombination value was  $15 \pm 2.6\%$ .

In addition to providing excellent resistance to the four leaf rust races used in the genetic analysis, the main resistance gene also gives resistance to several other races. No other gene in hexaploid wheat is known to provide resistance to such a broad range of the leaf rust races prevalent in Western Canada.

The fact that the tenacious glume character of the synthetic hexaploid is due to one gene suggests that the original, primitive hexaploid wheat was nonfree threshing and that subsequently a simple mutation in a D-genome chromosome gave rise to present-day free-threshing common wheats.

### Genetics of Wheat

Two genes conditioning resistance to leaf rust, *Lr17*, from Klein Lucero and

Maria Escobar, and *Lr18* from Africa 43, P.I. 170925, and P.I. 170916-2c, were isolated. These two partially dominant genes were independent of each other and of *Lr1*, *Lr2*, *Lr3*, *Lr10*, and *Lr16*. Both of these genes gave good resistance in rust nursery tests. Studies of European varieties resistant to leaf rust indicate that most varieties possess gene *Lr3*. Genes *Lr1* and *Lr16* are present in a few varieties.

Excellent leaf rust resistance of the adult plant type was found in a synthetic hexaploid. It is conditioned by a single gene and is derived from *A. squarrosa*. This gene is independent of *Lr12* and *Lr13*, two genes conferring adult plant resistance derived from the varieties Exchange and Frontana, respectively. The resistance of Thatcher in the adult stage to leaf rust race 9 is conferred by a single gene.

Backcross lines of common wheat were produced which have the stem rust resistance from rye (WRT 238) and which appear to be meiotically stable. However, the baking quality differs somewhat from lines not having the translocation. An unidentified gene for stem rust resistance in the variety Red Bobs was determined to be an allele at the *Sr10* locus. In addition, Red Bobs carries the *Sr7b* gene.

## CEREAL RUSTS

### Stem Rust of Wheat

As a contribution to the Canadian External Aid program, a number of wheat varieties were tested for their reaction to Kenyan races of stem rust. Previously, races had been identified in Kenya on a group of differential host varieties that no longer have significance in their breeding program. New differential host varieties were selected and a new system of race nomenclature was developed so that race identification could be related directly to the breeding program. There are good sources of resistance to all the wheat stem rust races present in Kenya.

Wheat stem rust infections in all parts of Canada in 1968 were lighter than they have been for many years. The main

physiologic races found in 1968 were C18 (15B-1L Can.) and C20 (11). Eight other races were found in lesser amounts. The race distribution picture was about the same as it was in 1967. At present, there is no serious threat to the stem rust resistance of the varieties Manitou, Selkirk, and Pembina.

### Leaf Rust of Wheat

Inheritance of virulence in wheat leaf rust was determined on a number of varieties and backcross lines containing single genes for rust resistance. Virulence was conditioned by single recessive genes against host resistance genes *Lr1*, *Lr2*, *Lr11*, and *Lr17* and on the adult plant resistance of Thatcher. Virulence on *Lr18* was conditioned by a single dominant

gene. Single genes conditioned virulence on genes *Lr24* and *Lr3*. Virulence was recessive in some races of leaf rust and dominant in others. All genes for virulence segregated independently.

### Crown Rust of Oats

Six new genes (*Pc38* to *Pc43*) for crown rust resistance were identified in strains of wild oats, *Avena sterilis*, from the Middle East. Two of these genes (*Pc38* and *Pc39*) were found to possess outstanding resistance to races of crown rust prevailing in Canada in 1968, and are currently being used in the oat breeding program. Four other promising lines of *A. sterilis* are being studied and preliminary results indicate that other sources of resistance may be available.

Investigation of the electrophoretic patterns of soluble protein and enzyme extracts obtained from rust fungi showed that changes in the number of protein bands, or changes in their position, or both, cannot be reliably correlated with taxonomic differences between rusts at the species, forma speciales, or physiologic race level.

A study of asexual variation in the virulence of oat crown rust isolates revealed an unusually high rate of variation in one culture at the Saia locus, regardless of the method of culturing involved. Instability at this site continued despite repeated single spore subculturing. Nuclear irregularities in this culture are suspected.

Losses caused by crown rust in excess of 20% occurred in field trials of Kelsey and Eagle oats in 1968 even though rust did not appear till well after heading. The losses were intensified by unseasonably cool wet weather in August and September, which delayed maturity of the crop and encouraged rust development.

The majority (82%) of the 1968 survey isolates from the western crown population were virulent on the differential varieties Landhafer and Sante Fe. In contrast, only 8% of the isolates from Eastern Canada were virulent on these same varieties. The difference was also noted with respect to the ability of cultures to attack gene *Pc42*, but no correlation was noted between virulence on Landhafer - Sante Fe and on *Pc42*.

### Physiology of Parasitism

*Tryptophan metabolism.* Extracts from healthy and rust-infected wheat leaves were assayed with *Lactobacillus plantarum* for their tryptophan content. Six days after inoculation with rust, extracts from resistant reacting plants contained 50 to 80% more tryptophan than those from healthy plants. In the susceptible reaction the increase in free tryptophan was even more pronounced and exceeded 450% of control values. L-Tryptophan(methylene- $C^{14}$ ), introduced as a tracer, was converted to acidic ether extractives to a greater extent in susceptible reacting plants than in resistant reacting plants. Increased indoleacetic acid (IAA) levels in susceptible reacting plants have been attributed by others to lower IAA-oxidase activities in such tissues. Our results suggest that, in addition, increased IAA synthesis may contribute to the rise of auxin levels in susceptible plants after rust infection.

*Folate metabolism.* The total content of folic acid derivatives in wheat leaves was measured with *Lactobacillus casei*. In leaves with 6-day-old rust infections it was 50% higher than in healthy leaves. Extracts from all samples were fractionated on DEAE-cellulose columns. In each case, folate activity in the eluates emerged in five major and three minor peaks. Differential assays with *L. casei*, *Streptococcus faecalis*, and *Pediococcus cerevisiae*, and treatment of the eluate fractions with chicken pancreas conjugase showed that all eight peaks contained mixtures of folate compounds in various states of oxidation and conjugation. The rise of folate levels in susceptible reacting wheat leaves was largely due to an increase of 5-methyltetrahydropteroylglutamate (5-methyl $H_4$ PtGlu) and its di- and tri-glutamates. In the resistant reaction, there was a much less pronounced increase of these three components of the folate fraction, accompanied by an increase of higher conjugated forms of 5-methyl $H_4$ -PtGlu. Susceptible reacting leaves showed a much higher ratio of methylated to formylated folates than resistant reacting leaves.

The folate profile of rust spores differed markedly from that of wheat leaves. Non-

conjugated folates were virtually absent in all spore extracts. Pteroylglutamate (folic acid) and some of the conjugated formylated derivatives of tetrahydropteroylglutamate present in dormant uredospores were not detected in germinated spores. After 6 hr of germination, spores had lost approximately 50% of their total folate content. Only insignificant folate activity was recovered from the germination medium.

*C<sub>1</sub>-Transfer reactions.* In efforts to follow some of the C<sub>1</sub>-transfer reactions mediated by folate coenzymes in wheat leaves, formic acid-C<sup>14</sup> was fed to detached leaves and the metabolic products of this C<sub>1</sub>-donor were determined after metabolic periods ranging from 2 to 24 hr. Activity was detected in many tissue components. Significantly, the activity in choline reached a peak after 4 hr declining to near background levels at 24 hr of metabolism, whereas that in betaine rose continuously until, at 24 hr, it became the most heavily labeled compound of all. Betaine can thus be considered as a storage "pool" for C<sub>1</sub>-fragments in wheat leaves arising from formate, with choline as a possible intermediate. Other compounds of interest that contained radioactivity were serine and the nucleic acid degradation products adenine, guanine, cytidylic acid, and uridylic acid. Little or no incorporation occurred in thymidylic acid and in methionine or its degradation products.

Infection with rust led to many changes in the C<sup>14</sup>-labeling pattern of susceptible plants but not in that of resistant plants. In susceptible tissues rust infection caused a decline of incorporation into most of the formate-derived components, possibly owing to isotope competition in enlarged precursor pools. Notable exceptions were betaine and the nucleic acid degradation products mentioned above. These products

contained more activity in susceptible infected plants than in healthy plants where nucleic acid synthesis was less active.

The formate-C<sup>14</sup> feeding experiments have provided little information on the possible metabolic role of 5-methylH<sub>4</sub>-PtGlu and its conjugates in wheat leaves. In microbial, avian, and mammalian metabolism these compounds participate as coenzymes in the synthesis of methionine. According to our results this does not seem to be the case in wheat, even though 5-methylH<sub>4</sub>-PtGlu is present in higher concentrations than any of the other folate derivatives. The metabolic function of methylated folate compounds is of particular interest in the present project because the folate profile of susceptible reacting leaves differed from that of resistant reacting leaves, largely in respect to 5-methylH<sub>4</sub>-PtGlu and the ratio of methylated to formylated folates.

### Chemical Control of Cereal Rusts

Parathion effectively controlled crown rust in greenhouse and field trials, but failed to control oat stem rust and the wheat rusts.

Maneb and other rust fungicides had no beneficial effects on yield in the absence of foliar diseases.

In field experiments wheat treated at different rates with thiazole (G 696) yielded significantly more than the control plots. However, even at the lowest rate of application (2 lb/acre) applied twice during the season, the cost of the chemical would be excessive at present prices. Unless a chemical can be found that has a higher order of efficacy or a considerably lower cost there seems to be little hope of economical control of rust in cereals with chemicals.

## CEREAL DISEASES

### Smuts

The isolation of monokaryotic haplonts of loose smut, *Ustilago tritici* (Pers.) Rostr., of wheat was accomplished by microsurgery after teliospores had been germinated on a medium containing ben-

zoic acid. The plus haplonts of *U. tritici* grew well on a minimal medium and did not require proline as did those of *U. nuda* (Jens.) Rostr., the loose smut pathogen of barley, thus providing further evidence that the two species are not synonymous.

A new race of loose smut of wheat that is virulent on Thatcher and its derivatives was found in Western Canada. Thatcher had been immune to loose smut since its release in 1934.

## Viruses

*Barley yellow dwarf.* When oat leaves inoculated by aphids with barley yellow dwarf virus (BYDV) were detached after 6 and 48 hr feeding periods, only 3 and 29% of the plants became infected compared with 69% of the control plants on which the inoculated leaf was left intact. The same results were obtained for barley. Therefore, the rate of movement of BYDV out of inoculated leaves was comparable with that of plants inoculated with mechanically transmissible viruses rather than leafhopper transmissible viruses. When aphids were allowed to feed near the tip or the base of oat leaves and these leaves were then detached 48 hr after inoculation, the number of infected plants in each treatment was the same. This suggested that once the virus has reached the conducting cells of the phloem the movement of virus down the leaf is relatively rapid.

The transmissibility of an isolate of BYDV from oats varied in a cyclical manner. The percentage of aphids that transmitted the virus from oats to oats reached an initial peak 6 days after the virus source plant was inoculated and then varied in a cyclical manner as the age of the infection increased. In one experiment in which transmissibility was tested for 38 days there were five major peaks in the transmission curve.

*Aster yellows.* Common and durum wheat, oats, wild oats, barley, rye, and Triticale were moderately to highly susceptible to a noncelery-infecting isolate of the aster yellows pathogen obtained from naturally infected barley in Manitoba. The isolate produced distinctive symptoms on asters. On the basis of these symptoms and the differential transmission to several hosts, it is considered to be different from previously described strains of aster yellows. The susceptibility of Triticale and wild oats to aster yellows has not been recorded previously, nor has the susceptibility of rye and the high

susceptibility of oats and some common wheats been previously reported from North America. Nearly one-half of all aster yellows isolates tested in Manitoba in 1968 were cereal-infecting.

## Bacteria

*Bacterial diseases of wheat.* Special tests of advanced generation selections are made annually by field inoculation with *Xanthomonas translucens* (Jones, Johnson & Reddy) Dowson, the bacterial black chaff organism. Lines of wheat particularly subject to head discolorations are discarded throughout the breeding program. In spite of this program bacterial black chaff was sufficiently severe in farmers' fields in 1968 to cause appreciable yield losses. Wheat in an area of approximately 150 sq miles was infected, and much of the leaf area on the plants destroyed. Head discoloration was evident but distribution was not consistent. The disease was also common in experimental plots of wheat and Triticale (*Triticum durum* Desf.  $\times$  *Secale cereale* L.). Special forms of *X. translucens* were isolated from several collections of wheat plants and one collection of quackgrass, *Agropyron repens* (L.) Beauv., in Manitoba in 1968.

*Inoculation techniques.* A technique for hydraulic flooding of tissues with bacterial suspensions was developed for studying hypersensitivity in cereals to incompatible bacterial plant pathogens. It was also found efficacious in producing bacterial lesions with compatible pathogens. It produced a susceptible reaction on 25 varieties of wheat and may be useful when selecting for very high resistance in a large group of varieties of diverse genetic origin.

## Seed Treatment

The oxathiin fungicides Vitavax and Plantvax were found to be completely effective against loose smut of barley under field conditions with no apparent effect on the malting quality of the harvested seed.

The effects of 47 seed treatment fungicides on the microflora of barley seed that was naturally infested (95 to 100%) with *Cochliobolus sativus* (Ito & Kurib.)



Drechs. ex Dastur and other fungi were investigated after 7 days on moist filter paper. Each fungicide had a characteristic and reproducible effect on these organisms. Fungicides that contained mercury or maneb were highly effective against all organisms, whereas specific effects were associated with other fungicides. Least survival (best control) of *C. sativus* was obtained with Ceresan M, Pandrinox

APX, and Panogen PX among the mercurials and Green Cross SWF 850, SWF 860, Chemagro 4497, and Chipman 53-64 among the nonmercurials. The incidence of *Acremoniella* sp. detected was high on seed treated with Dexon; *Cephalosporium* sp. with Vitavax; *Streptomyces* spp. with Green Cross SWF 850; and *Cladosporium* spp. with Green Cross 3922.

## FIELD CROP INSECTS

### Soil Insecticides

Bioassays with the onion maggot, *Hylemya antiqua* (Meigen), were used to determine the toxicity of fonofos (Dyfonate) in soil. The amount of insecticide required was influenced by the amount of organic matter present. Ten to 12 times more fonofos had to be used in surface soil than in soil in the B horizon to obtain equivalent mortality.

### Grasshopper Surveys

*Camnula pellucida* (Scudder) replaced *Melanoplus sanguinipes* (Fabricius) as the dominant grasshopper species in Manitoba in 1968. The most severe and extensive infestation occurred in a community pasture. Cool, wet weather throughout the season in most areas delayed development, and damage was limited.

## INSECTS AND MITES IN STORED PRODUCTS

### Biology

*Insect population studies.* Infestations of rusty grain beetles, *Cryptolestes ferrugineus* (Stephens), were initiated in the autumn of 1967 in wheat of 11.5 and 13.5% moisture content stored in circular metal granaries containing 1,000 bu each. The infestations were concentrated within a 2-ft radius of a point at which water had been added at weekly intervals during the summer of 1967. The heating that accompanied the infestation in the wheat was first detected near the floor of the granary. In the zone 2 ft above the floor, the peak temperature was reached in the third week in September; in the zone 6 inches below the grain surface (6 ft above the floor), the peak temperature was reached in the first week in December. The greatest number of rusty grain beetles in a 300-g sample from the wheat at 13.5% moisture was 3,000 larvae and 967 adults recorded at the end of November; in wheat at 11.5% moisture, the corresponding numbers were 335 larvae and 91 adults recorded in mid-December. The moisture content at the

surface increased to 16 to 17%. After the maximum levels were reached, the temperature and numbers of insects steadily declined throughout the remainder of the winter.

No significant rise in temperature or insect numbers occurred the following summer or autumn.

*Life history of Cynaesus angustus* Le Conte. *C. angustus*, a tenebrionid beetle, discovered in poultry houses, granaries, and flour mills in Manitoba develops most rapidly at 35 C and 90% relative humidity on whole-wheat flour, requiring 6 weeks to develop from egg to adult. Development occurs between 22.5 C and 37.5 C. Optimum relative humidity for development is 70%. This insect may become a major pest in the prairies if residues of flour and cracked grain are allowed to accumulate undisturbed over long periods of time.

*Varietal reaction of stored grain to grain insects.* Thirty-nine cereal varieties grown in Western Canada in 1965-66 were assessed for resistance to infestation

by five cosmopolitan species of stored-grain insects. *Sitophilus granarius* (L.) and *Rhyzopertha dominica* (Fabricius) did not multiply on unbroken seeds of hulled oats, but *S. granarius* populations did increase on the hull-less variety Vicar. *C. ferrugineus* and *Tribolium* spp. multiplied extensively on crushed oats. Significant varietal differences ( $P < 0.05$ ) in the rates of multiplication of all insects were observed in at least two cereals.

## Ecology

*Chemical control of insects.* The toxicities of DDT, methoxychlor, lindane, malathion, and bromophos applied on filter papers were compared at 26.7, 15.5, and 10.0 C against the confused flour beetle, *Tribolium confusum*; the red flour beetle, *T. castaneum* (Herbst), the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.); the merchant grain beetle, *O. mercator* (Fauvel); and the rusty grain beetle, *Cryptolestes ferrugineus*.

Methoxychlor was ineffective against all species except *T. castaneum*. DDT was more toxic to all species at 10.0 and 15.5 than at 26.7 C but was slightly more toxic at 15.5 than at 10.0 C. Lindane was more toxic at 10 than at 15.5 C to *T. castaneum* and *O. surinamensis* but was more toxic at 15.5 than at 10 C to *O. mercator* and *C. ferrugineus*. Bromophos was much less effective at 15.5 and 10.0 than at 26.7 C against both *Tribolium* species and *O. surinamensis*. *T. confusum* was the most susceptible to DDT, lindane, malathion, and bromophos. Malathion was the most effective insecticide at all three temperatures employed.

Wettable powders (w/p) of methoxychlor and lindane and an oil solution (o/s) of lindane were applied to surfaces of concrete, wood, and metal to determine their residual toxicities against insects and their rates of uptake into wheat, oats, and barley. The insecticides were more toxic to *T. confusum* adults when applied on wood surfaces than on either metal or concrete. Lindane (w/p) persisted the longest on the three surfaces; its uptake in wheat increased with time of storage. The rates of uptake of lindane by wheat stored on wood and metal were similar. The bottom 2.2 cm

layers of wheat, oats, and barley contained lindane at concentrations of 87.1, 86.1, and 47.7 ppm respectively, after storage for 24 weeks on metal treated with lindane (w/p). The corresponding uptake of methoxychlor by wheat, oats, and barley from metal was 3.8, 23.3, and 17.3 ppm, respectively. Methoxychlor residues of 3.8 ppm in the bottom layer of wheat stored on metal gave complete mortality of the rusty grain beetle.

High residues of lindane occurred in wheat, oats, or barley stored on concrete, wood, or metal surfaces that had been treated with lindane (w/p). Residues were much lower on surfaces treated with lindane (o/s), but residual toxicity was also lower.

The rusty grain beetle, *C. ferrugineus* and the flour mill beetle, *Cryptolestes turcicus* (Grouvelle), were assessed for tolerance to chloropicrin. Two strains of the rusty grain beetle, one obtained from England and the other from the Winnipeg area, had approximately the same tolerance; 50% mortality occurred at concentrations of 1.3 mg/liter at 66 F and 1.16 mg/liter at 76 F. However, an English strain of the flour mill beetle was more resistant than either strain of *C. ferrugineus* and concentrations of 2.22 and 2.46 mg chloropicrin per liter were required at these temperatures to obtain 50% mortality.

Two experimental compounds BAY 77488 (phenylglyoxyloxynitrile oxime *O,O*-diethyl phosphorothioate) and BAY 78182 (*o*-chlorophenyl glyoxyloxynitrile oxime *O,O*-diethyl phosphorothioate) in various formulations were used as residual contact insecticides against three stored products insect species. BAY 77488 20% wettable powder was the most effective formulation against adults of *T. confusum* and *O. mercator*, and BAY 78182 25% emulsifiable concentrate against larvae of *Trogoderma parabile* Beal. Higher dosages were required for *T. parabile* than for the other species, but all formulations were superior to malathion against this insect.

*Reaction to feeding compounds.* An antifeeding compound, AC-24055 (4-(dimethyl-triazeno) acetanilide), inhibited oviposition and acted as an insecticide against some species of stored products

beetles. Granary weevils on treated wheat kernels died within 19 days without producing progeny. *T. confusum*, *C. turcicus*, and *T. parvipes* died shortly after hatching in a treated food medium. Some kinds of cereal packages treated externally with AC-24055 protected the contents from insect entry for periods of up to 6 months.

Extracts of raw wheat germ with either diethyl ether or hexane elicited aggregating and feeding responses from adults of the confused flour beetle, *T. confusum*. However, when the diethyl ether used for extraction had a relatively high concentration of peroxides, the extract became repellent. The repellent is formed during the extraction process and is not a normal component of the wheat germ.

*Reaction to physical components.* The dermestid beetle *T. parvipes* laid more eggs on cotton than on any other of seven types of oviposition sites. An oviposition site that provided crevices for insertion of the ovipositor was more important than food in stimulating oviposition.

*Factor analysis of environmental and biological variables in bulk grain ecosystems.* Interrelations among temperature, moisture, and viability of grain, and mites, insects, and fungi were studied from 8,135 samples collected at monthly intervals from two 500-bu wheat bulks stored in a granary at Winnipeg, Man., for 8 years during 1959–67. The bins were fumigated once with phosphine ( $\text{PH}_3$ ) in August 1965, to determine the effect of the chemical on the existing relationships in the grain bulk ecosystems. Eleven factors, accounting for 59.3% of the total variability, were extracted from 32 variables by the principal-components factor analysis method. The general factor, time, affected all major field and storage fungi and the grain moisture and viability, but not one arthropod species. Both temperature and moisture affected the abundance of mites, insects, and fungi; temperature was more important for most mites and insects, whereas moisture was more important for most fungi.

## FUMIGANT ANALYSES

### Determination of Phosphine

Coulometric, thermionic, and flame photometric detectors used with gas-liquid chromatography were compared for sensitivity, accuracy, reproducibility, and speed for the measurement of traces of  $\text{PH}_3$  in foodstuffs, air, and water. Based on a response at 10% of recorder scale with a reproducibility to within  $\pm 10\%$ , the lower limits of absolute detectability of  $\text{PH}_3$  were: coulometric, 50 nanograms ( $5 \times 10^{-8}\text{g}$ ); thermionic, 20 picograms ( $2 \times 10^{-11}\text{g}$ ); and flame photometric, 5 picograms ( $5 \times 10^{-12}\text{g}$ ). With a 100-g sample of foodstuff or water, these amounts correspond to a relative sensitivity of 500, 0.2, and 0.05 ppt for the coulometric, thermionic, and flame photometric detection methods. By appropriate choice of operational parameters (column temperature, etc.),  $\text{PH}_3$  can be determined

within 30 sec by these supersensitive methods.

### Rapid Method of Measuring Sorption Affinity

Appropriate amounts of flour, ground cereal, or other powdered or granular substrate were vibration-packed into a gas chromatographic column. Several micrograms of fumigant gas were injected into the carrier gas stream (helium preferred). The comparative response (area or peak height) on packed vs. unpacked columns was correlated with the sorption affinity of the substrate for the test gas. If the response is significantly reduced at higher column temperatures, chemisorption is indicated. The affinity of various materials for methyl bromide and  $\text{PH}_3$  was thus explored. Results are quantitative, reproducible, and rapidly obtained.

## PEDOLOGY

### Reconnaissance and Detailed Soil Surveys

Approximately 166,400 acres were covered by reconnaissance or low intensity survey (scale: 2 inches = 1 mile) and 179,200 acres were covered by detailed or high intensity survey (scale: 4 inches=1 mile) in the southern half of the Virden map sheet area (N.T.S. 62F). Salinity investigations in the Souris basin and Whitewater Lake sections of the map sheet area were undertaken in cooperation with personnel from the Research Station, Lethbridge, Alta. Preliminary maps and reports describing soil suitability for irrigation in the Souris basin section are available.

About 945,000 acres were covered by low intensity survey in the Swan Lake map sheet area (N.T.S. 63C). Preliminary field investigations in The Pas map sheet

area (N.T.S. 63F) were also undertaken to establish a tentative soil legend and to plan the survey of the map sheet area in the summer of 1969.

Exploratory surveys or "Biophysical Surveys" were conducted in the Cormorant Lake, Wekusko Lake, and Cross Lake areas of the Precambrian Shield section of northern Manitoba. These interdisciplinary investigations were carried out in cooperation with foresters, wildlife biologists, and recreation experts from the Canada Department of Forestry; the Research Station, Winnipeg; and the Manitoba Department of Mines and Natural Resources. The study related patterns of soils and vegetation to identifiable geomorphological segments of the landscape. These segments of landscape or "Geomorphologic Units" have been demonstrated to be very useful for multiple resource-use planning.

## MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Ceresan M	DuPont of Canada Limited
Chemagro 4497	Chemagro Limited
Chipman 53-64	Chipman Chemicals Limited
Dexon	Chemagro Limited
Dyfonate	Stauffer Chemical Co.
G 696	UniRoyal (1966) Ltd.
Green Cross 3922	Green Cross Products (Division of the Sherwin Williams Co. of Canada)
Pandrinox APX	Morton Chemical of Canada Limited
Panogen PX	Morton Chemical of Canada Limited
Plantvax	UniRoyal (1966) Ltd.
SWF 850	Green Cross Products (Division of the Sherwin Williams Co. of Canada)
SWF 860	Green Cross Products (Division of the Sherwin Williams Co. of Canada)
Vitavax	UniRoyal (1966) Ltd.

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# Experimental Farm Indian Head, Saskatchewan

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## INTRODUCTION

This report outlines the significant results of the research program at the Experimental Farm, Indian Head, for 1968. None of the research is reported in detail. Significant progress on long-term projects is mentioned. Results of our testing programs become part of the information on which practical recommendations are

made for the guidance of farmers in Saskatchewan.

In October 1968 the poultry research program and staff were transferred to the Research Station, Brandon, Manitoba.

J. Roe Foster  
Director

## METEOROLOGY

The total precipitation in 1968 at the Experimental Farm was 12.78 inches, much lower than the 72-year average of 17.13 inches. Rainfall from April 1 to July 31 was only 3.29 inches, again much below the average of 8.25 inches for this period. During these 4 months only three useful rains were recorded, one in May (0.55 inch), one in June (0.45 inch), and one in July (0.39 inch). Other rains were light and ineffective. Precipitation in August was 5.17 inches, a high for this month, but early crops benefited little from the moisture. At seeding time Indian

Head clay soils held approximately 7.5 inches of available soil moisture in summerfallow fields and 4.3 inches in stubble fields. Surface moisture was excellent at seeding time and emergence of crops was uniform. Summer temperatures were not extreme, hours of sunshine were slightly above the longtime average, and evaporation from May 1 to September 30 was 20.3 inches, very close to the 33-year average of 20.6 inches. These factors all had a marked influence on the yield of crops produced under the extremely dry conditions.

## FIELD HUSBANDRY

### Weed Control

*Green foxtail.* Benzadox was applied at 0.5 to 2 lb/acre alone, mixed with a bromoxynil-MCPA mixture at 8 oz/acre, and mixed with MCPA at 8 oz/acre. At 1 lb/acre, benzadox controlled green foxtail, but both wheat and barley were slightly injured. Broad-leaved weeds were effectively controlled by both mixtures. Under 1968 conditions TCA at 0.5 and 1 lb/acre did not effectively control green foxtail. MSMA was applied at 2, 3, and 4 lb/acre to green foxtail growing in plots of wheat and barley. At all rates of the chemical both crops were injured somewhat at first, but recovery was satisfactory. Green foxtail was not controlled by the

2-lb rate, but was severely retarded by the heavier rates.

*Canada thistle.* During the summerfallow period, herbicides were applied to dense patches of Canada thistle. Of the 17 chemicals tested, picloram and amitrole were the only two that eradicated the weed. Smooth-leaved thistles were more difficult to control than the spiny-leaved type. In 1968 wheat was sown in an area where picloram had been applied at 0.25 lb/acre in 1965. The wheat averaged 32 bu/acre, just slightly below the checks. In the same test a granular formulation containing a mixture of borates and picloram was applied at 25 and 50 lb/acre. These rates contained picloram at 0.5 and



1 lb/acre. Thistles were eradicated. In the spring of 1968 wheat was sown in the greenhouse in soil taken from these plots. The total weight of plant material was reduced by 28 and 40% respectively. Later in the year, the yield of wheat sown under field conditions was affected very little.

*Continuous use of herbicides.* Weed infestation has been reduced in plots where an amine or an ester of 2,4-D has been applied to wheat each year for the past 23 years. The checks averaged 45 weeds per sq yard; the plots receiving 4 oz/acre of 2,4-D, 23 weeds per sq yard; and the plots receiving 16 oz/acre of 2,4-D, 10 weeds per sq yard. Under field conditions some movement of weed seeds from plot to plot by equipment and wind could not be prevented.

### Soil Fertility and Rotations

*Rotations.* The sequence of crops in one rotation at Indian Head has not been changed since 1911. Wheat on summer-fallow in this rotation, which contained a grass-legume mixture, yielded 35.1 bu/acre in 1968. In the same rotation, wheat after corn produced 9.8 bu. The higher yield of wheat on summerfallow demonstrated the value of reserve soil moisture in a year like 1968 when only 3.29 inches of precipitation was recorded during the growing season. Phosphate fertilizer did not increase yields in this rotation.

Plots sown continuously to wheat for the past 12 years yielded 19.4 bu/acre in 1968. To produce this yield, 40 lb/acre of N and 11 lb/acre of P were needed. Wild oats were effectively controlled by triallate applied in the fall. Wheat on summerfallow in the 2-year rotation produced 31.7 bu/acre. When all costs were considered the difference between these two sequences was small.

*Fertilizers.* From 1965 to 1968 N and P were applied at several rates to wheat sown on summerfallow on a Ryerson soil. This soil was low in available N and P. Increases in yield in 1968 were similar

to previous years except at one rate, 5 lb/acre of N and 8.8 lb/acre of P. This fertilizer increased yields by 9.1 bu/acre, three times the average over the past 4 years. A test comparing several rates of N and P applied with wheat sown on summerfallow on Indian Head heavy clay was completed in 1968. The average increase with 8.8 lb/acre of P was 3.1 bu and with 17.6 lb/acre, 5 bu. Under the extremely dry conditions in 1968, yields increased progressively as the rate of P was increased from 4.2 to 21 lb/acre. The maximum increase of 9.4 bu/acre occurred with the heaviest rate. This shows that the fertilized crop used soil moisture efficiently. For the past 22 years, barnyard manure has been applied to test plots at 9 tons/acre, once every 3rd year. The yield of wheat on summerfallow on these plots was increased by 7.5 bu/acre in 1968. These plots had 144 lb/acre of available nitrate N and 68 lb/acre of available P at seeding time.

The relationship between row spacing, rates of seeding, and rates of fertilizer was studied on two project farms in eastern Saskatchewan. Wheat sown on summer-fallow in rows 6 inches apart significantly outyielded wheat in rows 9 and 12 inches apart. Yields increased significantly as rates of seed and fertilizer were increased; the highest yield occurred at the seeding rate of 3 bu/acre, and 100 lb/acre of 11-48-0.

Three sources of N, urea (45-0-0),  $\text{NH}_4\text{NO}_3$  (33.5-0-0), and N in solution (28-0-0) were compared on stubble crops. In all cases increases in yield were similar. Fall applications compared favorably with spring applications.

Various rates of N and P have been applied to brome-grass-alfalfa mixtures in eastern Saskatchewan for the past 4 years. In a 19 test-year average, 20 lb of N per acre was the most economical rate. Further increases in yield, resulting from additional P or higher rates of N, were very small. Precipitation was below normal during most of this period and no doubt had an adverse effect on the response to fertilizer.

## PLANT SCIENCE

### Cereals

Varieties, strains, and plant breeders' material were evaluated in cooperative tests. There was no rust to indicate differences in resistance. The lack of effective rain until August favored the late-maturing varieties, which tended to yield higher than early-maturing ones. Because frost occurred before the crops matured, frost damage affected grades. There was little difference in yield among Manitou, Canthatch, and Thatcher. Stewart 63 was the highest yielder among the durumms; Hercules, a new variety, was lower yielding, but is earlier and has short, strong straw. Garry and Sioux were the highest yielding of the oats, and Fraser was about 4% less. Galt was the highest-yielding barley; Paragon yielded significantly more than Conquest. Redwood 65 flax yielded significantly more than Norland; Noralta yielded about the same as Norland, but was earlier maturing. Rosner triticale yielded less than Manitou; only one line yielded slightly higher than Manitou. On dry land, Pitic 62 wheat yielded 23% more than Manitou, but matured 6 days later; Conquest barley yielded 31% more than Manitou wheat. The following seed increase of new varieties was made: CT 282 (wheat) 1,766 bu, Hercules (durum wheat DT 191) 1,485 bu, and BT 308 (barley) 720 bu.

*Management practices.* There was no reserve moisture from 1967 in sod crops and as no effective rain was received until early in August 1968, hay yields were very low. Normal differences in yields of dry matter did not show up because of lack of moisture. Alfalfa seeded with grass in alternate rows, or in the same row, produced the same yield of dry matter. Alfalfa seeded at 1, 2, and 3 lb/acre with

grass produced the same yield. Clipping Russian wild ryegrass after seed harvest had no effect on seed yield the following year. A high rate of N (100 lb/acre) applied in the fall of 1967 increased seed yield of Russian wild ryegrass by 85 lb/acre in the dry year of 1968. The importance of winter-hardy varieties was indicated when Vernal alfalfa, in a management test, failed to survive the winter of 1967-68.

*Plant breeding.* Thirteen hundred pounds of Foundation seed of the new brome grass variety Magna, developed at the Research Station, Saskatoon, Sask., was distributed from here in 1968 and an additional 1,280 lb was produced in 1968. A satisfactory seed set was obtained from the four crossing blocks of wheat × wheatgrass hybrid plants. All these plants are of the tall wheatgrass (*Agropyron elongatum*) type. Nine lines of oats selected for forage qualities were entered in the Cooperative preliminary test at three locations. About 1,850 lb of the low-coumarin sweet clover line S-7204 was produced in cooperation with the Research Station, Saskatoon. Five acres of Sawki Russian wild ryegrass produced 50 lb of Breeder seed. The first seed crop of Russian wild ryegrass is invariably small. To supply the increasing demand for seed of the popular rapeseed variety Echo, the number of Foundation seed producers was increased from 13 to 27. Five acres of Breeder seed of Echo was grown in 1968, and 2,700 lb of seed produced. Forty-five acres of Bronowski oilseed rape were grown, producing 1,200 bu of seed for the Research Station, Saskatoon. This is a low sulfur content introduction, the seed being used to produce a high protein meal for feeding tests.

## SOILS — HORTICULTURAL CROPS

### Vegetable Varieties

Poor growing conditions made field evaluation of warm-season crops difficult in 1968. Potatoes yielded well, but tended to oversize under the wet fall conditions.

### Soil Fertility

*Effect of N and P fertilizers on the specific-gravity of potatoes.* Data collected over a 3-year period have indicated that the applications of P alone resulted in high

specific-gravity values, being approximately the same as that found in the check potato tubers. The applications of N alone produced lower specific-gravity values, which ranged slightly lower than that produced by the high rate of P. The application of 50, 100, 150, or 200 lb/acre of N with 22, 44, 66, or 88 lb/acre of P produced somewhat lower specific-gravity values, particularly at the high rates of N and P.

*Effect of two sources of N and P on potatoes.* Averaged data (1964-68) from paired subplots, one subplot of each pair being fertilized with various rates of ammonium nitrate - phosphate (23-23-0) and the other one with combinations of ammonium nitrate (33.5-0-0) and triple superphosphate (0-45-0) at equivalent rates of N and P, showed that yields and specific-gravity values of potatoes were essentially the same regardless of nutrient source. The total and marketable tuber yields (in cwt/acre) and specific-gravity values of tubers from the ammonium ni-

trate - phosphate subplots were 276.9, 193.1, and 1.0696 respectively; whereas those from the combined fertilizer subplots were 276.2, 196.9, and 1.0697.

*Field equipment for safe application of radioactive fertilizer.* A portable device for safely applying radioactive fertilizer was developed at the Experimental Farm. The device consists of two boxes of different sizes. The larger box, which serves as a carrying case, is fitted with handles but no lid, has a partial open bottom at one end, and is lined at the other end with several lead plates. The smaller box is fitted with a hinged lid covered by lead plates, and when in operation is placed inside the lead liner of the larger box. The thickness and number of lead plates required for protection depend on the total activity of the radioactive fertilizer. The radioactive fertilizer, contained in small envelopes, is stored in the smaller box and is readily accessible for placement in the soil through the open bottom at one end of the larger box.

## PUBLICATIONS

### Research

EMMOND, G. S. 1968. The distribution of radioactive phosphorus in several potato varieties. *American Potato Journal* 45: 217-219.

### Miscellaneous

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application of radioactive phosphorus to potatoes. *Canadian Journal of Soil Science* 48:222-224.

HERGERT, G. B., and G. S. EMMOND. 1968. A fertilizer placement seeder for horticultural crops. *Canadian Journal of Plant Science* 48:630-633.



# Research Station Melfort, Saskatchewan

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## INTRODUCTION

The Research Station, Melfort, specializes in the production and utilization of forage crops and has research programs under way in animal nutrition, horticulture, cereal crops, and soils aimed at solving problems facing the agricultural producer. The Station is located on very productive soil in a mixed farming area and has research projects at a number of sites representing the main soil types in northeastern Saskatchewan. As the agricultural area expands to the north and east, new agricultural problems associated with changing soil and climatic conditions become evident. In the summer of 1968 some preliminary work was under-

taken in the Saskatchewan River Delta area on a 2,000-acre project being developed by the Saskatchewan Government. We plan to undertake more research work in the summer of 1969 to determine the adaptability of various cereal and forage crops and the cultural practices required for optimum production.

The Station publishes "Research Highlights" yearly to provide farmers and extension workers with the results of our work. This is available free from the Station.

S. E. Beacom  
Director

## PASTURE RESEARCH

### Animal Management Practices

Four systems of managing steers on brome-grass-alfalfa pasture were compared for the second consecutive year. The systems included (i) maintaining a constant 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 silage; (iii) maintaining a stocking rate as in (ii), but supplementing pasture with rolled barley; and (iv) "put and take" stocking. Results in the order of the above systems were: yields of dry matter—3,821, 4,149, 3,967, and 3,494 lb/acre; average daily gain—2.42, 2.23, 2.74, and 2.35 lb/head; gain per acre—274, 403, 510, and 284 lb; average stocking rate—1.0, 1.5, 1.6, and 1.1 steers/acre. Approximately 60% of the steers fed barley on pasture graded Canada Choice or Good. Steers on the other systems graded Standard or lower. Returns after deducting costs of supplementary feed were about \$20/acre higher for the barley-fed group than for any other system.

### Forage Comparisons

*Palatability of crested wheatgrass varieties.* Palatability studies conducted from 1963 to 1965 showed that sheep preferred Fairway crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., to S-5565, a tall-growing strain of the same species. A replicated grazing trial was established in 1965 to determine if differences in palatability would affect animal performance. This year, as in previous years, no significant differences in gain per acre or in average daily gains occurred between strains when grazed separately or when free choice was allowed. Liveweight gains averaged 499 lb/acre, and average daily gains averaged 0.42 lb/head. S-5565 produced approximately 7.5% more dry matter per acre than Fairway, but was less efficiently utilized for gain.

*Russian wild ryegrass vs. crested wheatgrass for pasture.* During the second year of a test in which crested wheatgrass (CWG) was compared with Russian wild ryegrass (RWR) as pasture for yearling steers, CWG produced approximately 8% more liveweight gain per acre than RWR

(389 lb vs. 359 lb). Average daily gains were also higher for CWG (2.58 vs. 1.95). However, due to the tendency of CWG to go dormant during midsummer, the length of the grazing season and the average stocking rate were slightly lower for CWG than for RWR. Production of dry matter was similar for both species.

### Northern Range Investigations

In 1961 a "northern range" pasture was established on Gray Wooded soil near Garrick, Sask. (lat 53° 30' N). By July 1962, an adequate stand consisting primarily of bromegrass, crested wheatgrass,

and alfalfa had been established. Fertilizer treatments of 67 lb N and 65 lb N+34 lb P/acre were applied in July 1962. The same areas received 90 lb N and 90 lb N+50 lb P/acre, respectively, in April 1965. Residual benefits from the fertilizers applied in 1962 were exhausted by the end of 1963. The residual influence of the N fertilizer applied in 1965 had disappeared by the end of 1967, but the N+P treatment continued to stimulate production throughout 1968. The N and N+P treatments increased the average carrying capacity for the 1962-68 period by 30% and 49%, respectively.

## ANIMAL SCIENCE

### Beef Cattle

*Grinding forage for wintering calves.* An early- and late-cut alfalfa hay were fed in each of six forms—long; chopped (3-4 inch lengths); and hammermilled to pass 2-inch, 1-inch, ½-inch, and ¾-inch screens—to groups of yearling steers, each comprised of four Angus and four Charolais × Angus. All groups were hand-fed twice daily to appetite. Average daily gains (lb) for the 77-day test were (in order from long hay to ¾-inch grind): early-cut hay, 1.10, 1.15, 1.51, 1.58, 1.62, and 1.73; late-cut, 0.64, 0.66, 0.99, 1.10, 1.36, and 1.24. The crossbreds consistently outgained the Angus steers when fed the early-cut hay (avg 0.17 lb), but not when fed the late-cut hay (crossbreds averaged only 0.06 lb/day more). Corresponding average daily intakes of dry matter (lb) were: early-cut hay, 17.8, 17.4, 18.7, 18.6, and 20.7; late-cut hay, 14.9, 14.2, 17.3, 17.8, 19.3, and 19.4.

*Effect of an antibiotic - Sulfa drug feed additive on the performance of newly weaned calves.* A chlortetracycline-sulfamethazine preparation (Aureo S-700) was added to the grain portion of a ration to provide recently weaned and shipped beef calves with 700 mg of the active ingredients per head daily for 4 weeks. The test involved 106, 400-lb calves, half treated and half serving as controls. The additive increased daily gains (1.63 vs. 1.03 lb/head per day), reduced the feed required per pound of gain (6.4 vs. 15.4 lb), and

had a beneficial but variable effect on the number of calves requiring treatment for shipping fever.

### Sheep

*Utilizing slough hay in lamb finishing rations.* Pelleting (¾-inch die) supplemented and unsupplemented lamb finishing rations consisting of ground (¾-inch screen) slough hay (about 70%) and wheat (about 30%) increased daily gains by an average of 44% (0.56 vs. 0.39 lb), reduced feed requirements per pound of gain by 21% (6.01 vs. 7.61 lb), improved carcass grades, and increased net returns. Supplementing the ground rations with molasses (5%), alfalfa meal (10%), or rapeseed meal (5%) reduced gains, markedly in the case of molasses. When rations were pelleted, however, the three supplements all caused increases in daily gain. A testosterone - estradiol benzoate implant had no effect on the ewe lambs except to reduce dressing percentage and carcass grade slightly. A progesterone - estradiol benzoate implant increased the rate of gain of wether lambs by 40% (0.57 vs. 0.41 lb) and reduced feed required per pound of gain by 32% (5.21 vs. 7.68 lb). Dressing percentage was reduced slightly, but net returns were increased.

### Swine

*Fiber level in breeding rations.* Performance of Yorkshire sows fed *ad libitum* a 17% protein ration that contained 8.5% or 12.7% crude fiber was determined over

two reproductive cycles. Combining the results from first and second litters, the 19 sows fed the high-fiber ration farrowed and weaned more pigs per litter (0.9 and 1.0 pigs, respectively) although the average birth weight of their offspring was 0.18 lb less than from sows fed the low-fiber ration.

*Supplementary copper in breeding rations.* Increasing the Cu level of a 17% crude protein ration by 125 ppm had no significant effects on the reproductive performance of first-litter Yorkshire sows. The sows receiving Cu had significantly ( $P < 0.01$ ) higher hemoglobin (Hb.) levels during the 4-week lactation period. Significantly higher ( $P < 0.05$ ) initial Hb. levels in the blood of their offspring did not persist if Fe administration was delay-

ed from the 3rd to the 14th day after birth.

*Medication of starter rations for weanling pigs.* Aureo SP250 (aureomycin, sulfamethazine, penicillin), TNA 290 (terramycin, furazolidone, arsanilic acid), and copper sulfate (125 ppm Cu) were compared as additives to starter rations (22% crude protein) for weanling Yorkshire pigs over the 15 to 55 lb weight range. None of the additives were able to completely prevent the occurrence of scouring. Use of Aureo SP250 or TNA 290 improved average daily gain and efficiency of feed conversion but not to the extent that feed cost per pound of gain was reduced. Supplementary copper sulfate reduced feed cost per pound of gain by 0.5 cent.

## SOIL SCIENCE

*Residual effect of nitrogen and phosphorus fertilizers.* In the fall of 1966 and spring of 1967 four levels of N (from  $\text{NH}_4\text{NO}_3$ ), 0, 40, 80, and 120 lb/acre, in combination with four levels of P ( $\text{NH}_4\text{H}_2\text{PO}_4$ ), 0, 8, 17, and 25 lb/acre, were applied to stubble plots at Melfort. Arlo rapeseed, *Brassica campestris* L., was seeded as the second crop after fallow in the spring of 1967. Because rainfall and yields were low, it was decided to measure the residual effect of the fertilizer by seeding Conquest barley in the plots the next year. The fertilizer had no residual effect where the recommended level (40 lb N, 8.4 lb P/acre) had been applied, but a residual response of up to 290 lb of barley per acre was obtained where higher levels of N (80 lb/acre) or of P (25 lb/acre) had been applied.

*Phosphorus fertilizer for barley on stubble.* In 3 successive years on six test sites located in three soil zones (Black, Black-Gray, and Gray), P fertilizer was applied at various levels along with N to determine the response of Conquest barley when grown as the second or third crop after fallow. Soil tests for  $\text{NaHCO}_3$ -extractable P showed that at all but two sites, P levels in the top 6 inches of soil were in the very low to low range (0-15 ppm). The other two sites were in the

medium (16-20 ppm) and very high (51+ ppm). At all but the last site a yield response to P could be expected. In each year at two of the six sites, no response to P was obtained despite low P levels in the soil. It appears that a more accurate test for available P is required.

*Relationship between soil test values and the response of barley to nitrogen fertilizer.* In all but a few cases, optimum yield responses were not obtained when Conquest barley grown on stubble was fertilized according to recommendations made on the basis of soil tests. Because of this, exchangeable ammonium and nitrate N levels were obtained before and after incubation (2 weeks at 30 C) and related to crop yield over 12 experimental sites. Of these, exchangeable ammonium (without incubation) was the only one that was significantly related to yield. Exchangeable ammonium recovered from plots receiving  $\text{NH}_4\text{NO}_3$  the previous fall was highly correlated to rapeseed and barley yields.

*Soil moisture.* Soil moisture studies over a 6-year period on summerfallow and stubble on four northeastern Saskatchewan soils ranging from light loam to heavy clay showed that in the spring, stubble land contained about 90% as much moisture in the top 4 ft as did summerfallowed land. This enabled



stubble land to produce from 73 to 93% (depending on soil texture) as much grain as did summerfallowed land.

On summerfallowed soils, 5 to 20% of the precipitation received during the 21-month summerfallow period was stored, half of it during the first fall and winter. Wheat production per acre inch of water ranged from 139 to 190 lb on summerfallowed and from 110 to 186 lb on stubble, depending on soil texture.

*Crop sequence studies.* A grain-fallow rotation was compared with a fallow, wheat (seeded to brome-alfalfa), hay, hay (break), wheat, wheat cropping sequence, on three soils in northeastern Saskatchewan. The hay, grain rotation yielded greater net returns, and over the past 3 years at Melfort and Somme, the available N in the soil of comparable fields was about 30% higher under the longer rotation. A reduction in the amount of summerfallow in these soils appears to be justified.

*The effect of legume residues on soil nitrogen supply.* Sweet clover, *Melilotus officinalis* (L.) Lam.; alfalfa, *Medicago sativa* L.; and red clover, *Trifolium pratense* L., were grown to determine their value for returning nitrogen to the soil at two locations in northeastern Saskatchewan from 1956 to 1960. Yields of dry matter and N were determined for each crop at five stages of growth.

Sweet clover produced the greatest yield of top growth at all harvest dates.

The root weights of alfalfa and red clover had surpassed those of sweet clover by the full bloom and mature seed stage, respectively. Percentage of N in the top growth of the legumes ranged from 1.87 to 2.61 on September 15 of the first year and from 2.58 to 2.89 by June 15 of the second year. After June 15, a sharp decline in percentage of N in the top growth occurred, especially in sweet clover. Percentage of N in the root growth of sweet clover also declined rapidly after June 15, whereas that of alfalfa and red clover increased.

On the basis of the N content of the plant material, sweet clover, alfalfa, and red clover used for green manure in late June or early July of the second year would have returned 62 to 80, 54 to 85, and 45 to 68 lb N/acre, respectively. If a crop of hay or silage was removed and only the stubble used for green manure, the average N return to the soil from sweet clover, alfalfa, and red clover would have been 9, 18, and 13 lb N/acre, respectively.

*Liquid vs. granular nitrogen fertilizer.* Liquid (28-0-0) and granular (33.5-0-0) fertilizers applied to provide 25 lb N/acre to Conquest barley on stubble at three different dates for 3 consecutive years at Melfort were equally effective in increasing crop yields. Nitrogen applied at seeding time generally gave better yields than when applied at the two- to three-leaf or four- to five-leaf stage of plant growth.

## PLANT SCIENCE

### Cereals

*Oat breeding.* Selection is continuing for a high-yielding, disease-resistant oat variety that has strong straw and plump kernels. A high-yielding selection with low percentage of hull (Rodney × Exeter) was advanced to the Cooperative Tests. Two years' data verify the good yield potential of this selection. Ten promising selections from three crosses were advanced to preliminary trials in the Black soil zones of Manitoba and Saskatchewan. Most yielded well, but disease resistance was unsatisfactory.

*Variety tests—barley.* Numerous two-rowed barley varieties of Swedish origin were compared with Betzes and Hannchen. Several have superior straw strength and outyielded the standards by 5% to 15%. One strain, W 5853, outyielded Betzes by an average of 25% over the past 3 years.

*Triticale.* Six strains of Triticale were compared with Manitou and Pitic 62 wheat. None of the Triticale strains equaled the yield of Manitou, but Pitic 62 outyielded Manitou by 14%. Pitic 62 and the strains of Triticale ripen at least 10

days later than Manitou; hence there is considerable risk of frost damaging the grain before harvest.

*Tame buckwheat.* This crop is arousing interest in Western Canada. Newly developed Ottawa strains were compared with Tokyo, the only licensed variety. Yields from plots grown on summerfallow ranged from 1,000 to 2,000 lb/acre; however, no strain was significantly higher yielding than Tokyo. Buckwheat is easily damaged by frost. Seeding the last of May or early June is recommended.

### Forage Crops

*Sainfoin.* A high-yielding, winter-hardy strain of sainfoin, *Onobrychis viciifolia* Scop., was developed through selection and evaluation. Dry-matter yields from 1965 to 1968 exceeded those of alfalfa by 20%, and seed yields at Melfort have varied from 1,300 to over 3,000 lb/acre. Because sainfoin does not cause bloat, its use as pasture will be investigated. Sainfoin produced large amounts of high-quality nectar and was preferred by honey and bumble bees as a source of nectar over rape, birdsfoot trefoil, white clover, and red clover in 1968.

In greenhouse studies sainfoin seedlings were susceptible to bromoxynil, 2,4-D, and 2,4-DB, but tolerated MCPB at rates up to 32 oz/acre.

*Alfalfa seed production.* Because leaf-cutter bees, *Megachile rotundata* Fabr., prefer sunshine and warm temperatures (70 F or over), they are usually effective pollinators in this area from about July 1 to August 10. In 1968, because of cool damp weather, only 137 hr of sunshine with temperatures above 69 F occurred (223 hr in 1967). Notwithstanding, a 61% increase in cocoons occurred (15,000 allotted, 24,200 recovered per acre) and 127 lb of seed were produced per acre. Comparable fields pollinated by wild bees averaged 21 lb of seed per acre.

*Rapeseed.* In 1968 Target, *Brassica napus* L., yielded significantly more than Echo, *B. campestris*, when seedings were made between May 15 and May 25. Conversely, Echo outperformed Target when seeded between May 29 and June 12. All seedings before May 15 or later than June 12 were damaged by frost. Fertilizer

(fallow received 40 lb P/acre; stubble received 40 lb N and 40 P/acre) increased yield of Target and Echo by 4.2% and 13.5% on fallow and 8.6% and 7.9% on stubble, respectively.

*Vetch.* Thirty vetch (*Vicia* spp.) samples, representing 16 species, were obtained from Russia, Romania, and Poland. They were grown in the greenhouse during 1966-67 and in an introduction nursery during 1966-68. Chromosome counts were conducted on 23 samples. Eight had a diploid chromosome number of 12, whereas 12 were  $2n = 14$ .

*Vicia cracca* L., *V. pisiformis* L., and *V. silvatica* L. maintained perennial stands and were reasonably winter-hardy. *V. unijuga* A. Br. is an exceptionally hardy perennial, which may have some value as a low-growing, ornamental hedge.

### Horticulture

*Corn varieties respond differently to plastic.* Late-maturing varieties of corn showed greater yield responses to plastic mulch and cloche treatments than did early-maturing varieties. Averaging all varieties tested, the use of the plastic mulch hastened maturity by about 7 days, whereas the use of the cloche hastened maturity by 8 days. The cloche treatment produced a lower yield response than did the mulch treatment except with the late-maturing varieties. Averaging both cloche and mulch treatments, the yield increases for the early, medium-early, medium-late, and late varieties were 14, 19, 33, and 46%, respectively.

*Vegetable variety trials.* In 1968, 47 new varieties were included in 161 varieties of 19 kinds of vegetables tested. Some of the varieties of superior yield or quality were: Mary Washington asparagus; Bush Blue Lake bean; Deep Cylinder beet; Jade Cross Brussels sprouts; Evergreen Ballhead cabbage (best storage quality), Early Cross cabbage (best early variety); Pioneer pickling cucumber; Jack Frost head lettuce; and Rocket tomato. The FS 6339 potato seedling showed considerable promise with its heavy yield of smooth, shallow-eyed, red tubers.

*Prairie Regional Potato Trials.* The Station has accepted the responsibility of in-

roducing new seedlings and varieties to the Prairie Region from sources other than the isolation station at Alma, N.B. Fifty-four of these seedlings and varieties were increased at Melfort in 1968 to go into the Prairie Adaptation Trials in 1969.

*Fruit breeding.* The second phase of the Prairie Cooperative Fruit Breeding project got under way at the Station; four trees of each of nine selections were planted in the newly established second-test orchard.

## PUBLICATION

### Research

ZANDSTRA, H. G. 1968. Automated determination of phosphorus in sodium bi-

carbonate extracts. Can. J. Soil Sci. 48:219-222.



# Research Station Regina, Saskatchewan

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## INTRODUCTION

This is a report of the work carried on at the Research Station, Regina, in 1968. The Station is the main center for research on the control of weeds in the Prairie Provinces. There are two main aims of this program. The first one is to develop more efficient methods of controlling weeds in cereal and forage crops. The second aim is to ensure that herbicides do not harm crops, animals, or

humans and that herbicides do not pollute the environment.

This station is also the main center for the production and distribution of seed of new cereal and forage crop varieties developed by the Research Branch.

J. R. Hay  
Director

## WEED SECTION

*Brush control.* In 1967 a number of tests were set out in a community pasture for the control of aspen poplar regrowth. The area had been bulldozed in the winter of 1965-66, and disced and seeded to a mixture of brome - alfalfa - alsike clover in the summer of 1966. Regrowth was 2 to 3 ft high at the time of treatment.

One year after application, best results were obtained with butyl ester of 2,4-D at 2 lb/acre. Control was comparable using volumes of 3, 6, and 10 gal of water per acre as the carrier. The results were the same when oil, water, or an emulsion of oil and water was used as the carrier for 2,4-D. At 2 lb/acre the butyl ester of 2,4-D was statistically superior to the butoxy ethanol ester of 2,4-D. The butoxy ethanol ester of 2,4-D was superior to the dimethylamine salt and to a mixture of the dodecyl amine and tetradecyl amine salts of 2,4-D, when applied at equivalent rates.

Aspen poplar regrowth was controlled by 2,4-D applied between November and April. Alfalfa was not injured by treatments made during this dormant period. The control of aspen poplar, however, was not quite as good as that obtained from early summer applications. Oil had to be used as a carrier for winter treatments to ensure penetration of the solution through the bark.

Balsam poplar was more resistant to 2,4-D than was aspen poplar. Effective

control of balsam poplar was obtained with picloram at 1 lb/acre. Picloram gave only fair control of aspen poplar 1 year after application at 1 lb/acre.

Excellent control of prairie rose was obtained with picloram at the rate of 0.5 lb/acre.

*Povertyweed control.* Various herbicides were applied to povertyweed, *Iva axillaris* Pursh, growing in established grasses on saline Regina heavy clay soil in 1963. In the first year after application, 2,4-DB controlled topgrowth very effectively. 2,4-D ester was less effective than the 2,4-DB in the first year, but with repeated annual treatments the growth reduction was similar. After 3 years, plots treated annually with 2,4-DB at 24 oz/acre, or 2,4-D ester at 32 oz/acre, contained less than 1% of the number of shoots in the untreated check plots. In 1968, the fourth year of the test, no povertyweed emerged in the treated plots.

A single application of picloram at 11.2 oz/acre in 1963 gave 95% control of povertyweed for 5 years. Grass was severely injured in 1963-65, but by 1968 the grass growth was good. In another test, dicamba at 40 oz/acre gave over 90% control for 3 years with no apparent injury to the grass.

*Tolerance of grasses to picloram.* Picloram applied in 1967 at the rate of 1 and 2 lb/acre to an established stand of

bromegrass greatly reduced forage yields in 1968.

In greenhouse tests, picloram applied to the soil surface had a harmful effect on the growth of several forage species. Tolerance of the forage plants to picloram was based on plant emergence, survival, height, and oven-dry weight. Bromegrass and crested wheatgrass were unable to survive the 1 oz/acre rate of picloram. Russian wild ryegrass tolerated 1 oz/acre. Kentucky bluegrass and meadow fescue tolerated 2 oz/acre, and reed canarygrass and creeping red fescue 4 oz/acre. Plant emergence and survival of oats were not affected by picloram at 16 oz/acre, but even at 2 oz/acre plant height was reduced.

Although picloram gives excellent control of several perennial weeds, it has a harmful effect on established grasses, and will interfere with establishment of new species.

*Leaching of picloram in soils.* Picloram leached readily in several soils of southern Saskatchewan and followed a pattern typical of the movement of anions in soils. The downward movement of picloram was correlated with the water-holding capacity of the soils. The chemical moved down more readily in sandy than in clay soils. The width of the band of picloram in the soil columns was determined by both the total amount of water percolated and the rate of water percolation.

*Soil water content and herbicide adsorption.* Adsorption of atrazine and linuron on soil colloids was three to five times lower at water-holding capacity than under slurry conditions. This is probably due to the higher adsorption area that is exposed as the soil aggregate size decreases. This could explain the reported anomalies in correlation between adsorption measured in slurry conditions and the herbicidal activity obtained under field conditions.

*Adsorption of herbicides by soil and root systems.* Herbicides lose their biological activity when strongly adsorbed to soil or organic matter. The total capacity of soil and root tissue to adsorb diuron was equal to the amounts adsorbed by

roots and soil separately. The total adsorption of ipazine, linuron, and atrazine was less than the sum of the adsorption on the separate components. Ipazine showed the greatest reduction. The addition of root exudates to soil did not affect the adsorptive capacity of the soil for diuron and linuron. The reason for this effect on adsorption has not been determined.

*Fall applications of herbicides for control of wild oats.* In tests conducted between 1964 and 1968, fall applications of diallate gave control of wild oats equal to spring applications with no injury to flax. Triallate applied in the fall gave good control of wild oats with only slight injury to barley and wheat.

The main advantage of applying these chemicals in the fall is that it saves time in the spring and allows application in areas that are often too wet for good incorporation in the spring. Weed control has been no better, and there has been little difference in yields. The thinning of the wheat stands suggests that there is a greater hazard of wheat injury by fall applications than by applications made after seeding in the spring. Incorporation of the chemical into the soil in the fall exposes the fields to soil erosion by wind over the winter. The conventional treatment of applying the triallate after seeding in the spring is still considered to be the safest for the Regina area, from the standpoint of crop injury.

In tests in 1967 and 1968 comparable control of wild oats in wheat was obtained with granular and emulsifiable concentrate formulations of triallate.

*Fate of diallate and triallate in soil.* Chemical methods for determining diallate and triallate residues in soils using gas chromatography have been developed. These are much less time-consuming than the bioassay method.

Diallate and triallate were degraded in moist clay and loam soils, but there was no loss of chemical in sterilized soils. Thus, microbial degradation is an important factor in the loss of these herbicides in soils. Breakdown was relatively slow, approximately 60% was degraded in 3 months. There was no difference between the decomposition rates in Regina heavy clay and Oxbow Weyburn loam.

At normal rates of application diallate and triallate did not affect the action of the nitrification bacteria in the soil. Triallate was not readily moved down in clay or loam soils when water was applied to the surface.

Only 15% of the triallate in aqueous buffer solutions ranging from pH 4 to 8 was chemically degraded over a 6-month period. The vapor pressure of triallate, as determined with the gas chromatograph, was  $1.5 \times 10^{-3}$  mm Hg at 25 C. This is comparable to standard esters of 2,4-D.

*Cytological effects of triallate.* Roots and shoots of wild oats and Pembina wheat were examined cytologically after the seedlings were exposed to various concentrations of triallate in the form of vapor.

Shoot tissue of wild oats was damaged more readily than root tissue by triallate. During mitosis, there were more abnormal divisions in the meristematic tissue at the base of the first leaf than at the stem apex. Stunting of the shoot preceded the decrease in the number of cell divisions.

With wheat, the shoot tissue was also more sensitive to triallate than root tissue. Fewer abnormalities were observed in

wheat than in wild oats even at high concentrations. This supports the evidence from the field that wheat is considerably more tolerant to triallate than is wild oats.

*Bud development in leafy spurge.* The role of nutrition in the correlative inhibition of bud growth in leafy spurge was demonstrated. In this species the aerial shoots strongly inhibit the growth of the buds that are present on the roots. The hypothesis that this inhibition of bud growth is mediated by the nutritional demands of the shoot was well supported by an experiment in which seedlings were decapitated so as to induce the growth of lateral shoots. In tests where the number of lateral shoots that were allowed to develop was varied, and these treatments were combined with a range of N levels, the number of shoots required to exert a given degree of inhibition of the buds on the roots was positively correlated with the N supply. For example, at the lowest N level the inhibiting effect produced by only two lateral shoots was considerably greater than that produced by six shoots at the highest N level. This phenomenon had previously been demonstrated in quackgrass and in flax.

## CEREAL SECTION

*Root growth of wheat varieties.* The pattern of root growth of six varieties of wheat was studied in wet and dry soil. Roots of Thatcher penetrated the dry soil more quickly than wet soil. Roots of Thatcher penetrated both wet and dry soil more rapidly than did those of other varieties. When the soil dried out at the surface, root growth of Thatcher increased in the moist layers below. Two unnamed varieties adapted to the Canadian prairies had root patterns similar to Thatcher. Nainari 60, Lemhi 53, and Koga II produced more roots than Thatcher at high moisture levels, but suffered more under dry conditions.

These studies were conducted in glass-faced boxes. Loam soil was more satisfactory for these tests than clay soil because the loam soils tended to accentuate differences in response to high and low levels of moisture. It was also easier

to separate the roots from the loam soil than from the clay soil.

*Cereal and oil seed testing program.* An extensive cereal and oil seed testing program on the adaptability of varieties here and on three other locations was conducted in 1968. Wheats from Mexico and other countries have been the subject of intensive study in recent years. The Station carries on the International Wheat Test with varieties from all over the world, as well as with more than 300 lines from Mexico. To date none of these foreign lines is completely adapted to conditions in south-central Saskatchewan. Some of the lines under test have outyielded Manitou under high fertility conditions, but under drought conditions they have little advantage. This phase of the program has, however, yielded some valuable parental material, which is being used in crosses by Canadian plant breeders.



## SEED SECTION

*Seed distribution.* In 1968, 4,666 bu of Paragon, a new variety of malting barley, were distributed to 123 selected seed growers in Manitoba, Saskatchewan, Alberta, and British Columbia. In addition to the main distribution of Foundation seed, 77 select seed growers in these four provinces received a total of 3,060 lb of Paragon Breeder seed to establish Select seed plots. Paragon is shorter strawed, higher yielding, and 4 to 5 days later maturing than Conquest. Paragon has good resistance to stem rust and to both loose and covered smuts. Seed of this new barley is now available through normal seed channels.

Breeder seed of Oro, an Argentine type rapeseed, was also distributed in 1968. Its performance compares favorably with Target.

*Breeder seed.* Breeder seed of 31 varieties of wheat, durum wheat, oats, barley, flax, rye, Russian wild ryegrass, Orbit tall wheatgrass, and Oro rapeseed were carried

on inventory in 1968. Twelve acres were devoted to increasing Breeder seed of 10 varieties of four crop kinds. Three of these were Breeder line increases. In addition Breeder seed of Sawki Russian wild ryegrass and Orbit tall wheatgrass was produced.

*Winter increase.* The winter increase of plant-breeding material at Brawley, California, for Canadian plant breeders was continued in 1968. Four acres of plots were maintained, servicing 12 plant breeders. This service is designed to speed up the progress of plant-breeding programs.

*Varietal verification.* In 1968, 2,164 samples of seed collected by the Plant Products Division from seed growers and the seed trade were tested for purity under field conditions. Although many of these contained some impurities, only six exceeded the tolerance for Registered and Certified grades.

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## VISITING SCIENTISTS

### *Food and Agriculture Organization postdoctorate fellow*

J. KRZYMANSKI, M.Sc., Ph.D., 1967-68	Oilseed crops
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### *National Research Council postdoctorate fellows*

M. BECHYNĚ, B.Sc., Ph.D., 1966-68	Oilseed crops
G. S. DOGRA, B.Sc., M.Sc., Ph.D., 1968-69	Insect physiology
R. STOKER, B.Sc., Ph.D., 1968-69	Physiology of drought resistance

## INTRODUCTION

The Research Station at Saskatoon carries on a broad research program involving the breeding, evaluation, and management (including irrigation and fertilization) of grasses, legumes, oilseed crops, wheat, and potatoes; and the ecology and control of some of the more important insect pests, plant diseases, and weeds of these crops, and of black flies and mosquitoes affecting man and animals. We also conduct research on the epidemiology of western encephalitis, the histophysiology

and nutrition of several insects, the physiology of drought resistance in wheat, pesticide residues in plants and soils, and soil surveys and characterization. The accomplishments during 1968, for selected subjects, are summarized in this report.

The Director was on leave for 1 year, participating in a Bicultural Development Program at Quebec City.

H. McDonald  
Acting Director

## CROPS

### Bromegrass

*Breeding.* Magna bromegrass, tested as synthetic S-6325, was licensed in 1968. Derived largely from the southern variety Fischer, Magna combines the good forage yields of most southern varieties grown in Western Canada with better seed production. In Western Canadian cooperative trials Magna yielded 16% more hay and 28% more seed than northern common. The excellent seed yield may result from an elimination of plants with deviating chromosome numbers. Usually one-third to one-half of the plants in bromegrass have chromosome numbers above or below the normal number of 56. Preliminary counts of the 14 parent clones of Magna showed 13 plants with 56 chromosomes and 1 with 55.

### Oilseeds

*Rapeseed breeding.* Oro, the first rapeseed variety to produce a seed oil free of erucic acid, was licensed in 1968, and was well received by growers and crushers.

A new allele,  $E^d$ , which contributes approximately 3.5% erucic acid to the seed oil, was identified. Four other alleles,  $e$ ,  $E^a$ ,  $E^b$ , and  $E^c$ , previously identified at Saskatoon, contribute 0, 10, 15, and 30% erucic acid respectively. It is now possible

to develop a variety with the level of erucic acid, between 0 and 60%, that the industry desires.

Rapeseed plants with seed essentially free from glucosinolates were selected. New analytical techniques developed at Saskatoon, which allow the detection of these undesirable compounds at flowering, are accelerating the development of well-adapted glucosinolate-free varieties. The genetic control over the presence of these compounds is being studied in rape and mustard seed.

*Mustard seed breeding.* From the cross of Oriental mustard (*Brassica juncea* L.) and turnip rape (*B. campestris* L.), we obtained  $F_2$  progeny that do not contain either the glucosinolate sinigrin, which gives mustard its hot flavor, or any of the undesirable glucosinolates found in rapeseed. It appears feasible to develop from this cross a new oilseed crop that will combine the desirable attributes of both parental species.

*Bioassay for glucosinolates.* A laboratory culture of the migratory grasshopper was found to be capable of discriminating between wafers of crushed rapeseed that differed by as little as 0.75 to 1.0 mg/g in total glucosinolate concentration. Six different strains could be screened at one

time. Feeding preferences were inversely proportional to the glucosinolate concentration of the food consumed.

## Wheat

Over 100 varieties and strains of foreign wheat were yield-tested and their suitability as bread and feed wheats are being investigated in cooperation with universities and other research stations. Some wheat breeding is under way to obtain a high-yielding feed wheat with identifiable seed characteristics.

In 1968, some well-fertilized, irrigated Mexican wheats yielded over 100 bu/acre compared with 70 bu/acre for Manitou. Without irrigation the newly licensed Pitic 62 yielded 20.5, 32.5, and 57.4 bu/acre in 1966, 1967, and 1968 respectively, or 143, 133, and 140% of the yield of Manitou for these years. Mexican varieties such as Pitic 62, Nairnari 60, and Lermo Rojo responded favorably to P fertilizers, but broadcast applications of up to 200 lb of N per acre failed to benefit yields. The yield of certain foreign varieties was also greatly influenced by row spacing.

# ENTOMOLOGY

## Grasshoppers

*Reproductive biology of the migratory grasshopper.* Egg production appears to be closely linked with the mating process. The fact that males with testes removed were still able to stimulate egg production in virgin females suggests that material transferred from the accessory glands of the male during impregnation induced the stimulus to egg production. Implantation of accessory glands from mature males into virgin females resulted in an oviposition rate that was greater than that of virgin female controls. Further implantation has suggested that the short hyaline glands of the accessory gland complex are the responsible ones.

*Density-dependent variation in egg-pod size.* Field measurements made at 36 locations in Saskatchewan during the past 6 years indicated highly significant negative correlations between the number of eggs per pod laid by females of the migratory grasshopper and the nymphal densities of the same and the preceding generations. During this period the species increased moderately in numbers, whereas the average size of egg pods (in terms of numbers of eggs per pod) declined, followed by a decrease in nymphal density and an accompanying increase in egg-pod size. This evidence is highly suggestive of the presence in this species of density-dependent fertility factors similar to those demonstrated by Albrecht for two species of the migratory locust.

*Control.* During 1968, 14 insecticides were tested on grasshoppers in the laboratory. Only CIBA 9643 (CIBA Company Limited), a carbamate, appeared as promising as the dieldrin standard or the currently recommended dimethoate.

## Wireworms

*Separation of eggs from soil.* An improved method has been developed to separate click beetle eggs from field soil samples. The method will greatly enhance future studies on the behavior, ecology, and population dynamics of these insects. Recovery of known numbers of eggs from soil averaged 99% (96 to 100%) in replicated tests. A total of 2,014 eggs were recovered from 14 of 320 field soil samples processed in 1968.

*Seasonal feeding activity and crop damage.* Wireworm damage in grain crops planted in fields summerfallowed the previous year was generally higher than that in crops planted on stubble. Field and laboratory studies indicate that these differences were not caused by differences in wireworm numbers or in feeding potential. There were at least twice as many wireworm-killed plants in summerfallow-crop plots as in stubble-crop plots even though there were no more wireworms, and larvae collected from both conditions fed about the same amount per larva in the laboratory.

## Flea Beetles

*Control.* In previous studies on the control of flea beetles in rapeseed no difference was found between the efficiency of carbofuran (Furadan) and lindane formulations in protecting seedlings. However, in 1968, carbofuran, applied as a seed coating or sown in granular form with the seed, was superior to the lindane formulations; this might have been attributable to the fact that the beetles did not attack until the initial formation of true leaves, which seemed to maintain carbofuran toxicity but not lindane toxicity.

## Black Flies

*Control.* Dursban (Dow Chemical Company), applied to the Saskatchewan River at 0.11 ppm for 15 min, eliminated 60% of *Simulium* larvae 6 miles downstream, and at 0.2 ppm for 15 min, 99% of the larvae 12.5 miles downstream. Methoxychlor at 0.2 ppm eliminated 98% of the larvae 7 miles downstream and 70%, 17 miles downstream.

## Mosquitoes

*Endocrine and neuroendocrine systems.* It was determined that certain intensely staining bodies in the ecdysial glands of pupae and newly emerged adults of the yellow-fever mosquito are pycnotic nuclei of degenerating gland cells. A neurosecretory pathway leading from the brain through the circumesophageal connectives and along the ventral nerve chain was discovered in larvae and pupae of *Culiseta inornata* (Williston).

## Western Encephalitis

*Mosquito abundance in relation to weather.* A tentative formula has been derived for forecasting outbreaks of western encephalitis (WE) in Saskatchewan. The formula is based on the average mean weekly temperatures at six light trap sites during the second and third

weeks of June, and on the median date of first appearance of *Culex tarsalis* Coquillett in the six traps. The formula proved to be reliable during the past two non-epidemic seasons (1967 and 1968), but still has to be applied to an epidemic season.

*Vectors of the arthropod-borne encephalitis.* During the 1967 season, WE virus was isolated from the bloods of 2 of 553 nestling birds (33 species), of 4 of 414 garter snakes, and of 13 of 635 leopard frogs. A total of 20,288 female mosquitoes, representing 18 species distributed in 1,144 species pools, were negative when tested for WE virus. Three other strains of virus were isolated from mosquitoes; two of these have been tentatively identified as Flanders-Hart Park virus (at the National Communicable Disease Center Laboratory in Atlanta); the other has not yet been identified, but appears to be related to the Bunyamwera group. Six indicator chicken flocks, consisting of 24 birds each, did not acquire WE infections.

## Insecticide Residue Studies

*Residues in plants and soil.* The fate of dieldrin in soil and in wheat plants was studied with C<sup>14</sup>-labeled dieldrin. About 95% of the root-absorbed radioactivity in wheat plants was identified as dieldrin and more than 90% of the radioactivity in soil was recovered as unchanged dieldrin 1 year after incorporation into the soil. Dieldrin was therefore not metabolized by microorganisms present in the soil or by wheat plants.

The various components of a commercial formulation of chlordane were isolated by column and gas-liquid chromatography and identified by infrared and mass spectroscopy. Potatoes grown in soil treated with chlordane at 10 lb/acre had a residue of 0.11 ppm. Peeling the potatoes removed 90 to 100% of the residue, and about 10 to 30% of the residue was lost by boiling the potatoes in water.

# PEDOLOGY

## Soil Survey

*Classification and mapping.* The Pedology Section, working cooperatively with

in the Saskatchewan Institute of Pedology, assisted in the reconnaissance mapping of 3,600,000 acres in the forest reserves within the Shellbrook, St. Walburg, and Swan

Lake map sheets, and the agricultural and forested area of the Hudson Bay Sheet. Work towards publishing reports and maps of the soils of the Rosetown and Saskatoon sheets was continued, and reports and maps were published for the Willow Bunch Lake Sheet and for 39 Indian Reserves.

*Soil characterization.* Studies on the nature and distribution of Fe and carbonate minerals disclosed two facts. (i) The free Fe content of the parent material of Saskatchewan soils is generally low.

Soil formation has resulted in little movement of free Fe in Chernozemic soils, somewhat more in Solonchic soils, and still more in Podzolic soils. The amount of free Fe in some soils previously considered to be Podzols of the Canadian system is lower than that required by definition to qualify for this group of soils. (ii) Calcite accumulates in horizons that have experienced a net removal of dolomite, indicating an environment of fluctuating conditions of removal and accumulation of carbonate minerals in some soils.

## PLANT DISEASES AND PLANT PHYSIOLOGY

### Root Diseases of Wheat

*Infection and disease severity.* Common root rot infections, caused by *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur, in field plots were rare in wheat seedlings to the three-leaf stage, abundant in plants between the fourth- and sixth-leaf stages, and increased little thereafter. Disease severity, however, increased after the period of maximum infection. Sharp differences in disease, both in incidence and severity, were evident between resistant and susceptible varieties on the basis of subcrown internode lesions but not on basal stem and crown lesions.

*Crop residues.* In 1968, wheat grown on stubble land at seven locations derived benefit from the previous crop residues in a lessening of the severity of common root rot. Disease ratings were significantly lower where the residues were cultivated into the soil than where they were removed. The reduction in disease was not reflected in increased yield. N applications increased disease ratings significantly, but had no measurable effect on yield.

*Pathogen viability.* Conidiospores of *C. sativus* were strongly viable after 3 years' storage at a relative humidity of 50%, and viability was low after 1 year at a relative humidity of 65%.

*Soil microbiology.* Treatment of soil in field plots with methylmercuric dicyandiamide at 5 ppm of the active ingredient decreased common root rot in wheat, but had no influence on grain yield.

### Diseases of Grasses

*Leaf and stem spots.* A stem eyespot of creeping red fescue seed crops in northern Alberta was shown to be caused by *Phleospora idahoensis* Sprague. The disease appeared to be most severe in humid microclimates. The pathogen was occasionally found on seed. A leaf spot of timothy, caused by *Heterosporium phlei* Gregory, resulted in heavy foliage damage to Climax seed crops in north-eastern Saskatchewan in 1968. High resistance to *Selenophoma* and *Pyrenophora* leaf spot diseases of brome grass was found in selections from high-yielding northern/southern hybrids of *Bromus inermis* Leyss., in some introduced *Bromus* species, and in hybrids between species in the Zerna group of *Bromus*.

### Diseases of Oilseeds

*Blackleg of rape.* This disease, caused by *Leptosphaeria maculans* (Desm.) Ces. & de Not., is widespread and potentially very important in Saskatchewan. Four pathogenic strains designated "rape", "Thlaspi", "Sisymbrium", and "Lepidium" were identified following their isolation from various hosts. All the strains attack rape. The sexual stage of the pathogen was collected on *Brassica napus* L., *Thlaspi arvense* L., *Sisymbrium loeselii* L., *Descurainia sophia* (L.) Webb, and *Lepidium* sp. Seed transmission of the fungus was found in rape, turnip rape, and oilseed radish.



## Drought Resistance in Wheat

*Drought avoidance.* The water status (water potential and osmotic pressure) in field-grown wheat varieties was measured from the third- to the seventh-leaf stage. Straw and grain yields were used as indices of productivity. No unequivocal relationship between productivity and water status was found. An assessment of the water economy of wheat varieties may require the measurement of water flow and

gas exchange in addition to the water status.

*Drought tolerance.* In field tests, treating wheat seeds with CCC (Cyanamid of Canada) led to an early retardation of growth. Subsequently, during heading growth, stimulation occurred and increased straw and grain yields resulted. These observations applied to the varieties Manitou and Selkirk but not the semi-dwarf variety Lermo Rojo.

## EXPERIMENTAL FARM, SCOTT

### Control of Weeds in Oilseed Crops

*Flax.* Bromoxynil effectively controlled most common weeds in flax without crop injury unless it was applied during a period of warm humid weather, when crop burning occurred. Three new materials, C6313, C6989, and C9122 (CIBA Company Limited) were very effective on wild buckwheat, Russian thistle, stinkweed, flaxweed, and lambsquarters in 1968. Flax was tolerant of all three materials.

*Rapeseed.* Until very recently, chemical weed control in rapeseed has not been possible due to the narrow range of selectivity between the crop and many of the weeds. Of a number of herbicides tested

during the past year, nitrofen, RD7693, and SWH1170 (distributed by Green Cross Products, Winnipeg, Man.) provided reasonable weed suppression and crop tolerance.

*Sunflowers.* Like rapeseed this crop shows very limited tolerance for most herbicides. Excellent results were obtained in 1967 with prometryne applied premergence to the crop and incorporated. Under dry soil conditions in 1968 the results were unsatisfactory. Paraquat or diquat applied just when the sunflowers were starting to break the soil surface resulted in a complete kill of the weeds that had emerged at the time of treatment. Some coded materials used for the first time in 1968 showed some promise in this crop.

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# Research Station Swift Current, Saskatchewan

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## INTRODUCTION

Research related to the stabilization of agriculture in the driest region of Western Canada is the main objective of the Research Station at Swift Current. Cereal grains are grown throughout the region on a variety of soils, and cattle are raised in large numbers on natural grasslands and grass-alfalfa mixtures. Irrigation is practiced on small acreages.

Despite the extremely dry conditions during the growing season relatively high wheat yields were obtained on project farms throughout the region. Although the May-June-July precipitation was half of the long-term average, the wheat yields were near average at all locations. Moisture conserved during the summer-fallow year was a major factor in carrying the crops through to maturity.

The research program in cereal crop breeding was expanded by the appointment of another plant breeder and the

transfer of the cereal breeding projects and some of the personnel from the Research Station, Regina. The soil research section was strengthened by the appointment of a soil microbiologist.

Mr. J. J. Lehane retired from the soil science section in February after 31 years of service. He was a recognized authority on soil moisture conservation and utilization and through his research in this field made a major contribution to agriculture.

This report presents the highlights of the research projects that were completed in 1968 and contains brief statements on some of the main research projects in progress. More detailed information on various subjects can be obtained directly from the research scientists, or from the publications listed at the end of this report.

J. E. Andrews  
Director

## CLIMATE

The climate of southwestern Saskatchewan is semiarid and is characterized by wide extremes in temperature. Since the Research Station was established in 1921, the annual precipitation has averaged 34.95 cm. The average during May, June, and July has been 15.65 cm. In 1968, precipitation was far below average during the first 4 months of the year, and surface soil moisture conditions were barely adequate to germinate seeds throughout a large portion of the area. Dry weather persisted during the growing season and the crop was short and light, except in isolated regions. Heavy precipitation during the harvest season caused extensive damage to the wheat crop.

Soil and air temperatures were 5.5 C above average for March, but near the long-term mean during the rest of the

year. Maximum air temperatures exceeded 32 C on only 4 days during the summer. The frost-free period was 126 days, from May 20 to September 24.

Sunshine was slightly above average during the summer months but near the long-term average for the entire year. Winds were slightly above average with the greatest increase in April and May. Evaporation rates were below average as a result of the cool wet weather during most of August and September. Water loss from small lakes and reservoirs in the area was from 65 to 75 cm.

The number of growing degree-days above 5.5 C was about 10% below average for the year. The subtotal for the period May through August was 1,474 degree-days; approximately 1,460 degree-days are required to mature Thatcher wheat at Swift Current.

# ANIMAL AND PASTURE SCIENCE

## Range and Pasture Management

*Fall rye for spring pasture.* Fall rye pastures that were grazed by yearling steers of an average weight of 326 kg produced 253 kg/ha in animal weight gains. When grazed at a rate equivalent to 0.13 ha/Animal Unit Month (AUM) they provided 54 days of grazing in May, June, and July. The estimated dry matter yield was 2,000 kg/ha. This liveweight gain was about 2.5 times that on the best perennial dryland pastures, and approximately 10 times that on native grassland.

*Early spring use of Russian wild ryegrass.* Pastures sown to Russian wild ryegrass, *Elymus junceus* Fisch., and alfalfa, *Medicago falcata* L. var. Rambler in 35-cm rows produced sufficient herbage to support yearling steers for 28 days when stocked at a rate equivalent to 0.58 ha/AUM. However, gains were less (65 kg/ha) when pastures were grazed in April and May than when grazed in May and June (98 kg/ha).

*Russian wild ryegrass for early winter grazing.* Pastures sown to Russian wild ryegrass in 20-, 41-, and 61-cm rows produced enough herbage for 42 pasture days when grazed at 0.29 and 0.37 ha/AUM by 375-kg heifers during October and November from 1964 through 1966. In 1967 decreased grazing capacity developed on the grass sown in 20- and 41-cm rows when grazed at both rates.

In 1968, the grass sown in 20-cm rows provided only 22 pasture days when grazed at 0.29 ha/AUM, and 26 days when pastured at 0.37 ha/AUM. The fields with rows spaced 41 cm apart and grazed at 0.29 ha/AUM were pastured for 26 days, and for 38 days when grazed at 0.37 ha/AUM. Where the rows were spaced 61 cm apart, the 0.29 ha/AUM rate provided sufficient herbage for 36 days of grazing, and 42 days at the lighter rate of 0.37 ha/AUM. Despite the dry summer, the fields sown in 61-cm rows and grazed at 0.37 ha/AUM produced enough herbage to provide pasturage for a period equal to that obtained from 1964 to 1967 inclusive.

*Evaluation of Altai wild ryegrass and green needlegrass.* Altai wild ryegrass, *Elymus angustus* Trin., green needlegrass, *Stipa viridula* Trin. var. Green Stipa, and Russian wild ryegrass, *Elymus junceus* Fisch. var. Sawki, seeded in 90-cm row spacings in May 1966, were grazed during September and October after removal of the seed crops. Seed yields were 138, 111, and 305 kg/ha respectively. Liveweight gains were 78, 21 and 10 kg/ha respectively. Altai wild ryegrass performed very well in this test.

*Classification and distribution of native plants.* Classification of vegetational associations has proceeded to a point where species distribution is becoming the more important part of the project. Extensions of the range of *Festuca*, *Danthonia*, and *Stipa* species were recorded. A lichen species not previously reported for North America was collected on the bank of the South Saskatchewan River; its confirmed identification is *Squamarina (Lecanora) crassa* (Huds.) Poelt.

*Physiological characters of native grasses.* Excessive morbidity occurred when native grasses were cloned, even under an optimum moisture regime; this delayed completion of greenhouse tests dealing with fertility and moisture stresses. Sexual development of native grasses in the greenhouse differed among species: species of *Festuca*, *Poa*, and *Koeleria* rarely set seed, whereas species of *Stipa*, *Andropogon*, *Bouteloua*, *Puccinellia*, and *Muhlenbergia* set seed profusely. There appeared to be few morphological differences among ecotypes of grass species collected in different localities in the Prairie Provinces; one possible exception was *Festuca scabrella* Torr., which has local expressions of width and color of leaf and the extent of the creeping-root character.

## Forage Evaluation

*In vitro digestion.* The *in vitro* digestibility of forage dry matter was found to be biased by a relatively high solubility of the minerals by the acid medium of the pepsin treatment in the two-stage procedure. The digestibility of organic



matter was therefore the preferred criterion. Improvements in the artificial rumen technique designed to produce more accurate estimates of in vivo digestibility directly from in vitro digestion were attempted by adjusting the fermentation duration according to the maturity of the forage. This approach was found to be impractical because of interactions in the reaction of different forage species to the effect of fermentation duration with advancing maturity. As an average fermentation duration, 48 hr was found to give the most accurate estimates of in vivo digestibility. A relationship was established between the digestibility of forage and the voluntary intake of metabolizable energy by sheep. Alfalfa hay with a digestibility of 53% and grass hay of 56% were adequate for maintenance. Both hays provided nutritional levels of half that required for maintenance when the digestibility decreased to 45% and twice that required when it increased to 70%.

*Sensory evaluation.* Sensory ratings of growth stage, composition, color, and texture of hay explained most of the variation in the nutritional value. The criteria of freshness, cleanness, and odor were of minor importance. This apparently occurred because harvest dates of the hays studied were deliberately varied, but conservation and storage conditions were kept as constant as possible. Sensory ratings predicted the quality of hay more accurately than did the system recommended in the Canadian Hay and Straw Inspection Act.

*Rate and mode of breakdown during mastication of roughage.* Sheep fed identical diets showed different ability to masticate roughage and to pass it through the reticulo-omasal opening. Thus, the particle size of omasal digesta and the particle shape (length and width) were related to the amount of feed eaten. Voluntary consumption of different species of hay at similar maturity was correlated with the rate and mode of breakdown during artificial mastication.

## **Turkey Nutrition**

*Amino acid balance.* A free amino acid diet was fed to male poults to 21 days of age. Blood plasma was obtained by frontal

heart puncture with a heparinized 10-ml syringe. With the amino acid mixtures studied, approximately 70% of the control growth was achieved with 65% of the feed intake from 7 to 21 days of age. Growth data from the supplementation of different levels of lysine, threonine, and arginine showed that a level of dietary arginine higher than 2.25% is required within the present amino acid pattern.

*Limiting amino acids in cereal grains.* Three studies were conducted to elucidate the limiting amino acids found in wheat, wheat plus oats, and corn. All basal rations supplemented with amino acids (met, lys, arg, leu, thr, val, and ileu) showed a growth response with the exception of threonine in the wheat basal. The efficiency of feed utilization was greatly improved by the supplementation of amino acids, with the exception of threonine in the wheat basal and valine in the corn basal. Valine supplemented in the wheat basal produced a 1,016-g average bird at 28 days of age, whereas methionine and lysine produced 933- and 957-g average birds.

*Influence of strain on nutrient density level.* Four strains of turkeys were fed three nutrient density levels from day-old to market weight. The feed intake level of two strains was higher than that of the two others. Males and females were fed separately. Toms were marketed at 24 weeks of age, whereas hens were marketed at 20 weeks. The turkey producer in the future will be demanding strains with the higher feed intake level and faster growth rate, thereby reducing risk and producing a more efficient bird. A complete market evaluation of the four strains with the defined nutrient worth of the finished product on each of the three nutrient density levels is being determined.

*Rapeseed oil in chick starter diets.* The growth-depressing effect of 10% rapeseed oil as compared with 10% soybean oil in chick-starter diets was confirmed. The disagreement between this finding and reports by other workers was attributed to a higher saturated fatty acid content in the diets used in the other studies. There was no difference in feed conversion or dietary

metabolizable energy between diets containing rapeseed oil and soybean oil.

*Fatty acid deposition in chickens.* Broiler chicks deposited relatively more palmitic, palmitoleic, stearic, and oleic acids and less linoleic and linolenic acids than they consumed from diets containing 10% soybean or rapeseed oil. A decrease in the level of erucic acid in the depot fat to 50% of the dietary level was associated with an increase in oleic acid. Little change in fatty acid composition of the abdominal depot fat was disclosed by gas chromatographic analysis at weekly intervals to 6 weeks of age.

*Skin lesions caused by rapeseed meal.* Severe thickening and cracking of the skin on the soles of the feet, typical of biotin-deficiency lesions, was caused by feeding meal from certain rapeseed varieties to both turkeys and chickens. Supple-

mentary biotin did not prevent the development of the lesions.

*Effect of fat on finish and quality of market turkeys.* Carcasses of heavy tom turkeys fed an unsupplemented control diet, and diets containing unsaturated fat (rapeseed oil) or saturated fat (palm oil) from day-old to 24 weeks averaged 73%, 82%, and 100% grade A for finish. Chilling overnight in ice water improved the grades of those fed the control diet and the rapeseed oil diets to 86% and 95% grade A. The fatty acid composition of the carcass fat was similar to that of the dietary fat. Increasing levels of dietary fat increased the fat content in breast and thigh meat at the expense of tissue protein. Feed consumption and conversion were inversely proportional to nutrient density in diets of constant energy-to-nutrient ratios.

## ENGINEERING SCIENCE

### Irrigation

*Uniformity of water application by sprinklers.* Three methods of calculating uniformity of water applied by sprinklers were compared by calculating the coefficients Cu, U, and A using data from 775 uniformity tests conducted at Swift Current, Sask., from 1954 to 1959. The comparisons were based on correlation and regression analyses. It was concluded from this study that any of the three uniformity coefficients is acceptable to measure uniformity of water application by sprinklers. However, the coefficient U is the most practical, because it is the soundest statistically and the easiest to calculate.

*Irrigation ditch maintenance with soil sterilants.* The results of recent work at the Chesterfield Flats irrigation project near Leader, Sask., lead us to think that control of vegetation in irrigation ditches may be possible with chemicals. Several soil sterilants were applied in 1965, and some of these have kept the ditches relatively free of weeds. Simazine and atrazine at 22 kg of active ingredients per hectare have provided good control. Treatment of a strip 2.4 m wide would cost \$90 per km.

The chemicals were applied in the fall, and the first water in the following spring was run off through a drainage channel. Alfalfa and brome grass were damaged near the outlets but not excessively. Leakage of the first water, or where treated soil was washed out into the fields as a result of ditch breakage, caused serious injury in a few instances.

When ditches were weedy at the time of treatment, weed control was not as good as that on ditches that were free from weeds. Ditches that were weedy at time of spraying needed retreatment after three seasons, whereas clean ditches did not.

The sterilants (triazines, diuron, monuron, and bromacil) were not completely effective on deep-rooted plants such as dandelion, alfalfa, or prickly rose, *Rosa acicularis* Lindl., Russian thistle, Canada thistle, perennial sowthistle, and smooth brome were the first to invade the ditches after treatment.

Contact herbicides may be required to control weeds that invade the ditches after the application of sterilants. More research

is needed before we come to definite conclusions on the use of soil sterilants for the control of vegetation in irrigation ditches.

### Grain Harvesting

*Artificial drying.* Combining spring wheat at a higher than usual kernel moisture content followed by artificial drying has been practiced for the past few harvest seasons. Quality studies concerning the effect of this procedure on 1000-kernel weight, crude protein, germination, and total P were made in 1967. Spring wheat was windrowed daily, starting at a kernel moisture content of over 50% and continuing until the grain reached a 14% moisture content. Samples of field-matured grain were compared with threshed and artificially dried samples. Kernel weight and crude protein content were not affected by the threshing and drying process after the kernel moisture was reduced to about 35%. Germination and total P content were seriously affected by the threshing and drying procedure, particularly at early stages of maturity. This was not caused by the artificial drying, but by the immaturity of the grain when threshed. Spring wheat should not be threshed and artificially dried until the kernel moisture has been reduced naturally to 20% to maintain good germination and high P content.

### Equipment Research

*Automatic depth control for a discer.* A discer was instrumented with a depth-sensing device on each gang. For some of the studies one gang was operated on automatic control. The depth-sensing device is subject to inaccuracies caused by dead furrows and wheel marks, which leave depressions by ridges in the field surface. Results on fields of Wood Mountain clay loam with selected uniform surfaces were:

- (i) On a stubble field that had not been tilled for 1 year the depth-sensing device indicated a depth variation of  $\pm 4.45$  cm. At speeds of 5.6 km/hr the automatic control system reduced the variation to  $\pm 1$  cm.
- (ii) On a summerfallow field that had been tilled three or four times, the

depth-sensing device indicated a depth variation of  $\pm 2.5$  cm along the length of the field and across the width of the machine.

### Plot Equipment

*Seeders.* A seeder, with hoe-type openers developed for the direct seeding of plots, performed extremely well. A four-row plot seeder with adjustable side-band fertilizer attachments is being developed for the Research Station, Melfort, Sask. An adjustable spring-loaded packer is attached to the double disc opener. A four-row seeder, with wheel packing ahead of and behind each furrow opener, is being developed for the Research Station, Lethbridge, Alta.

*A lysimeter weighing system.* The errors previously reported when employing remote readout were caused by ground loop currents. An alternative method of connecting the instruments eliminated the errors.

*Plot combines.* A plot combine is being developed to cut three rows of cereal grain seeded in 22.9- and 30.4-cm spacings. The combine will be self-cleaning and will use air separation instead of sieves.

*Sickle bar forage plot harvester.* A simple sickle bar forage plot harvester with a hinged sample box or a suspended canvas sample collector is being developed.

*Data logger scanner.* A 30-point scanner was designed and constructed for use with a Hewlett-Packard Data Logger. Information from 30 sites can be coded and programmed.

### Laboratory Apparatus

*Laboratory spraying attachment.* An ultralow-volume spraying attachment was developed for the Research Station, Saskatoon, to be used on a laboratory sprayer described in the Research Report for 1967. Tests conducted with the attachment showed that performance would be improved by incorporating velocity feedback to form a closed-loop speed regulator for each of the controllers used on the attachment. Performance was adequate to collect some useful data on distribution of particle sizes.

# PLANT SCIENCE

## Wheat

*Breeding.* Two sawfly-resistant selections were grown in cooperative tests. C.T. 766 represents an improvement in yield, maturity, resistance to lodging, and in kernel size compared with Cypress, the currently recommended sawfly-resistant variety. C.T. 766 was judged equal to Marquis in quality in 1967; however, its sawfly resistance is probably not as effective as that of Cypress. C.T. 774 is in the national tests for the first year. It has more resistance to sawfly damage and root rot than does C.T. 766, but is 2 days later in maturity.

The search for a hard red spring wheat capable of outyielding Manitou under dryland conditions in southwestern Saskatchewan is centered on a convergent program involving foreign and domestic varieties as well as some hybrids involving spring and winter types. Fifty-four of the more advanced selections from this program were evaluated for yield, quality, and rust resistance.

*Varieties.* High-yielding foreign wheats continue to be in the spotlight. In four dryland and two irrigated tests Pitic 62 yielded 25% more than Manitou. Five other foreign wheats yielded less than Manitou.

Manitou is the best of the quality hard red spring wheats, whereas Cypress is recommended for sawfly-infested areas.

## Rye

*Breeding.* Nine hybrid populations of fall rye were established during the past year for the purpose of combining the large kernel and lodging resistance characteristics of such varieties as Harrach, Universal, Heertvelder, Danae, Sangaste, Loraszpatonai, and Cougar with the winterhardiness of Petkus  $\times$  Dakold selections. Selection for desirable combinations of height, vigor, and kernel characters was continued in the Petkus  $\times$  Dakold, Dominant  $\times$  Antelope, and Select II  $\times$  Antelope populations.

*Varieties.* Frontier fall rye continued to exhibit the best combination of winterhardiness and yielding ability.

## Alfalfa

*Breeding.* The present emphasis in the alfalfa breeding program is on selecting two divergent growth types, i.e., stemmy plants and very leafy plants, with the objective of assessing the yield potential of these two types, and their relative value for pasture purposes.

An assessment of a number of populations for content of chemical constituents showed that genotypic variability was as great for them as for morphological characters. Among the elements, S concentration was much greater in *Medicago sativa* L. than in *M. falcata* L. Low concentration of S seemed to be strongly associated with characters typical of *M. falcata* types, i.e., plants with small leaves, short branch internodes, and slow recovery after cutting. There was very little variation between plants for in vitro digestibility of leaves, indicating that selection for high or low digestibility in alfalfa would not be feasible other than selection for leafiness. It was concluded that selection for certain chemical constituents together with certain morphological characteristics would bring about a desired change more quickly than if selection for each was on an independent basis.

*Varieties.* Varieties introduced from Europe and the USA have not matched the performance of locally bred varieties, mainly because they lack winterhardiness. Rambler, Roamer, and Beaver are the recommended varieties. Two synthetics, LC-A and LC-B, bred in Lethbridge and a yellow-flowered synthetic, 3651 from Swift Current, performed well in evaluation trials.

*Winterhardiness of alfalfa varieties in relation to sugar content and etiolated re-growth.* In tests of eight alfalfa varieties of varying known hardiness, the quantities of hexoses and pentoses in the fall and spring were poorly correlated with winterhardiness. Etiolated growth of plants taken from the field in the fall also displayed very little relationship with the degree of winterhardiness.

## Russian Wild Ryegrass

*Breeding.* The breeding program with Russian wild ryegrass emphasizes resistance to leaf spot diseases and increased seedling vigor as measured by seed size and ability to emerge from a 6-cm depth of soil in greenhouse flats. Heritability for both of these characters appeared to be high, and excellent progress was made in developing vigorous, disease-free lines.

## Intermediate Wheatgrass

*Breeding.* The breeding program with intermediate wheatgrass, *Agropyron intermedium* (Host) Beauv., aims to produce strains that establish quickly and have a high yield potential. Seedling vigor is being assessed by seed weight and ability of seeds to emerge from a 7.5-cm depth of seeding in greenhouse flats. Wide differences in seed weight and seed quality were found in populations of differing genotype.

*Nitrate accumulation.* The effects of six rates of N fertilizer and five frequencies of clipping on the nitrate content of forage from intermediate wheatgrass grown on irrigated land were studied throughout the growing season. The nitrate content of the forage increased with increasing rates of N fertilizer, and varied with the date of harvest. Toxic levels of nitrates (2,000 ppm) were found from June 5 to July 17 in samples harvested from grass that had been fertilized with 300 and 175 kg of N fertilizer per hectare in the spring. Toxic levels were not found in samples from grass fertilized at lower rates. There was an interaction between frequency of clipping and fertilizer rates.

## Tall Wheatgrass

*Breeding.* The breeding program with tall wheatgrass, *Agropyron elongatum* (Host) Beauv., was terminated in 1968. The recently released variety Orbit is recommended across Canada.

## Altai Wild Ryegrass

*Breeding.* Altai wild ryegrass, *Elymus angustus* Trin., has been evaluated at Swift Current for more than a decade. This evaluation established that the species is highly nutritive, cures well, and appears

to be especially useful for grazing cattle in fall and winter. More than 200 plants were selected in 1968 from a space-planted nursery. Leafiness, adequate culm formation, and freedom from aphid damage were the main criteria of selection. An expanded breeding program with this species has been planned for 1969.

## Management and Physiology

*Irrigated pastures.* A Troy bluegrass plus alfalfa mixture gave the highest yields of forage, 13,000 kg/ha, for 1,000 animal grazing days per hectare through the summer season. The inputs included 700 kg/ha of an N-P fertilizer (26-13-0) and 40 cm of applied water.

*Fertilizer effects on natural grassland.* Fertilized grass was 2 weeks earlier in growth in the spring of 1968, and after fall rains remained green until freeze-up. In an experiment to study the effect of increased rates of fertilizer, increased yields resulted from up to 200 kg of N per hectare, but beyond this rate of application yields were reduced.

*Grass-alfalfa mixture tests.* During very dry seasons like 1968, the largest portion of the yield of perennial forage was obtained from the lowest part of the crop. In a clipping trial on dry land, the yield of forage dry matter from a 4-cm cutting height was 800 kg/ha compared with 400 kg/ha from an 8-cm cutting height.

*Rate of water uptake by seeds of different sizes in Russian wild ryegrass.* Twenty genotypes of Russian wild ryegrass were each fractionated into three weight classes with a seed blower and germinated in a CaCl<sub>2</sub> media of 0, 3, 6, 9, 12, and 15 atm tension in darkness at 20 C and 65% relative humidity. The amount of water taken up and germination were determined at various intervals.

Results showed that the 100-seed weight varied between genotypes and was influenced mostly by the amount of small seeds present. Seed weight had little effect on the amount of water taken up in 0 to 8 hr, but increased in influence between 12 and 20 hr, reached a maximum effect from 20 to 32 hr, and gradually declined from 36 to 96 hr. Seed weight had no effect

on the rate or percentage of germination at all moisture tensions. As tension increased, the percentage and rate of germination decreased as did the rate of water uptake. Tension greatly influenced the rate of water uptake during 0–12 hr, declined during 16–48 hr, and increased again during 72–96 hr.

*Studies with "alfalfa sick soils."* Two varieties of alfalfa (Alfa and Rambler) grown in two "alfalfa sick soils" and two normal soils did not show any differential growth response of either tops or roots to root-zone temperatures of 10, 15, and 20 C. Fertilizer applications of N, P, and

K did not amend the growth-depressing effect of the "alfalfa sick soils." Alfalfa grown in the "sick soils" produced about 50% as much top growth as that grown in the normal soils and less than 40% as much root growth. Nodulation was also adversely affected by the "sick soils."

Extracts from "alfalfa sick soils" produced a depressing effect on alfalfa growth in sand culture. The extracted soils, however, produced better growth than unextracted soils. This definitely indicates that there is some agent in the soil that depresses the growth of alfalfa, and it can be extracted with water.

## SOIL SCIENCE

### Crop and Soil Management

*Measurement of evapotranspiration.* Continuous measurements from a recording lysimeter were used to evaluate the usefulness of several empirical and instrumental methods of estimating evapotranspiration of this semiarid region. The mean temperature methods of Thornthwaite and Blaney, and Criddle are inadequate for describing the evapotranspiration regime on a daily basis, but predict the water requirement of alfalfa on a weekly basis with reasonable accuracy. Evaporation pans, atmometers, and Penman's semi-empirical method can be used to estimate actual evapotranspiration to within about 1.5 mm/day on a day-to-day basis. All methods require some modification to bring absolute estimates in line with actual values.

*Influence of some environmental factors on soil moisture use by spring wheat grown in a growth room.* Total and rate of moisture use by wheat were directly proportional to light intensity under warm-day conditions (27 C). Under cool-day conditions (21 C) plants developed more slowly, and a decrease in light intensity from 17 to 9 cal cm<sup>-2</sup> hr<sup>-1</sup> prolonged the growth period. Although plants at the higher light intensity used water more rapidly, those at the lower intensity took a longer time to mature and eventually used as much or more water. An increase in the day temperature from 21 to 27 C reduced the

total dry matter produced and the total moisture used by wheat. Plants used less water at a slower rate when grown at higher soil moisture stress. At about the late tillering to stem-extension stage of development, wheat was surprisingly insensitive to changes in moisture stress. An increase in soil moisture stress during this period did not result in a reduced rate of moisture consumption. Chinook wheat grown under conditions of good soil aeration used less water to produce grain than that grown under poor aeration.

*Cold tolerance of winter wheat.* Decenylsuccinic acid (DSA) was tested to determine if it would increase the coldhardiness of winter wheat. The growth of Kharkov winter wheat was suppressed by DSA on short exposure at 10<sup>-4</sup> M. Continuous exposure killed the winter wheat. Barley was more resistant to DSA and did not appear to be damaged at this concentration. However, root uptake of P<sup>32</sup> was inhibited. In this study DSA did not increase the coldhardiness of winter wheat.

*Effect of method of drying on soil structure.* Laboratory investigation of a clay soil showed that the effect of freezing and thawing and subsequent drying on the percentage of aggregates less than 1 mm in diameter was influenced by the initial moisture content, initial size of soil aggregates, and the method of drying. Air-drying at normal room temperature caused aggregation of soils that initially

consisted of 100% fine aggregates, but deaggregation occurred when the soils were initially coarsely aggregated. These reactions were magnified at high moisture contents. Freeze-drying tended to reduce all aggregates to less than 1 mm in diameter and this effect increased with increased initial moisture content.

*Initiation of soil movement by wind.* The two most important factors controlling soil erosion by wind are the quantity of crop residue on the soil surface and the amount of soil in aggregates greater than 1 mm in diameter. Wind-tunnel studies were conducted to determine the wind

velocity required to initiate soil movement (initiation velocity) with quantity of crop residue and quantity of aggregates greater than 1 mm in diameter as variables. The crop residue was placed in the soil in an upright position with the height constant at 15 cm and varying rates up to 4,200 kg/ha. Aggregates greater than 1 mm in diameter were varied from less than 10% to more than 40% of total soil mass. Wind velocity was measured at a height of 30.5 cm above the soil surface. The initiating velocity was observed to be an exponential function of both variables and could be estimated with the following equation:

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$$I = \exp 6.044 + 0.000177S + 0.0233C$$

where  $I$  = initiating velocity, cm/sec  
 $S$  = crop residue, kg/ha  
 $C$  = % aggregates > 1 mm in diameter  
coefficient of multiple correlation = 0.974

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*Crop residues for control of erosion by wind.* In a 2-year study, seven cereal and oilseed crops were compared on the basis of their seed and residue yields and the resistance of the residues to decomposition during summerfallow tillage. Oats and barley produced more seed than did wheat, but current prices favor wheat as a cash crop. For residue production (trash cover) the cereal grains, mustard, and rapeseed were superior to flax and peas. In terms of adequate amounts of residue remaining for effective wind erosion control after the 21-month summerfallow period, the cereal grains were more effective than rapeseed, mustard, flax, or peas. Rapeseed residue broke down more readily than residue from any other crop, and by the end of the summerfallow period it had decreased to 6.4% of the original amount. Only the cereal grains provided residues after summerfallow tillage that exceeded the minimum requirements for effective control of erosion by wind.

*Control of winter-annual weeds.* A late fall application of 2,4-D ester at 0.42 kg/ha was as effective as cultivation for the control of winter annual forms of stinkweed, *Thlaspi arvense* L., and flixweed, *Descurainia sophia* (L.) Webb. The chemical treatment is preferred because it does not destroy trash cover and standing stubble, which are required for wind erosion

protection and the trapping of snow for moisture conservation.

*Effect of rate of seeding on yield of wheat.* A seeding rate of 22 kg/ha produced a significantly higher yield of wheat than seeding rates of 44, 66, and 101 kg/ha on fallow land in 1968, but did not influence yields from stubble land. Moisture use was nearly identical under all treatments because all available moisture was exhausted.

*Influence of soil aeration on seed set and yield of wheat.* Poor soil aeration caused poor seed set in Chinook and Manitou wheat. Under good aeration, Chinook produced 82% seed set and yielded 26.7 g of grain per pot compared with 54% and 11.5 g/pot when grown under poor aeration. The poor aeration caused abnormal development of the anthers; the pollen grains aborted, but neither the stigmas nor ovaries were affected.

#### Soil Fertility

*Residual value of field-applied phosphorus fertilizers.* Triple superphosphate (0-45-0) was applied at 100, 200, and 400 kg/ha on Orthic and Rego Brown and Black soils at Swift Current and Brandon. After 3 crop years on the Black soil and two on the Brown soil, all broadcast rates supplied adequate P to produce maximum yields. In several instances, sideband applications alone did not produce maximum

yields. The quantity of  $\text{NaHCO}_3$ -extractable P has gradually declined since the time of application. Nevertheless, even after 3 years,  $\text{NaHCO}_3$  extracts nearly 50% of the amount applied. The relationship between the amount applied and the amount extractable with  $\text{NaHCO}_3$  is almost linear.

A comparison of the  $\text{NaHCO}_3$ -extractable P and A values shows a very high degree of correlation between the two methods and also a good quantitative agreement. The evidence shows that the  $\text{NaHCO}_3$  extraction method gives a satisfactory estimate of the availability of residual P.

*Availability of different phosphorus sources.* Growth-room studies conducted with  $\text{P}^{32}$ -tagged fertilizers showed that the initial P status of the soil does not affect the relative availability of mono-ammonium phosphate, ammonium polyphosphate, triple superphosphate, and urea phosphate. In addition all sources were equal in availability for barley. But in separate field experiments the yield increase obtained from the urea phosphate was considerably less than the increases obtained from the other sources.

*Phosphatic fertilizer for irrigated alfalfa.* The  $\text{NaHCO}_3$  extraction method gave reasonably satisfactory separation of soils into those on which applications of phosphatic fertilizer were profitable and those that did not require P. Annual applications of P resulted in increased amounts of  $\text{NaHCO}_3$  extractable P in the soil. This residual P was detectable from the first year of application and increased with increasing rates and numbers of applications. Late fall applications were as effective as spring applications.

*Fertilizer on native rangeland.* The effect of single applications of mixed fertilizers (16-20-0) has persisted for up to 6 years, in yield of dry matter and in P content of the forage. Where N and P were applied singly and in combination, a residual response to both N and P continued. There was no measurable increase of N in the soil in either the nitrate or ammonia forms. The yield response on native rangeland was more closely related to the  $\text{NO}_3\text{-N}$  content of the soil before fertilizer was applied than to any other soil measurement.

*Phosphorus fertilizer tests for wheat on summerfallow.* Rod-row fertilizer tests were conducted on 14 representative soils in southwestern Saskatchewan. Each test comprised P applications at 0, 4.9, 7.3, 9.8, 14.6, and 19.5 kg/ha. Wheat was the test crop. The average rate of P required to maximize net returns was 16.3, 6.8, and 9.9 kg/ha for 1966, 1967, and 1968. The correlation coefficient between the rate of P required to maximize net returns and  $\text{NaHCO}_3$ -extractable P was significant ( $r = 0.521$ ). The regression equation was:

$$y = 15.9 - 0.38x$$

where:  $y$  = rate of P, kg/ha, required to maximize net return

$x$  =  $\text{NaHCO}_3$ -extractable P, kg/ha  
standard error of estimate = 2.6 kg P/ha.

This indicates that the rate of P required to maximize net returns on soils with very low  $\text{NaHCO}_3$ -extractable P is approximately 14 kg/ha, and that it is not profitable to apply P to soils with greater than about 40 kg/ha  $\text{NaHCO}_3$ -extractable P.

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## INTRODUCTION

This is a report of the activities of the Northern Research Group during 1968. The Group consists of the Research Station at Beaverlodge and the Experimental Farms at Prince George, B.C., Fort Vermilion, Alta., Fort Simpson, N.W.T., and Mile 1019, Alaska Hwy., Y.T. Research is mainly concerned with increasing the efficiency of production of cereal, oilseed, grass, legume, fruit, and vegetable crops on the 5 million acres now cultivated in northern British Columbia and Alberta and with assessing the potential for pro-

duction of the areas in northwestern Canada that have not yet been developed.

The report emphasizes research that was completed during 1968, presents progress made on long-term projects, and outlines research started during the year. The research is not described in detail and, unless significant to application of the results, the location is not specified. Detailed technical accounts of completed research are listed. Reprints can be obtained from the Research Station.

A. A. Guitard  
Director

## CROP-CLIMATE RELATIONSHIPS

### Regional and Cultural Influences on Moisture Use by Spring Wheat

Moisture studies conducted for 12 years at Beaverlodge, McLennan, and Baldonnel showed that all locations receive similar amounts of precipitation, but that Beaverlodge has a higher rate of evaporation. The higher rate is caused by higher wind velocity and more bright sunshine at Beaverlodge than at McLennan, which is 100 miles NE, and at Baldonnel, which is 100 miles NW. Consequently, a crop of wheat at Beaverlodge requires 1.7 inches more water than a crop at McLennan to produce the same yield and 2.5 inches more than a crop at Baldonnel requires.

During this study spring wheat grown on summerfallow used water 17% more efficiently than wheat grown on stubble. It required 10.1 inches of water to produce 34.1 bu/acre of wheat on summerfallow, whereas 9.2 inches were required to produce 26.3 bu on stubble. Wheat seldom evapotranspired at its potential rate, and evapotranspiration on summerfallow was higher than on stubble. In 40 determinations at the three locations the actual annual rate of evapotranspiration averaged 60% of the potential rate and varied from

30 to 98%. On summerfallow, evapotranspiration averaged 65% of the potential, whereas on stubble it was only 56%.

### Accuracy of Atmometers for Estimating Water Consumption by Spring Wheat

The total amounts of water evaporated from the black Bellani plate atmometers were compared with those consumed by crops of spring wheat under dryland conditions for 11 years at Beaverlodge, McLennan, and Baldonnel. Based on 84 sets of data, the association was not significant. During very wet periods the relationship was extremely close, probably because much water was lost by evaporation from soil and plant surfaces as well as by transpiration. When soil moisture supplies were adequate but the surface was dry, crop moisture loss was less than evaporation from the atmometers. When soil moisture supplies were inadequate, moisture loss from the crop was much below that from the atmometers.

### Thermoperiodicity in Spring Wheat

Most of the agricultural land in the upper Peace River region lies between elevations of 2,000 and 2,400 ft, but there

are areas of fair agricultural soil at elevations of over 3,000 ft. To determine the maximum altitude for the production of spring wheat, two tests were established near Beaverlodge at elevations of 2,300 and 3,050 ft. Identical soil was placed in tanks at the two locations and climate and crop response precisely measured for 7 years. Mean climate was identical at the

two locations except that there was a 7-degree F difference in thermoperiod, the lower elevation having warmer days and cooler nights. The wheat at the lower elevation grew more vigorously, developed more rapidly, produced more heads, yielded 4 bu/acre more grain, and ripened 8 days earlier than the wheat at the higher elevation.

## SOILS

### Sulfur Deficiency for Cereal Production

Many of the coarse-textured Gray Wooded soils in the Peace River region have been found deficient in S for maximum production of spring cereals. The deficiency occurs in soils formed on a number of parent materials. Most sites that responded to applications of S were low in water-soluble  $SO_4$  throughout the profile, but small responses were obtained at two sites that had a soluble  $SO_4$  content of approximately 100 ppm at a depth of 2 ft. At a few of the locations the soils were equally deficient in both N and S. On these soils the application of either nutrient alone did not increase yields of oats, but when the two were applied together yields were increased by as much as 300%. Most of the soils lacked N more than S; on these soils, applying N alone increased yields and adding S caused a further increase.

### Fixation of Gaseous Ammonia by Soils

By use of extraction with  $K^+$ , the capacity of air-dry surface soil to fix gaseous

$NH_3$  was estimated to be 2.5 to 8.5 meq/100 g for 11 mineral soils and 39 to 190 meq for four organic soils. Organic matter accounted for most of the fixation of  $NH_3$  in the mineral soils, with an average of 87 meq/100 g of organic matter. Values for ten cultivated mineral soils and one cultivated muck soil fell within a range of 60 to 108 meq/100 g of organic matter. Easily hydrolyzable N accounted for  $\frac{1}{3}$  of the fixed  $NH_3$  in the organic soils and for  $\frac{1}{2}$  in the mineral soils.

The presence of  $O_2$  during treatment with gaseous  $NH_3$  approximately doubled fixation in an extremely acid organic soil, a nearly neutral muck soil, a Podzol, and a Black soil. Fixation during treatment with gaseous  $NH_3$  was similar for air-dry and moist soils. Concentrations of gaseous  $NH_3$  of less than 2 meq/100 g were not fixed by the organic matter in air-dry soils. Treatment of the soils with  $NH_4Cl$  solution instead of gaseous  $NH_3$  caused very little fixation.

## CROPS

### Fruit Composition in the Genus *Amelanchier*

In cooperation with Professor F. H. Wood, of the Department of Food Science, University of Alberta, fruit of seven *Amelanchier* species was collected several times during the 1967 and 1968 picking seasons and analyzed for a number of characteristics. Species analyzed were *Amelanchier alnifolia* Nutt., *A. bartramiana* (Tausch) M. Roemer, *A. stolonifera* Weig., *A. spicata* (Lam.) K. Koch.,

*A. sanguinea* (Pursh) DC., *A. rotundifolia* (Lam.) Duin., and *A. florida* Lindl. There were single entries for all species except *A. alnifolia*, saskatoon, for which there were seedlings from the variety Smoky, an acid selection from Smoky, and the variety Forestburg. For most characteristics there were wide variations due to season, maturity, and genotype. Acidity, total solids, and total pectin displayed the greatest variability among species. Total solids, titratable acidity and pectin content on a

fresh-weight basis were more variable among selections of *A. alnifolia* than among species.

*Solids.* For all picking dates total solids ranged from 17.7% for the Smoky seedlings to 27.9% for the acid selection from Smoky. Percentage of total solids decreased with ripening, but was higher than that of most other fruits; the solids contained a high proportion of insoluble material. Refractometer solids ranged from 13.3% for the Smoky seedlings to 17.2% for the acid selection from Smoky. A juice recovery of 60% was obtained from the pulp of Smoky seedlings at 40 psi.

*Acidity.* *Amelanchier* is less acid than most other fruits. The pH ranged from 4.2 for *A. spicata* to 4.5 for the Smoky seedlings. Titratable acidity, measured as the amount of 0.1 N NaOH required to neutralize 100 g of fruit, ranged from 31 ml for the Smoky seedlings to 47 ml for Forestburg. The high pH and low titratable acidity are a deterrent to gel formation and good palatability.

*Total reducing sugars.* On a fresh-fruit basis the total reducing sugars ranged from 9.3% for the Smoky seedlings to 11.4% for *A. rotundifolia*. On a dry-weight basis the range was from 35.4% for the acid selection from Smoky to 54.1% for the Smoky seedlings. On a fresh-fruit basis fructose ranged from 6.9% for the Smoky seedlings to 8.3% for Forestburg. On a dry-weight basis the range was from 24.6% for the acid selection from Smoky to 40.1% for the Smoky seedlings. The high total reducing sugar and high fructose decrease palatability.

*Organic and ascorbic acids.* Five organic acids were identified with  $R_F$  values of .14, .30, .48, .59, and .88. The first four have  $R_F$  values similar to gluconic, tartaric, malic, and oxalic acids. There was little variation in the quantity of the various acids present in the different genotypes. Malic acid predominated, followed closely in quantity by oxalic. Ascorbic acid ranged from 23.56 mg/100 g in the Smoky seedlings to 36.71 in the fruit of *A. stolonifera*.

*Pectin.* On a fresh-fruit basis total pectin, measured as percentage of anhydrogalacturonic acid, ranged from 1.18 in the Smoky seedlings to 1.78 in the acid selection from Smoky. On a dry-weight basis the range was from 6.07% in *A. sanguinea* to 7.21% in *A. florida*. On a fresh-weight basis total pectin was higher than in other fruits, but on a dry-weight basis it was lower.

### New Forage Varieties

Aurora alsike clover (Canadian License No. 813, 1961) and Boreal creeping red fescue (Canadian License No. 1022, 1966) were registered with the Crop Science Society of America and granted Registration No. 8 and 6 respectively. Both varieties have been certified by the Herbage Seed Scheme of the Organization for Economic Co-operation and Development.

Two O.E.C.D. varieties developed by W. Weibull, Landskrona, Sweden, were licensed for production in Canada and are described below. Licensing was based on data compiled at Beaverlodge.

*Tetra alsike clover.* (Canadian License No. 1147, 1968). This clover is a tetraploid and has larger leaves and blossoms than Aurora, matures seed about 5 days later, and is more susceptible to winter injury. It is similar to Aurora in seed and herbage yields throughout Western Canada except that in areas with mild winters it may produce more herbage.

*Reptans creeping red fescue.* (Canadian License No. 1148, 1968). In Western Canada it is similar to Boreal in hardness, turf quality, and establishment. It is considered a satisfactory alternate to Boreal for turf and pasture.

### Northern Native Grasses

In a preliminary survey of grass ecotypes in northwestern Canada, 1,200 specimens were collected and established in a genecological garden at Beaverlodge in 1967. They were screened for agronomic characteristics and for disease during 1968. From this preliminary information, northwestern Canada was divided into 15 collection districts and a 5-year collection program was started.

As part of this program 1,450 collections were made from the Smithers, Fort St. James, and Kitimat areas in British Columbia and from the Beaverlodge, Peace River, Swan Hills, Lesser Slave Lake, and Edson areas in Alberta. The grasses collected belonged to 65 species of 30 genera. The most prevalent genera were *Poa* with 309 collections and *Agropyron* with 286.

### **Stem Eyespot of Creeping Red Fescue**

A stem eyespot disease of creeping red fescue was identified as *Phleospora idahoensis* Sprague. The fungus was first discovered in a few isolated fields in 1966. In 1968 it was found in most fields in the Beaverlodge area, and some growers reported seed losses as high as 50%. Studies have been started on the control of the pathogen by crop sanitation and by the development of resistant varieties.

### **Unique Yields of Grass Seed**

A unique combination of factors controlling the seed production of grasses resulted in the highest plot yields ever recorded at the Station. The only apparent cause of these high yields was the higher-than-normal soil temperature during much of the winter. A heavy snow cover prevented soil freezing until early February when chinooks reduced the snow cover and frost penetrated the soil.

Maximum seed yields for creeping red fescue were 2,000 lb/acre for plots seeded in 1967, whereas the previous high had been 1,200 lb. Meadow fescue, with previous high yields of 1,000 lb/acre, yielded 1,800 lb/acre. Golfrood Chewings fescue and S59 red fescue, which normally yield very little seed, yielded 400 lb/acre. Russian wild ryegrass, which had never produced more than 15 lb/acre of seed in the year after planting, yielded 357 lb/acre.

Microscopic examination of the tiller growing points indicated that in certain species development was taking place throughout the winter. For example, some growing points of Russian wild ryegrass started to develop floral primordia about mid-January. For grasses that did not undergo morphological development during the winter, it is thought that the above normal seed yields were caused by certain

physiological changes that were ultimately expressed as unusually large numbers of seed heads.

### **Distance and Time Requirements for Preventing Cross Pollination of Sweet Clover by Honey Bees**

With honey bees being used as pollinators, S7115, a low-coumarin strain of white blossom sweet clover, averaged 14.2% contamination by the high-coumarin strain, Arctic, when isolation distances were 50 to 100 yards. When 200 to 250 yards of isolation were provided, the contamination was only 3.3% and with 300 to 350 yards contamination was reduced to 0.65%. A slight admixture of S7115 with plants of Arctic at the first two isolation distances slightly increased the first two contamination percentages.

Honey bees, confined for 2 hr after pollinating high-coumarin strains of sweet clover, did not appreciably contaminate low-coumarin strains. Overnight confinement guaranteed no contamination of fields when colonies were moved from one field to another.

### **Forage Production Potential of the Slave River Lowland**

A program to determine the forage production potential of the Slave River Lowlands was started with the establishment of a research site at Grand Detour on the Slave River approximately 40 miles NW of Fort Smith. The production of native and cultivated grasses and legumes, the nutrient sufficiency of the soil, and the major climatic characteristics will be studied for three of the most extensive and suitable soil complexes.

The Slave River Lowland is bounded on the S by the Northwest Territories - Alberta border, on the E by the Precambrian Upland, on the W by the Palaeozoic Upland, and on the N by Great Slave Lake. It extends from 60° to 61° 31' N and from 111° 30' to 113° 50' W. It is essentially an area covered with alluvial sediments, through which the Slave River flows. The total land area is estimated at 2 million acres; about 70% of it is considered to be arable. Of the arable land, about one-half consists of open meadows and the other half of forest, much of which has been burned over.

## ANIMALS AND INSECTS

### Performance of Beef Cattle in the Yukon Territory

A small Hereford × Shorthorn herd was maintained at Mile 1019 from 1962 to 1968 to determine performance of the animals on locally grown feeds in the rigorous winter environment. The animals were maintained outside during the winter on hay and grain produced on the farm supplemented by a standard mineral mixture.

Seventy-one calves from 21 females made an average daily gain of 2.4 lb from birth to weaning. The highest average daily gain was 3.3 lb and the lowest 1.8. Of the 71 calves weaned during the 7-year period, 19 exceeded 500 lb and 5 exceeded 600 lb at 170 days. Average daily gain to 1 year for 43 of the animals was 1.5 lb with a high of 2.0 and low of 1.0 lb. Average daily gain of steers on pasture was 2.0 lb in 1964, 1.5 in 1965, and 1.5 in 1967.

The particularly excellent gain of calves to weaning suggested ample milk production. Gains on pasture were normal and no difficulties were experienced with outside wintering even when the animals were allowed to range in the bush. There appeared to be no climatic or feed quality

restriction associated with the production of beef cattle in the southern Yukon.

### Uritone for Control of *Nosema apis* in the Honey Bee

Uritone<sup>1</sup> fed for 11 days to bees inoculated with 10<sup>5</sup> spores of *Nosema apis* Zander per bee did not control the disease. Doses of 500 ppm, 1,000 ppm, and 1,500 ppm of Uritone were given and compared with 33 ppm of fumagillin as Fumidil-B.<sup>2</sup> In the Uritone treatments the incidence of nosema ranged from 4.5 to 8.0 × 10<sup>6</sup> compared to a trace of spores with fumagillin. Uritone was toxic to the bees at the concentrations tested.

### Irradiating Brood Frames for Control of European Foulbrood in the Honey Bee

In a cooperative test with the Apiculture Section of the Entomology Research Institute and the Commercial Products Division of the Atomic Energy Commission, brood frames infected with European foulbrood were irradiated with dosages of up to 800,000 rad. Although incidence was lowered, the disease was not eliminated. It was concluded that control of European foulbrood by irradiation is impractical.

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<sup>1</sup> Parke, Davis and Company Limited.

<sup>2</sup> Abbott Laboratories Limited.



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## INTRODUCTION

A number of developments that took place during the year at the Research Station, Lacombe, are of special interest.

Producers and processors have accepted a more accurate system for evaluating swine carcasses. The system is the result of a hypothesis proposed by researchers at Lacombe a number of years ago and proved by a series of studies in cooperation with the Livestock Division, Canada Department of Agriculture, and the Meat Packers Council of Canada. The new grading and payment system put into operation across Canada on December 30, 1968, should further improve the quality of Canadian swine, and benefit consumers as well as producers. Research on the evaluation of beef carcasses is now in progress.

A new project was initiated early in the year with the importation of representatives of the French Simmental (Pie Rouge) breed of cattle. These were bred pure and crossed with the traditional British breeds, Hereford, Aberdeen Angus, and Shorthorn, to ascertain the contribution this breed might make to the Canadian beef industry.

The addition to our staff of a statistician and a programmer, both highly qualified, is particularly gratifying. Dr. T. Fujishima, a postdoctorate fellow from Japan, is also most welcome. He is working on poultry genetics.

J. G. Stothart  
Director

## ANIMAL SCIENCE

### Beef Cattle

*Selection for yearling weight in Short-horn cattle.* A program of single-trait selection for weight at 1 year of age has progressed through 8 years. Environment has improved during this period with the result that yearling weight of the control herd has increased at the rate of  $17.0 \pm 3.5$  lb annually. The annual increase for the selected herd of  $21.7 \pm 2.6$  lb over the same period suggests that the average genetic improvement is 4.7 lb/year.

Weaning weight (180 days) has increased slightly in the selected herd ( $0.23 \pm 0.94$  lb/year) and decreased slightly in the control herd ( $-0.72 \pm 1.51$  lb/year).

*Evaluation of the Simmental breed in Canada.* Four bulls and eight heifers of the French Simmental (Pie Rouge) breed, imported by the Department in 1967, were released from quarantine in April 1968. Semen from each of the four bulls was used with semen from a privately owned Simmental bull to inseminate 299

cows of the Hereford, Aberdeen Angus, and Shorthorn breeds. Simultaneously, 205 cows in the same herd were bred to Charolais bulls to provide a comparison of the two breeds. The Simmental heifers were straightbred to develop a nucleus herd of the breed at Lacombe. The imported Simmentals, kept on a moderate feeding level, have grown well under the climatic conditions at Lacombe.

### Swine

*Cryptorchidism in pigs.* An 8-year study of cryptorchidism involving 1,771 litters of two breeds, the Lacombe and Yorkshire, was concluded. Three types of this defective condition were observed. The most common type was the condition in which one or both testicles were retained in the coelom at birth. The rarest was a nullitesticular condition in which one male, classified as double cryptorchid at birth, was found on autopsy at 15 months of age to be lacking testicles. A unitesticular condition in which the animal

possessed only one testicle was established by autopsy for 26 of 122 mature cryptorchids postmortemed. Most (21) of these animals were normal until at least 42 days of age, but one testicle atrophied completely after that age. Cause of atrophy was not established.

Breeding studies were conducted for 6 years to provide genetic information on the cryptorchid condition. In the Lacombe tested, 5 sires cryptorchid at birth produced 33 litters with an average incidence of 10.9% cryptorchids among their male progeny, and 21 cryptorchid sires that were normal at birth produced 129 litters with 3.8% cryptorchid males. In the Yorkshires tested, 4 boars cryptorchid at birth produced 25 litters with an average incidence of 31.4% cryptorchid male progeny.

*Synthetic sex hormones and feedlot performance of pigs.* A combination of diethylstilbestrol, methyltestosterone, and Tylosin fed during the finishing period provided a slight improvement in rate of gain and feed efficiency of barrows and gilts. Carcass measurements were not significantly altered by the treatment, but there was a significant ( $P < 0.05$ ) reduction in fat and a concomitant increase in protein in the carcasses of treated barrows. Chemical fat was decreased in all cuts, but the increase in protein content was significant only for ham and loin. The treatment was not shown to cause any change in chemical composition of gilt carcasses.

### **Carcass Research**

*Predicting lean content of beef carcasses.* Carcasses from 149 bulls, ranging

in weight from 474 to 766 lb, were measured and trimmed in accordance with retail trade requirements to investigate the reliability of predictors of lean content in the carcass. The correlation between carcass weight and total lean per hundred pounds of cold carcass weight was 0.16. Average rib fat was a reasonably good predictor of this measure of total lean with a correlation of  $-0.67$ . Measurements of fat taken with the Danish Introscope, a technique that does not require cutting of the carcass, were correlated  $-0.56$  with lean yield. Visual appraisal of the animals before slaughter was of no value in predicting lean yield. The best individual judge had a correlation of 0.22 between his type rating and lean yield, but the average correlation for 57 judges was zero.

*Detection of taint in pork.* Detailed studies using taste panel techniques were conducted with pork products from market-weight carcasses of barrows, gilts, boars, and ridglings. Cooking aroma, though lowly correlated ( $r = 0.28$ ) with flavor, was considered objectionable for pork from 16% of the gilts, 14% of the boars, 7% of the barrows, and 6% of the ridglings. Since cooking aroma does have a definite bearing on consumer reaction to pork products, there is a need for a discerning criterion of taint.

One technique developed at Lacombe utilizes dry heat to volatilize the substances responsible for cooking aroma. An instrument comparable to an electric soldering iron applied to the fat gives an almost instantaneous release of any aromas present. The temperature of the iron ensures thorough self-cleaning within 2 to 5 sec after application.

## **PLANT BREEDING AND PATHOLOGY**

### **Cereal Crops**

*Mexican wheats in central Alberta.* The late maturity of some of the promising Mexican wheats may be a limiting factor in their use in central Alberta. Pitic 62 outyielded Manitou at Lacombe and Acme by 31 and 23% respectively in 1967 and 1968, but required 5 to 10 days longer to

mature. These differences are highly significant, but an early fall frost, which is a hazard in this area, did not occur in either of these years. The use of this variety in central Alberta will be determined by its maturity and potential yield as a feed grain in relation to the yield of other feed grains and their maturity.

*Agronomic, yield, and quality relationships in wheat.* In a cooperative study with the Research Station at Winnipeg, 330 random lines from a single cross between varieties of hard red spring wheat with widely differing characteristics showed a highly negative correlation between N content and yield. Maturity, height, kernel weight, and yield were positively interrelated. Large negative correlations were observed between sedimentation value and tolerance index and between N content and starch damage. Sedimentation value and dough development time showed a strong positive relationship. The mean value for lines fell within the range of the parents, with the exception of sedimentation value and height. Sedimentation value was higher and height was lower than the parental range.

Five of six quality traits were more highly heritable than yield. The exception was dough development time. The correlation coefficients of 7 of the 21 possible phenotypic combinations were significantly different from zero. Of these combinations, 1,000-kernel weight and yield, and sedimentation value and tolerance index would be an aid to breeders. The other five would be detrimental.

*Root rot in barley.* Gateway and Olli had more root rot than Conquest and Galt, and all varieties had more root rot when grown on fallow land than when grown on stubble land. Maximum development of the disease occurred by mid-August. Recommended fertilizer application resulted in less root rot in all varieties under all cultural conditions.

*Peroxidase activity in diseased plants.* When roots of barley were attacked by *Pythium* spp., *Fusarium* spp., and *Helminthosporium sativum* Pamm., King & Bakke, peroxidase activity was markedly increased in the leaves of the plants. With net blotch the upper leaves of barley plants showed a higher peroxidase activity when the lower leaves were infected. Leaves of plants infected with loose smut also showed high peroxidase activity. These fungi appear to exert some systemic effect on the plant.

## Forage Crops

*Legume-grass mixtures.* Second harvest-year yields of birdsfoot trefoil in mixtures with six grass species on Gray Wooded soils averaged 4,936 lb/acre, whereas the same grasses with alfalfa averaged 2,075 lb. Red clover - grass mixtures averaged 3,828 lb/acre. The average legume contribution to the total yield was 65, 30, and 80% for trefoil, alfalfa, and red clover, respectively.

*Supernumerary chromosomes in crested wheatgrass.* Detrimental effects of supernumerary chromosomes on agronomic traits in crested wheatgrass, especially when present in high frequencies, have been reported. A study at Lacombe indicated that if basic plants of synthetics are free from supernumerary chromosomes, the synthetics remain free when multiplied from Breeder to Registered to Certified seed classes.

## Horticultural Crops

*Deciduous ornamentals with a pyramidal form.* Substitutes for the Lombardy poplar, which lacks hardiness in this region, have been under test for many years. The following trees proved hardy and are recommended: Griffen poplar is a selection of the Russian poplar, but grows only about 30 ft high compared with 50 ft for its parent. Sutherland caragana, a selection of the common caragana with the same flower, leaf, and bark characteristics but with acute-angled crotches that give it a definite pyramidal habit, is relatively fast growing in the region. Pyramidal crabapple is a fast-growing tree with an attractive columnar habit of growth.

*Effect of mulching materials on soil temperatures.* Clear polyethylene mulches maintained soil temperatures at a significantly higher level than black or a combination of black and clear. Temperatures at 2 inches below the soil surface were recorded three times daily for 61 days. Under wide widths (36 inches) temperatures were higher than under narrow (18 inches). The temperatures of unmulched and asphalt-mulched soils were similar; both were significantly lower than the temperature under either the clear or black polyethylene.

# CROP MANAGEMENT AND SOILS

## Weed Control

*Triallate granules to control wild oats.* During 2 years of testing, a granular form of triallate proved as effective as the liquid form for the control of wild oats when applied on fallow land in the spring or in the late fall. On stubble land the granular form applied at 1.5 lb/acre gave 90% control compared with 80% for the liquid. With either form of the chemical, degree of control was affected by rates of application, moisture conditions, and extent of incorporation in the soil.

## Soils

*Soil aggregation.* Of several carbohydrate fractions separated from a Black Chernozemic soil after hydrolysis with either 1 N or 3 N H<sub>2</sub>SO<sub>4</sub>, the pentose fraction was most closely related to the water stability of aggregates. The hexose fraction, organic C soluble in 3 N H<sub>2</sub>SO<sub>4</sub>, and uronic acids were of lesser value in explaining aggregate stability. There was no relationship between total organic C and aggregate stability.

*Nitrogen fixation by red clover.* Fixation of atmospheric N by red clover resulted in increased soil N available to subsequent cereal crops. A 2-year stand of red clover – timothy hay grown on a Gray Wooded soil at Chedderville contributed about 50 lb of N per acre to the increased yield of the two succeeding crops of barley and oats. Approximately 83% of this N was used by the first cereal crop and the remainder by the second crop. It appears that little or no carry-over of fixed N is available for a third cereal crop.

*Forage production on peat soils.* Preliminary results indicate that peat soils in Alberta, properly managed, can produce forage yields equivalent to yields on mineral soils in the same area. Tests on drained, well-decomposed peat with fertilizers produced up to 4,000 lb of dry hay per acre. The peat soils were slower to warm in the spring, and the growing season was somewhat shorter than on adjacent mineral soils.

*Summerfallow tillage.* With a fallow-wheat rotation on a loam soil in the Black

soil zone of central Alberta, extra tillage over that required to control weeds had no effect on the yield of wheat. Four tillage operations usually controlled weeds. The extra tillage had little or no effect on soil moisture conserved, wind-erodible aggregates, compaction, or nitrate accumulation. Insufficient tillage adversely affected yield, moisture conservation, and nitrate accumulation.

*Soil test for sulfur.* Water-soluble sulfate in the 0 to 6-inch surface layer of 34 Black Chernozemic, Dark Gray, and Gray Wooded soils was found to be accurate for predicting the S fertilizer requirement of legumes growing on these soils. Increasing the depth of sampling to 12 or 24 inches did not improve the prediction value of the test.

*Sulfur in the atmosphere of west central Alberta.* Over a 3-year period rainwater from 36 sites in west central Alberta was found to contain 0.1 to 0.2 lb of sulfate S per inch of precipitation, or 2 to 4 lb/acre per year. This is very low compared with some highly industrialized areas which have recorded up to 300 lb/acre. There was a remarkable uniformity between the different locations and years. Six locations were in a 6- to 15-mile radius of a S-extraction plant. These sites did not vary greatly among themselves nor did they show a higher S concentration than sites at a considerably greater distance from the plant.

*Copper deficiency on barley.* Copper deficiency was observed with barley on 5 of 29 sites tested in central Alberta. At 4 sites the deficiency was not marked, but at the other site there was practically no seed set. At this latter site a severe deficiency of Mn compounded the problem.

*Chemical characteristics of humic acids.* The amount of humic acid extracted from a Solonetzic soil sequence at Vegreville, Alta., was in the order: Solonetz < Solod < Black. No marked differences were observed in the C, N, total acidity, carboxyls, phenol hydroxyls, and carbonyl groups content of the humic acids studied. The infrared spectra and the pK values from the titration curves of the humic acids also

did not reveal any marked differences. The data suggest a similarity in the chemical characteristics of the humic acids studied.

*Carbohydrate fractions of a Gray Wooded soil.* Organic C, N, hexose, pentose, uronic acid, hexosamine, and hexosamine-N content were significantly greater

in soils from Breton plots in a 5-year rotation of grain and legume than in a wheat-fallow sequence. The content of organic C, N, and carbohydrate materials in the soils increased considerably after applications of manure, NPKS, and NS, whereas lime had no effect.

## SOLONETZIC SOIL SUBSTATION, VEGREVILLE

*Water infiltration into Solonetzic soils.* Laboratory studies of a Solonetz soil showed extremely low water infiltration rates for both the Ap and Bn horizons. Extreme difficulties were encountered in attempting to establish the 15 atm percentage with a pressure membrane apparatus. The addition of  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ , and  $\text{NH}_4^+$  increased the rate of water movement and improved the structure of the Bn horizon of various Solonetzic soils. The addition of  $\text{Na}^+$  had opposite effects.

*Nitrogen fertilizer for bromegrass on a Solonetz soil.* Ammonium nitrate, ammonium sulfate, and urea supplying 100 lb of N per acre annually were equally effective at Vegreville in increasing the yield of bromegrass except during a drought year, 1966, when urea was the least effective of the three. About 45% of the N applied as urea was recovered in the crop compared with over 55% from the other fertilizers. Nitrate levels in the bromegrass were highest in years of adequate rainfall and were increased equally by the three fertilizers. All nitrate levels were well below recognized toxic levels.

*Effect of summerfallow on moisture reserves in Solonetzic soils.* In the spring of 1968 there was about 2.6 inches more water stored to a depth of 42 inches in fallow plots than in continuous wheat plots on a Solonetzic soil at Vegreville. Drought conditions prevailed in 1968, and the yield of fallow wheat was 24.1 bu compared with 11.3 bu for continuous wheat. The difference in stored soil moisture was sufficient to account for the increased wheat yield on fallow. Although impeded by the Bn horizon, moisture penetration and removal are both significant factors affecting crop production on Solonetzic soils.

*Irrigation and fertilization of bromegrass on a Brown Solonetz.* The application of 400 lb of ammonium nitrate fertilizer with 2 inches of irrigation water increased the yield of bromegrass on Hemaruka loam from 1,049 to 3,954 lb of dry matter per acre in 1968. The addition of 2 inches of water without the ammonium nitrate reduced the yield slightly to 984 lb/acre. Although these results suggest considerable promise for this method of stimulating forage crop growth, no information is available on its long-term effects on the salt status of the soil.

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# Research Station Lethbridge, Alberta

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M. A. KHAN, G.V.Sc., M.S.	Toxicology
W. A. NELSON, B.Sc., M.Sc., Ph.D.	Physiology (ectoparasites)
R. H. ROBERTSON, B.A., M.Sc.	Serology
J. A. SHEMANCHUK, B.Sc., M.Sc.	Biting-fly ecology
J. WEINTRAUB, B.A., M.S.	Physiology (reproduction)

## VISITING SCIENTISTS

### *Colombo Plan Trainees*

P. S. MAHALLE, April to December 1968

Irrigation and fertilizer use

B. E. Q. NABBAH, June to September 1968

Irrigation practices

## INTRODUCTION

This report features a short review of research conducted by members of our multidisciplinary group on various problems related to cryobiology. Within the six sectional groups, steady progress was made on many other problems of regional importance. These advances include the encouraging results obtained in the large project on crossbreeding of cattle, the determination of the inheritance of root-rot reaction in wheat, and the introduction of Earligold, an early-maturing muskmelon. The findings of other research not reported but being conducted here will be included in later reports as results become available.

We continue to receive good cooperation from the provincial extension service and other agencies in the prompt dissemination of our research findings.

An organic chemist was appointed to cooperate in our studies on insect attractants and repellents and on pesticide residue problems in livestock. Our drainage engineer, Mr. E. Rapp, resigned in October 1968.

We regret the death on September 22, 1968, of Dr. C. C. Steward, of the Veterinary-Medical Entomology Section, who was transferred here from Guelph in 1964.

Dr. T. H. Anstey, Director, was at Rothamsted Experimental Station, England, from August 1968 to February 1969 on a Nuffield Foundation Travelling Fellowship.

M. W. Cormack  
Acting Director

## CRYOBIOLOGY

A multidisciplinary Cryobiology Group comprising a winter-wheat breeder, a cytogeneticist, a forage legume breeder, a plant physiologist, a plant pathologist, and an insect physiologist reviews and integrates all of our research on cold hardiness of plants and insects and related problems of winter survival. Research conducted by members of the group includes:

- Crossing winter-hardy genetic stocks of winter wheat from several countries to obtain winterhardiness superior to that of Winalta.
- Producing monosomic lines in Winalta and reciprocal chromosome substitutions in Cadet and Kharkov 22 MC for genetic analysis of winterhardiness in wheat.

- Breeding alfalfa to combine winterhardiness and resistance to stem nematode disease.
- Evaluating the winterhardiness of strains of sainfoin obtained from the USSR.
- Studying changes in the complement of enzyme proteins and their isozymes associated with cold hardening in winter wheat and the synthetic and natural growth regulators that affect hardening.
- Investigating the influence of psychrophilic pathogens on winter survival of crops.
- Examining the extent to which insects escape freezing by supercooling and the causes of variation in this ability.

## ANIMAL SCIENCE

### Beef Cattle

*Growth of bulls, steers, and partial castrates.* The growth rate of bulls, of steers castrated at 8 and 26 weeks of age,

and of steers partially castrated at 8 weeks of age did not differ before weaning in October at an average age of 181 days or during the ensuing winter. During the

subsequent finishing period in the feedlot, the rate and efficiency of growth of the partial castrates exceeded that of the steers, but was less than that of the bulls. As a result, partial castrates reached the target slaughter weight of 440 kg 21 days earlier than the steers but 21 days later than the bulls. Bulls had less fat in the 11th rib-cut and over the *longissimus dorsi* than steers or partial castrates and consequently their carcass grades were generally lower. The percentage of separable muscle was greater in bulls than in steers and partial castrates.

*Isocaloric rations for steers.* Four rations differing in the ratio of barley to hay were given to four groups of steers in amounts that supplied approximately equal digestible energy (DE) intakes at equal body weights. Steers gained faster and their DE requirement per unit gain decreased as the proportion of barley in the ration increased. Differences in the products of digestion apparently were mainly responsible for the differences in DE utilization.

*Effect of raw sugar on salt consumption by ruminants.* Total intake of salt by cattle fed a mixture of salt and sugar increased from 61 g/head per day when no sugar was added to 394 g/head per day with a salt-to-sugar ratio of 1:4. The increased salt intake suggests that intake of the supplement was governed more by a desire for sugar than the requirement for salt. The mixture would have to contain at least 70% sugar to raise the salt intake enough to prevent siliceous calculi from forming.

*Performance of crossbred beef cattle.* In a lifetime productivity study under range conditions, Brahman  $\times$  Hereford cows (in 11 calf crops) weaned 122% more calves and produced 146% more pounds of beef to weaning than a contemporary group of Herefords.

*Cattle crossbreeding research.* In a cooperative study with Ross Ranches, Ltd., Manyberries, Alta., closed populations developed from a crossbred foundation (Brown Swiss, Hereford, Holstein, and Red Angus) are being compared with those from a straightbred foundation (Here-

ford). At weaning in 1968 the Hereford bull calves weighed 184 kg and the heifers 166 kg, whereas the crossbred bull calves weighed 213 kg and the heifers 204 kg.

The Three Walking Sticks Ranch, Duchess, Alta., is cooperating in examining how to utilize heterosis in commercial beef production. Angus, Hereford, and Holstein cows are mated to Angus, Beefmaster, Brahman, Brown Swiss, Charolais, Hereford, Holstein, Jersey, and Shorthorn sires by artificial insemination to produce the experimental cow herd. All female offspring will be mated to Simmental sires to compare their relative range performance and the feedlot and carcass characteristics of their crossbred progeny. The third calf crop was weaned in 1968, and 180 bull calves are being individually fed at the Station.

*Shade for finishing of steers.* A 2-year study of the value of shade for yearling steers self-fed barley on irrigated pasture revealed no significant differences attributable to shade, but there were certain economic advantages. The slightly higher feed costs per kg of gain of the steers with shade were offset by the 1.2% lower dressing percentage and thus lower selling value of those without shade.

## Sheep

*Relationship of body capacity and weight to wool production.* Body capacity and body weight were significantly ( $P < 0.01$ ) correlated in three breeds of sheep. The correlations between these criteria and the quantity of wool produced were positive. In Romnelet yearling ewes the correlation coefficient was 0.81 ( $P < 0.01$ ) between the body weight and greasy fleece weight and 0.68 ( $P < 0.01$ ) between body capacity and greasy fleece weight. In Romnelet yearling rams body weight and clean fleece weight were not related. Results indicated that ewes produced more clean wool per unit of body weight or body capacity than the rams; wool production efficiency was not related to body weight or body capacity; and neither body weight nor body capacity affected the quality of wool produced, but both were related to the quantity of wool produced per animal.

## Poultry Nutrition

*Influence of dietary sodium fluoride on the utilization and metabolizable energy value of a poultry diet.* The addition of 0.08% F from NaF to a basal chick diet decreased the feed consumption, body weight gain, and metabolizable energy of the feed and increased the energy required per unit gain. The metabolizable energy, feed-to-gain ratio, and energy required per unit gain of a basal-restricted group were about the same as those of the full-fed basal groups.

*Response of two lines of chickens to graded levels of dietary phosphorus.* Battery-fed broiler crossbreds and Single Comb White Leghorns responded differently to suboptimal levels of dietary P. Battery-type, dietary P level, and line of chickens each had a significant effect on livability. The battery-type  $\times$  dietary P and the battery-type  $\times$  line of chicken interactions also significantly affected livability. Voluntary food intake by chickens on the low-P diets was lower in the crossbreds than in the Leghorns.

## VETERINARY-MEDICAL ENTOMOLOGY

### Cattle Grubs

*Biology.* A method was devised to estimate rate of development of puparia of cattle grubs at temperatures that are sub-threshold for normal emergence of adults. Varying periods of exposure to subthreshold temperature were combined with an optimal standard temperature for which rate of development is known. It was found that development is arrested at 10 C. No adult flies emerged from puparia at temperatures below 17 C. A consistent thermal constant of 225 degree-days was obtained for puparia of *Hypoderma lineatum* (de Villers) when the threshold temperature was set at 10 C. A threshold setting at the minimum temperature for emergence (17 C) gave inconsistent values for the thermal constant ranging from 50 to 150 degree-days.

*Control.* Cattle grubs have been sampled annually within organized warble-control areas in Alberta to assess the principle of maintaining warble-free counties. Surveys indicated that continuous total treatment may not be necessary to prevent reinfestation once the grubs have been exterminated from a designated area. There was no resurgence of grubs when 70% of the cattle were treated with systemic instead of contact pesticides for control of lice.

Sodium alginate was tested as an adjuvant in immunization of cattle against grub infection. It had no significant effect on the antigenic activity of a vaccine prepared from first-instar larvae of *H. lineatum*.

### Ectoparasites

*Sheep keds.* The sheep ked was found to be a vessel feeder (solenophage) when it was observed on a transilluminated mouse ear. The haustellum of the ked probes the subepidermal tissue with a reciprocating motion accompanied by continuous activity of the prestomal teeth. The labella penetrate blood venules of 30 to 100  $\mu$  immediately on contact. Blood sucking begins after the prestomal teeth have everted to anchor the labella to the vessel. Saliva enters the vessel during engorgement, which is complete in 5 to 10 min. Biopsy of sheep skin containing the mouthparts indicated that keds tend to feed from venules around wool follicles and near the apocrine glands.

### Biting Flies

*Black flies.* Ecological studies on black flies in Alberta showed that *Simulium arcticum* Malloch is the most common species in large streams in drainage basins. It is the main pest of livestock along the Athabasca River in the north central part of the province, where it attacks cattle in large numbers. The species is numerous in the Crownsnest-Oldman drainage system, but is inconspicuous as a pest of cattle. Its economic importance is determined by differences in behavior at the subspecific level.

*New pests.* A serious pest of man and animals at Fort McMurray, Alta., was identified as a biting midge, *Culicoides obsoletus* (Meigen). It has been a major concern in new residential and industrial development because it attacks persistent-



ly in the afternoon and evening during June, July, and August.

### Livestock Pesticides

*Toxicology.* Investigations of side effects associated with certain organophosphorus pesticides showed no relationship between the presence of cattle grubs and the syndrome of toxicosis. Yearling cattle with larvae of *Hypoderma bovis* (Linnaeus) were treated with the systemic compounds coumaphos, crufomate, and trichlorfon. Dead and dying grubs caused lesions in the spinal canal 48 hr after treatment. They induced no clinical symptoms of poisoning such as ataxia or paralysis in the hind limbs.

Further experiments showed that toxicity of coumaphos adversely affects growth rate in yearling cattle on a high level of nutrition in feedlots as well as on pasture. Appetite as indicated by food consump-

tion was unaffected by the treatment. Reduced rates of gain previously observed in treated cattle on summer range are related, therefore, to nutritional disturbances rather than to toxic impairment of grazing ability.

*Evaluation.* Bromophos was found to be a highly effective pesticide against horn flies, mosquitoes, and other biting flies when used as a low-volume, fine-droplet spray on cattle.

Use of pesticides on yearling cattle for protection against biting flies provided a consistent increase in rate of gain when pasture exceeded grazing requirements. Maximum increase in individual animals during a 70-day grazing period between July 1 and September 15 was 354 g/day. There was no difference between treated and untreated yearlings on overgrazed irrigated pastures.

## PLANT SCIENCE

### Cereals

*Leaf spot mutation in barley.* A non-parasitic leaf spot found in Parkland barley appears to be from a mutation in that variety. The inheritance of spotting was associated with semisterility in crosses with translocation stocks T4-5a and T1-5b, indicating that the gene is located on chromosome 5. Further testing showed the gene to be independent of the gene *b* for lemma and pericarp color (chromosome 5), but associated with the gene *ms* for male sterility (26% recombination).

*Inheritance of root-rot reaction in wheat.* Inheritance of reaction to common root rot, caused chiefly by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, was studied in F<sub>3</sub> populations of common wheat, *Triticum aestivum* L., from crosses between the root-rot-resistant, hollow-stemmed varieties, Thatcher and Pembina, and the moderately root-rot-susceptible, solid-stemmed variety, CT 733. The results showed that the resistance of Thatcher and Pembina, which appear to have the same gene complement, is controlled by a major recessive gene and one or two minor genes.

No association was found between inheritance of root-rot reaction and the in-

heritance of stem solidness, which determines resistance to the wheat stem sawfly, *Cephus cinctus* Norton. Therefore, there should be no difficulty in incorporating root-rot resistance into sawfly-resistant varieties.

### Forage Crops

*Native and cultivated grasses for range pasture.* Weight gains of yearling ewes during a 7-month grazing season were 2.6 and 3.2 times as great on crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., and Russian wild ryegrass, *Elymus junceus* Fisch., as they were on native range. Where the ewes had free choice in grazing they went first to crested wheatgrass in early spring, then to the native range, and then to Russian wild ryegrass. Liveweight gains were 2.2 times as great under the free-choice system as they were on native range alone.

*Fertilizer on native range and seeded pasture.* A 6-year-old seeding of brome-grass, *Bromus inermis* Leyss., and creeping red fescue, *Festuca rubra* L., produced only one-third as much dry matter as native fescue grassland when neither was fertilized. When N and P fertilizers were applied, the seeded grasses showed the greatest response. At the highest rate of

fertilization (1,015 to 1,120 kg of N per ha and 815 to 860 kg of P per ha) 3-year cumulative yields on seeded pasture exceeded those on native grasses by 4.6 times on N-treated plots, and by 2.6 times on N- plus P-treated plots.

*Growth of grasses at four root-zone temperatures.* Six native grass species, and six introduced grass species, were germinated and grown for 90 days at root-zone temperature of 7, 13, 18, and 27 C. In general, the introduced species were superior to the native species in percentage and speed of germination, and they germinated, emerged, and grew more readily at lower root-zone temperatures. Introduced species produced about 10 times as much weight of leaf and about 8 times as much weight of root as the native species produced at comparable growth stages.

*Irrigated pasture.* In a comparison of grasses for irrigated pasture, grazing yearling Hereford steers made an average daily gain of 1.0 kg/head on orchardgrass, *Dactylis glomerata* L., and 1.3 kg on pubescent wheatgrass, *Agropyron trichophorum* (Link) Richt. Orchardgrass made more uniform seasonal growth and was easier to manage than pubescent wheatgrass. By the end of the fourth season pubescent wheatgrass had become quite weedy.

*Field corn trials.* Variety trials showed that field corn can be grown successfully for silage on much of the irrigated land in southern Alberta. Plot yields as high as 22 metric tons of dry matter per ha were recorded, and many hybrids produced more than 16 metric tons. In cooler seasons yields were lower, but still good silage crops were produced in the favored areas. Grain production is risky with the hybrids currently available.

## Horticultural Crops

*Low-temperature growth responses of tomatoes.* The effects of low temperatures on several growth phases of tomatoes were studied. The tests, each conducted over a 2-week period, included seed germination at 8.5 C, rate of seedling growth at a night temperature of 10 C, root and top growth

of plants in soil at 15 C, and fruit set at a night temperature of 4.5 C.

Varietal response to growth rate at low temperatures differed in all phases studied, and varieties that performed well in some phases did not always perform well in others. Of the varieties studied, six grew well under most of the low-temperature conditions. These were Earlinorth, Bonita, Azerbidzivisky, P.I. 205040, P.I. 280597, and Cold Set.

*Seed-coat color in common beans.* In crosses between a white-seeded and a green-seeded variety of *Phaseolus vulgaris* L., seed-coat color was found to be inherited as a simple recessive. Other parental characters that were inherited as a unit with green seed-coat color were white cotyledons (after emergence), white flowers, yellowish-green anthers, and dull dark green mature leaves and pods. It is proposed to incorporate this green seed-coat color into the variety Limelight through a backcrossing program.

*Earligold muskmelon.* Earligold is an early-maturing muskmelon (cantaloupe), *Cucumis melo* L., developed for the southern Canadian prairies. It produces ripe fruit 7 to 10 days earlier than the small-fruited varieties, Wheat City and Farnorth. Its fruit size is comparable with that of imported muskmelons. Earligold yields well, producing high-quality fruit at "full slip," with excellent flesh color, texture, and flavor. It was developed at the Station from a cross between a large-fruited selection of Farnorth and an Oregon State University selection.

*Vegetable variety trials.* Variety trials showed that many kinds of vegetables can be grown successfully on irrigated land in southern Alberta. Some of these vegetables are now in commercial production; others could be grown where microenvironments are favorable. Crops tested recently include snap beans, red beets, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celery, sweet corn, cucumbers, lettuce, muskmelons, okra, onions, peas, peppers, pumpkin, radishes, squash, and tomatoes.

## SOIL SCIENCE

### Soil Fertility and Management

*Factors affecting soil productivity.* It was found in tests that grassland soil organic matter has some quality that allows a crop (oats) to respond to P fertilizer. This quality is progressively destroyed as poplar trees advance on the grassland; it is nonexistent under coniferous trees. However, by removing the trees and establishing grass, this quality of grassland soil organic matter returns, and the crop again responds to P fertilizer.

Water intake rates and levels of available P had more effect than other soil properties on the growth of barley on a group of irrigated Brown Solonetz and associated Chernozemic soils. Their effect on yields in the field was of equal importance. In the greenhouse the fertility factor was predominant. Some measure of water intake rate is essential in assessing the suitability of these soils for irrigation.

*Fertilizing fescue grassland and barley.* Application of increasing rates of N (0 to 1,120 kg of N per ha) or N plus P (0 to 860 kg of P per ha) fertilizer on fescue grassland vegetation resulted in increasing yield, palatability, and length of growth period of the forage. The residual effect of the fertilizer persisted throughout the 4-year study. Composition of species changed distinctly at the higher rates of fertilizer.

Four barley varieties responded differently to N fertilizer in a greenhouse experiment. At high N levels the differences were pronounced and consistent. Betzes and Hannchen were highest in yield and lowest in protein, Palliser was intermediate in both respects, and Compana was lowest in yield and highest in protein. At low N levels differences between varieties were small and irregular.

It is suggested that relative yield capabilities of genotypes can be estimated by controlled experiments of this sort. To check further on this proposal and the extent to which results of other greenhouse experiments can be extrapolated to field conditions, a fully automated rain shelter that provides 150 m<sup>2</sup> of plot area

was constructed. Detailed plans are available on request.

*Conservation practices on cereal stubble.* The ultimate aims of fallow cultivation are to control weeds and to leave the stubble in an upright position. The wide-blade cultivator and the heavy-duty cultivator loosened some cereal stubble during each of three tillage operations and left, after the third, a trash cover that contained about 90% loose material. Generally, the loosening effect was not influenced by variations in speed or depth of operation, or stubble height. The loosening of stubble by disc machines was least for deep tillage (6 inches) and greatest for shallow tillage (2 inches) on stubble high enough to strike the spacer spools on the machines.

Two tillage operations with the wide-blade cultivator, or one with the heavy-duty cultivator, or, infrequently, one with the one-way disc left stubble upright. One additional of any of these operations usually flattened the residue.

### Irrigation and Drainage

*Evapotranspiration relationships.* Daily evapotranspiration differed for perennial sward, annual row crops, and annual close-seeded crops, and in each case depended on the stage of crop development. But as soon as the crop reached the "full ground cover" stage, potential evapotranspiration for all crops could be calculated directly from a formula involving radiation and mean temperature. Introduction of a coefficient into the equation permitted correction for periods of below-maximum vegetation.

Evapotranspiration by orchardgrass from June to September was 38.8, 37.2, and 34.9 cm with water tables at depths of 91, 122, and 152 cm. This amounted to about 60% of the potential evapotranspiration and was nearly all due to transpiration. Evaporation from a bare soil in 1967 was not high enough to cause salt accumulation on the soil surface. It seems that most salinization of such a soil would occur outside the growing season.

*Tile drainage performance.* Tile drains, installed at slopes ranging from 0.15 to 0.4%, effectively intercepted groundwater movement in an irrigated problem area of coarse-textured soils overlying finer materials. As a result, the water table was maintained at a safe level and salinity was reduced. Relief drains, 15 cm in diameter, installed at similar slopes 305 to 527 m apart, were not as effective as the interceptor drains.

In a waterlogged saline soil underlain by glacial till, closely spaced tile, 0.9 m deep, provided adequate correction. "Zippered" plastic-lined mole drains at a depth of 0.6 m were moderately effective but short-lived. Unlined mole drains showed little improvement over the check treatment.

*Permeability calculated from desaturation data.* A simplified procedure for calculating permeability of saturated and partly saturated soils was developed. The method involves the use of parameters obtained from capillary pressure-desaturation data and the relative permeability equations of Brooks and Corey. Calculated values agreed within 27% of laboratory measurements of permeability of three disturbed soils, each packed at five different values of porosity.

## **Soil Physics and Chemistry**

*Salt-affected soils.* Water movement through the Ap horizon of a Solonchik soil was almost as slow as it was through the Bn horizon. The low rate of water transmission through such soils made it very difficult to determine moisture contents in equilibrium with 15 bars pressure (wilting point). The addition of salts containing  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ , and  $\text{NH}_4^+$  increased the rate of water movement and improved the structure.

The mobility of ions in clays plays an important part in ion diffusion in soils. The addition of silt to bentonite gels increased the equivalent conductance, and consequently the mobility, of adsorbed  $\text{Na}^+$  by a factor of at least 1.3. The influence was not so pronounced when sand was added. The addition of these materials apparently changes the geometry of the pores, causing increases in the tortuosity factor.

*Extraction of organic phosphorus.* The P contained in the organic matter constitutes a major part of the total P content of Chernozemic soils. A procedure utilizing extraction with Dowex A-1 resin was more closely correlated with humic acid P than was the commonly used 1 N NaOH extraction. Neither method was completely satisfactory for analysis of the Bm horizon of Chernozemic soils.

*Infrared absorption studies.* When humic acids extracted from soils formed under grass, parkland, and tree vegetation were treated with  $\text{H}_2\text{O}_2$ , the mineral residue displayed infrared absorption patterns characteristic of the original soil-forming processes. For example,  $\text{CaCO}_3$  bands at 1,325 and 780  $\text{cm}^{-1}$  were strong in preparations from Chernozemic soils and weak or absent in Podzolic samples. As transformation from Chernozemic to Podzolic humic acids progressed, a band at 830  $\text{cm}^{-1}$ , tentatively attributed to  $\text{NO}_3$ , became discernible, whereas the quartz band (780  $\text{cm}^{-1}$ ) decreased.

Spectra of mineral matter obtained by the peroxidation of lichens and mosses generally differed from those of the parent rock. Nevertheless, certain features of the spectra obtained for lichens and mosses, such as the intensities of  $\text{CaCO}_3$  bands (1,325 and 780  $\text{cm}^{-1}$ ), were indicative of the amounts of  $\text{CaCO}_3$  in the parent rock.

## **Soil Classification**

*Land-vegetation typology.* Land-vegetation mapping units (ecosystem-types) were established for the Upper Oldman River Basin, Alta., with special reference to their value for watershed research and management. The ecosystem-types were defined by delineating the types of surficial deposits and then examining the variation in soils and vegetation. Soils were closely associated with the types of surficial deposits, being Gray Wooded and Brown Wooded on calcareous materials and Podzolic and Acid Brown Wooded on noncalcareous materials. Vegetation was affected primarily by its position on the slope and by groundwater seepage, which in turn were associated with hygrophytes and with gleyed soils.

# CROP ENTOMOLOGY

## Aphids

Alberta winters may not prohibit survival of the oat bird-cherry aphid, *Rhopalosiphum padi* (L.). Aphids of this species were found alive during the winter on sprouting grain beneath field-stored barley.

Two of five genera of gall aphids (Eriosomatinae) could not be separated by chromosome counts. Comparisons of total complement lengths and areas of the somatic chromosomes gave more accurate distinctions between species and may prove more useful than chromosome counts alone.

## Cutworms

The widespread damage caused by the red-backed cutworm, in the Peace River region in 1967, extended south as far as Olds, Alta., in 1968. The pale western cutworm was not a problem in 1968.

A cabinet developed for rearing cutworms features a chain-sprocket mechanism that moves groups of individual dishes to readily accessible feeding positions.

Choline is essential in the diet for development of pale western cutworm larvae.

## Grasshoppers

In 1968 a delay in hatching reduced spring damage, but considerable control was required in the fall. Less infestation is expected in 1969. In Alberta 5,600 sq miles of light and 1,700 sq miles of moderate infestations are expected, with the two-striped grasshopper as the predominant species.

Copulation affects fecundity and longevity of females. Those that copulated once laid more eggs and lived longer than those that copulated more than once. But because fertility with the single copulation was low, the total production of fertile eggs from single or multiple copulations was the same.

## Wheat Stem Sawfly

Production of new sawfly-resistant wheats requires dependable sawfly infestations. A quarter of a million sawfly stubs can be collected in a day by two men using a modified potato digger. The sawfly

nursery of 20 acres was established at the Station by adding 240,000 sawflies. Within 8 years infestations exceeded 80%.

Visual estimates ranked varieties accurately for sawfly resistance but not for damage or the differences in resistance among varieties. Sawfly cutting of less than 50% was usually underestimated and surveys using visual estimates alone underestimated the sawfly population.

## Pollinating Insects

Seven subgenera of *Bombus* have been compared for behavior. Evolutionary trends unseen in morphological studies were found. Subspecies are diverging because they can no longer share habitats and are separated spatially. Traits not common to all species of the subgenus were found in two or more subgenera, showing flaws in a taxonomic system based on morphology alone.

North American solitary bees and parasites that nest or parasitize in hives of the alfalfa leaf-cutter bee, *Megachile rotundata* F., were found to have shorter incubation periods than *M. rotundata*; hence they could be destroyed by incubating and light-trapping.

## Soil-borne Insects

The sex attractant of the sugar-beet wireworm, which is produced in the fifth and sixth abdominal segments of the females, decreased in amount within 4 hr after mating. The male receptors were located on the sixth, seventh, and eighth distal antennal segments. The males of this species responded only to sex attractants of their own species, whereas males of the Pacific coast wireworm responded to attractants from both species.

## Cabbage Maggot

Differences between rutabaga varieties in resistance to *Hylemya brassicae* (Bouché) were determined by confining newly hatched larvae to whole roots or to segments. Resistance was mainly a characteristic of the root surface. Wilhelmsburger was the most resistant of the varieties tested.

## Insect Cold Hardiness

Experiments showed that the extent of insect supercooling is determined by the quality and quantity of ice nucleators in the materials in the digestive tract. In this, the nature and the contaminants of the food of an insect are of prime importance.

Freezing temperatures of pine needles rose with increasing needle length, showing that the quantity of ice nucleators is critical, rather than the quantity of water involved. As in insects, the efficiency of the nucleators and the abundance determine freezing temperatures.

## PLANT PATHOLOGY AND PHYSIOLOGY

### Cold Hardening of Wheat

CCC (Cyanamid of Canada Limited) induced a small but significant increase in the cold hardiness of winter wheat plants grown at either 5 C or 20 C. Kharkov 22 MC was grown in vermiculite and watered daily with nutrient containing  $3 \times 10^{-3}$  M,  $3 \times 10^{-4}$  M, or  $3 \times 10^{-5}$  M CCC. The greatest increases in cold hardiness were observed when plants that had been fed  $3 \times 10^{-4}$  M and  $3 \times 10^{-5}$  M CCC reached the four- to six-leaf stage of development. Plants grown at 20 C and fed  $3 \times 10^{-3}$  M CCC had less cold hardiness than the control plants fed plain nutrient.

### Alfalfa Diseases

The stem and bulb nematode, *Ditylenchus dipsaci* (Kühn), caused the formation of galls on the upper taproot areas of alfalfa plants in the greenhouse. It was shown histologically that here, as in stems, the nematodes destroyed the parenchymatous tissues and thus formed cavities. Nematode infection did not materially alter the reaction of Roamer, Rambler, or Vernal alfalfa to bacterial wilt when these varieties were inoculated with both pathogens simultaneously, but alfalfa infected with bacterial wilt was a relatively poor host for *D. dipsaci*.

An inhibitor produced by a strain of the alfalfa wilt bacterium, *Corynebacterium insidiosum* (McCull.) Jensen, did not pass through a millipore filter. Production of this inhibitor was retarded in a medium containing a commercial potato extract. This extract interfered with the assay of the inhibitor against a sensitive strain of *C. insidiosum*. The alfalfa wilt bacterium, previously shown to persist in wilt-infected alfalfa stems for 10 years, was not viable after 20 years in these stems. *C. insidiosum* persisted for 41 days in wilt-infected

alfalfa roots buried in soil with moisture at field capacity and held at 20 C.

### Soil-borne Pathogens

Four fungicides were applied to the soil of field plots at three rates for control of pea root rot. Root rot was lower in peas grown in soil treated with benomyl (Benlate; formerly du Pont 1991), Demosan (E.I. du Pont de Nemours & Company, Inc.), Bayer 33172 (Chemagro Corp.), and the lowest rate of Chemagro 4497 (Chemagro Corp.) than in those grown in soil treated with the higher rates of Chemagro 4497 or in untreated soil. Yields of untreated plots differed little from those of plots treated with benomyl and Demosan. Yields of plots treated with Bayer 33172 were low due to severe phytotoxicity. The cool moist growing season in the Lethbridge area in 1968 was probably favorable for the growth of peas and minimized the adverse effect of root rot on yield.

The development of an efficient root-rot testing procedure has made possible recent genetic and cytogenetic analyses of the reaction of wheat to common root rot. Field soil, naturally infested with root-rot pathogens, was used in controlled-environment tests and yielded consistent results with relatively small numbers of plants.

### Crop Residue

The residue from a rapeseed crop of 33.6 kg/ha left on the soil by a combine harvester reduced the growth of subsequent cereal crops. The reduction in growth may have been caused by a toxin from the residue and not from pathogenic action or a nutritional deficiency. The adverse effect from the rape residue did not persist into the second growing season. Loss of yield could probably be reduced by distributing the residue uniformly.

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## INTRODUCTION

This report summarizes the main research findings for 1968 at the Research Station, Agassiz, and the Small Fruits Substation, Abbotsford. Completed research is reported in more detail in the scientific papers and other publications listed at the end of this report. Reprints of these articles are available from the authors.

Two varieties developed in the small fruit breeding program of the Station were named and released this year. Cheam strawberry, which has proved to be well adapted in British Columbia and Washington State, is intended primarily for the processing trade. A new raspberry variety,

Matsqui, has superior fruit quality and offers particular promise for mechanical harvesting.

Excellent progress was made during the year in the application of automated equipment to many soils analysis procedures, thereby greatly increasing the scope of the research without increasing manpower. Research in poultry physiology was instituted to develop management procedures designed to overcome some of the stress problems associated with intensive egg production.

M. F. Clarke  
Director

## SOILS

### Interpretation of Soils Data by Computer

A system of computer storage, retrieval, and processing of soils data has been devised and tested. The aim is to develop a standardized method for recording all relevant soils information collected by various agencies engaged in pedological and edaphological research in British Columbia. During 1968, data describing 177 profiles of soils of British Columbia were coded and assembled on punched cards; over 24 thousand observations were recorded. The coding method devised is open-ended, allowing additional information to be added for any soil at any time.

### A Universal Method for Colorimetric Determination of Phosphorus in Soil and Plant Materials

A modified ascorbic acid method for colorimetric determination of P, which can be conveniently used for all common-

ly used soil and plant analysis procedures, has been described. This method is not affected by moderate variations in acidity, temperature, time, and reducing reagent. It tolerates many of the interfering ions found in soil and plant extracts, including  $Fe^{+++}$  up to 800 ppm. The proposed method has been found to be more precise than other colorimetric procedures.

### Availability of Forms of Phosphorus

In a growth-chamber study of 32 different soils of British Columbia the uptake of P was correlated with the Al-P and Fe-P fractions. The total uptake by corn and peas was better related to Al-P and Fe-P of the sand particle-size fraction than to that of silt- and clay-size fractions. Among eight soil-extraction methods, including isotopic exchange, the P uptake was correlated best with the bicarbonate method ( $r=0.884$ ) and the calcium acetate method ( $r=0.846$ ).

## VEGETABLES

### Hydrocooling of Sweet Corn

Freshly harvested ears of sweet corn, cv. Mellogold, hydrocooled by immersion in water held at 3–4 C were compared with ears stored at a constant temperature of 22 C. Air-stored ears reached ambient temperature after 3 hr and then rose above the air temperature. These ears continued to increase in specific gravity and percentage total solids, whereas hydrocooled ears remained at relatively constant values for approximately 24 hr.

If hydrocooling facilities are available and ear temperature is reduced to 4 C, sweet corn will keep for 24 hr before processing.

### Effect of Varying Soil-water Regimes on Snap Beans

Bush beans were grown in weighing lysimeters to determine their response to five soil-water regimes. The highest yields and quality were obtained when soil moisture was maintained close to field capacity, i.e., applying irrigation when soil water fell to 88% of available. Delay of irrigation until soil water dropped to 60% of available resulted in a significant reduction in yield. Plants irrigated when soil water reached 32% of available were small and low in yield. Similarly, plants provided with ample water before blossom and then subjected to water stress gave low yields. Plants grown under stress conditions before flowering recovered if ample water was provided after blossom, but they did not yield as well as plants given ample water throughout the growing period.

### Herbicides for Vegetable Crops

Several herbicides were tested as pre-planting, preemergence, and postemergence treatments for sweet corn, bush beans, brassicas, and potatoes. A summary of some of the results follows. Rates are expressed as acid equivalent or active ingredient in pounds per acre.

*Sweet corn.* Considerable work was done to find effective preemergence treatments for the control of barnyardgrass.

In a planting of Early King sweet corn, seasonal control of barnyardgrass was obtained with the following: Linazine at 2 lb; Linazine at 1.5 lb + oil at 1.5 gal; linuron at 1.5 lb; linuron at 1 lb + dalapon at 8 lb; C6313 at 3 lb; NC4780 at 2 and 4 lb; VCS438 at 2 and 4 lb; and SD15418 at 4 lb. These treatments also gave seasonal control of broad-leaved weeds. VCS438 at 4 lb reduced yield (ear and stover). There was also a tendency for linuron at 1.5 lb to cause some decrease in yield.

*Bush beans.* Six herbicides were tested singly or in combination, or both, as pre-emergence treatments on Harvester bush bean. UC22463 at 6 and 8 lb gave excellent control of grasses and broad-leaved weeds and showed no adverse effect on germination and yield of crop. Dinoseb emulsifiable concentrate at 2 lb + monolinuron at 1 lb gave good control of broad-leaved weeds, but only initial control of grass. Metobromuron at 1.5 lb gave slightly better control of broad-leaved weeds than the dinoseb–monolinuron mixture. C6989 at 4 lb reduced germination of the crop and failed to control chickweed. A mixture of C6989 at 2 lb + metobromuron at 1 lb improved grass control but injured the crop.

*Cabbage.* Research continued on the study of the effect of herbicides in combination with soil insecticides on direct-seeded cabbage. In 1968 the insecticides fensulfothion (Dasanit), thionazin (Zinophos), and carbofuran (Furadan) were tested for root-maggot control and herbicide compatibility. The best preplant weed-control treatments were trifluralin at 1 lb and chlorthal at 6 lb + CDEC at 4 lb, followed by SD11831 at 3 lb. None of these herbicides or their combinations with any of the three insecticides affected crop germination or yield. In the preemergence trial, C7019 at 2 and 4 lb gave very good weed control, but showed some incompatibility with the soil-applied insecticides thionazin and fensulfothion. There was no evidence of incompatibility with carbofuran. Propachlor at 4 and 6 lb showed considerable promise and appeared

compatible with all three insecticides. In the postemergence trial no significant difference in efficacy was found between nitrofen E25 and nitrofen 50W. Nitrofen E25 caused more injury to cabbage than nitrofen 50W. Triton XA increased the effect of the treatments only slightly. Nitrofen gave good control of redroot pigweed and wild buckwheat, but did not control shepherdspurse, common chickweed, low cudweed, corn spurry, ladysthumb, or barnyardgrass. Nitrofen and nitrofen-picloram mixture appeared to be compatible with the insecticides.

*Potatoes.* Several herbicides were tested singly and in mixture as preemergence or

postemergence treatments on Kennebec and Pontiac potatoes. C6313 at 1 and 2 lb, applied preemergence to the crop but after weeds had emerged, proved more effective than when applied at 2 and 4 lb before weed germination. Grass control with postemergence application of the diphenamid-dinoseb mixture increased directly with rate of application. Metobromuron at 1.5 lb gave complete control of broad-leaved weeds, but resulted in poor grass control when applied after the emergence of the crop. Propanil at 1 and 1.5 lb and prometryne at 1 lb controlled most broad-leaved weeds with the exception of purslane and chickweed or the grasses.

## SMALL FRUITS

### New Varieties

*Cheam strawberry.* The strawberry variety Cheam (BC-3) was released by the Station. It has better winterhardiness and greater resistance to root rots, including red stele, than the widely grown variety Siletz. The fruit is uniform, moderately firm, and medium red. The plant is vigorous and produces runners profusely. Under conditions where red stele and other root rots were present or where there had been winter injury, Cheam outyielded Northwest.

*Matsqui raspberry.* The raspberry variety Matsqui (BC-202) was named by the Station late in 1968. It was selected because of its attractive bright red fruit, which is firm and medium to large in size. The fruit is also more tolerant of rot than that of Willamette, does not darken when picked, and shakes off readily. This last characteristic suggests that Matsqui might be well adapted to mechanical harvesting. The plants are vigorous and have smooth, sturdy, upright canes. They are susceptible to aphids, but have remained virus-free. Therefore the variety may be virus tolerant.

### Red Raspberries

*Variations in self-fertility in the red raspberry.* Of seven red raspberry cultivars examined for self-fertility, one of these,

Ore-US 1314, showed much reduced drupelet set (crumbliness) when flowers were self-pollinated. Open-pollinated flowers gave normal drupelet set. Ore-US 1314 produced a large amount of aborted pollen and it was assumed that this was the cause of the reduced drupelet set on selfing. It is possible that self-infertility, caused by partial or complete male sterility, might be found for other cultivars.

*Effect of viruses on pollen quality of red raspberries.* During the study of the effect of different viruses on the growth and fruiting of four raspberry cultivars, pollen quality was examined. In May 1968 flowers were collected from which pollen from five clones of each of the following was examined: Fairview, Newburgh, Sumner, and Willamette. No single virus or virus combination was uniformly associated with reductions in the amount of normal pollen in each of the varieties. For example, tomato ringspot caused the greatest reduction in Fairview, black raspberry necrosis in Newburgh and Sumner, and the combination of viruses the greater reduction in Willamette.

*Methods of analyzing for resistance to powdery mildew.* Seedlings of 18 progenies of red raspberry at Agassiz, B.C., and 59 progenies at Dundee, Scotland, were examined for resistance to powdery mildew, and the data were analyzed according to

two models. The analysis based on the model for discontinuous variation supported the hypothesis that segregation was controlled by two additive genes for resistance and one epistatic gene for susceptibility. This analysis gives information on the possible genotypes of the parents, which facilitates predictions on the proportion of resistant seedlings expected in breeding programs.

The analysis based on the model for continuous variation also indicated that inheritance was predominately additive with significant genetic interactions. However, the estimates of parental contributions to the progenies were more widely based, because allowance was made for the effects of different gene variabilities, of modifying genes, and of environmental influences on expression of the disease. Estimates of combining ability obtained from this model facilitate predictions of mean resistance of progenies.

The use of both models appeared to provide a more complete assessment of parental resistance contributions than either model used alone.

### **Response of Strawberries to Herbicides**

*Reaction to chloroxuron and simazine.* Six varieties, Agassiz, British Sovereign, Hood, Northwest, Puget Beauty, and Siletz, were planted in the spring of 1967

so that a study of variety response to the herbicides chloroxuron and chloroxuron-simazine combination could be made. In the first year, plants treated with chloroxuron showed differences in varietal reaction that ranged from no effect to considerable chlorosis and reduction in leaf size. Leaves of British Sovereign and Puget Beauty showed considerable chlorosis and reduction in leaf size. Siletz exhibited slight chlorosis, but leaf size was reduced. Northwest and Agassiz showed moderate chlorosis, and leaf size was reduced only slightly. Hood showed no apparent injury, and no chlorosis or reduction in leaf size. In 1968, the total yield of fruit was not affected by any of the herbicidal treatments.

*Herbicides for new plantations.* Several herbicides were tested on a new plantation of Northwest variety. Lenacil at 1.6 lb gave fair control of most weeds, but did not control redroot pigweed or barnyard-grass. Chlorthal at 8 and 12 lb provided good control of grasses, but no control of shepherdspurse and common groundsel. Diphenamid at 4 and 6 lb applied after shallow cultivation gave fairly good control of all weeds. Chloroxuron at 5 lb and diphenamid-chloroxuron mixtures provided satisfactory control of most species except prostrate knotweed and barnyard-grass.

## **ANIMAL SCIENCE**

### **Soybean Meal vs. Rapeseed Meal for High-producing Dairy Cows**

Soybean meal and rapeseed meal were compared as the main sources of supplemental protein in grain rations for 20 high-producing Holstein-Friesian cows fed corn silage as the only source of roughage. Milk production of the cows fed rapeseed meal declined sharply during the first 2 weeks of the experiment, then continued to decline at a rate greater than that for the cows fed soybean meal. Average daily milk production for the 120-day trial, expressed as 4% fat-corrected milk,

was 47.4 and 41.4 lb for the soybean- and rapeseed-fed groups. The results indicate that rapeseed meal is not suitable as the sole source of supplemental protein in grain rations for high-producing cows receiving corn silage as the only roughage.

### **Energy Loss as Undigested Grain by Dairy Cows Fed Corn Silage**

A study was conducted to determine the apparent energy loss as undigested kernels when corn silage was fed as the only roughage to milking cows. Hand-separation of the fed silage revealed that corn kernels

represented 18% of the silage dry matter. Total feces collection followed by separation showed that corn kernels represented 2.3% of the fecal dry matter. In vitro digestibility of the kernel residues gave a dry-matter digestibility of 43%, whereas digestibility of kernels in the silage as fed was 65%. This indicated that the more digestible carbohydrate fractions had already been removed from the fecal kernels. Further calculations from the digestibility data revealed that less than 1% of the energy or digestible dry matter consumed as corn kernels in the silage was lost in the feces.

### **Effect of Hormones on Beef Production from Holstein-Friesian Steers and Bulls**

Thirty-six Holstein-Friesian bull calves reared to 475 kg liveweight grew more rapidly and were more efficient but showed less response to hormone implants than did a comparable group of 36 steers. Bulls had heavier heads and hides, lighter hind-quarters, less abdominal and rib fat, and in the cooler shrunk more than steers. Hormone treatment increased hide weight and rib moisture in steers, but decreased these characteristics in bulls. Bulls had heavier livers than steers, and hormone treatment increased liver weight in steers.

## **POULTRY**

### **Enzyme Activities of Chicken Spermatozoa**

Chicken spermatozoa were found to contain appreciable amounts of lactic dehydrogenase, glutamic oxalacetic transaminase, creatine phosphokinase, aldolase, phosphohexose isomerase, acetyl cholinesterase, and leucine aminopeptidase. They contain small amounts of glutamic pyruvic transaminase, glutamic dehydrogenase, and no amylase. The relative activity of the various enzymes indicates that the hexose monophosphate shunt is of little importance compared with the glycolytic cycle. Glutamic oxalacetic transaminase is the main route of glutamic metabolism in chicken spermatozoa.

### **Effect of Cold Stressing Chicken Embryos**

An experiment was conducted to determine if cold temperature stress could be applied on the 17th day of incubation to prevent weak and potentially slower growing embryos from hatching without having a harmful effect on the posthatching per-

formance of surviving embryos. On the 17th day of incubation, White Leghorn embryos were subjected to either  $21.2 \pm 1$  C,  $11.3 \pm 1$  C, or  $5.2 \pm 1$  C for 0, 4, 8, 12, 16, 20, or 24 hr.

Exposure of 17-day-old embryos to  $21.2$  C for 24 hr had little effect on hatchability. Temperature exposures of 11.3 and 5.2 C had a much more severe effect. There was an interaction between hours exposed to cold stress and storage time before setting. A regression analysis of chick weight on time exposed to cold showed that body weight to 6 weeks was not influenced by exposure of embryos to  $21.2$  C. A similar analysis showed  $11.3$  C had a deleterious effect on 2-, 4-, and 6-week body weight of males but not females. Male chicks from embryos exposed to 5.2 C for 8 hr were 1.2% lighter than the controls; at 4 and 6 weeks they were 4.3% and 7.3% heavier than the controls. It was also noted that male chicks exposed to 5.2 C for 12 hr on the 17th day of incubation increased in weight from 4 to 6 weeks of age faster than the controls.



# MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
C6313	CIBA Company Ltd.
C6989	CIBA Company Ltd.
C7019	CIBA Company Ltd.
Dasanit	Chemagro Corp.
EPTC	Stauffer Chemical Co.
Furadan	Niagara Chemical Division, FMC
Lenacil	E. I. DuPont de Nemours & Co. (Inc.)
Linazine	Niagara Chemical Division, FMC
NC4780	Fisons (Canada) Ltd.
Propachlor	Monsanto Chemical Co.
SD15418	Shell Canada Ltd.
SD11831	Shell Canada Ltd.
UC22463	Union Carbide Corporation
VCS438	Velsicol Corporation
Zinophos	Cyanamid of Canada Ltd.

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# Research Station

## Kamloops, British Columbia

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## INTRODUCTION

The Research Station, Kamloops, B.C., works mainly on problems of the ranching industry. In 1968 the Station did research on the management of cattle and vegetation on both natural and reseeded ranges, the testing of species and varieties for winter feed, the management of irrigated pastures, the improvement of organic meadows, and the classification of alpine

soils. Research was also done on the ecology, physiology, and control of several species of ticks, cattle grubs, mosquitoes, and black flies. As in other years, many of the experiments were done on ranches with excellent cooperation from the ranchers.

R. H. Handford  
Director

## YIELDS OF FORAGE AND BEEF FROM RANGELANDS

Yields of pinegrass, *Calamagrostis rubescens* Buckl., from plots clipped at different dates and frequencies for the third consecutive summer differed significantly in 1968. In general, the plots clipped early and frequently yielded less than those clipped later and less frequently. Differences in yields had not been significant in either 1966 or 1967.

At the end of the growing season pinegrass plants were pulled out of the soil by hand from the same plots for 3 consecutive years. Yields were reduced each year; the main reduction occurred a year after the plants were first pulled out. The "pulling out" was similar to that done by cattle but more nearly complete.

N, applied as  $\text{NH}_4\text{NO}_3$ , had a marked effect on yield, nutritive value, and palatability (utilization) of pinegrass in the first year after application. There was some residual effect in the second year but none in the third. N also increased the protein content of the plant in the first year after application but not in the second or third.

S, in the form of gypsum, did not significantly increase yields when it was used alone, but interacted with N to increase yields beyond those obtained with N alone. The response to applications of P, K, or micronutrients was negligible.

The protein content of pinegrass declined more slowly in plants to which

atrazine or paraquat had been applied at rates that had no significant effect on yields than it did in plants that were not sprayed. Paraquat was the most effective; plants sprayed in mid-June contained 15.3% of crude protein on August 11 compared with 10.9% in untreated plants.

In a growth-room experiment, pinegrass grown on various soils contained considerably more silica than did timothy, brome grass, or orchardgrass. The pinegrass also selected more silica from soils with higher silica contents. The silica content of pinegrass in British Columbia is high, ranging up to 18% of dry matter.

Native pinegrass pastures in the Cariboo area were fully utilized by yearling Hereford cattle in 1968. Three fields averaged 11.5 lb of live beef per acre. This falls short of a 5-year average of 19.3 lb on pinegrass at Pass Lake, near Kamloops, but is well above the 4-year average of 7.8 lb on Opax Mountain near Pass Lake. Differences in beef yields appeared to be due mainly to more or less permanent differences in soil cover, tree cover, and slope; and to seasonal differences in precipitation. An interesting feature of the trials in the Cariboo was the difference in rate of gain of cattle from the Station that entered the pastures at an average of 673 lb each and local cattle that entered at 457 lb; the average daily gain of the Station cattle was 1.25 lb and the local cattle 1.91 lb.

Crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., produced more beef per acre than Russian wild ryegrass, *Elymus junceus* Fisch., in grazing trials in 1967 and 1968. The difference was marked on a very dry site but relatively small on a site subject to subirrigation. On the dry site, heavy grazing in 1967 decreased the grazing capacity in 1968, but the wheatgrass was affected less than the ryegrass.

Native sedge, *Carex* spp., in a peat

meadow showed further response in 1968 to fertilizers applied in 1961. A group of 10 Hereford steer calves fed hay from unfertilized parts of a peat meadow, mostly sedge, gained an average of 0.6 lb/day in a winter-feeding period of 84 days; a group fed hay from a part of the same meadow that had been fertilized with high rates of 14-14-28 gained 0.8 lb; and a group fed alfalfa hay gained 0.9 lb. All groups had access to iodized salt; no other feed supplement was offered.

## YIELDS OF FORAGE AND BEEF FROM ARABLE, IRRIGATED LAND

Striking evidence has been obtained in a 4-year series of experiments that weather in a given growing season is a main factor in making corn silage competitive with alfalfa hay as a winter feed for cattle in the Thompson Valley. In 3 out of 4 years, gains of Hereford steer calves were greater on alfalfa hay than on corn silage (Pioneer 383) fortified with urea. In the fourth year (1967-68), the gains per day, feed efficiency, and yield of beef per acre were higher for the steers that fed on silage; the difference more than compensated for the higher cost of producing, harvesting, and storing the corn. The average gain per animal per day on corn ranged from 0.47 lb in 1964-65 to 1.57 in 1967-68; on hay the range was 0.77 lb in 1965-66 to 1.23 in 1967-68. The heat units in the 1967 growing season (3,276) were well above those in the preceding years and the dry-matter content of the silage averaged 30.7% during the 1967-68 feeding period, much higher than before.

Both forages were supplemented with salt, bone meal, and vitamins throughout the tests, but urea was added only to the corn silage.

The advantageous effect of early seeding on the maturity of corn at harvest and on the yield of dry matter per acre was demonstrated in 1968. Pioneer 383 planted April 30 yielded 30% more than it did when planted May 15; further increases occurred with earlier dates to April 1, and decreases with later dates to June 15.

Yearling Hereford steers that fed on alfalfa hay and rolled barley in the winter of 1967-68 and grazed on irrigated pasture in the following summer brought a better net economic return than steer calves similarly treated. Grades, in general, were good, even though the animals received no grain in the summer and were marketed direct from the irrigated pastures. Grades were adversely affected by overweight in a few yearlings and by lack of finish in a few calves. Fat color was satisfactory in all groups.

In a trial seeded on irrigated land in 1967, and sampled for the first time in 1968, Vernal alfalfa outyielded Lahontan when the varieties were harvested two to five times; the yields were practically equal when they were harvested six times. The plots clipped two, five, or six times during the season yielded less than those clipped three or four times.

Markedly less damage by ice sheets was done to reed canarygrass, Kentucky bluegrass, and orchardgrass when leaves protruded through the ice than when the plants were completely encased. Alfalfa varieties Du Puits and Ladak suffered somewhat less damage when their stems protruded; all other legumes tested were damaged to some extent in both treatments. Meadow foxtail, smooth brome-grass, timothy, and red fescue were not injured even by complete encasement. The plants were under treatment for 60 days at  $-4\text{ C} \pm 1\text{ C}$ .

# PHYSIOLOGY, ECOLOGY, AND CONTROL OF TICKS

From a study of the occurrence of the Rocky Mountain wood tick (RMWT) we have concluded that it may become abundant in clearings made for the construction and servicing of electric power lines and oil pipe lines, presumably because of favorable effects on host numbers and microclimate. On experimental plots, the reduction of shrubs by means of herbicidal sprays has tended, in the main, to reduce tick numbers, but long-term trends are not yet clear.

Diapause of the RMWT has been broken under various chilling and illumination regimes. The most successful, as judged by the minimal time (7 days) required by the females to engorge, was chilling at 5 C in an 8:16 photoperiod for 3 to 4 months followed by exposure to a constant temperature of 10 C and a photoperiod of 11:13 hr under fluorescent light. Apparently a different set of stimuli is effective in nature; ticks produced and retained in outdoor "rodentaria" were ready to feed from mid-December onwards.

A skunk, a pig, and a coyote were paralyzed by the RMWT in laboratory experiments in 1968; these species of mammals are not known to have been paralyzed by this tick previously. The pig's squeal was impaired during paralysis, a symptom similar to the loss of whistle in paralyzed marmots. Yields of larvae, nymphs, and adults were high on a porcupine, but no paralysis occurred. Porcupine droppings and lairs are seen on a high proportion of tick foci in forested areas of British Columbia; porcupine are probably an important host of the RMWT.

During experiments with sterilized males, we learned that females of the RMWT will mate more than once. Females that were mated to males that had been sterilized by gamma irradiation laid few to no fertile eggs, but those subsequently mated also to normal males laid the normal quantity of fertile eggs. This would likely reduce the prospects of using the technique for purposes of control.

Experiments in 1968 showed that the recommended use of BHC to protect cattle from the RMWT will not result in lindane residues in excess of the tolerance of 0.7 ppm recently proposed by the Codex Alimentarius Committee of WHO and FAO, provided that the animals are withheld from slaughter for at least 30 days after treatment. The experiments also showed that perianal fat samples are as satisfactory as omental fat samples, provided that the animals are not too thin; the perianal samples are much more easily taken. This work was done in cooperation with the Analytical Chemistry Research Service of the Department and the Entomology Branch and the Livestock Branch of the British Columbia Department of Agriculture.

Although larvae of the ear tick have been found in the ears of several host species in British Columbia, it was not until the spring of 1968 that free-living stages were observed in nature. Larvae were abundant on the roof of a mountain-side cave north of Oliver; the cave is known to be a shelter for mountain sheep, one of the tick's hosts.

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# Research Station Saanichton, British Columbia

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## INTRODUCTION

This report summarizes our main research results and program in ornamental and greenhouse crops for 1968. Detailed scientific and technical accounts are published in appropriate journals listed at the end of this report. Reprints are generally available from the authors. The program of the Post Entry Quarantine Station operating here in cooperation with the Production and Marketing Branch is expanding.

We were greatly shocked and saddened by the sudden passing of Mr. R. H. Turley on April 8, 1968. Dick Turley served in the Department for nearly 30 years. Early in his career he worked on forage crops and flax at the Central Experimental Farm, Ottawa. In 1949 he transferred here, where he made important contributions in the field of turfgrass and cereal research.

H. Andison  
Director

## PLANT SCIENCE

### Grapes

*Evaluation of early grape varieties.* Although temperatures for the growing season (April 1 to October 30) were marginal for grapes with 1,526 heat units in day-degrees above 10 C (50 F), at least 10 varieties produced from 15% to 20% soluble solids. The following varieties grown by the high (Kniffen) and low (Guyot) wire planting systems produced (in lb/plant) respectively: Seibel 9549 32, 22; Foch 25, 17; Diamond 21, 12; Aurora 19, 10; Himrod 16, 7; and New York Muscat 13, 12.

### Greenhouse Tomatoes

*Feeding methods in soilless culture.* Nutrient solution culture of greenhouse tomatoes in sawdust has been developed to avoid the problems of soil compaction and of soil-borne diseases that have plagued the industry in this area. Nutrient solutions containing all the major and minor elements are supplied daily to satisfy all the plant's requirements. Research during the past 2 years has shown that an alternative simplified feeding method, by which most of the nutrients can be mixed with the sawdust before planting, is effective. By this method only nitrogen and potassium have to be applied daily in solution. Yields of 10.2 lb/plant

have been obtained compared with 9.1 lb for the complete nutrient solution method.

*Volume of rooting medium in soilless culture.* A 2-year study of the effect of varying the volume of a sawdust rooting medium from 0.6 to 1.2 cu ft failed to show any significant differences. Where one part sphagnum peat was mixed with three parts sawdust, the volume of rooting medium per plant was reduced to 0.4 cu ft without reduction in yield or fruit size, and with a saving of labor and material.

*The effect of B-Nine on a spring greenhouse tomato crop.* Single and repeated aqueous sprays of B-Nine (UniRoyal (1966) Ltd.) were applied during the propagation period to a spring planting of Vantage tomatoes. Although closer spacing of fruit clusters resulted, the most marked effect was delayed ripening rather than the desired earlier maturity.

### Growth Regulators on Rhododendrons

*Effect of phosfon and photoperiod on growth and flower bud production in hybrid rhododendrons.* The effects of phosfon and photoperiod on plant growth and flower development of established rooted cuttings of rhododendron varieties A. R. Whitney, A. Bedford, and A. Van Welie were investigated. Regardless of the photoperiodic treatments, flower buds developed

in all the phosfon-treated plants of varieties A. R. Whitney and A. Van Welie and in most of the A. Bedford specimens, but bud abortion occurred in A. Bedford.

Plants that did not receive phosfon generally failed to produce flower buds, except for A. R. Whitney, which in 122 long days produced large flower buds on 60% of the specimens, and A. Bedford, which in 91 or more long days produced very small flower buds.

Restriction of growth either by phosfon or by limiting the period to 61 long days resulted in an average plant height of 11.2 and 12.4 inches respectively, compared with an average height of 29 inches for plants receiving 152 long days and no phosfon.

### Weed Control

*Varietal variation in seedling lawngrass sensitivity to 2,4-D.* Growth-room ex-

periments in which different rates of 2,4-D amine were sprayed over seedlings of bluegrasses, bents, and fescues at 1 inch high demonstrated marked differences in sensitivity among varieties. As a group, fescues were more tolerant than bluegrasses or bents, and showed less variation among varieties. Among the bluegrasses, Delta proved very sensitive, whereas Arista was more resistant; among the bents, Penncross was sensitive, and Highland much more resistant. These variations show the usefulness of such information, which could lead to earlier applications than is normally considered safe.

*Herbicide treatments for heather liners.* As a result of experiments with heathers in which 13 different herbicides were tested, a simazine spray at 1.5 lb/acre of the active ingredient or a granular application of 3 lb/acre was found to be safe and effective in controlling weeds among newly rooted cuttings of four representative species planted either in spring or fall.

## PLANT PATHOLOGY AND ENTOMOLOGY

### Diseases

*Phytophthora root rot of ornamentals.* Growth-room experiments on root rot with soil drenches of nabam and of mancozeb have been continued. When these materials at 4,000 ppm active ingredient were drenched onto 6-inch pots of soil infested with vermiculite cultures of *Phytophthora lateralis* Milbr. & Tucker just before and immediately after planting *Chamaecyparis lawsoniana* (A. Murr.) Parl. var. *ellwoodii* only partial control was obtained. In similar studies nabam and mancozeb at 8,000 ppm and at 12,000 ppm also applied twice as pre- and post-plant drenches completely prevented root rot. Only nabam caused a slight phytotoxic, but temporary, yellowing of some branchlet tip leaflets. Both materials caused a slight reduction in development of the root system, which otherwise was normal in color.

*The effect of D-D soil fumigant on bulbs, and its degradation products and persistence in soil.* When analyzed 2 months later, samples from field plots of mineral soil treated with D-D (Shell Chemical Co.)

at 45 gal/acre in two applications under ideal conditions did not contain significant levels of D-D. When analyzed 1, 2, and 3 months later, soil samples from field plots treated at 100 gal/acre and others at 200 gal/acre applied in two applications contained significant levels of D-D. These results show that in 3 months gas does not escape from a mineral soil that has been treated at high rates late in the growing season.

In a laboratory experiment in which bulbs were forced in a captive atmosphere of D-D at the same high rates as in the field tests and without aeration, the root and shoot growth of irises and tulips were significantly impaired. In tulips, injury to the basal plate scale tissues and the flower embryo of the bulbs was evident 2, 4, 6, and 10 weeks later.

*Chemical control of root diseases of Douglas-fir seedlings.* Nursery soil fumigated with methyl bromide at 0.5 and 1 lb/100 sq ft and with D-D at 30 and 60 gal/acre improved seedling emergence, shoot and root growth, and control of root

diseases. Seed treatment with thiram reduced postemergence damping-off. Both fumigants reduced nematode populations; D-D was less effective than methyl bromide in reducing fungus populations. Methyl bromide at the higher rate limited shoot growth. Interactions between the nematode *Xiphinema bakeri* Williams and the fungus *Cylindrocarpon radicola* Wr. caused corky root disease; *Paratylenchus* sp. and *Fusarium oxysporum* Schlecht. were involved in root rot, and *Pratylenchus* spp. reduced shoot growth.

### Ecology of the Garden Symphylan

Trials were started to determine the effects of population density on the habits and development of symphylan populations. After 6 months the amount of feeding in laboratory cultures increased 6.7 times for 10, 5.2 times for 25, 2.8 times for 50, and 1.6 times for 100 symphyllans, placed initially in separate cultures. Bi-weekly counts of symphyllans trapped in the bottom of culture containers did not provide a reliable measure of population trends during the first 6 months.

Food preference in laboratory trials showed significant differences in numbers of symphyllans attracted to various food materials. Higher numbers were found on garden beets than on lettuce, cabbage, celery, or carrots when all five materials were offered simultaneously. On paired diets with lettuce as control, no differences occurred between cabbage and lettuce, fewer numbers were present on celery, and higher numbers on beets and carrots. Where only single diets were offered, greatest numbers occurred on carrots, no differences appeared among beets, lettuce, or cabbage, and fewest numbers were found on celery.

### Systemic Pesticide

Benomyl (Benlate; DuPont of Canada Ltd.), a new systemic fungicide, as a foliar application at 4 oz actual per 100 gal at 3-week intervals, gave excellent control of powdery mildew on Spartan apples, roses, greenhouse cucumbers, and tuberous begonias. At this rate it controlled 2-spotted spider mite but not the European red mite. At this rate as a drench (20 oz per 10-inch pot), it was not effective on greenhouse cucumbers and tuberous begonias.

## PUBLICATIONS

### Research

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- TONKS, N. V. 1968. Effectiveness of the systemic insecticide oxydemetonmethyl applied in liquid fertilizer for green peach aphid control on chrysanthemum. *Canadian Journal of Plant Science* 48: 332-334.

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## PROFESSIONAL STAFF

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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
K. WILLIAMS, B.S.A.	Chemistry of pesticides

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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

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### **Substation, Creston**

F. M. CHAPMAN, B.S.A.	Officer in Charge; Field crops
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### **VISITING SCIENTIST**

N. SHANMUGANATHAN, Ph.D. National Research Council postdoctorate fellow 1967-68	Fungus physiology of parasitism studies
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## INTRODUCTION

This report summarizes the principal findings of the 1968 research program at the Research Station, Summerland.

Detailed scientific and technical accounts are published in appropriate journals. A list of current year's publications is included at the end of the report. Generally reprints are available from the authors.

The Station and the Canada Department of Agriculture gained much favorable

publicity and recognition when this Station's entry of its invention, the Rolltherm Cooker-Cooler, won the top award in Paris, France, in November 1968 at a food industry international competition for innovations in food-processing techniques and equipment.

C. C. Strachan  
Director

## AGRICULTURAL ENGINEERING

### Tomato Harvesting

A two-man self-propelled tomato harvesting aid was constructed and field tested. The unit is hydraulically driven and has a speed of about 0.1-0.5 mph. The workers lie on padded boards and pick directly into field lugs carried on the machine. Increases in the picking rate were 18-31% higher than the usual pail-to-lug method.

### Tree Fruit Harvesting

Experiments were carried out to determine the possibility of harvesting var-

ious tree fruits by the shake-and-catch method. Sweet cherries, sour cherries, prunes, crab apples, clingstone peaches, and Haralson and Winesap apples were harvested by this method.

All the fruits were damaged somewhat in harvesting, but most would be satisfactory for processing. The prunes were acceptable for fresh market sale. Most cherries required considerable shaking to dislodge them. A preharvest hormone spray made them separate more readily.

## ANIMAL SCIENCE

### Legume Bloat in Cattle

*Bloat and the chemical constituents of alfalfa.* Lipids, Zn, and Ni were positively correlated with bloat. Bloat increased sharply and then decreased sharply between Ca contents of 1.8 and 2.1%. Lipids, tannins, and Ca were positively associated with 18S protein. Mg was not correlated with either bloat or 18S protein. This is further evidence that 18S protein is a key factor in pasture bloat.

*Effect of wilting on 18S protein in hay and silage.* The decline in 18S protein content was measured in alfalfa harvested by flail and sickle mowers. The 18S protein content of the flail-mowed alfalfa hay declined from 4.7% to 4.2% after wilting for 12 hours. By the third day 18S protein had decreased to 2.0%. No comparable decline in 18S protein occurred in the sickle-mowed hay. Silage from flail-mowed alfalfa contained only a trace of 18S protein, irrespective of wilting time.

# ENTOMOLOGY

## Codling Moth

*Autocidal control.* Sterilized moths were released for the third year in a 10-acre commercially operated apple orchard. Because of an error, one release of substerile moths was made early in July. This error resulted in a sudden and severe larval infestation, which made it necessary to spray 65% of the orchard with azinphos-methyl. Releases were continued in the remainder of the orchard and adequate control was obtained. Total fruit injury due to codling moth in the release section averaged 0.71%. Of this total, 0.17% was due to second-brood larvae, and most of the remainder was caused by larval progeny of the substerile moths released in early July.

*Chemical control.* Phosalone (Zolone) at 3 lb/acre, Gardona at 6 lb/acre, diazinon at 4 lb/acre, and diazinon at 4 lb/acre combined with superior-type oil at 5 gal/acre were compared for control of the codling moth on Red Delicious apples in a four-spray seasonal program. Phosalone and Gardona gave commercial control of the codling moth in a heavily infested orchard where check trees averaged 77% injured fruit. Diazinon alone and in combination with oil reduced codling moth entries below 5%, but the percentage of stings was high and commercial control was not obtained.

## Fruit-tree Leaf Roller

*Integrated control.* When applied at the prepink stage of apple tree development, azinphos-methyl at 2.5 lb/acre, diazinon at 4 lb/acre, and parathion at 1 pt/acre gave excellent control of the fruit-tree leaf roller. The treatments did not adversely affect predators of phytophagous mites, and application at this early stage did not interfere with the program of releasing sterile codling moths. Dormant oil - ethion at 6 and 8 gal/acre applied at the half-inch green stage of apple tree development reduced fruit-tree leaf roller, but did not provide adequate control.

## Orchard Mites

*Biology.* The pear rust mite is a serious pest of pears in British Columbia, because,

unlike other orchard mites, it feeds on the fruit and russets the skin. Control in past years has been hampered by lack of biological knowledge. Studies in 1968 showed that the mites winter in small cracks and under bark chips on the twigs. In early spring, the mites move to the buds, where they feed and lay their eggs under the bud scales. Hatching starts about the time pears are in full bloom. The young mites feed first in the axils of petioles and peduncles, and by the time the flowers reach the calyx stage, the mites have russeted the basal half of these stems. Control measures are ineffective after the calyx stage, because the mites soon move onto the young fruitlets, where they feed and rapidly reproduce.

*Integrated control.* A project to develop integrated control of orchard mites in 10 commercial orchards extending from the Okanagan to the Similkameen valleys of British Columbia was started in 1967 and continued in 1968. Sprays were applied only when necessary. In general, the orchards received one prebloom spray to control aphids, European red mite, and San Jose scale, and two or three summer sprays of azinphos-methyl or diazinon to control the codling moth. Predacious phytoseiid mites were present in all the test orchards, but the McDaniel spider mite was virtually absent. The apple rust mite and the European red mite became the important phytophagous mites, and both were controlled without disturbing the predacious mites. The average cost of chemicals for insect and mite control in the 10 orchards was \$26.50/acre, compared with \$91/acre in orchards under a full spray program.

*Chemical control.* Handgun applications of fenazaflor (Lovoal) at 20 or 30 oz/100 gal and GS 19851 at 30 oz/100 gal gave excellent initial and residual control of the European red mite and the McDaniel spider mite. Chlorphenamide (Galecron) at 15 or 20 oz/100 gal and Plictran at 4 oz/100 gal were not as effective as the previously mentioned materials, but they provided commercial control. Benomyl (DuPont 1991) at 8 oz/100 gal did not control the European red mite, but was



effective in controlling the McDaniel mite. GS 19851 caused a ring-type injury to the fruit of McIntosh and Stayman apple trees.

### **Pear Psylla**

*Biology.* Declines of pear psylla populations during late July and August occur commonly in abandoned pear orchards and to a lesser extent in commercial pear orchards. In the past, the decline was attributed to predation and direct mortality of eggs and young nymphs caused by dry, hot weather. Investigations recently completed suggest that another important factor causing midsummer population declines is reduced fecundity and delayed ovary maturation in females. At one time, it was surmised that the delay in ovary maturation was due to a weak imaginal diapause induced by long photoperiods and high temperatures. Laboratory experiments failed to demonstrate a diapause, and a histological examination of

the neuroendocrine systems of females ruled out the possibility of a diapause condition. Other experiments suggest that nutritional factors, as reflected by growth vigor of the host tree, are to a large degree responsible for population declines. During late July and August, less than 2% of females reared on healthy vigorous trees exhibited a delay in ovary maturation. In contrast, up to 87% of females reared on trees of poor vigor and stressed by insect and mite injury exhibited a delay in ovary maturation.

*Chemical control.* M2060 at 3 gal/100 gal as a dormant spray reduced adult pear psylla 94 to 96% on Bartlett and d'Anjou pear trees. Egg mortality on treated trees was 97 to 99% compared with 33 to 37% on untreated trees. Chlorphenamidine at 3.75 lb/acre applied in July gave excellent kill of pear psylla eggs and nymphs. Mortality of adults was good, but significantly poorer than in plots sprayed with Perthane at 4 and 8 lb/acre.

## **FRUIT AND VEGETABLE PROCESSING**

### **Drum-dried Fruit Sauces**

Applesauce flakes made from Golden Delicious and Spartan apples were stored at 32 F, 70 F, and 100 F, in air and N. After samples had been stored for 6 months, a trained taste panel could detect no significant difference in flavor among reconstituted sauces made from Golden Delicious flakes stored at the three temperatures. Spartan flakes developed unacceptable flavor after 3 months at 100 F.

Gas-liquid chromatographic analysis of dried applesauce volatiles showed that more than 50% of the original volatiles are lost in drum-drying, whereas freeze-dried material loses only about 30%. All samples showed browning degradation after several months' storage at temperatures above 70 F. The browning reaction involves thermal degradation of sugars during processing. The products of this reaction are being identified.

### **Continuous Process for Frozen Apple Slices**

A continuous process for sulfiting apple slices before freezing was developed in

the pilot plant and has been put into commercial production by processors in Canada and in the USA.

In this completely automated process, apple sectors are immersed for 5 min in 1,200–1,500 ppm SO<sub>2</sub> solution, passed through a continuous vacuum unit, and into a postvacuum dip in 120 ppm SO<sub>2</sub> containing 0.5–1.0% salt. Vacuum treatment time is 8 min and sectors are immersed in the postvacuum dip for 3 min. The treated slices containing 100–120 ppm SO<sub>2</sub> may be frozen immediately.

### **Wines**

Very rapid heating of grape pulp to 190 F followed by rapid cooling to 70 F was carried out in a swept-surface heat exchanger. The color index of red wine made from juice extracted from heated pulp was almost double that of wines made by fermenting on the skins. In addition the heat treatment yielded a much milder flavored wine relatively free from harshness.

## Processing Evaluation of Golden Delicious Seedling Selections

Applesauce and pies made from canned and frozen slices of seedling selections 9E-13-47, 8C-29-24, and 10C-6-25 were compared with those made from standard Golden Delicious. Pies from 9E-13-47 (Kendall × Golden Delicious) were judged excellent, rating higher than Golden Delicious, whereas sauce made from it was scored equal to the standard.

Products made from 8C-29-24 and 10C-6-25 received a low color rating when compared with Golden Delicious products;

however, judged on their own merits, these selections could be considered highly acceptable.

## Continuous-roll Cooker and Cooler

The continuous-roll cooker-cooler for 100-fl-oz cans was further modified and is ready for commercial manufacture. Improvements include a recirculation system for cooling water that has reduced water use by 80%. A commercial trial pack of blueberries was processed in the cooker. Agitation prevented clumping of blueberries and reduced sterilization time from 90 min (still cook) to 7.5 min.

# PLANT NUTRITION, SOILS, AND IRRIGATION

## Calcium Deficiency Symptoms in Spartan Apple

Quite marked deficiency symptoms occurred on the leaves of Spartan apples grown in Ca-deficient nutrient solution cultures. The symptom is a marginal browning of the leaf, starting at the tip and progressing toward the pedicle as severity increases. Symptoms are most severe on the current year's growth and on sucker growth. Many of the leaves drop before normal leaf drop occurs.

## Irrigation Management of Grapes on Sandy Soils

In first-year results, the yield of grapes was increased as the frequency and the amount of irrigation was increased on a coarse sandy soil. Yields were 12.1 lb/plant at 16-day irrigation intervals, 15.1 lb at 11 days, and 18.6 lb at 7 days. Acid content was increased in the most fre-

quently irrigated plots, but total solids content was not affected. There was no appreciable difference between cover-cropped plots and clean-cultivated plots.

## Magnesium Deficiency and Leaf Analysis for Tree Fruits

Results of sand culture and field experiments showed that Mg analyses alone are preferable to cation ratios for assessing the severity of Mg deficiency in tree fruits.

## Irrigation Response of Alfalfa Varieties

At our Substation, Creston, Du Puits, which yielded 5.22 tons of hay (15% moisture) per acre in three cuttings, exceeded Vernal and Lahonton when grown on Lister heavy clay soil and supplied with 12 inches of sprinkler-applied irrigation water. In an adjacent test without irrigation, the yield of this variety was 2.56 tons of hay per acre in two cuttings.

# PLANT PATHOLOGY

## Collar or Crown Rot of Apple Trees

Dexon 5% granules applied at 112 g/ft<sup>2</sup> to tree sites in a gravelly sandy loam in April 1967 and in April 1968 significantly reduced the number of recoveries of *Phytophthora cactorum* (Leb. & Cohn) Schroet. from the treated soil compared with the control soil, at levels of 0-5 inches and 5-10 inches. When Dexon and Chemagro 4497 5% granules at 112 g/ft<sup>2</sup>

and DNOC 75% soluble powder at 3.8 g/ft<sup>2</sup> were applied to tree sites in a silt loam in May 1968, *P. cactorum* was recovered less frequently ( $P = 0.05$ ) from the soil treated with Dexon and Chemagro 4497 at 0-5 inches than from the DNOC-treated and control soil. There were no significant differences in recoveries at the 5-10-inch level, and no significant differences in the numbers of trees lost to crown rot disease.

## Physiology of *Gloeosporium* Species

Inhibition of amylase by phenolic compounds was examined as a possible explanation of persistence of starch in bull's-eye rotted tissue of Yellow Newtown apples. Chlorogenic acid, the main phenolic compound of apple fruit, inhibited amylase only slightly. When, however, chlorogenic acid was partly oxidized to quinones by fungal oxidases, amylase was very strongly inhibited (90% amylase inhibition at 0.05 mM chlorogenic acid). However, chlorogenic acid at this concentration, before or after oxidation, had no measurable effect upon fungal cellulase. Therefore the overall effect in rotted tissue is a sparing action on starch, while cellulose is hydrolyzed.

## Fire Blight—Evaluation of Bactericides

Recent reports of failure of germicides to disinfect tools used for summer cutting of fire blight prompted a reevaluation of this problem.

Failure of disinfection was related mainly to three factors: the short time that bacteria may be exposed to disinfectant action (5 to 15 sec), interference of organic matter, and dilution effects. Mercury and chlorine lost effectiveness rapidly with reduction in exposure time or increase in organic matter. Phenol activity fell less rapidly from these causes, but more rapidly with dilution.

On the average, bactericidal activity of Lysol was affected less by adverse conditions than that of the other materials tested. A concentration of 5% was found to be best for field use.

## Virus Reinvasion of Heat-treated Apple Clones

Buds from apple trees of seven varieties, given heat therapy (1–5 weeks at 38 C) at University of California, Davis,

were perpetuated on clean rootstocks. The trees were indexed at Summerland after 1 year, and again after 4–5 years. Of trees that gave negative readings on common indicators in the first indexing, most were still clean in the second indexing, but 2 of two M IX and 1 of eight M II gave positive readings for Spy epinasty or chlorotic leaf spot viruses. For one McIntosh clone, buds removed from the first propagated tree 1 year after treatment yielded trees that were still clean in the second indexing, whereas buds removed the following spring yielded trees that subsequently indexed positive for Spy epinasty virus.

## A Flexuous-rod Virus from Sweet Cherry

During the last 3 years, an unusual virus has been repeatedly isolated from a Lambert variety field tree, which had originally shown etched ring symptoms on 35% of the fruits. The herbaceous host range of this virus is smaller than that of the necrotic ringspot virus—sour cherry yellows virus (NRSV-SCYV) group, and it is confined to plant species that are also susceptible to NRSV or SCYV. The dilution end point is between 1:1,000 and 1:10,000, the thermal inactivation point is between 42 C and 48 C, and the particle length, as measured by electron microscope, is around 700 m $\mu$ . Sap inoculation of stone fruit seedlings has been unsuccessful.

On the basis of the characteristics studied, the virus belongs to the apple chlorotic leaf spot (CLS) group. This is confirmed by preliminary serological tests with an apple-CLS antiserum. The virus differs in details of host range from apple-CLS and from CLS types isolated from European sweet cherry varieties (Scotland and New York), almond (Scotland), and apricot (Switzerland).

## POMOLOGY

### Influence of Temperature on Quality of Delicious in Controlled-atmosphere Storage

In air storage a 25% increase in the keeping life of Delicious apples occurs at 30 F, as opposed to 32 F. In controlled-

atmosphere (CA) storage experiments (2.5% CO<sub>2</sub> and 3.0% O<sub>2</sub>), firmness, titratable acidity, and soluble solids were nearly identical after 8.5 months' storage for both Delicious and Golden Delicious held at 30 F and 32 F. However, a slight

incidence of physiological disorders, which occurred only in fruit held at 30 F, indicated that 32 F should be the CA holding temperature for these two varieties.

### **Apple Storage Scald—Use of Ethoxyquin in Conjunction with Waxing Treatment**

The current procedure of washing apples with hot water and detergent followed by application of wax complicates the use of scald-inhibiting chemicals applied at the time of packing.

In experiments designed to investigate scald control, the detergent wash and waxing process did not reduce the effectiveness of ethoxyquin on Stayman and Delicious when applied 1–2 weeks earlier as a postharvest dip. Incidence of scald on apples dipped in ethoxyquin was less than 1% for both waxed and nonwaxed fruit, but on untreated Stayman was 47% and on untreated Delicious 8%. It was shown also that ethoxyquin-impregnated paper wraps applied to fruit after waxing provided an effective alternative to ethoxyquin dips.

### **Compact or Spur-type Seedlings in Apple**

Five mutants of McIntosh and one mutant each of Delicious, Golden Delicious, and Spartan with compact or spur-type growth habit were used in crosses with cultivars of standard growth and in two crosses with both parents of compact growth. Only one cross, Golden Delicious × McIntosh, (Wijcik) gave a characteristic segregation of seedlings for growth habit. In this cross, 44% of seedlings had very distinct spurry and sturdy, but not necessarily dwarf, growth. In the second year of growth, the compact seedlings had, on the average, only 1.8 side shoots in comparison with 8.7 side shoots in the standard type of seedlings. The central shoot of the compact seedlings was sturdy, with short nodal distances and with large leaves. The results show that the desired compact growth habit can be transmitted to the sexual progeny of apple.

### ***Prunus tomentosa* as a Rootstock for Peaches and European Plum**

*Prunus tomentosa* Thunb., Nanking cherry, has proved to be an interesting

dwarfing rootstock for peaches and European plum. The trees are small, well anchored, very productive, and show good, though not perfect, compatibility with the root. Trees were planted 6 × 12 ft, and trunk and height measurements at the end of the second growing season were 4.5 inches in circumference and 92.0 inches in height. The average crop per peach tree was 9.0 lb. Four percent of the peach trees died during the first growing season; none died in the second season, but a few trees appeared weak. This rootstock may become of commercial importance for peaches and plums.

### **Alar and Ethrel Permit Mechanical Harvesting of Sour Cherries**

Treatments of 2,000 ppm Alar applied 2 weeks after bloom, or 500 or 1,000 ppm Ethrel applied 1 week before mechanical shaker harvesting, or both, permitted the successful picking of Montmorency cherries in a commercial block that could not otherwise be harvested mechanically. Ethrel alone was less effective than Alar plus Ethrel in improving the quality of the mechanically harvested fruit, but Ethrel alone was sufficient to permit adequate fruit removal.

### **Influence of Timing and Concentration of Annual Applications of Alar to McIntosh Apples**

The plant growth suppressant Alar was applied to McIntosh apple trees at 500, 1,000, and 2,000 ppm during two seasons. Treatments applied 1 and 2 weeks after full bloom gave maximum growth reduction of both shoots and fruit. Fruit firmness increased after all applications (the last treatment was approximately 30 days before harvest), but the maximum response followed the treatment applied 2 weeks after full bloom. The magnitude of all measured responses was influenced more by the timing than by the concentration of the chemical employed.

### **Light Regimes Within Standard-size Apple Trees Determined Spectrophotometrically**

A portable spectrophotometer was employed to measure spectral intensity between 380 and 1,000 m $\mu$  within standard-

sized apple trees. The spectra of sun patches or flecks deep within the canopy were similar to full-sun spectra at the top of the canopy. Full-shade spectra were rich in the near infrared and very poor

in the photosynthetically active light. By averaging numerous individual readings, light zones were demonstrated that were very similar to those obtained by using uranyl oxalate actinometry.

## VEGETABLES AND ORNAMENTALS

### Breeding for Earlier, Smoother Field Tomatoes

In trials in 1968, crosses involving Globetrotter, Summerdawn, BV-132-2111, High Crimson, Cold Set, Fireball, and Sioux were superior to the standards Fireball, Swift, and Summerdawn. Many of these lines should be available for extensive trial by 1970.

### Sprinkling Delays Tomato Maturity in Cool Years

In 1966, the number of heat units from May 21 to August 10 inclusive was 27,183, and overhead sprinkling reduced the first pick by 33%. Comparable figures for 1967 were 35,538, with a yield reduction of 3.4%; and for 1968, 30,830, with a yield reduction of 25%. Of the 25 years before 1968, 16 years had less than 30,830 heat units during this crucial period.

## MANUFACTURERS OF PESTICIDES AND OTHER CHEMICALS IDENTIFIED BY TRADE NAMES

<i>Trade name</i>	<i>Manufacturer</i>
Alar	UniRoyal Chemical Company
Chemagro 4497	Chemagro Corporation
Dexon	Chemagro Corporation
Gardona	Shell Chemical Company
GS 19851	Geigy Chemical Company
M2060	Montecatini Chemical
Perthane	Rohm-Haas Company
Phoslone	May and Baker (Canada) Limited
Plictran	The Dow Chemical Company

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# Research Station Vancouver, British Columbia

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## INTRODUCTION

This is the sixth report of the Research Station, Vancouver. It covers the work completed and in progress in 1968.

Both the report and reprints of the publications are available on request. Cor-

respondence should be addressed: Research Station, 6660 N.W. Marine Drive, Vancouver 8, B.C., Canada.

R. E. Fitzpatrick  
Director

## VIRUS CHEMISTRY AND PHYSIOLOGY

*Physical-chemical studies of the ribonuclease-bentonite complex.* The orientation and adaptation of the ribonuclease molecule within the clay matrix of bentonite was assessed by X-ray diffraction, differential thermal analysis, and infrared studies. The optimal inhibitory effect of the enzyme by bentonite, measured by a shift of the *c*-axis values from 12.6 Å to 34 Å, was at pH 5, after pretreatment of the clay with Ba<sup>++</sup> and EDTA. Disruption of the secondary and tertiary structure of the protein molecule did not cause amplification of the *c*-axis. The same effect was observed when bentonite was replaced by vermiculite. The active sites of ribonuclease were not ionically engaged by the clay, and steric hindrance was postulated, to explain the lack of RNA degradation by the ribonuclease-bentonite complex.

*A mycoplasma-like organism isolated from asters infected with aster yellows.* A mycoplasma-like organism was isolated from asters infected with aster yellows disease from a liquid culture grown aerobically at 25 C. The microscopic colonies could be subcultured from broth onto agar and vice versa, but they required plant extract instead of the usual serum fraction. Viability of the organism was established by measuring the incorporation of thymidine-H<sup>3</sup> into the mycoplasma DNA. The organism is morphologically similar to *Mycoplasma salivarium* and *M. hominis*, and is resistant to penicillin but sensitive to tetracycline. It cannot break down urea, and does not grow at 37 C or at 25 C under anaerobic conditions. Studies are in progress to establish whether the organism

is the sole etiological agent of the aster yellows disease, and if genetic factors influence the infection.

*In vitro breakdown of viruses.* It was found with the spectrophotometer and the electron microscope that the protein coat of native tobacco mosaic virus (TMV) is digested by pepsin, only in 0.1 N but not in 0.01 N HCl. However, in 0.1 N HCl the exposed TMV-RNA is also hydrolyzed. Since RNA hydrolysis cannot be separated from the specific pepsin action, this enzyme is unsuitable for identifying a nucleoprotein such as TMV.

Viruses were exposed to various treatments in order to separate the two macromolecular constituents. Although the anionic detergent sodium dodecylsulfate effectively dissociates viruses, little attention has been paid to cationic detergents. It was established by spectrophotometry and electron microscopy that treatment of TMV with cationic detergents, at neutral or slightly acid pH, resulted in a rapid release of soluble viral protein. The precipitate formed simultaneously contained the nucleic acid component and some undissociated virus.

*Physicochemical characterization of plant viruses.* A virus isolated from *Prunus* spp. was serologically related to the Y strain of cucumber mosaic virus. The viruses were weakly antigenic, but apparently serologically identical in gel precipitin tests. Purification of the *Prunus* virus by the butanol method gave a low yield of virus, and contained an infectious component sensitive to ribonuclease. Puri-

fication by the Scott procedure resulted in greater yields of virus. Partially purified preparations from virus-infected cucumber plants contained five electrophoretic components, which were partly separated by electrophoresis. The mobility of the virus was  $-3.0 \times 10^{-5} \text{ cm}^2 \text{ v}^{-1}$  at pH 8.7.

Based on analyses of recovered nucleotides and amino acids the composition of tomato ringspot virus was 40% RNA and 60% protein. Analyses showed that the virus protein subunit was composed of approximately 217 amino acid residues. Based on sedimentation and diffusion rates the molecular weight of the virus was  $5.5 \times 10^6$ , and its extinction coefficient was  $10.0 \text{ cm}^2/\text{mg}$ . Electrophoretic mobilities of the virus in 0.1 ionic strength phosphate buffer were  $-2.60 \times 10^{-5}$  and  $-1.59 \times 10^{-5} \text{ cm}^2 \text{ v}^{-1} \text{ sec}^{-1}$  at pH values of 7.38 and 6.55, respectively.

The surface area of that portion of the virus protein subunit exposed to nucleic acid and aqueous medium was estimated from the surface areas of charged and dipolar amino acids. This area and the protein subunit volume were determined for many viruses from their amino acid composition. The surface-to-volume ratios ( $s/v$ ) were from  $0.05 \text{ \AA}^{-1}$  to  $0.06 \text{ \AA}^{-1}$ , regardless of the size or shape of the virus. The  $s/v$  ratios of simple spherical and cylindrical shell models with virus dimensions were in agreement with the  $s/v$  ratios predicted

from amino acid composition for the icosahedral viruses. For the rod-shaped viruses, however, the surface of the embedded RNA had to be taken into account to obtain a better correlation between the  $s/v$  value for the cylindrical model and that for the subunit.

*Physiology and cytology of virus-infected plants.* The composition of inclusions in the cells of virus-infected plants were studied in situ in broad bean leaves infected with bean yellow mosaic virus, using differential enzymatic digestion. One method employed frozen thick sections, prefixed in glutaraldehyde and exposed to proteinases and nucleases, after which ultrathin sections were cut. Another method employed the new water-soluble embedding medium glycol methacrylate, whereby tissues could be directly incubated with the enzymes. Both methods showed that crystalline inclusions were composed entirely, or almost entirely, of protein, whereas dense band inclusions were entirely of protein. The differential action of pepsin and trypsin suggested that the protein in both types of inclusions contained substantial numbers of tyrosinyl and phenylalanyl groups, but fewer residues of the basic amino acids. Since there was no evidence for the presence of nucleic acid, it is highly unlikely that the inclusions represent the protein moiety of crystallized virus particles.

## PLANT PATHOLOGY

### Potatoes

*Potato leaf roll virus.* An 11-year study of the epidemiology of potato leaf roll virus in the lower Fraser Valley was completed in 1968. The vector, *Myzus persicae* (Sulzer), overwinters outdoors in the nymph stage on sugar beet stecklings, on cruciferous crop plants, and on weeds. By mid-June alate aphids disperse from these hosts; some settle on and colonize potato plants infected with leaf roll in fields and in cull piles. The flight reaches a peak in mid-August and ends in September. The progressive increase in new infections in main crop potatoes, which occurs in July, August, and September, in spite of good

local aphid control, shows that viruliferous aphids comprise a part of this flight.

Year-to-year fluctuations in the numbers of alate aphids and in the spread of leaf roll virus are accounted for by the differences in winter survival of aphids and infected tubers and by the inconsistent occurrence of sufficiently warm and dry weather, which is required for maximum aphid dispersal.

*Potato virus X and potato virus S.* Eradication of potato viruses X (PVX) and S (PVS) by nutrient culture of axillary buds from heat-treated plants was continued during 1968. PVX was more readily eradicated than PVS. Besides the 14 varieties listed in 1967, the following

varieties are now free from PVX and PVS: Alaska 114, Avon, Columbia Russet, Gold Coin, Huron, Katahdin, Keswick, Pentland Glory, Red La Soda, and Sebago.

Successful propagation and maintenance of these clones in a virus-free condition depends on reliable indexing to detect chance infections. Mechanical inoculation to *Gomphrena globosa* L. was used to detect PVX, and serology to detect PVS. The PVX inoculation was reliable, but some PVS-infected plants were not detected. Some infected plants were detected by examining leaf sap in the electron microscope for the presence of flexuous rods. Another reliable method was mechanical transmission to *Chenopodium quinoa* Willd. or *C. amaranticolor* Coste & Reyn. Those potato plants that were selected for propagation were triple indexed using all the tests.

The elimination of PVX and PVS from clones of Notted Gem and White Rose varieties resulted in total and marketable yield increases of 11% and 14%, respectively.

The retention of infectious sap was measured. Freshly extracted sap from PVX- and PVS-infected potato plants was applied by an atomizer to various surfaces in a shaded screenhouse. At prescribed intervals inoculations were made to virus-free plants of a susceptible potato variety. PVX remained infectious for 6 hr or less on wood, iron, rubber, jute, cotton, leather, and human skin, and for 24 hr on soil. PVX in sap in a beaker remained infectious for 5 days. PVS remained infectious for 3 hr or less on all surfaces. PVS in sap in a beaker remained infectious after 1 but not after 5 days.

### Small Fruits

*Mummy berry of blueberry.* Ferbam remains the most effective fungicide tested for control of mummy berry, *Monilinia vaccinii-corymbosi* (Reade) Honey, of highbush blueberry. Nevertheless, dodine and the systemic benomyl (Benlate, formerly known as Fungicide 1991) also gave good control; benomyl was used at the low rate of 2 oz toxicant/acre. Zineb and captan did not significantly increase yield, although zineb effectively reduced leaf

shoot and flower cluster infections. Berry size was not affected by the fungicides.

The varieties Atlantic, Dixi, Fraser, Grover, Johnston, Pacific, and Rubel are resistant to ascospore infection, and Atlantic, Collins, Dixi, Fraser, Grover, Pemberton, and Stanley are resistant to conidial infection.

*Red stele of strawberry.* An isolate of *Phytophthora fragariae* Hickman, from strawberries grown in soil previously free from red stele and inoculated with races A1, A2, A4, and A5, proved to be a new race similar to Hickman's race 12. This is the first record of a new race of *P. fragariae* being produced in a mixture of known races.

### Forage Legumes

*Virus infection and chloroplast development.* The chloroplast components, chlorophyll and CO<sub>2</sub> fixing 18S protein, were proportionally decreased in chlorotic virus-infected leaves; and when greening in etiolated bean seedlings was inhibited by antibiotics, the chlorophyll and 18S protein were also lowered. However, the pattern of reduction with the antibiotics tested was different from that in virus-infected leaves. Chloramphenicol, an inhibitor of chloroplast protein synthesis, reduced 18S protein strongly, but only slightly affected chlorophyll. Cycloheximide, which inhibits nuclear and cytoplasmic protein synthesis, reduced chlorophyll more than 18S protein, as did actinomycin D, which inhibits RNA synthesis on a DNA template. Therefore inhibition of chloroplast development in virus-infected plants does not appear to take place at the RNA or protein synthesis levels, and may be due to a Jacob-Monod repression of the chloroplast genome either directly or via the nucleus.

### Nematodes

*Survey in horticultural crops.* A survey of plant-parasitic nematodes associated with horticultural crops in the lower Fraser Valley was started in the fall of 1967. More than 1,400 samples have been collected from 170 farms.

In strawberry and raspberry plantings the root-lesion nematode *Pratylenchus* spp., dagger nematode *Xiphinema* spp.,

and spiral nematode *Helicotylenchus* spp. were most commonly associated with poor crops. *Tetylenchus* sp. was widespread in highbush blueberry plantings and was often associated with poor bush conditions.

The northern root-knot nematode, *Meloidogyne hapla* Chitwood, was found in most of the vegetable-growing muck soils

sampled, but it appeared to cause damage only to carrots. In some cases entire fields were unmarketable.

The bulb and stem nematode, *Ditylenchus dipsaci* Kühn, and the lesion nematode *Pratylenchus* spp. were still found to be an important problem in growing bulbs, even though their presence has long been known.

## ENTOMOLOGY

### Aphids

*Survey and taxonomy.* Interesting and unusual aphids occurred in yellow pan water traps maintained throughout the summer in Richmond and North Vancouver. An annotated list of the aphids of British Columbia and a host-plant index are being compiled.

*Morphology and fine structure.* The structure of the stylets, crumena, and labium of the balsam woolly aphid, *Adelges piceae* (Ratzeburg), was investigated with the electron microscope. The central duct in each mandible contains three dendrites. Previous work at the Station had shown the presence of two dendrites in the central duct of *M. persicae*.

*Chemical control.* In early spring sugar beets grown for seed were side-dressed with granular disulfoton, carbofuran, and aldicarb (Temik) to reduce overwintering populations of green peach aphids. The beets are suspected to be a source of early populations of aphids in potatoes. The rate was 1 and 2 g toxicant/10 inches of row. The three-row plots were replicated four times in randomized blocks. The effects of the insecticides were assessed by counting the aphids on ten leaves and ten 20-cm flower heads in the center row of each plot at weekly intervals. The aphids were present in numbers on the flower heads. In 40 heads/sample on June 6, the results with aldicarb showed only 6 aphids, with carbofuran 1,014, with disulfoton 345, and untreated 882. This pattern persisted until harvest.

Six weekly bioassays of flower heads with aphids showed highly significant

reductions in the number of progeny produced within 48 hr after using 2 g of aldicarb.

### Leafhoppers

*Morphology and fine structure.* Studies are in progress on the morphology and fine structure of the feeding apparatus of leafhoppers. Electron micrographs have been obtained of the structure and musculature of the salivary syringe, food pump, stylets, and stylet sheaths.

*Aster yellows disease.* Attempts were made to extract and purify the agent of aster yellows disease from insect vectors. Infectivity was obtained from crude homogenates, millipore filtrates, and ultrafiltration retentates. Aster plants infected with aster yellows showed reduced symptoms of the disease after tetracycline at 1,000 ppm was injected into the stems and leaves.

### Root Weevils

*In blueberry and strawberry.* Laboratory tests were conducted with adults of the black vine weevil, *Brachyrhinus sulcatus* (F.), fed on excised leaves from four blueberry varieties, to determine if the unacceptable varieties Cabot and Weymouth remained unacceptable under temperature regimes with means of 51, 59, and 74 F. The acceptability of these varieties increased slightly with the temperature, but two acceptable varieties were also proportionately more acceptable, based on weight gain, preoviposition period, feeding rate, fecundity, and longevity of the weevil. Efforts to detect a chemical difference between these varieties, which might account for their unacceptable or acceptable properties, have been unsuccessful. Analyses

were conducted for oxalic, ascorbic, and benzoic acids, protein nitrogen, Na, K, Ca, Mg, and moisture content.

Tests with six strawberry varieties showed no similar effects on the fecundity of the weevil, but the variety Siletz reduced fecundity significantly.

### Wireworms

*Chemical control.* Single applications of parathion, carbofuran, and fonofos (Dyfonate), all in 10% granular formulation, at 4 lb toxicant/acre gave good protection to field corn in silt loam infested with 5.5 *Agriotes obscurus* (L.) per sq ft. The insecticides were broadcast and worked into the top 3 inches of soil immediately before seeding. At harvest, the yield in the treated plots was about twice that of the untreated plots. Carbofuran gave the best results.

In peat soil planted to potatoes, single applications of carbofuran and fonofos in 10% granular formulations and fonofos emulsion (4 lb toxicant/gal) at 4 lb toxicant/acre were incorporated to a depth of 6 inches to control a heavy infestation of *Agriotes lineatus* (L.) and *Ctenicera lobata* (Esch.). With carbofuran 92% of the tubers were marketable, with fonofos granules 56%, with fonofos emulsion 43%, and without treatment 29%.

### Leatherjackets

*Chemical control.* In pasture on silt loam, several materials were tested for their effects on larvae of the European marsh crane fly, *Tipula paludosa* Meig. The insecticides were sprayed once on the grass, and the fertilizers were applied as granules. The following materials had no effect: lime at 500 lb, cyanamide at 200 lb, ammonium sulfate at 150 lb, malathion at 3 lb toxicant, and dimethoate at 6 oz toxicant/acre. DDT at 2.5 lb toxicant/acre reduced the population by 96%, carbofuran at 3 lb by 87%, and parathion at 0.25 lb by 63%.

In pasture on peat soil, single sprays of parathion at 0.5 lb toxicant/acre and carbofuran, fensulfothion (Dasanit), and thionazin (Zinophos) each at 2 lb reduced the population by 93%. Dimethoate at 6 oz toxicant/acre and arprocarp (Baygon) at 1.5 lb were ineffective. The un-

treated population of leatherjackets averaged 46 per sq ft in both loam and peat soils.

*Biological control.* *Siphona geniculata* DeGeer, a parasite of *T. paludosa* imported from Germany in early 1968, was reared successfully in the laboratory for four generations. Adults of the parasite and the parasitized leatherjackets were released during the summer at two sites. No recoveries have yet been made.

### Root Maggots

*Compatibility.* The insecticides fensulfothion, carbofuran, and thionazin were applied to four brassica crops singly or combined with 6 preseeding, 8 preemergence, and 18 postemergence herbicide treatments, in four replicates. The herbicides did not affect the insecticides. Fensulfothion and carbofuran were particularly effective.

In peat and sandy loam soils, insecticides with and without fungicides and lime were incorporated into the soil for maggot and clubroot control. The fungicides mercurous chloride and quintozone were broadcast and disked into the soil before seeding. The insecticides chlorfenvinphos (Birlane), fensulfothion, diazinon, carbofuran, and thionazin were applied as granules and drenches.

The insecticides had no significant effect on germination or clubroot. Carbofuran allowed the least maggot damage in both soils. Thionazin was effective in organic but not in mineral soil. The fungicides had no effect on maggot damage, and did not appear to affect the insecticides.

### Residue Chemistry

*Thionazin residues in carrots.* Methodology was developed for determining thionazin residues in plant material using sweep codistillation cleanup followed by gas chromatographic determination with flame photometric detection. This method was used to study the degradation of thionazin in carrots grown in treated soil. At three different rates of application, initial residues were reduced to approximately one-third of their original values 42 days after the final drench.

*Degradation of dieldrin.* After 6 months no significant differences existed between the rate of degradation of dieldrin in moist soil adjusted to pH 9 and the rate in the same soil adjusted to pH 4.

When dieldrin was incubated in liquid media with the fungus *Trichoderma viride* Pers. strain 12, gas chromatographic analysis showed degradation losses of up to 30%. Radiotracer methods will be used to verify these results.

When dieldrin-treated soil was inoculated with this strain of *T. viride*, the fungus was ineffective until the soil had been chemosterilized with Formalin.

*Carbofuran residues.* A study of residues of this carbamate insecticide in a number of vegetable crops has been initiated using gas chromatographic determination with microcoulometric detection. Determination of carbofuran and its degradation product 3-hydroxycarbofuran in some crucifers and in potatoes shows that tolerably low residues may be expected after application rates that give effective control of soil insects.

#### Advisory Work

Many inquiries about insects were received from industry, government departments, and the public. A list of some of the insects follows.

*Merchant grain beetle.* *Oryzaephilus mercator* (Fauv.) has become the major cupboard pest in homes and apartment buildings, replacing the Australian spider beetle, *Ptinus ocellus* Brown.

*Cat flea.* *Ctenocephalides felis* (Bouché) is responsible for a great many inquiries in the late summer and early fall when it becomes established in lawns. It has become resistant to the common chlorinated hydrocarbons.

*Black carpet beetle.* In central British Columbia, *Attagenus piceus* (Oliv.) is the most common insect in establishments handling grain or its products. Farther north the confused flour beetle, *Tribolium confusum* Duv., was found in feed plants.

*Angoumois grain moth.* *Sitotroga cerealella* (Oliv.), not established in the province, was recorded from a heated warehouse in a sample of seed wheat from Mexico.

*Rusty grain beetle.* In Vancouver, *Cryptolestes ferrugineus* (Steph.) appeared in large numbers in terminal elevator bins containing mixed feed oats. A fumigant mixture of ethylene dichloride, ethylene dibromide, and carbon tetrachloride was used to control the infestation.

## PEDOLOGY

Activities during the year concerned basic and special soil surveys and land inventory projects instituted under ARDA, within the area designated by the boundary of the Canada Land Inventory in British Columbia. Personnel have continued to cooperate with government departments, universities, research institutions, professional associations, and others engaged in the same research projects.

#### Basic Soil Surveys

*Quesnel-Cottonwood map sheets, 93G SE and 93B NE.* The report on this area was written and is ready for publication. The soil and capability maps are in the blueprint stage and will soon be submitted to the Cartography Section.

*Bonaparte River, 92P W half.* The field work and final checking was completed by September 1968. The preliminary map and working legend were prepared. This project should be completed by July 1969.

*Williams Lake - Alexis Creek, 93G SE and 93B NE.* The 800,000 acres remaining to be mapped were completed, and a preliminary map was prepared. Only minor reediting and checking are needed.

*Tulameen Sheet, 92H NE.* The report for this area of about 2 million acres was written during the winter 1968-69, and submitted for publication.

*Princeton Sheet, 92H SE.* The map of this area of about 2 million acres is in the final stages of preparation.



Charlie Lake – Beatton River, 94A, N half, and 94H, S half. Two parties working in the area during the 1968 field

season mapped about 7.6 million acres. This project should be completed by September 1969.

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