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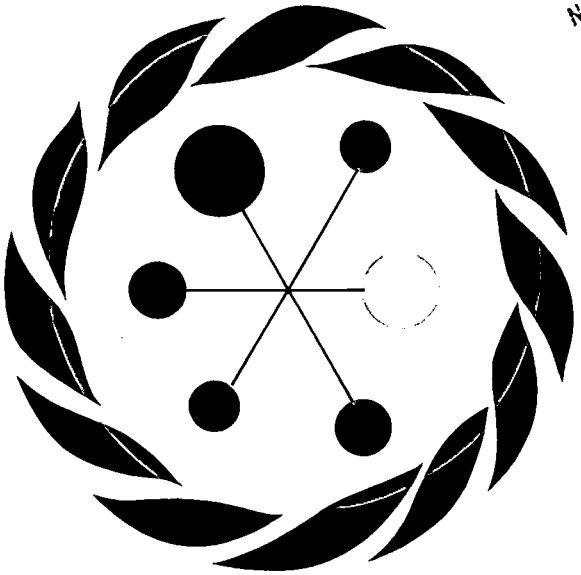

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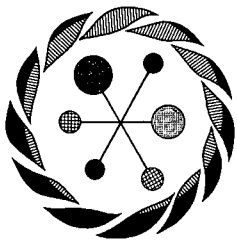

The symbol on the cover depicts the inlay on the floor of the lobby of the K. W. Neatby Building, Central Experimental Farm, Ottawa. The center of the symbol is composed of an asymmetrical arrangement of the basic chemical elements of agricultural science as represented by Daltonian symbols. The colors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

research report
1969

Research Branch
CANADA DEPARTMENT OF AGRICULTURE

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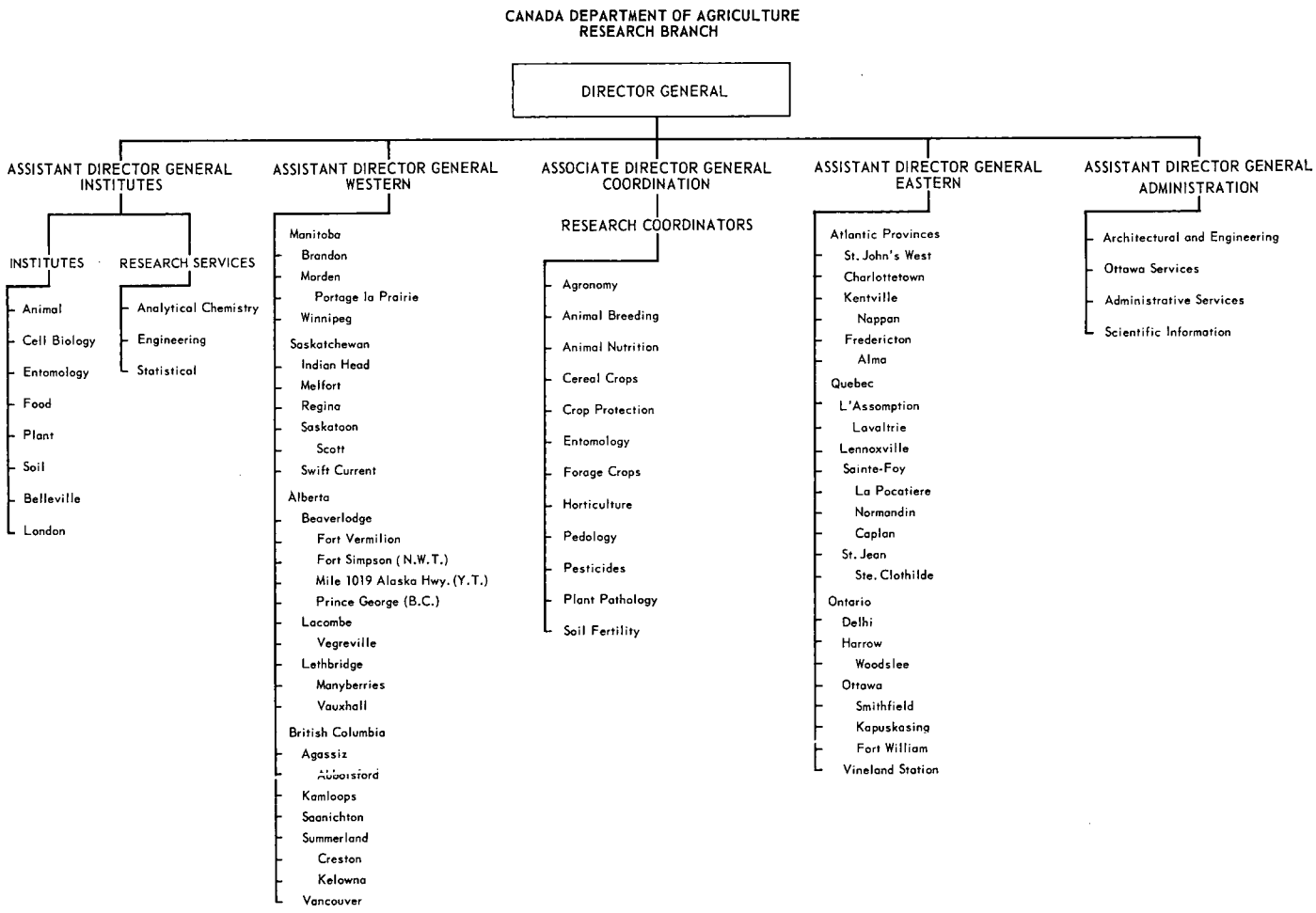
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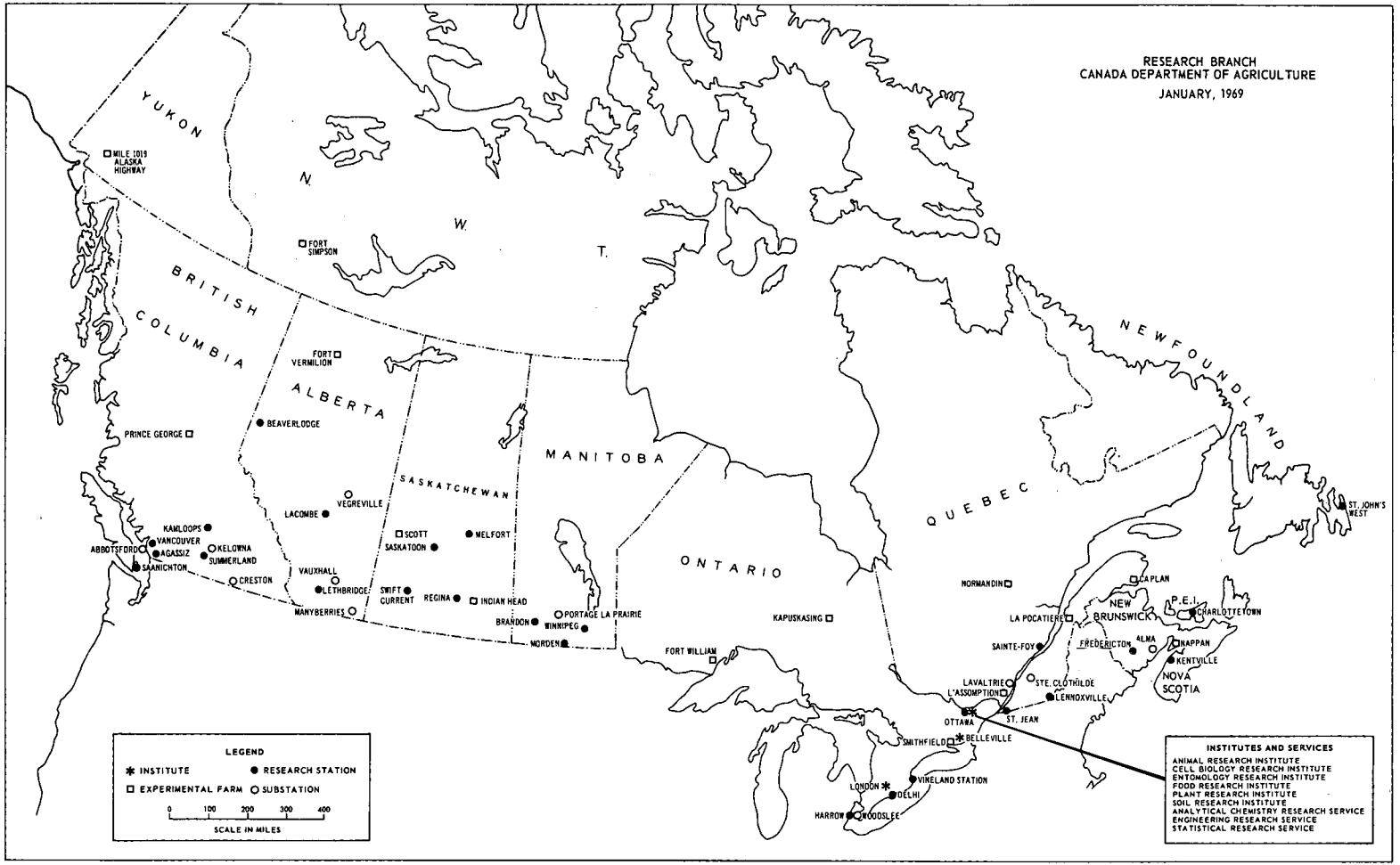
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FOREWORD

The Research Branch is 51 Research Stations, Experimental Farms, Institutes, and Services scattered across Canada. But it is also a coordinated, closely knit organization in which planning, cooperation, and common objectives and goals effectively guide the efforts of all units in the continuing task of solving the problems of a rapidly changing agriculture. Not only is attention given to immediate urgent problems but to anticipated problems resulting from technological change and market developments.

Emphasis in the research program is being given to innovation: of substitute crops, of crop adaptations, of new methods of pest and disease control, and of crop management techniques. The recently introduced system of "management by objectives," accompanied by a continuous review of programs, is the device by which direction is provided and progress measured.

Several appointments and transfers of directors were made during the year. Dr. J. S. Clark was appointed Director of the Soil Research Institute; Dr. W. B. Mountain was transferred from Vineland Station to be the Director of the Entomology Research Institute; Dr. G. M. Weaver, formerly of Harrow, Ont., was appointed Director of the Research Station at Vineland Station, Ont.; Dr. J. E. Andrews was transferred from Swift Current, Sask., to be the Director of the Research Station at Lethbridge, Alta.; Dr. A. A. Guitard, previously at Beaverlodge, Alta., was transferred to be Director of the Research Station at Swift Current, Sask.; and Dr. L. P. S. Spangelo, formerly of the Research Station, Ottawa, was appointed Director of the Research Station at Beaverlodge, Alta.

B. B. Migicovsky

Director General

AVANT-PROPOS

La Direction de la recherche se compose de cinquante et une Stations de recherches, Fermes expérimentales, Instituts de recherches et Services répartis à travers tout le Canada. Mais elle est en fait une organisation dont la planification, la coopération, les objectifs et buts communs sont continuellement coordonnés et intimement liés en vue de concentrer les efforts de toutes les unités vers la solution des problèmes que pose une agriculture en constante évolution. Elle s'oriente non seulement vers la solution immédiate des problèmes urgents mais également elle s'applique à anticiper les nouveaux développements créés par les changements technologiques et les fluctuations des marchés agricoles.

Les programmes de recherches sont particulièrement marqués par le souci d'innover, c'est-à-dire, de trouver des cultures nouvelles ou d'adapter des cultures à des climats ou des sols différents. Il faut donc découvrir des nouvelles techniques de gestion des cultures et des nouveaux moyens de lutte contre les maladies et les ennemis des plantes cultivées. A cette fin, on a récemment institué un système de "gestion par objectifs" doublé d'une révision continuelle des programmes de recherches en vue d'en assurer la direction et d'en mesurer les progrès.

Au cours de l'année écoulée, plusieurs directeurs ont été nommés ou permutés à différents postes. Le Dr J. S. Clark a été nommé Directeur de l'Institut de recherches sur les Sols; le Dr W. B. Mountain a été permuté de la Station de Vineland Station au poste de Directeur de l'Institut de recherches en Entomologie; le Dr G. M. Weaver, auparavant de la Station de Harrow, Ont., a été nommé Directeur de la Station de recherches de Vineland Station, Ont.; le Dr J. E. Andrews a été permuté de Swift Current, Sask., au poste de Directeur de la Station de recherches à Lethbridge, Alb.; le Dr A. A. Guitard, auparavant de Beaverlodge, Alb., a été permuté au poste de Directeur de la Station de recherches à Swift Current, Sask.; et le Dr L. P. S. Spangelo, auparavant de la Station de recherches d'Ottawa, a été nommé Directeur de la Station de recherches de Beaverlodge, Alb.

B. B. Migicovsky
Directeur général

Research Station
St. John's West, Newfoundland

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Departures

A. G. VALENTI, B.Sc. Dr. (Geol.), M.Sc. Resigned 1969	Soil survey
G. T. MORGAN, B.Sc., M.Sc. Died October 1969	Nematodes

INTRODUCTION

The Research Station at St. John's West aims to solve regional agricultural problems and places emphasis on potato breeding for resistance to wart and the golden nematode, reclamation and use of peat soils, and control of insects and plant diseases.

The Station's first wart-resistant potato variety, Pink Pearl, was released for commercial production in 1969 and met with favorable reception. In the same period, and as a result of experimental work here, Pyrethrum insecticide was registered for use in Canada to control blow fly infestation during the drying of salt codfish.

As a result of a tragic accident in July, Glendon T. Morgan, nematologist, died in October. He was a competent and resourceful research scientist, who made valuable contributions to the understanding of the behavior and control of the golden nematode in Newfoundland and elsewhere. His professional capability will be greatly missed in the Atlantic Provinces.

H. W. R. Chancey

Director

SOIL SCIENCE

Soil Survey

Field activities in 1969 were directed toward correlating the soils of the Avalon Peninsula and checking established boundaries between soil series, drainage, and stoniness. Survey work was also extended to the isthmus that connects the Avalon Peninsula to the main part of the island.

Studies on seasonal changes in soil color disclosed small increases in value and chroma during early summer and subsequent decreases during winter, together with a small increase in oxalic acid extractable Fe.

Forest soil fertility studies showed decreased productivity when available K is present at levels over 190 kg/ha (170 lb/acre) and generally increased productivity with increased available P.

Peat Soils

Fertility. In studies on interactions between initial and maintenance fertilizer treatments on the growth and ecology of grass–legume mixtures on peat soils, results obtained from trials the first year after seeding were directly comparable with 1963 results. A similar study reported in 1967 was of limited value because the legumes winter-killed.

Patterns resulting from plotting percentage of clover against total yield were similar to those obtained in 1963, though not quite so clearly defined owing to a wider response to seeding-year treatments. However, this also resulted in a clearer definition of some of the specific interactions. Thus, there were similar trends in each of the three maintenance nutrient series for an increase in the percentage of clover and a decrease in total yield where high initial K and P were used together. Where maintenance P was high, total yields were also increased. Contrary to former findings, initial high rates of N and K and low rates of P were ineffective, so that obtaining an acceptable clover percentage yield under an initial low rate of P was extremely dependent on an application of at least a similar amount in the maintenance year. Some of the best yields of the experiment were obtained from plots given a high rate of initial P and no maintenance P, but this treatment produced only medium clover content.

PLANT SCIENCE

Head Size in Late Cabbage

Because Newfoundland consumers prefer cabbage weighing 0.68 to 1.8 kg (1.5 to 4.0 lb), an experiment was conducted with Evergreen Ballhead cabbage on mineral soil at St. John's to determine the plant spacing and fertilizer treatment that would give the highest yield of heads in that weight range. N at rates of 100.9 and 201.8 kg/ha (90 and 180

lb/acre) and P and K each at 201.8 and 403.6 kg/ha (180 and 360 lb/acre) were tried in all combinations, with plant spacings of 25.4, 35.6, and 45.7 cm.

Plants spaced 25.4 cm apart and given 201.8 kg N/ha gave significantly higher yield of heads in the 0.68 to 1.8 kg range. Since 22.8% of the heads from rows spaced at this distance were below 0.68 kg, it is probable that even higher levels of N could be utilized. On the other hand, both the 35.6 cm and 45.7 cm spacings with 201.8 kg N/ha appeared to be too wide because a large percentage of the heads exceeded 4.5 kg.

Weed Control in Vegetables

The treatments are expressed in kilograms of active ingredient per hectare.

Rutabaga. Treatments tested for controlling weeds in York rutabaga grown on mineral soil at St. John's included: preplanting incorporated applications of vernolate at 2.2 and 3.4 kg/ha, EPTC at 2.2 and 3.4 kg, cycloate at 3.9 and 5.0 kg, and nitralin at 1.7 and 2.8 kg; postemergence applications of nitrofen at 1.7 and 2.8 kg/ha, and preemergence applications of propachlor at 4.5 and 6.7 kg/ha.

EPTC at 3.4 kg/ha, vernolate at 2.2 kg, and nitrofen at 2.8 kg were considered to be the best treatments.

Cabbage. Treatments tested on mineral soil in which Bergkabis cabbage was grown included preplanting incorporated applications of nitralin at 1.1 and 2.2 kg/ha and bensulide at 4.5 and 9.0 kg, and postemergence applications of nitrofen at 1.1 and 2.2 kg/ha.

Nitralin at 1.1 kg/ha gave the best control.

Lettuce. Preemergence applications of CDEC at 3.4, 5.6, and 7.8 kg/ha were tested on mineral soil for controlling weeds in Premier Great Lakes lettuce. CDEC at 7.8 kg/ha was the most effective treatment and because no visible crop injury occurred at that rate, it is likely that higher rates would provide better weed control.

Forage Crops

Annual forages. Maris Kestrel marrow-stem kale was compared with three oat varieties and one corn variety in a test of annual crops for forage production. The prevailing cool, wet weather was extremely unfavorable for corn, which produced only 2,890 kg of dry matter per hectare (2,574 lb/acre) compared with a mean of 4,780 kg (4,275 lb) for the oat varieties and 9,480 kg (8,447 lb) for the kale. The long, cool fall season generally experienced in Newfoundland appears to favor the utilization of kale as a livestock feed.

ANIMAL SCIENCE

Grazing Trials on Peat Pastures

Results confirmed those reported in 1968 that lamb gains on a clover - timothy - tall fescue mixture were greater than those on a mixture of clover with reed canarygrass alone or reed canarygrass and tall fescue. Copper calcium edetate injections, substituted for slow-release bullets, proved more effective in producing responses to Cu. Gains were increased by the Cu treatment given to lambs grazing timothy swards not receiving fritted trace elements in the fertilizer, but were decreased on those that did. The response to Cu of lambs grazing the mixtures containing reed canarygrass were of lesser magnitude and the reverse of those grazing timothy, indicating that reed canarygrass might not take up Cu from the soil as readily as timothy. However, final evaluation awaits the completion of Cu analyses of blood, liver, and forage samples.

ENTOMOLOGY

Cabbage Maggot

Experiments in 1969 showed that pelleting of swede turnip seed with wettable powder insecticides was an efficient and economic method for controlling root maggots. This method also ensured correct placement of insecticides with minimum amounts of toxicant being introduced into the soil environment. Rate of application was 10 g of insecti-

cide per 28.35 g of seed with methyl cellulose as a sticker. The fungicide captan was also added at 0.5 g per 28.35 g of seed. The percent control obtained for the various treatments was as follows: carbofuran (Furadan 75 W.P.; Niagara Chemicals), 97; carbofuran (Furadan S.P.), 94; chlorfenvinphos (Birlane 25 W.P.; Shell Canada Ltd.), 84; trichloronat, 81. The following were ineffective: pirimiphos-ethyl (PP 211 35% Seed Dressing; Plant Protection Ltd.); fonofos (Dyfonate Seed Treatment T.F. 42-68 and 45-67; Stauffer Chemical Co.); Chipman B-3 (Chipman Chemicals Ltd.), and bromophos. Fonofos was extremely phytotoxic and caused 90% seedling reduction, whereas chlorfenvinphos caused 39%. All other treatments were nonphytotoxic.

Aphids

The aphid *Drepanosiphum platanoides* Schrank was found infesting Norway maple trees at Mount Pearl on June 17, 1969, in numbers large enough to cause leaf necrosis and early defoliation. It was identified by the Entomology Research Institute and was the first specimen of this species recorded from Eastern Canada. This aphid is common in Western Canada, where it was introduced from Europe.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and the Golden Nematode

To increase genetic variability in the breeding program, about 1,500 seedlings derived from crosses of wild or cultivated diploid or tetraploid species were raised in the greenhouse. In addition, approximately 18,000 seedlings were raised from crosses between commercial varieties or specific selections and wart- and eelworm- resistant material. Field evaluation of almost 20,000 first-year selections was made at harvesting and less than 1,000 were retained for further testing. Screening for wart resistance will probably reduce this number by half.

In the greenhouse, testing of selections for wart, caused by *Synchytrium endobioticum* (Schilb.) Perc., eliminated several hundred susceptible seedlings, but 580 selections were planted in four-hill units at St. John's and as single hills at Avondale. This number was later reduced to 80 because of wart susceptibility and undesirable horticultural characteristics. One hundred and eight selections were grown in duplicate 10-hill plots at St. John's and also assessed for wart resistance; 22 were promising enough to include in 4 × 20 hill trials in 1970. Wart resistance in these selections derives from Fredericton seedling F5318 and the German variety Mira. Two of the selections were also resistant to the golden nematode, *Heterodera rostochiensis* (Wr.).

Replicated Potato Yield Trials

In trials with seven named varieties and five numbered seedlings at St. John's and four other centers, Kennebec gave the highest yield of marketable tubers and Superior the lowest. Sable produced good yields, and appears to be quite suitable for Newfoundland conditions. Pink Pearl outyielded the control variety Arran Victory at four of the five centers, but the percentage of marketable tubers was lower than for other varieties. Urgenta produced as well as Pink Pearl, but was the most susceptible to blackleg infection, caused by *Erwinia atroseptica* (van Hall) Jennison. A sister seedling to Pink Pearl gave good yields, but had a lower dry matter content than Arran Victory; the other four seedlings varied in performance from center to center.

Effect of Dinoseb on Growth and Yield of Potatoes

Previous experiments have shown that the herbicide dinoseb can control potato wart disease and 1969 trials further confirmed its effectiveness. Rates of 5.6, 11.2, and 22.4 kg/ha (5, 10, and 20 lb/acre) were applied to the soil prior to planting and to the same plots as a preemergence spray 16 days later. Dinoseb was not mixed with the soil and seed pieces were planted directly in the treated area. Reduction in plant vigor was observed 3 weeks after the second application, following which the plants died. Potatoes planted in plots treated with dinoseb in 1968 but not in 1969 produced wart-free

crops. Potatoes grown in plots not treated in 1968 were heavily wart infected. When dinoseb was applied at 11.2 and 22.4 kg/ha to heavily infested soil immediately after the potatoes were planted, no phytotoxic effects were observed and no wart-infected tubers were harvested. An unsprayed adjacent area yielded 25% wart-infected potatoes. The herbicide nitrofen failed to control wart infection.

Biotypes of Potato Wart

It is now apparent that biotypes similar to, or perhaps identical with, European types 2 and 6 occur widely in Newfoundland, but the common European type 1 is rarely found. Occasionally, slight infections were recorded at one center on the resistant variety Urgenta and on seedlings bred from it and from the variety Ultimus. In all other areas where they have been grown, wart symptoms were not observed. This year, however, three samples of wart-infected tubers, allegedly Urgenta, were received from growers in widely separated localities. Infection of Urgenta by samples of wart from these three centers has been confirmed by greenhouse tests, and it seems probable that a further wart biotype, possibly corresponding to European type 8, is present in Newfoundland.

Clubroot of Brassicas

Roots derived from intercrosses of Gelria, Wilhelmsburger, Novitas, and York, which showed no clubroot infection in 1968 field trials, were planted in the greenhouse and the plants allowed to interpollinate. Resulting seed was field sown in July, but none of the roots harvested were completely free from clubroot, caused by *Plasmodiophora brassicae* Wor.

In trials to control clubroot and root maggot with a combined insecticide–fungicide seed dressing, 6 g chlorfenvinphos plus 6 g Agrox NM (Chipman Chemicals Ltd.) mixed with 28 g seed gave 78% control of clubroot. Other treatments consisting of chlorfenvinphos combined separately with captafol (Difolatan; Chevron Chemical Co.) and Agrox DB at the same rate gave little control of clubroot infection.

PUBLICATIONS

Research

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Miscellaneous

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Research Station
Charlottetown, Prince Edward Island

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INTRODUCTION

The research program of the Research Station at Charlottetown is concerned with soil and plant nutrition, pest control, variety development and testing, and management practices related to the production of cereal crops, forage crops, potatoes, tobacco, vegetables, and small fruits. The program also concerns the breeding and management of dairy cattle. This report summarizes the results from selected research projects; further information on the results presented or on other aspects of the research program may be obtained by contacting the Research Station or individual scientists.

G. C. Russell
Director

CEREALS

Variety Testing Highlights

The German two-rowed barley variety Volla seems well suited to Maritime culture. In 1967, it demonstrated exceptional tolerance to late seeding, high sterility, and *Helminthosporium sativum* Pamm., King & Bakke. In 1968, an ideal year for barley production, Volla led most yield trials. Although results in 1969 were variable, the performance of this variety was satisfactory in all trials, and in New Brunswick it demonstrated a strong superiority on soils of low pH. Such soils are common in Maritime potato rotations.

Pathology and Entomology

Disease surveys showed that *Erysiphe graminis* DC. ex Mérat f. sp. *tritici* Marchal, *H. sativum*, and *Leptosphaeria avenaria* Weber are the primary pathogens encountered on wheat, barley, and oats respectively in the Maritime Provinces. Yield decreases caused by these and other leaf pathogens reached a maximum of 27%, 12%, and 14% respectively, in field experiments where infestations were partly controlled.

The use of benomyl (Benlate; DuPont of Canada) banded into the soil with the seed at a rate of 0.45 kg/3.66 km of row resulted in a decrease in the severity of mildew and significantly increased wheat yields.

Disease resistance studies have located or characterized cultivars and selections of the three cereals that possess varying degrees of resistance to their respective primary pathogens.

The western half of Prince Edward Island experienced an outbreak of barley jointworm, *Tetramesa hordei* (Harris). Infestations ranged from 2% to 95% on the basis of galled stems.

Nutrition and Management

Potassium increases efficiency of N utilization by barley. Herta barley, grown on nutrient solutions with an NH_4^+ source of N and low (10 ppm) K concentration, showed severe ammonium toxicity symptoms and significantly lower yields than with high (100 ppm) K concentration or with an NO_3^- source of N. Potassium-deficient barley accumulated significantly higher levels of free ammonium-N, amino-N, and amide-N in the tissue than plants receiving adequate K.

Drilling high-analyses fertilizer with the seed can reduce barley yields. In a fertilizer-placement field experiment, yields of barley (2-year average) fertilized with 415 kg/ha (370 lb/acre) of a 19-19-19 fertilizer containing diammonium phosphate and urea as the N sources were 3,000 kg/ha (55.5 bu/acre) when the fertilizer was broadcast, 2,910 kg/ha (54.1 bu/acre) when it was drilled with the seed, and 3,425 kg/ha (63.7 bu/acre) when it was placed to the side of and below the seed. Corresponding yields for an equivalent amount of 15-15-15 fertilizer containing NH_4NO_3 as the N source were 3,425 kg/ha (63.7 bu/acre) when broadcast, 3,270 kg/ha (60.8 bu/acre) when drilled with the seed, and 3,665 kg/ha (68.2 bu/acre) when placed away from the seed. The highest grain yield of 3,765 kg/ha (70 bu/acre) occurred with 448 kg/ha 15-15-15 (400 lb/acre) broadcast before seeding, plus 224 kg/ha 7-28-5 (200 lb/acre) drilled with the seed. Results indicated that at high rates of fertilization, all the fertilizer should not be drilled with the seed, particularly if high-analyses fertilizer

blended from diammonium phosphate and urea is used and that a low N, high P, low K fertilizer be used for drilling with the seed.

Adequate N at vegetative stage boosts grain yields. Herta barley and Opal wheat, grown in hydroponic culture with 20 or 100 ppm N, were compared with basic 20 ppm N treatments that were increased to 100 ppm N for 1 week at weekly intervals from emergence to maturity. Providing adequate N (100 ppm) at different stages of development followed by reversion to the basic 20 ppm N level showed that supplementary N applied in the early vegetative stage, 3–5 weeks after emergence, was the most effective for increasing number of heads per plant, yield, and kernel weight of grain.

POTATOES

Insect and Disease Control

Seventeen spray materials were screened for insecticidal properties; four proved satisfactory for the control of all species of foliage insects. These were endosulfan, endosulfan 4 + parathion 2, C8353 (CIBA Co. Ltd.), and carbofuran (Furadan; Niagara Chemicals). Six granular insecticides were applied to the soil at time of planting. Of these, aldicarb, fensulfothion, and disulfoton gave good control of foliage insects.

In ultralow-volume foliage sprays, using 420 ml of concentrated material per hectare, good insect control was obtained with phosphamidon 90%, phenthoate 85%, and malathion 95%.

Under the weather and disease conditions encountered in 1969, the fungicides Daconil 2787 (Diamond Shamrock Chemical Co.), mancozeb, Polyram (Niagara Chemicals), CA6904 (CIBA Co. Ltd.), zineb (Siaprit; Green Cross Products), and captafol (Difolatan 4 Flowable; Chevron Chemical Co.) gave good control of late blight on the foliage. MBR4880 (3M Company), fentin hydroxide (Du-Ter; Philips-Duphar Co.), and NF-35 (Green Cross Products) gave poor control; the last-named showed no merit. The foliage disease control efficiencies were reflected in the yields of tubers; yields of plots treated with the three inferior fungicides were significantly lower than those of plots treated with the six that provided good protection.

Eight chemical dusts for treating seed were tested for the control of fusarium seed-piece decay, verticillium wilt, and blackleg. Seed was artificially contaminated with respective disease organisms, and then chemically treated at the rate of 10 g dust/kg seed. Control of decay, caused by *Fusarium coeruleum* (Lib.) Sacc., was achieved with Polyram 7% dust, Polyram 7% dust + 0.1% diazinon, mancozeb 6% and 8% dusts + 0.1% diazinon, and CA6904, 7% dust. Highly effective control of wilt, caused by *Verticillium albo-atrum* Reinke & Berth., was obtained with Busan 72, 10% dust (Buckman Chemical Co.). Neither Polyram nor mancozeb dusts were effective in controlling this disease. None of the chemicals under test proved effective in the control of blackleg, caused by *Erwinia atroseptica* (van Hall) Jennison. Both Busan 72 and CA6904 showed phytotoxic action at the rates employed.

The fungicide benomyl was used as a furrow treatment prior to the planting of seed artificially contaminated with spores of *V. albo-atrum*. Significant wilt control was obtained at 1.81, 3.17, and 4.53 kg/3.66 km of row. Although superior wilt control was obtained at the 4.53-kg rate, the control was not reflected in increased yields over other treatment levels. Highly significant yield increases over untreated controls were recorded at the three rates under test.

FORAGES

Diseases

Root-lesion nematode and fusarium root rot studies on forage legumes. A greenhouse study showed that both the fungus *Fusarium oxysporum* Schlecht. and the root lesion nematode *Pratylenchus penetrans* (Cobb) Filip. & Stekh. significantly reduced foliage and root yields of Empire birdsfoot trefoil. Foliage and root yields were reduced 17% and 48%, respectively, by the fungus and 62% and 67%

by the nematode. When the fungus and nematode were combined, foliage and root yields were reduced 83% and 90%, respectively.

A greenhouse study was conducted to compare the effects of three cutting managements on Empire birdsfoot trefoil. The most severe management (cut at 2.5 cm every 3 weeks) resulted in the greatest reduction of both foliage and root yields. When root-lesion nematode-infested soil was compared with noninfested soil, foliage yields were reduced 18%, 57%, and 55% and root yields 4%, 44%, and 22% for the following three treatments: no cut, cut at early flowering, and cut at 2.5 cm every 3 weeks.

Susceptibility of Medicago *and* Trifolium *to root-lesion nematodes and clover-root curculios.* Forty-three *Medicago* species and 51 *Trifolium* species were screened in the field to determine possible sources of resistance to attack by the clover-root curculio, *Sitona hispidula* (F.), and root-lesion nematodes *Pratylenchus* spp. Some of the more promising species were later screened in the greenhouse for susceptibility to root-lesion nematodes. Since many of the species tested were annuals, curculio damage to these could not be determined the second year. Root-lesion nematodes were recovered in varying numbers from almost all species, either in the field or in the greenhouse. Present data indicate little promise of resistance in any of the species tested.

Physiology and Management

Regrowth physiology. The effects of 20 growth regulators alone and in combinations on stimulating regrowth of alfalfa were evaluated in the greenhouse. Gibberellic acid was the most effective stimulant; an application of 100 ppm to the roots after cutting produced a 58% increase in dry matter yield 3 weeks after treatment, and a 130% increase in weight of leaves. In a field experiment, alfalfa sprayed with a mixture of 10 ppm gibberellic acid, 5 ppm kinetin, and 1 ppm 2,4-D showed a 20% increase in yield without loss of quality.

An automatic gel-filtration technique was used to examine the metabolism of phlein, the main food reserve in stem-base tissue of timothy. Potassium-deficient timothy plants, unlike those deficient in N and P, showed an effluent pattern with an extremely low level of phlein, which indicated that K played an important role in the biosynthesis of phlein. There was a reduction in the content of both phlein and sugars following cutting. It is suggested that phlein in timothy stem-base tissue during regrowth was decomposed to fructose and sucrose without the production of short-chain fructosans.

Nitrogen treatments effective in promoting late seasonal production in pastures. Fertilization of a natural pasture sward of timothy, Kentucky bluegrass, and wild white clover, with an annual mid-June treatment of 75 kg N/ha, 119 kg P/ha, and 213 kg K/ha (69, 106, and 199 lb/acre) supplemented by 75 kg N/ha in mid-July, and again in mid-August, increased the 3-year average yield to 13.91 metric tons of dry matter per hectare, an increase of 5.94 tons over the untreated plots. Increasing the N levels to 94 and 112 kg/ha in mid-June, July, and August did not produce significant yield increases over the 75-kg/ha rate, but increased production during August, September, and October. Manure at 22.4 metric tons/ha (10 tons/acre) applied once every 3 years produced an average yield increase of only 0.31 metric ton of dry matter per hectare.

Liming increases fertilizer efficiency on forages. Liming the soil to a pH of 6.2 before seeding increased the efficiency of fertilizer applied to an alfalfa–timothy mixture by as much as 100% compared with unlimed soil at pH 5.5. On unlimed plots, 672 kg of 5-10-30 per hectare were required to produce the same dry matter yield as was obtained with 336 kg/ha, or one-half the amount of fertilizer, on limed plots. With high-quality hay valued at $32/metric ton, dollar returns per dollar invested for production, harvesting, and storage were $1.20 and $1.90 for the 672 kg/ha fertilization rate on the unlimed and limed plots respectively.

Forages respond to molybdenum and lime. Applications of Mo to soil at a pH of 5.5 or above increased the yield of alfalfa on Culloden and O'Leary soils, but gave no response on Acadia soil. Bromegrass showed a marked response to application of lime, but very little response to application of Mo. Much higher Mo contents occurred in plants where lime and Mo were applied together than when either treatment was applied alone.

Manganese toxicity studies. In a greenhouse experiment conducted with an acid soil (pH 4.7) from a field producing potato plants

with Mn toxicity symptoms, the addition of dolomitic limestone markedly reduced tissue Mn levels and toxicity symptoms on beans, peas, and barley, as well as the water-soluble and exchangeable Mn levels in the soil. Soil Mn levels were well correlated with soil pH changes. Manganese toxicity symptoms occurred at tissue levels greater than 800 ppm for beans, 550 ppm for peas, and 175 ppm for barley.

CRUCIFERS AND OTHER HORTICULTURAL CROPS

Insect Control

Control of the cabbage maggot. Continued annual field testing showed that maggot control can be achieved with carbofuran, fensulfothion, chlorfenvinphos (Birlane; Shell Canada Ltd.), trichloronat, fonofos (Dyfonate; Stauffer Chemical Co.), thionazin, or phorate. Two new compounds, pirimiphos ethyl (PP 211; Chipman Chemicals Ltd.), and N2596 (Chipman Chemicals Ltd.) also proved promising as good residual insecticides for all-season control in rutabagas following a single, preplanting, subsurface application. Of the above compounds, thionazin and phorate showed a constant rate of loss of toxicity during the season and became ineffective if early-planted crops were left in the field until late in the fall. However, if the rutabagas were planted late or harvested as soon as they matured, maggot infestations were minimal.

Bioassays with first-instar larvae of the cabbage maggot showed that toxic residues of fensulfothion, trichloronat, chlorfenvinphos, and fonofos, or their metabolites, in an estimated range of 2.5 to 15 or more ppm, were present in rutabagas at time of harvest following commercially recommended rates of application, or rates sufficient to give good root maggot control. Only thionazin and carbofuran showed little or no toxic residues in the roots at recommended rates.

Control of foliage-feeding insects in crucifers. Endosulfan and azinphos-methyl were effective in controlling larvae of all species of foliage-feeding pests of stem crucifers early in the growing period. However, mevinphos, a material that is only toxic for a short period, had to be used during harvesting. Sprays of mevinphos up to five times the recommended rate of about 190 ml/ha failed to control the cabbage looper protected in heads of broccoli. Tests showed that the insects were not resistant to the insecticide. A drench treatment applied from a 5-cm shower nozzle (gravity flow) directly over the larger heads at the currently recommended rate in about 5,700 liters of water per ha gave almost complete control of all stages of larvae.

Nutrition and Management

P increases rutabaga yields. Experiments conducted in two fields in 1969, where soil tests indicated low P levels, showed that P applications had a marked effect on rutabaga yields. The P was applied in bands on either side of the row prior to seeding. Yield of marketable rutabagas was increased from 18.3 to 36.0 metric tons/ha in one field (20–30 ppm P-Bray) and from 44.4 to 54.3 metric tons/ha in the other (75–90 ppm P-Bray) by the addition of 65 kg/ha of P. Higher rates of applied P had very little effect on yield. Response of rutabagas to P was similar to results obtained in earlier experiments with Brussels sprouts and broccoli.

Aster yellows control in carrots. Propoxpur (Baygon; Chemagro Corp.) and carbofuran granular insecticides, applied in the furrow below the seed at 1.68 kg actual/ha were most effective in reducing the incidence of aster yellows in Touchon carrots. Disulfoton, fensulfothion, aldicarb, phorate, and methaphenamiphos (Bayer 68138; Chemagro Corp.) were less effective than propoxpur and carbofuran. Where aster yellows was reduced, it is assumed that the vector, the six-spotted leafhopper, was reduced.

Molybdenum and lime requirements of cauliflower. A greenhouse study showed that, without application of both Mo and lime, the cauliflower crop produced very poor yields on Culloden, O'Leary, and Acadia soils. Without added Mo, lime treatment up to pH 6.5 failed to increase the yield of cauliflower on Culloden and O'Leary soils.

Effect of plant spacing on single-harvest yield and size of broccoli. Spacing of plants affected both the yield and size of broccoli heads in tests conducted in 1968 and 1969. Single-harvest yields increased to a maxi-

mum of 8.1 metric tons/ha when spacing was reduced from 50 × 50 cm to 40 × 40 cm. Further decreases in spacing to 28 × 28 cm had very little effect on yields and closer spacing decreased yields.

Broccoli head size decreased as the distance between plants was decreased. Accordingly, head size may be regulated by spacing, and within wide limits, plant spacing had only a slight effect on total single-harvest yield.

Soil and fertilizer N and P for Brussels sprouts. Yield potential of a soil for production of Brussels sprouts was predictable from soil tests, whereas fertilizer N and P requirements were not. Soil nitrate N was the best test for N availability at transplanting time and the Morgan method the best for available soil P. For maximum yields of sprouts, 80 kg N and 40 kg P/ha were sufficient under the conditions tested.

Effect of terminal bud removal on maturity of Brussels sprouts. Experiments with the variety Jade Cross have shown that time of removal of the terminal bud affects maturity. Sprouts on plants that had the terminal bud removed when the sprouts were just beginning to form (the earliest terminal bud removal treatment employed) were the first to mature and were ready to harvest about 30 days before those on plants that were not debudded. Later removal of the terminal bud resulted in correspondingly later maturity.

Maximum single-harvest yields were obtained from plants that were debudded when 9–11 whorls of sprouts had formed. The interval between the 9- and 11-whorl stage in the Atlantic Provinces is generally about 10 days. However, the actual time of debudding can be extended over a period of 3 weeks without markedly affecting yields, and result in a harvesting succession of approximately the same duration.

TOBACCO

Tobacco transplants grown from seed in individual containers of compressed peat 4.45 cm × 4.45 cm were compared with plants produced in beds and transplanted directly to the field in the conventional manner. Field comparisons of transplants were made at increasing levels of applied N. Peatpot transplants matured 7–8 days before standard transplants at all N levels, but plants were smaller and cured tobacco lacked size and finish. Yield was reduced slightly and returns per acre were reduced significantly by this method of transplanting. Increasing levels of applied N retarded maturity and caused a higher percentage of green leaf grades in cured tobacco regardless of transplanting method.

ANIMAL NUTRITION

Urea and soybean meal were compared as protein supplements in calf starter diets containing ground hay, grain, minerals, vitamins, and 5% molasses. These starters were fed as the sole diet, after weaning at 5–6 weeks of age, for an 8-week test period. Grain protein supplement combinations studied were: (1) barley – soybean meal; (2) barley–urea; and (3) barley–corn–urea. Complete diets averaged 18% crude protein; urea supplied 1/3 of this in diets 2 and 3.

Daily feed intakes of 2.59, 2.35, and 3.26 kg; daily weight gains of 0.84, 0.72, and 0.88 kg; and feed-to-gain ratios of 3.09, 3.26, and 3.46 were obtained with diets 1, 2, and 3 respectively. Intake of diets 2 and 3 was not significantly altered by the presence of 2.3% urea. Both urea diets produced acceptable growth, but reduced feed efficiency may eliminate the economic advantage of using urea to replace soybean meal in calf starters.

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INTRODUCTION

This report presents the main findings from research during 1969 at the Research Station, Kentville, and at the Experimental Farm at Nappan, where the animal research other than poultry is carried on. Further information may be obtained by consulting individual scientists. In addition, 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 Blueberries and Cranberries

In a water-culture experiment the growth of lowbush blueberry plants was significantly better with NH_4^+ as the source of N than with NO_3^-. It was also better at pH 4.5 than at pH 6.0. The source of N and the pH affected the levels of other nutrients in the roots and leaves, although their effects appeared to be independent of each other.

Partial defoliation of newly pollinated lowbush blueberry plants reduced the fruit set, the percentage of ripe berries at harvest, and the total yield of ripe fruit. Lowering the light intensity further decreased the percentage of ripe berries and the amount of reducing sugars in the ripe fruit.

The synthetic growth regulator 3-indolebutyric acid (IBA) effectively altered the growth habit of the aboveground shoot of the lowbush blueberry. When it was applied in lanolin or water to the midvein of leaves, it stimulated lateral shoot development in what is normally an unbranched stem.

Acetaldehyde, methyl and ethyl acetates, ethyl alcohol, and ethylene were all detected in the volatiles given off by fruit of the lowbush blueberry. Small green fruit were more active producers of acetaldehyde, ethyl alcohol, and ethyl acetate than were more mature fruit.

Cranberry leaves assimilated CO_2 at a rate of 40.0 mg/dm^2 per hr compared with 14.4 mg for the leaves of lowbush blueberry when light intensity was 1,000 ft-c of incandescent light and flow rate 800 cc/min. At 2,000 ft-c, rates of apparent photosynthesis were below the saturation level for shoots of the cranberry and above for shoots of the blueberry. An infrared gas analyzer was used to estimate the rates of apparent photosynthesis.

The greatest level of ethylene production occurred immediately after pollination in fruit of lowbush and highbush blueberry and cranberry. Following a low production in the early green stage, there was a rise in production of ethylene in the fruit of all three species long before the fruit was ripe. These results indicate that the initial effects of ethylene on the ripening of all three species occur at a rather early stage in fruit maturation.

Composite leaf samples from four commercial cranberry bogs in the Kentville area were analyzed for N and several cations. The samples were taken in mid-July, and consisted of fully matured leaves from the midstem section of the current season's growth. The range and mean value for each element was as follows: N, 1.39–1.81% and 160%; P, 0.12–0.15% and 0.13%; K, 0.54–0.58% and 0.56%; Ca, 0.45–0.61% and 0.50%; Mg, 0.15–0.18% and 0.16%; Mn, 295–675 ppm and 449 ppm; and Fe, 89–267 ppm and 136 ppm.

In a test of picloram for vegetation control in lowbush blueberry plantings there was almost total reduction of plant growth, except of grasses, at a rate of 0.64 kg/ha. A rate of 2.24 kg/ha was required to reduce grass growth. Lowbush blueberry plants were successfully transplanted into old pasture land 2 years after application of 4.5 kg/ha of picloram.

Apples

There was no significant difference in yield, trunk cross section, amount of bloom, fruit size, or fruit color between McIntosh apple trees sprayed with captan, dodine, or dichlone to control apple scab. The experiment lasted 5 years. Dodine injured 0.5% of the fruit in 1 year of the test, and precover

sprays of dichlone caused some fruit russeting The results indicate that any harmful effect of dichlone on yield occurs from precover sprays.

A depression in fruit size occurred in the year following treatment of Crimson Gravenstein apples with sprays of *N*-dimethylaminosuccinamic acid. In this experiment sprays of 1,000 ppm were applied at successive intervals from 2 weeks after full bloom until a few days before harvest.

Grapes

Field trials with grape cultivars, conducted at three locations in the Annapolis–Cornwallis Valley in Nova Scotia, showed that the successful growth of wine cultivars is not feasible. There were differences between locations, but lack of sufficient heat to fully mature the fruit is responsible for the unsuitability of the area.

Raspberries

Electrical impedance readings did not separate winter-hardy from tender raspberry cultivars in a 3-year experiment with six cultivars. Failure to obtain separation was due to the extensive physiological changes associated with the biennial growth habit of the raspberry. Impedance changes indicated when the rest period began in the fall and the resumption of growth in the spring. Bud injury was dependent upon desiccation of the canes during the winter. Although changes in moisture content of the canes might not be indicated by impedance measurements, frost injury was directly correlated after a severe cold spell in midwinter.

Vegetable Crops

The effect of fertilizers on trends in the nutrient levels in the laminae and petioles of cucumbers was similar in trials conducted at four locations. Furthermore, when the percentage of a nutrient in the lamina was expressed as a ratio of the percentage in the petiole, the values obtained tended to be constant. Yield response showed P to be of greater importance in cucumber nutrition than N or K.

At low pH values, high rates of applied Mn increased the Mn content of the tissues several times more than at high pH values in carrots grown in sphagnum peat in the greenhouse. Bronze-colored symptoms on carrot leaves appeared when the Mn content of the tops was more than 2,500 ppm. This symptom was associated with lowered yield only when the Mn content of the tops exceeded 8,000 ppm.

The cauliflower cultivar Pioneer exhibited severe Mo deficiency symptoms when grown in the same soil as the cultivar Snowball 84, which did not show the symptoms. In spite of this, the Mo requirement for optimum yield was the same for both cultivars, 3.36 kg/ha.

Field Crops

Small pulses of alternating current were found to be conducted chiefly in the channels of the cell walls of potato and in the roots and stems of alfalfa during electrical impedance studies with these crops. Impedance measurements usefully detected the state of water relations in these channels when the frequency of the measuring current was low (60 cycle/sec), when chloridized silver probes were used, and when cell-wall resistance was low compared with the cell membrane in series. Activation energies were calculated for the conductivity of these tissues, and 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 were also found to accompany endogenous and other changes in the plant. In particular, pulses of light or heat caused changes of impedance, which reflected 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.

Biology and Integrated Control

The population of the European red mite, *Panonychus ulmi* (Koch), in plots in an apple orchard were altered by applications of ryania, carbaryl, and Animert V-101 (Green Cross Products). Supplementary applications of Animert V-101 and dicofol directed against certain generations of the European red mite controlled outbreaks and altered faunal levels the following season. Ryania was largely innocuous to most species of predators with the exception of *Atractotomus mali* (Meyer) and *Diaphnocoris* sp. Carbaryl was detrimental to most predaceous species. Animert V-101 was selectively toxic to phytophagous mites and innocuous to all predaceous insects and *Typhlodromus pyri* Scheuten. These experiments indicate that phytophagous mite populations may be altered to almost prescribed levels with pesticides when predator populations are known, thus allowing selective chemicals to be used to complement the predator effect and maintain red mite numbers below the damage threshold.

In a 2-year study in Nova Scotia, in 1967 and 1968, the duration of each generation of the European red mite was similar. Field populations of red mites were separated into egg, larva, protonymph, deutonymph, and adult and the time each stage was present determined. This information on the seasonal history is used to assess red mite mortality and in the timing of chemical controls.

Insect Pathology

Up to 20% of adult apple maggots, *Rhagoletis pomonella* Walsh, died of abdominal bloating during routine rearing. Bloating was most common in flies fed high-protein diets. Feeding certain bacteria, notably *Pseudomonas* and *Aerobacter* species, separately and in mixture somewhat increased the incidence of the condition. Ingestion of an antibiotic markedly reduced its incidence, but did not reduce mortality.

The polyhedral protein of the polyhedrosis virus of the cabbage looper, *Trichoplusia ni* (Hbn.), was decomposed only slightly by highly proteolytic bacteria and fungi. These results, in an experiment to test the decomposition of polyhedra, indicate that the protein of this nuclear-polyhedrosis virus is highly resistant to microbial action.

Miscellaneous Insects

Apple maggot. An artificial medium of sucrose, brewers' yeast, cholesterol, choline chloride, salt mixture, formalin, shredded tissue paper, agar, and water was satisfactory for growth and development of larvae of the apple maggot. The concentration of brewers' yeast affected larval growth and development, and amounts less than 2.0 g/100 ml decreased the growth rate and pupation. Amounts greater than 8.0 g reduced pupation. The behavior and reproductive capability of adults obtained from larvae reared on this medium, especially those reared under xenia conditions, were not equal to those of adults from larvae reared on apple.

Two cover sprays of dimethoate (1.1 kg/ha) were effective for control of the apple maggot. The dimethoate was harmful to predaceous insects and mites, but did not lead to a buildup of the European red mite during the 3-year period of the experiment.

Mites. Fifty-seven species of 27 families of mites associated with apple trees were recorded in a survey of the Annapolis Valley of Nova Scotia. Five species were phytophagous, 34 were presumably predaceous, and 18 were presumably scavengers and fungus feeders.

A new phytoseiid mite was discovered on bark from dormant apple trees in Nova Scotia in early winter and prior to bud burst. The female was described as a new species and named *Amblyseius duncansoni* Specht and Rasmy.

Apple aphid. The density of apple aphids on 1-year-old trees in a controlled-environment cabinet under conditions of decreasing temperature and photoperiod equivalent to August 1 through November 14 remained almost static up to the time of defoliation. Alate forms disappeared and reproduction leveled off after a 13.3-hr day, 17 C light, and 13 C dark temperature regime was in effect. Aphids left the apex of the trees and became distributed evenly over the older leaves after vegetative growth ceased. Egg deposition occurred after the photoperiod was less than 11.8 hr/day and temperature

less than 12 C during light and 8 C during dark. This "autumn" population produced winter eggs equal to one-third its numbers at the time of beginning oviposition.

Pear psylla. The pear psylla, *Psylla pyricola* Foerster, had three generations in 1968 in Nova Scotia. Laboratory studies indicated that overwintering females require mating in the spring to produce fertile eggs. The adults became active by the end of March. Psyllid eggs and nymphs were preyed on by eight predaceous species in the laboratory. These and the larvae of another six predaceous species were associated with psyllas in the field. A few psyllid nymphs were parasitized by *Trechnites insidiosus* (Crawford).

Plant Diseases

The fungus *Phytophthora syringae* Kleb. caused a fruit rot of stored McIntosh and Red Delicious apples in Nova Scotia. Nine strains of each of the two cultivars did not vary in susceptibility. Infection apparently occurred when harvested apples were left in the orchards in boxes during a rainy period.

The systemic fungicide benomyl (Benlate; DuPont of Canada Ltd.) controlled verticillium wilt of strawberry plants when applied to the planting hole. It was less effective when the roots were dipped in the fungicide before planting and was ineffective as a foliar spray. Lanstan (Niagara Chemicals) and methomyl (Lannate; DuPont of Canada Ltd.) did not control verticillium wilt, and methomyl was phytotoxic to strawberry plants.

The crowns of 100 cold-stored, apparently healthy strawberry plants of each of the cultivars Acadia, Cavalier, Catskill, Gorella, Guardsman, Midway, Sparkle, Redcoat, and Surecrop contained representations of 43 genera of fungi. The roots contained 38, of which 36 were common to the crowns. Strawberry foliar and fruit pathogens were present in a small number of crowns and roots. In general, *Chaetomium* spp. and *Fusarium* spp. were the most prevalent. *C. cochliodes* Pall. was most common in Cavalier and Redcoat, the cultivars most susceptible to root rots in the field. The crowns and roots of apparently healthy dormant strawberry plants contained fungal flora similar to that associated with the black root complex.

Two isolates of the squash black rot pathogen *Mycosphaerella citrullina* (C.O. Sm.) Gross. sporulated well under constant or intermittent illumination. Sporulation was poor in darkness. Both isolates produced abundant pycnidia on potato dextrose agar and on peptone–dextrose–salts medium. Good production of perithecia took place only on V-8 juice agar.

Two isolates of the carrot black rot pathogen, *Stemphylium radicinum* (Meier, Drechsl. & Eddy), grown in liquid culture produced polygalacturonase and measurable amounts of pectin methylesterase and cellulase. Polygalacturonase was produced inductively. Sodium polypectate was hydrolyzed more rapidly by polygalacturonase than was pectin.

Pesticide Residues

Cover spray mixtures of captan and lead arsenate were found to be nearly nonphytotoxic to foliage of the apple cultivar Cortland. The amount of arsenical injury was increased when ryania was present in dodine – lead arsenate and captan – lead arsenate mixtures. Injury was not always reduced when zineb was added to lead arsenate or to a mixture of dodine, glyodin, or ryania and lead arsenate. Azinphos-methyl safened the mixture of dodine and lead arsenate in the first year it was tested, but not in the second.

Hg from cover sprays of organic and inorganic mercurials, and Ni and Cd from sprays of $NiCl_2$ and $CdCl_2$ accumulated in maturing apples. The water solubility of the compounds did not appear to be an important factor in the movement of these three elements. Considering the rather large amounts deposited in the foliage, the amount translocated to the fruit was small. A possible explanation is that the metal is firmly bound in the leaf and that only small amounts are released and translocated.

STORAGE

Both the size of the blossom cluster and the position in it of the flower from which the fruit was produced were found to influence the development of stem-cavity browning in McIntosh apples in storage. Position had a predominant effect; even the smallest terminal apples had as much stem-cavity browning as the largest lateral apples. The shape of the stem-cavity region of McIntosh apples had been shown previously to be influenced by the position in the blossom cluster, and these results suggest that position may influence stem-cavity browning through its influence on stem-cavity shape.

Storage of preclimacteric McIntosh apples in a low (6 ppm) ethylene atmosphere resulted in firmer fruit than storage in a high (1,570 ppm) concentration of ethylene. The fruit was stored for 189 days at 3.3 C. The difference in firmness measured by a Magness-Taylor pressure tester was 0.9 kg and it persisted for more than a week after the apples were removed to room temperature. Acidity levels and soluble solids content were increased slightly and core browning lessened by low ethylene storage.

The fresh-fruit quality of cranberries stored at 22 C in air was equal to that of berries stored in 5% and 10% CO_2 and superior to berries stored in 100% N_2. Fruit stored in 100% N_2 had a dull, watery appearance and acquired a slight aroma after 3 weeks of storage. No significant color or flavor differences between sauces prepared from the berries could be detected by a taste panel. The berries stored in air produced juice with the most commercially acceptable color.

Tomatoes stored in a controlled atmosphere (3% CO_2 and O_2) at 11 C for 4 to 8 weeks, and then ripened in air at 22 C for 7 days, had less rots, had better flavor, and were firmer than controls stored in air. The experiments were carried on for two successive seasons. The cultivars Longred and Viscount were judged to be better suited for controlled atmosphere storage than Harrow or K65. Another study showed that a high concentration of ethylene (900–2,000 ppm) and 3% CO_2 was as effective as a low concentration of ethylene and the absence of CO_2 in reducing the rot development of *Fusarium oxysporum* Schlecht. on tomatoes.

ANIMAL SCIENCE

Poultry

When eggs were held in the small-end-up pack position without turning, their hatchability was equal to or better than that of eggs packed small-end-down. When eggs were stored in the small-end-up position for 2 to 4 weeks, it was not beneficial to turn them daily as had been previously demonstrated for eggs stored small-end-down. Thus, the inconvenience and expense of daily turning were avoided without loss. Hatchability was equally good whether eggs were stored on their sides and turned through 180 deg daily or stored small-end-up without positional change. Evidence indicates that preincubation orientation of the egg in the small-end-up position is associated with a more centralized yolk position at setting time and the maintenance of the blastoderm location in the equatorial region of the egg. The daily moderate vibration of eggs during storage had no detrimental effect on hatchability whether eggs were stored small-end-up or small-end-down.

When the level of fish meal in a broiler chick ration was increased from 4% to 10% at the expense of soybean meal, there was a significant positive growth response, which was not affected by a further increase to 15% fish meal. However, 20% fish meal resulted in significantly higher mortality and lower body weights at 63 days of age. There were significant differences in growth rate and mortality among genotypes, but no significant interactions involving genotype, sex, or diet. Four thousand chicks representing four commercial broiler genotypes were used in the experiment.

When five commercial Leghorn genotypes were fed a 10% protein and a 16% protein rearing diet when they were between 56 and 147 days of age, mortality from a natural outbreak of Marek's disease was significantly different among genotypes and the birds grown on the higher-protein rearing diet ex-

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Departures

D. W. FREIND, B.Sc., M.Sc., Ph.D. Transferred to Animal Research Institute, July 1969	Swine nutrition
C. W. B. MAXWELL, B.Sc., M.Sc. Retired July 1969	Apple maggot control
J. W. MCALLAN, B.Sc., M.Sc., Ph.D. Died June 1969	Potato physiology
R. G. WHITE, B.S.A. Retired July 1969	Tree fruits and vegetables

VISITING SCIENTIST

D. LOPEZ-ABELLA, Agric. Engr. (Spain) National Research Council postdoctorate fellow, 1968-69	Aphid-borne viruses

INTRODUCTION

This report summarizes research that was completed at the Station during 1969 and progress made on other projects. As in previous years, the main emphasis was given to research on all aspects of potato production, animal nutrition, agricultural engineering, and soils.

The Horticulture Substation, McDonald's Corner, Queen's County, N.B., which was opened in 1947, was closed in December 1969. The Research Station, Kentville, N.S., has assumed responsibility for most of the research on horticultural crops in the Maritime Provinces.

We regret to record the death on June 14, 1969, of Dr. J. W. McAllan, in his 38th year. Dr. McAllan, a plant physiologist, had been a member of our staff since 1954.

Mr. G. C. Misener, an agricultural engineer, joined our staff in June. Mr. Misener has initiated research on potato harvesting and storage.

F. Whiting
Director

ANIMAL NUTRITION

Addition of Formic Acid to Grass Silage

Tests have shown that formic acid increases the digestibility and dry matter consumption of silages. Two identical silos were filled with direct-cut grass from the same areas. Formic acid at the rate of 0.5% by weight was added to the grass put into one silo. The two silages were fed ad lib. to steer calves with 2 kg grain/head daily. Half the animals on each kind of silage received a grain mixture containing antibiotic and the other half were fed the same mixture without antibiotic. The results were as follows (in kg):

Silage	*Grain*	*Avg daily gain*	*Daily silage intake*
Formic acid	+ antibiotic	0.90	13.2
Formic acid	0 antibiotic	0.84	12.8
Control	+ antibiotic	0.84	12.4
Control	0 antibiotic	0.83	12.2

Ensiled and Dry Barley for Fattening Steers

Several methods of preserving the barley crop for livestock feed were compared, with the use of 42 steer calves. The preservation methods were whole plant silage (barlage), ensiled high-moisture barley grain, and dry barley grain and straw. These feeds were fed in various combinations, and the average daily gains (kg/day) by the steers for the 104-day period were: barlage alone, 0.78; barlage plus 2.7 kg/day of hammered ensiled barley, 1.08; hammered ensiled barley ad lib. plus 0.9 kg/day of straw, 1.02; hammered dry barley ad lib. plus 0.9 kg/day of straw, 1.01; hammered ensiled barley to a maximum of 6.8 kg/day plus straw ad lib., 1.05; hammered ensiled barley to a maximum of 6.8 kg/day plus hay ad lib., 1.14. The steers that received the ensiled barley went on feed with fewer disturbances and had higher rates of gain during the first half of the feeding period than those fed dry barley.

Potato Waste

Potato waste (mainly peeled, whole, and pieces of raw potatoes) from a potato-processing plant was fed daily ad lib. with 0.9 kg of hay and 0.9 g of protein–mineral–vitamin–antibiotic supplement to yearling Holstein heifers. They consumed daily 34 kg (22% dry matter) and gained 1.5 kg. The dry matter in the potato waste was 84.4% digest-

ible by sheep and in whole potatoes 84.6% digestible.

Sulfur for Dairy Cows Receiving Urea

To determine whether lactating dairy cows fed urea in the grain mixture would benefit from S supplementation, three groups of eight cows were fed for 120 days on average-quality grass hay (1.3 mg S/g), and one of three grain mixtures (2.8, 4.2, and 5.5 mg S/g) each containing 2% urea. There were no significant differences in feed intake or milk production among the groups. S supplementation did not affect S or N balances.

Effect of Diethylstilbestrol on Rumen Microorganisms

The addition of diethylstilbestrol to a rumen fluid in a continuous-flow artificial-rumen fermentor did not affect protozoa numbers, pH, volatile fatty acid production, net protein synthesis, or the activities of alanine amino-transferase and alanine dehydrogenase. However, it did decrease the glutamic dehydrogenase activity.

Milk Replacer for Calves

Milk replacers containing zero (all-milk) or 70% of the total protein from a soybean protein concentrate (soy-milk) each produced average body weight gains of 372 g/day in Holstein bull calves to 7 weeks of age. The calves digested 91% and 89% of the dry matter, and 87% and 82% of the N supplied by the all-milk and soy-milk replacers, respectively. N retention (41% of that consumed) was the same on both replacers. Methionine supplementation (0.1% of the dry replacer) of the soybean protein did not affect calf performance.

Neutralizing the acid in a liquid-milk replacer (original pH 5.6) containing 23% whey powder and 10% stabilized nonhomogenized beef tallow with NaOH increased average body weight gains of calves by 98 g/day (322 vs. 420). Gross energy and apparent N digestibilities were both increased by about 3 percentage units.

Milk Replacer for Lambs

Cold liquid-milk replacers were fed to male lambs, from about 3 to 28 days of age, in three experiments. In each of the first two experiments two milk replacers were fed containing either all-milk protein or 46% of the total protein from a soybean protein concentrate, and the remainder milk protein. Both contained 15% homogenized beef tallow (air-dry basis). Average body weight gains were 250 and 148 g/day for lambs fed the all-milk and soy-milk protein replacers respectively. An average of 96.8% and 94.9% of the dry matter, and 95.3% and 91.6% of the N from the two replacers was digested. The soybean concentrate was largely insoluble in water, and settled out when the mixture was not stirred continuously. In the third experiment, the soybean concentrate was dissolved in 0.05 N NaOH to keep it in solution. The soybean remained in solution or suspension when the final liquid replacer was adjusted to pH 7.0. Milk replacers were formulated to contain 0 (all-milk protein), 50%, and 98% of the total protein from the soybean concentrate. The remainder of the protein was from milk. Average body weight gains were 100, 163, and 165 g/day for lambs fed the three replacers, respectively. Digestibility coefficients were 4 to 9 percentage units lower than in the first two experiments. These differences were attributed largely to the use of nonhomogenized tallow in the third experiment.

Creep Feed for Baby Pigs

Piglets given access to creep feed at 1 or 3 weeks of age did not gain significantly more weight from 3 to 5 weeks of age than piglets given no creep feed. Hematocrits at 5 weeks of age were higher (30.7 vs. 29.2) when creep feed was offered. Trypsin and chymotrypsin activities in intestinal digesta from creep-fed piglets killed at 5 weeks of age averaged 134 and 168 units/kg for piglets without creep feed.

At 5 weeks of age trypsin activity had increased 3.5-fold and chymotrypsin by 1- to 2-fold (ratio of chymotrypsin to trypsin 1.2). The values for both creep-fed and noncreep-fed pigs were included.

Potato Damage During Harvesting

The effects of conveyor speed, forward speed of the harvester, and stone population on the damage to the tubers were evaluated. The amount of damage to the potatoes was assessed 2 weeks after they were collected from the harvester. Damage was found to increase exponentially as the velocities of the conveyors increased. For the harvester studied, the rate of potato damage increased rapidly when the velocities of the conveyors were increased beyond those which corresponded to engine speeds above 1,300 rpm. Potato damage decreased with an increase in the forward velocity of the machine up to 3 km/hr. The presence of a large number of rocks significantly increased potato damage.

Drying Rates of Hay

In developing empirical equations to describe the drying curves of hay based on a simple meteorological parameter called "latent evaporation," hay samples were dried in a controlled environment in which the hourly rate of latent evaporation was kept constant during each test. A range in rates of latent evaporation was obtained by varying the combinations of dry- and wet-bulb temperatures, air velocity, and artificial radiation. From the data collected, drying equations for specific rates of latent evaporation for each stage of hay maturity (alfalfa early, full, and late bloom) were calculated. General equations for each stage of maturity were then developed. The form of the equations obtained was as follows:

$$R = \exp -C_1(\text{L.E.} \times t)^{G_2}$$

where C_1 and C_2 = constants for the equation

L.E. = hourly rate of latent evaporation

t = time in hours

R = (Mi - Me)/(Mo - Me)

Mi = moisture content at any time t, % dry-weight basis (D.B.)

Me = equilibrium moisture content for a specific L.E., % D.B.

Mo = original moisture content of sample at time t = 0, % D.B.

Correlation coefficients for the three general equations for early, full, and late bloom were 0.94, 0.91, and 0.96 respectively.

Barley Varieties for Low pH Soils

Out of several hundred varieties or selections of barley tested during the past 6 years, few have shown high tolerance to the "toxic" conditions often associated with a soil pH below 5.3. Before the 1969 trials, any one showing high resistance lacked high yielding ability under more favorable soil conditions. The German variety Volla is the first encountered at Fredericton that has given high yields under both sets of conditions. In 1969, on a soil of pH 5.0 and toxic enough to severely curtail the yield of 41 out of the 43 varieties tested, Volla yielded 4,207 kg/ha compared with 3,034 for Charlottetown 80, 2,851 for Herta, and 2,389 for Keystone. In a 1968 test, where the pH was 6.1 and no symptoms of toxicity were present, Volla yielded 4,169, Keystone 4,126, Herta 3,050, and Charlottetown 80, 2,862 kg/ha.

Digestibility of Timothy Varieties

In vitro digestibility studies with timothy varieties disclosed that all varieties declined in digestibility as maturity approached. The early varieties, Clair and Champ, reached the fully headed stage between June 15 and 20 and had coefficients of digestibility of dry matter (DM) between 70% and 75%. Climax reached the same stage 7 to 10 days later and had a DM digestibility of 66%. Later-maturing varieties, Bounty, Drummond, and Tiger, reached the heading stage 7 to 10 days later than Climax and had DM digestibilities of 60%. Climax, if left until the latter varieties had headed, had a DM digestibility of 57%. Although there was a slight gain in digestibility by using later-maturing varieties for late-harvested timothy, the early varieties were much superior in digestibility. The trend toward earlier harvesting, made possible by improved machinery and harvesting facilities, suggests that extension programs should emphasize greater use of early varieties, and breeding programs should concentrate on developing improved varieties with early maturity.

ENTOMOLOGY

Grain Aphids

In 1969, populations of aphids developing on barley (Charlottetown 80) and oats (Fundy) were sampled weekly during the period of infestation, June 9 to July 25. After July 25, emigration of winged forms eliminated the infestation. Three species were present, *Rhopalosiphum maidis* (Fitch), *Rhopalosiphum padi* (L.), and *Macrosiphum avenae* (Fab.). The plot area seeded in 1969 was in a different location from that seeded in 1967 and 1968, and a much higher incidence of *R. maidis* was recorded than in previous years. Nevertheless, all species emigrated at the same time. As in previous years barley supported a higher aphid population (347/tiller) than oats (232/tiller). No correlation was found between the auxin contents of the grains and the appearance of the winged aphid morphs.

Polymorphism in Potato-infesting Aphids

Studies on the factors influencing the determination of morph-type in potato-infesting aphids continued under artificial lighting (a combination of incandescent and fluorescent) and reared on excised potato leaves. *Macrosiphum euphorbiae* (Thomas) when reared from birth under a long day (18 L : 6 D) and a temperature of 10.5 C produced only viviparous females. Under a short day (13.5 L : 10.5 D) and at 10.5 C, viviparous females were produced followed by oviparous females. To determine if excised potato leaves present a host condition of senility that might influence the morph-type, this species was reared also on potato sprouts. Under short-day conditions oviparous females were produced on both sprouts and excised leaves. This species was also reared under short-day conditions of light provided by an incandescent bulb covered with red cellophane or a fluorescent bulb covered with blue cellophane to determine if light quality affected morph-type. Plant growth was poor under both conditions and it was difficult to keep the aphids on the leaves.

The aphids survived for one generation on artificial diets. First-instar nymphs were placed on diet cells and reared to maturity under short-day conditions at 10.5 C. Their offspring were transferred to excised potato leaves under a long day at 21.5 C. These offspring matured into oviparous females. Oviparae were also produced on whole plants under the short-day conditions. These tests indicate that light quality and host conditions have less effect on the production of oviparous females than does the length of day.

Blueberry Maggot

For the second consecutive year high maggot populations were present in Charlotte County, N.B. In control tests, both azinphosmethyl and carbophenothion dusts at the rate of 0.74 kg/ha of active ingredient were superior to calcium arsenate dust.

Blueberry Casebeetle

A further increase in populations of the blueberry casebeetle, *Chlamisus cribripennis* (LeConte), occurred during 1969 in Cumberland County, N.S., in eastern New Brunswick, and in Prince Edward Island. Studies carried out during the past year showed that the cultural practice of burning blueberry fields does not contribute significantly to the mortality of overwintering adults. Burning was done either in late fall or early spring, and the beetles apparently survived by remaining below the litter layer during the brief period required for the fire to pass over. Eggs were laid on the charred remains of the blueberry shoots, and enough new plant growth was present in time to support the hatching larvae.

Potato Flea Beetle

Current control recommendations are to spray for the potato flea beetle when plants emerge and again 10 days later. This may be unwarranted based on this year's evaluation of the economic loss of tubers. Varying the populations to 0, 10, 20, 30, and 40 flea beetles per plant caged for a 2-week period throughout the growing season showed that all plants recovered from flea beetle damage during the period of rapid growth of the plant. After the blossoming stage (July 23), all populations of beetles reduced weight and number of tubers. Varietal response to flea beetle damage also varied. In 1969 Katahdin, Kennebec, and Pontiac suffered the greatest loss, with injury being twice that of Green Mountain and Netted Gem and four to five times that of Sebago and Avon.

PLANT PATHOLOGY

Potato Virus X

Potato virus X incited local lesions in *Datura metel* L. (USDA PI 234199) plants at 13 C. The number of lesions in *D. metel* was comparable with the number produced in *Gomphrena globosa* L. plants. The lesions in *G. globosa* at 13 C were whitish and looked like rubbing injury. On the other hand, lesions in *D. metel* at 13 C were necrotic and appeared in 5–7 days; the *Datura* leaves were larger than *G. globosa*. Therefore, *D. metel* is a better local-lesion host of potato virus X for the low-temperature studies.

A polysaccharide, isolated from the mycelium of *Phytophthora infestans* (Mont.) de Bary, inhibited local-lesion formation by potato virus X on certain *Nicotiana* species, but not in other hosts tested. The inhibitory effect was almost instantaneous. Dilution and centrifugation of the virus–inhibitor mixture resulted in reduced inhibition. Maximum inhibition was obtained when virus and inhibitor were either in mixture or applied one soon after the other. The tobacco leaves that showed no lesions, because of complete inhibition, contained a high concentration of the virus when tested serologically. This indicates that the polysaccharide apparently has no effect on the virus multiplication, but inhibits local-lesion formation. This type of inhibition has not been reported previously.

Potato Spindle Tuber Virus

Nineteen tomato varieties or hybrids were screened as indicator plants for potato spindle tuber virus (PSTV). Twelve varieties reacted with visible symptoms, mainly veinal necrosis of leaves, reduction in leaf size, and stunting of entire plants. The other seven appeared to be immune. Also, 73 USDA introductions of *Lycopersicon* were tested. Eleven of these plants reacted with visible symptoms. These were distributed in four species, *L. glandulosum* Mull. (1), *L. hirsutum* H. & B. (3), *L. hirsutum* var. *glabratum* Mull. (1), and *L. peruvianum* (L.) Mill. (6). None of the tomato varieties of *Lycopersicon* introductions reacted with visible symptoms when inoculated with a milk strain of PSTV.

Two hundred and twenty-five samples of potatoes were collected from 22 "table-stock" fields in Eastern Canada, suspected of being infected with PSTV. By means of the tomato test, 85% of these samples were found to be infected with the virus, of which 73% was a milk strain and 12% a severe strain of the virus. This indicated that the mild strain is more prevalent than the severe strain in Eastern Canada.

One hundred and eighty-four clones, representing 43 species of *Solanum*, were challenged with PSTV and tested at least twice for resistance to the virus. Eleven clones representing 10 species were free from the virus. This suggests that it may be possible to develop varieties with resistance to PSTV.

Stylet-borne Viruses

It is well known that aphids acquire and transmit stylet-borne viruses best during superficial probing. Until recently it was believed that the stylets penetrate completely between the transverse walls of the epidermis. But this is not so. An electron-microscope study of these stylet paths has shown that some part of the stylets often breaks through the transverse wall into the cell cytoplasm. One or two of these breaks have always been found in tracks made when aphids acquired stylet-borne virus; but none has been found in tracks made when aphids failed to acquire virus. Thus it seems that these breaks may be necessary for aphids to acquire virus, and presumably the same applies to its transmission to healthy plants. These findings have opened up possible explanations of other features of this transmission.

Potato Virus S Lowers Yields

In an experiment carried out for 2 years, Saco potatoes infected with potato virus S yielded 20% less than similar potatoes that were virus-free. Because Saco potatoes are virtually immune to this virus, they were infected by grafting.

Leaf Roll Virus of Potatoes

Forty-one of an original 717 potato clones (6 crosses and 3 selfed lines) remained free from leaf roll virus after repeated attempts were made to infect them. Challenge inoculations were made with aphids, *Myzus persicae* (Sulz.), that had been colonized on excised infected leaves of *Physalis floridana* Rydb., and recovery tests were made with nonviru-

liferous aphids tested on healthy *P. floridana*. The screening began on plants grown from true seed and the process was continued for four subsequent tuber generations. Infected plants were discarded when found.

Introduction of Virus-tested Potato Stocks to Elite Seed Farms

Two thousand rooted cuttings and 7 kg of tubers free from all known viruses were introduced into the Elite Seed Farms in Prince Edward Island, New Brunswick, and Quebec for planting in 1969. The parent plants of these stocks were grown from tubers received from Vancouver and from which the latent viruses X and S had allegedly been eradicated.

Before the stocks were released, the parent plants were tested at Fredericton for freedom from viruses X, S, PSTV, and leaf roll virus. The newly introduced stocks included the following varieties: Kennebec, Sebago, Netted Gem, Red Pontiac, Katahdin, Green Mountain, and Irish Cobbler. They should be available to commercial growers by 1972.

Forecasting Late Blight Damage in Potatoes

As part of a program to determine the economic losses caused by potato diseases in New Brunswick, studies were made on the effect of time and degree of blight infection on potato yields. Various levels of blight infection were induced by altering spray schedules according to temperature and relative humidity and by inoculating plots with different concentrations of spores of the blight fungus. The data obtained indicate that these tests may be useful in predicting yield reductions caused by blight infections under particular weather conditions.

A program was initiated in cooperation with the Interdepartmental Committee on Air Surveys, Ottawa, to determine the feasibility of using color infrared aerial photography to detect potato late blight in commercial potato fields in New Brunswick. Similar photographs taken of test plots near Fredericton showed that the presence of 10% blight infection could be detected in photographs taken at an altitude of 1,000 ft.

Biochemistry of Resistance to Late Blight in Potatoes

As a result of studies on the depletion of energy reserves in the host during infection by the late blight pathogen, an attempt was made to delineate the relationship between certain enzymes of the host and resistance. Kinetic studies on the enzyme adenosinase, an enzyme that is activated under conditions of injury or stress in the host, attested a high degree of specificity, activity being dependent upon the presence of the 6-amino group of adenine. Experiments with C^{14}-labeled adenine in potato leaves showed over 90% of the label was incorporated into the RNA fraction of the leaf. Preliminary studies on the activity of adenosinase in varieties and seedlings derived from *Solanum tuberosum* and hybrids of *S. tuberosum* × *S. demissum* indicated that differences do exist. Moreover, the behavior of purified extracts of the enzyme on DEAE-cellulose columns and on polyacrylamide gels suggest that these differences can be ascribed to differing levels of a single enzyme.

Verticillium Wilts in Potatoes

Potato plants showing symptoms of verticillium wilt were collected from 72 fields in the Maritime Provinces, 26 in New Brunswick, 24 in Nova Scotia, and 22 in Prince Edward Island. *Verticillium dahliae* was isolated from plants from 7 fields (3 in N.B., 2 in N.S., and 2 in P.E.I.), and *V. nigrescens* from 13 fields (6 in N.B., 5 in N.S., and 2 in P.E.I.). *V. albo-atrum* was recovered from 68 fields including 6 of the 7 fields containing *V. dahliae* and 10 of the 13 fields containing *V. nigrescens*. In addition, *Cephalosporium* (in 14 fields) and *Gliocladium* (in 19 fields) were isolated from the wilted potato stems. Field isolates of *V. albo-atrum* differed in pathogenicity when they were tested in an environmental cabinet on the variety Kennebec and on the resistant seedling F6119, by using the root-dip method of inoculation.

POTATO BREEDING

Green Sprouting Early Potatoes

A replicated yield trial with 12 early-sizing potato seedlings (unlicensed cultivars) plus the varieties Warba and Irish Cobbler was conducted at the McDonald's Corner substation during 1969. The trial consisted of eight

replications with 25 plants of each seedling or variety in each replicate. Planting was done on May 2, and harvesting on July 23. Four of the replicates were planted with seedlings that had previously been green sprouted for 3 weeks in daylight at a temperature of 21 C. The other four replicates were planted with the same seedlings taken from common storage where the temperature was 7 C. At harvest, tubers were graded into Canada No. 1 size (4.8 cm) for early potatoes, and small, and a specific gravity determination was carried out.

The green-sprouted potatoes exceeded the nonsprouted potatoes in yield of marketable tubers by 28% and in specific gravity (1.070 vs. 1.067).

Parental Line Breeding at the Diploid Level

Parental lines possessing multiple disease resistances are being bred at the diploid level (2n = 24) by the use of selected diploid wild species, the South American cultivated diploid *Solanum phureja*, and haploids (2n = 24) of some tetraploid varieties (2n = 48). The species being used as a source of general (polygenic) resistance to late blight is the Mexican diploid species *S. verrucosum*. It has a high level of resistance, it is self-compatible thus facilitating inbreeding and selection, and it can be crossed directly with *S. phureja* and with some haploid clones. A parental generation of 476 seedlings from four sources has been screened by using a detached leaf technique and an inoculum of 16,000 spores of race 1,2,3,4,5,6,7 of *Phytophthora infestans* per ml. The results enabled the seedlings to be classified into five groups from highly resistant to susceptible. Several clones were retained from each resistant group within one of the sources, and selfed seed was obtained to initiate a second cycle of screening and selfing. Selection will be continued through several generations to obtain a range of homozygous *S. verrucosum* material from which the most resistant clones will be selected for use in crosses with *S. phureja* and haploids.

Stability Analysis of Seedlings in Potato Main Crop Regional Trials

Combined analyses of variance for marketable yield of seedlings in the 1965, 1966, 1967, and 1968 main crop regional trials showed that both variety mean square and variety–environment interaction mean square were highly significant. The interaction effect was then separated into two components for evaluating the relative stability of each of the seedlings used in the trials. These components were (i) linear response to environmental effects measured by a structural relationship parameter, and (ii) deviation from linear response expressed as a ratio of deviation variance to error variance. The two parameters were estimated by means of the principle of structural relationship analysis. There were six seedlings in the 1965-66 series, six seedlings and one variety in the 1966-67 series, and eight seedlings and two varieties in the 1967-68 series. All three trials had Katahdin and Sebago as check varieties. The results showed that the seedlings F5815, F6207, F6233, F6345, and F6367 had yielding ability and stability comparable to the check varieties. The highest yielders were unstable, whereas the most stable seedlings generally gave low yields.

SOILS

Effect of Selected Minor Elements on Plant Growth of Potatoes

The influences of minor-element deficiencies and toxicities in Netted Gem potatoes were studied in greenhouse sand cultures. Deficiencies of B, Mo, and Mn were studied. Mn, Zn, Cu, and As toxicities were each studied at a concentration of 20 ppm. Plant growth under these treatments was compared with plant growth in a complete nutrient solution.

Growth of Netted Gem was greatly restricted in the absence of either B or Mn and also in the presence of 20 ppm of either Cu or As. However, plant growth in the presence of 20 ppm of either Zn or Mn appeared to be only slightly affected.

Effect of Aluminum on the Growth of Potato Plants

Eight potato varieties, Netted Gem, Kennebec, Green Mountain, Huron, Katahdin, Keswick, Sebago, and Irish Cobbler, were grown in growth chambers in nutrient culture solutions containing either 0 or 20 ppm Al. The yields of tops, roots, and total plant for all varieties were lower with the 20 ppm of Al. Plant yields did not show a significant interaction between varieties and Al levels. The concentration and uptake of Ca, Mg, K, and Mn were lower in the tops and roots of plants grown in the solution containing Al. Both P and Al accumulated in the roots of plants grown in Al solutions and translocation into plant tops was reduced.

Netted Gem and Sebago potato plants, grown in sand cultures in a greenhouse, were watered daily with nutrient solutions containing 0, 5, 10, or 20 ppm Al. Plant tops, roots, and tubers were harvested 140 days after planting. Al at levels of 5, 10, and 20 ppm decreased the yields of plant tops, total plant, and tubers of both varieties. The yield of plant roots decreased when the level of Al reached 10 ppm. The number of tubers per plant decreased as the level of Al increased for both varieties. Sebago produced more tubers with lower specific gravity than Netted Gem. The specific gravity of the tubers from both varieties increased when 20 ppm of Al was added to the growth medium.

Response of Potatoes to N, P, and K

A 5-year field investigation on the response of the Netted Gem variety to N, P, and K in the upper Saint John River valley was completed. N (0, 90, 180 kg/ha), P (0, 59, 117 kg/ha), and K (0, 75, 149 kg/ha) were applied in a factorial arrangement at 37 locations. Without N, mean yields were reduced by 29%, without P by 16%, and without K by 9%. The mean rate of N required was 128 kg/ha with response varying from 90 to 157; for P a mean rate of 72 and a range of 0 to 108; and for K, a mean of 67 and a range of 0 to 112 kg/ha.

On the basis of these results a 3-4-2 (N–P_2O_5–K_2O) ratio has been projected as a general recommendation on intensively fertilized soils when soil test information is not available. Proposed rates of N, P, and K are 135, 78, and 75 kg/ha (i.e., N, P_2O_5, and K_2O) at 120, 160, and 80 lb/acre).

Denitrification in Podzols

Denitrification is recognized as a potential source of loss of fertilizer N in soils. The extent of and the factors affecting denitrification were investigated in Maliseet, Riverbank, and Interval soils. Only small amounts of applied nitrate were lost during 3 weeks of incubation when soil moisture was maintained at 100% available water. On the other hand, 40% of a 100 μg/g treatment disappeared after incubation of Riverbank soil for 3 weeks at 175% available water (below saturation). Denitrification increased with increasing water content and temperature and with the addition of an energy source such as glucose. Very little denitrification occurred at 4 C, but some was encountered at 9 C and it increased as the temperature was raised to 20 C.

The fate of fertilizer nitrate applied to Riverbank soil at high moisture content under an aerobic atmosphere was investigated by gas chromatography. N_2O was detected after 2 days; it increased in concentration to the fifth day, and then declined. Peak levels of N_2O were equivalent to 40% of applied nitrates (100 μg/g). N_2 was detected in 5 days and increased in concentration to the end of the experiment (19 days). At that time N_2 accounted for 85% of added nitrate, N_2O for 5%, and extractable nitrate for 10%. Other oxides of N were not detected.

Effect of Structure on Crop Yields in Salt-affected Coastal Alluvial Soils

In a greenhouse study with salt-affected coastal alluvial soils, when aggregate size was increased from < 1 mm to > 3 mm by the use of silica, the O_2 diffusion rate (g/cm^2 per min) increased from 22×10^{-8} to 39×10^{-8} and dry matter yield of barley increased from 59.9 to 65.5 g/pot and timothy from 15.4 to 18.7 g/pot.

Soil Survey

During 1969, the field work for the Soil Capability for Agriculture of the Campbellton (210) and Bathurst (21 P) areas was completed. The capability maps, report, and computer maps for the Woodstock (21 J) and Edmundston (21 N) areas were completed. Soil survey was made on approximately 80,000 ha in Gloucester County.

WEED CONTROL

The rates of herbicides in this summary are given as active ingredient or acid equivalent per hectare.

Control of Sheep Laurel in Lowbush Blueberries

The safest date to apply dicamba for control of sheep laurel (lambkill) in blueberries was the first week of October. Application of dicamba later in the fall often severely reduced the stand of blueberries for 1 or 2 years. The safest date to apply 2,4-D ester appeared to be later in the fall, but late applications gave very poor control of sheep laurel and no control of sweetfern.

Although dicamba alone is a more effective herbicide than 2,4–D ester for the control of sheep laurel among lowbush blueberries, it is more expensive. Economically, it is desirable to use lower rates of dicamba and mix it with 2,4-D where possible. Our results indicate that 2,4-D ester at 3.4 kg/ha for control of sheep laurel can be appreciably improved by the addition of dicamba at 1.1 kg/ha and the mixture applied during the first week of October. This mixture has also provided better control of sweetfern than 2,4-D applied alone. After treatment with either the 2,4-D ester or the herbicide mixture, the shoots must be burned early the next spring.

Chemical Burn of Lowbush Blueberry Shoots

Blueberry sprouts must be pruned periodically to promote fruiting. Traditionally they have been burned in the late fall or early spring. This burning destroys the surface mulch of organic matter and depresses the water-holding capacity of the soil. Several herbicides were tested for pruning. Paraquat was sprayed on blueberry shoots at 1.1, 1.7, and 2.2 kg in 225 liters of water/ha and dinoseb acid at 6.7 kg/ha. For comparison blueberry plants were oil burned on May 14, 1969. Paraquat at 1.7 and 2.2 kg gave a fairly satisfactory pruning effect, whereas diquat and dinoseb did not prune sufficiently. The oil burn was classified "good." Paraquat reduced the emergence of new shoots by 20% in comparison with the oil burn or other chemicals. This amount of thinning may lead to a higher yield if the plants are initially too thick.

Control of Barnyardgrass in Potatoes

Of 34 herbicides applied to potatoes as preplanting, preemergence, or postemergence treatments, several controlled barnyardgrass, *Echinochloa crusgalli* (L.) Beauv., for part of the season, but none had controlled more than 50% of this annual grass by September. Among the herbicides registered for use on potatoes the following gave good early-season control of barnyardgrass and also were associated with high yield of tubers: linuron at 2.2 kg/ha, and metobromuron at 3.4 kg/ha. The potatoes in all treatments were hilled during the early bloom stage of growth and thereafter new barnyardgrass seedlings increased rapidly in most plots.

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INTRODUCTION

Le principal objectif de la Ferme expérimentale de L'Assomption est d'améliorer le rendement et la qualité des tabacs au Québec. Ce rapport est un bref résumé des travaux de recherches poursuivis par cet établissement en 1969. Nous ne connaissions qu'une partie des résultats à la date ou ce rapport fut présenté. De plus amples renseignements peuvent être obtenus en s'adressant à la Ferme expérimentale ou aux agents de recherches. En avril, monsieur M. Lamarre s'est joint à notre personnel professionnel.

J. Richard
Le directeur

TABAC

Tabac à cigare

Etudes sur l'hérédité. Les résultats de la seconde étape de nos études sur l'influence du géniteur femelle, en se servant de matériel hétérogène, confirment ceux obtenus dans la première étape avec des cultivars connus de tabac à cigare et à pipe. Une contribution maternelle significative fut notée lorsque la génération F_1 (provenant d'un croisement entre des cultivars de tabac à cigare et à pipe) fut rétrocroisée réciproquement avec ses parents. On a remarqué que le géniteur femelle avait une influence significative sur les variables suivantes: nombre de jours requis de la plantation à la floraison; nombre moyen de feuilles par plant; indice de la feuille ([largeur/longueur] × 100); rendement; pourcentage de tabac séché vendable et pourcentage de tabac séché provenant des filasses.

Sélection. En 1969, le groupe de sélection se composait de 414 lignées hybrides et de trois cultivars commerciaux (Ottawa 705, R.H. 211 et Penbell 69). De ce groupe 14% ont été éliminées dans le champ d'après leurs apparences générales. Dans 81% des cas, cette élimination fut faite alors qu'un des parents était le cultivar Ottawa 705. D'autres lignées seront probablement enlevées du groupe lorsque nous posséderons les données de classification.

Test préliminaire. En 1969, cet essai a été fait sur 40 variétés ou lignées hybrides (14 cultivars connus et 26 lignées). La hauteur moyenne des plants après l'étêtage varia de 88.9 à 135.0 cm (35 à 63 pouces). Le nombre moyen de feuilles fut de 15 à 23, l'indice de la feuille varia de 33.8 à 59.0% et le nombre de jours de la plantation à la floraison de 56 à 67 jours. On ne possède pas encore les résultats complets sur les feuilles séchées.

Test avancé. Comme pour les années précédentes, dix cultivars ou lignées furent utilisés. Cet essai n'a pas montré de différence significative quant à la hauteur des plants après l'étêtage. Le plus grand nombre de feuilles fut produit par la lignée 290, qui est la plus tardive, tandis que la lignée 607 en avait le moins. L'indice de qualité n'a pas montré de différence significative entre les cultivars employés, probablement à cause des avaries subies au champ. Le meilleur rendement fut obtenu par la lignée 839, suivi de très près par le cultivar témoin R.H. 211 qui se classa premier pour l'indice de revenu.

Essais de dégustation. Notre jury de dégustation qui comptait 25 membres en 1968 á été augmenté à 50 membres en 1969. Onze épreuves furent faites sur des cultivars et des lignées hybrides. Les résultats démontrent que le cultivar témoin R.H. 211 fut le moins acceptable et la lignée S 11-3X la plus appréciée.

Résistance aux maladies. Des lignées hybrides de différentes générations et trois cultivars commerciaux témoins furent cultivés au champ dans le but d'évaluer principalement leur résistance à la pourriture noire de la racine causée par le champignon *Thielaviopsis basicola* (Berk. & Br.) Ferr. Ces lignées étaient les mêmes que celles du groupe de sélection. Des trois cultivars commerciaux témoins, Ottawa 705 et R.H. 211 étaient plus résistants que Penbell 69.

Séchage. La qualitée du tabac séché dans des conditions naturelles ou séché à l'aide de chauffage et de ventilation supplémentaires fut supérieure au tabac séché avec ventilation supplémentaire seulement. Par contre, aucune différence significative ne s'est montrée entre les deux premiers traitements. Le tabac séché en utilisant comme source de chaleur

du charbon de bois donna le plus haut indice de qualité, si l'on compare la moyenne de cet essai avec celles des trois autres traitements. Vu que le séchoir utilisé pour ce traitement est construit quelque peu différemment des trois autres, les résultats obtenus ne peuvent être inclus dans les études statistiques.

Tabac jaune

Évaluation des variétés et des hybrides. En 1969, nous avons comparé la valeur agronomique de différentes variétés et lignées. La variété Burford 205 s'est avérée la meilleure pour le rendement à l'hectare, mais moyenne pour la qualité de la feuille, le revenu brut et l'indice de maturité. C'est la Speight G-7 qui a produit la meilleure qualité. La Virginia 115 a produit le tabac le plus mûr et assuré le plus fort rendement brut. Les variétés Hicks Broadleaf et Delcrest 66 ont donné respectivement le plus faible rendement et revenu brut. Chez les hybrides, la lignée L 68 × Speight G-5 a été la meilleure pour le rendement et le revenu brut. Elle fut supérieure à la moyenne pour la qualité et l'indice de maturité. C'est la lignée L 68 × 138 P_1X qui a produit la meilleure qualité alors que L 68 × Bell 29 fut supérieure pour la maturité. La variété Speight G-7 et la lignée L 68 × Delcrest 66 ont produit le même nombre de feuilles, soit 16 par plant.

L'effet du pH sur la croissance du tabac. Les travaux effectués en serre en 1968 nous ont permis de mieux modifier le pH original (5.4) du sol au champ. Malgré tout, les pH désirés (4.5, 5.0, 5.5, 6.0, 6.5, 7.0) ont été atteints seulement dans les quatre premiers traitements. Les résultats obtenus en 1969 indiquent que seul l'indice de maturité n'a pas répondu aux traitements. En ce qui concerne les différentes doses d'engrais, une application de 672 kg/ha (600 lb/acre) produisit un résultat inférieur seulement pour le rendement et le revenu brut comparé à des applications de 1 345 kg/ha (1 200 lb/acre) et 2 017 kg/ha (1 800 lb/acre). Les analyses de tabac en laboratoire n'étant pas terminées nous ignorons l'effet du pH sur les constituants chimiques de la feuille.

Méthodes culturales. Cette année nous avons étudié le comportement de trois variétés de tabac jaune soumises à trois degrés de compacité et trois taux de fertilisation. Une majoration de la quantité de fertilisant de 1 120 kg/ha (1 000 lb/acre) à 1 680 kg/ha (1 500 lb/acre) a eu une légère influence négative sur le revenu. La variété Virginia 115 s'est révélée supérieure à Delhi 34 et Yellow Gold pour le rendement et le revenu. Un espacement de 56 cm (22 pouces) sur le rang comparé à 61 cm (24 pouces) et 66 cm (26 pouces) a augmenté le rendement et le revenu.

Répression des drageons du tabac. En 1969, quatre produits ont été comparés entre eux, soit: Penar (Pennsalt Chemicals of Canada Ltd.), Emgard (Emery Chemical Co. Ltd.), Off-Shoot-T (Proctor and Gamble Ltd.) et TSC 350 (Pfizer Co. Ltd.). Par rapport à un témoin, tous les traitements ont été plus efficaces pour le rendement et la répression des drageons. Le produit Off-Shoot-T s'est avéré le meilleur pour le revenu brut, l'indice de qualité et le contrôle des drageons. Par contre, le rendement à l'hectare et l'indice de maturité ont été inférieurs à la moyenne.

Répression des mauvaises herbes. Dans les études sur l'éradication des mauvaises herbes à l'aide d'herbicides, nous avons constaté que dans les parcelles ou aucun désherbage n'a été fait, le rendement a diminué de près de 50%. Des différents herbicides utilisés, soit en préémergence, soit en postémergence, l'herbicide Tillam (Stauffer Chemical Co.) a été le plus efficace. Il faut noter que pour les caractères agronomiques, il y a des différences significatives entre les traitements pour le rendement et l'indice de revenu seulement.

Répression des nématodes. Dans cette expérience, nous avons obtenu des résultats différents seulement pour l'indice de revenu. Le tabac traité avec aldicarb (Temik [Union Carbide of Canada Ltd.]) à raison de 45 kg/ha (40 gal/acre) a donné le meilleur rendement à l'hectare. Par contre, c'est avec méthomyl (Lannate [Dupont de NeMours]) à raison 7 kg/ha (6 lb/acre) de matière active qu'on obtient le meilleur indice de qualité, le meilleur revenu brut et la maturité la plus élevée. Dans l'ensemble, cinq nématicides ont fourni des rendements supérieurs à celui du témoin non traité. Il faut considérer que le comptage des populations de nématodes pour l'année 1969 n'a pas encore été fait.

Plantes fourragères

Effets des plantes-abri sur l'établissement. Les plantes-abri modifient considérablement les conditions microclimatiques auxquelles sont soumises les plantules fourragères lors de l'établissement. Il est généralement admis qu'elles ont une forte influence sur la quantité d'énergie lumineuse disponible au semis en voie d'implantation. Effectivement, dans nos expériences, les plantes-abri, les mauvaises herbes ou les deux ont intercepté jusqu'à 98% de l'énergie solaire disponible. Cependant, même sous un climat humide, l'humidité du sol a été le facteur prépondérant dans le succès de l'établissement des espèces fourragères.

Les mauvaises herbes, comme le chénopode blanc (*Chenopodium album* L.), l'amarante à racine rouge (*Amaranthus retroflexus* L.), l'échinochloa pied-de-coq (*Echinochloa crusgalli* (L.) Beauv.), le panic capillaire (*Panicum capillare* L.) interceptent approximativement la même quantité de lumière que les céréales: avoine, blé et orge, pendant que l'humidité du sol, à six pouces de profondeur, demeure plus élevée. Il en résulte une nette augmentation du développemnt des plantules d'espèces fourragères. De façon générale, le régime de paissance simulée améliore les conditions de luminosité auxquelles les semis d'herbage sont soumis; par contre, la disponibilité de l'eau dans le sol n'est pratiquement pas influencée par la fauche des céréales.

D'après les résultats de nos expériences, il appert que l'amélioration de l'établissement, qui résulte de l'emploi du régime de paissance simulée, est due à l'amélioration des conditions de luminosité. Les meilleurs établissements sont obtenus lorsque le semis est effectué sans plante-abri parce qu'une plus grande quantité d'eau est disponible aux jeunes plantules fourragères.

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INTRODUCTION

Ce bref rapport résume les expériences terminées en 1969. Il contient aussi les résultats d'essais en cours qui se prêtent à des conclusions finales. L'ensemble du travail expérimental est consigné dans un ouvrage que l'on peut se procurer sur demande.

En plus de ses travaux de recherches scientifiques, la Station collabore avec les autres institutions de recherches au Québec en ce qui a trait aux essais de variétés de céréales et de plantes fourragères. Son personnel participe activement à la préparation et à la rédaction des guides de productions végétales publiés par le ministère de l'Agriculture et de la Colonisation du Québec, afin de transmettre promptement au cultivateur les résultats des essais.

C. Bernard
Le directeur

ZOOTECHNIE

La valeur alimentaire des ensilages de maïs

La variété et le stade de maturité lors de la récolte sont souvent les facteurs déterminant de la valeur de l'ensilage du maïs dans les régions où les conditions climatiques sont défavorables. On a comparé, pendant trois ans, une variété hâtive , Pride 5, à une tardive, Warwick 600, les deux ensilées, soit au début, soit vers la fin de septembre. Des bouvillons alimentés avec ces ensilages ont fait des gains de 1 117 et 1 031 kg/ha pour les deux variétés récoltées hâtivement et de 1 304 et 1 484 kg/ha pour les mêmes variétés récoltées tardivement. Ils ont ingéré moins de matière sèche en consommant la variété hâtive. Leur croissance a été moins rapide avec la variété tardive, récoltée au début de septembre qu'avec les trois autres ensilages. Finalement, la proportion d'ensilage refusé par les bouvillons n'a pas différée d'un traitement à l'autre.

L'élevage d'agneaux au lait artificiel

En collaboration avec la Station de recherches de Fredericton et la Ferme expérimentale de La Pocatière, on a comparé des agneaux nourris par leur mère à d'autres nourris avec deux laits artificiels. L'un d'eux contenait de la protéine de lait, d'origine animale, tandis que l'autre était commercial. À l'âge de 2 à 4 jours, on a séparé de leur mère les agneaux nourris aux laits artificiels. Tous les agneaux avaient accès à de l'eau fraîche, à un foin de bonne qualité, et à des comprimés de moulée de début pour porc. On a sevré les agneaux lorsqu'ils pesèrent 13 kg et on les a alimentés en parquet jusqu'à ce qu'ils atteignent 40 kg.

Les agneaux élevés par leur mère ont pris 155 jours pour atteindre le poids final, tandis que les autres en ont pris 165. Les premiers ont ingéré 0.79 kg de matière sèche par jour, les derniers 0.89 kg. Les agneaux nourris par leur mère ont fait des gains moyens de poids journaliers de 0.24 kg, ceux nourris au lait artificiel contenant de la protéine de lait de 0.23 kg et ceux élevés au lait artificiel commercial de 0.22 kg.

Influence de la saison de naissance sur la puberté des béliers

Les techniques modernes d'élevage permettent des agnelages en dehors de la période normale du printemps. Une expérience, poursuivie avec des béliers croisés Dorset × Leicester, a pour but de comparer la puberté d'un groupe né en septembre à celui né en janvier.

La puberté a été établie par la date de la première éjaculation dans un vagin artificiel, sous des conditions normales. On a essayé de faire la récolte de la semence à chaque semaine à partir de l'âge de quatre mois.

Les 11 béliers nés en septembre ont éjaculé la première fois à l'automne suivant, durant la même période que les dix nés quatre mois plus tard. L'âge à la première éjaculation n'a pas semblé influencer le volume de semence ni sa concentration en spermatozoïdes.

Il en ressort, que les béliers ont atteint la puberté à une période spécifique de l'année, c'est-à-dire à l'automne, indépendamment de leur âge.

Croisement de races chez le porc

On effectue des croisements entre 8 races de porcs, afin de comparer la capacité de reproduction et les qualités maternelles des truies hybrides. Les races concernées sont: la Yorkshire, la Landrace, la Lacombe, la Hampshire, la Duroc, la Berkshire, la Large Black et la Tamworth. Grâce à la collaboration de l'Université Laval, du Collège Macdonald, de l'École d'agriculture et de technologie de Kemptville et de la Ferme expérimentale de Nappan, on a au delà de 800 truies à l'épreuve, distribuées en nombre égal parmi les 28 croisements possibles. Les critères d'évaluation sont la puberté, le nombre de porcelets par portés, ainsi que le poids de ces derniers à la naissance et au sevrage.

PRODUCTION VÉGÉTALE

Un herbicide pour le chou fourrager

Pour contrôler les mauvaises herbes dans le chou fourrager on avait déjà employé deux herbicides: C-7019 et C-6989 (Ciba). Le premier s'était avéré particulièrement efficace. On a donc voulu préciser les dates et les doses d'application, qui enrayent les mauvaises herbes et évitent les dégâts aux récoltes.

On s'est servi de la variété de chou fourrager Maris Kestrel semé sur un loam sableux de Sheldon. Les doses d'herbicide C-7019 étaient de 1.5, 3.0, 6.0 et 9.0 kg du produit actif dans 700 litres/ha, en préémergence et à 10, 20 et 30 jours après le semis, à une pression de 2.72 atmosphères. Une cote visuelle variant de 1 à 5 et attribuée à chaque parcelle reflétait l'absence totale de mauvaises herbes jusqu'à l'envahissement complet.

Les cotes de contrôle des mauvaises herbes, pour les doses d'herbicide dans l'ordre précité, étaient de 3.25, 2.66, 1.69 et 1.34. Des cotes de 2.12, 2.12, 2.62 et 2.06 indiquaient l'efficacité des arrosages en préémergence et à 10, 20 et 30 jours après le semis.

Le rendement du chou fourrager en matière sèche variait selon le traitement d'herbicide. Il passait de 10 287 kg/ha pour 6 kg/ha appliquée 30 jours après le semis à 6 577 kg/ha pour 3 kg/ha appliquée 30 jours après le semis.

En général, le rendement a diminué avec une application d'herbicide 10 jours après le semis.

Il en ressort que 6 kg/ha de l'herbicide C-7019, appliqué 30 jours après le semis, supprime les mauvaises herbes dans le chou fourrager, sans en diminuer le rendement.

La date de semis du blé d'hiver

Pendant deux années consécutives, les variétés Talbot, Richmond et Genesee ont été semées à 4 dates variant de la mi-août jusqu'à la fin septembre. Les différences de rendement dues aux dates de semis n'ont pas été constantes d'une année à l'autre. Les résultats des années combinées portent à croire que le choix, entre les dates de semis étudiées, est limité.

L'azote pour les pâturages

L'apport d'azote sous forme de nitrate d'ammoniaque a permis de doubler la production d'herbe d'un pâturage à base de graminées. En effet les rendements en matière sèche sont passés de 4 976 kg/ha, en sol ne recevant pas d'azote, à 10 997 kg/ha en sol recevant de l'azote au taux de 560 kg/ha.

Toutes les parcelles ont reçu en couverture 1 211 kg/ha de 0-15-30. L'azote a été épandu aux doses de: 0, 56, 112, 224, 226, 448 et 560 kg/ha. Ces quantités furent fractionnées en quatre applications égales.

On a trouvé que la dose optimum d'azote était 336 kg/ha, pour la saison de végétation. Cette quantité devrait être fractionnée en quatre applications de 84 kg/ha. Les rendements en herbe dépassaient 2 000 kg/ha à chacune des quatre coupes.

La teneur en protéines de l'herbe a augmenté avec les doses d'azote et s'est maintenue au dessus de 20% aux doses de 448 et 560 kg/ha. À la dose optimum de 336 kg/ha, la teneur en protéines de l'herbe dépassait 16% à chacune des quatre coupes.

L'azote nitrique a été absorbé en forte proportion par les plantes recevant une dose d'azote de plus de 400 kg/ha. La teneur en azote nitrique de ces plantes a même dépassé

0.14%, alors qu'un fourrage dont la teneur dépasse 0.125% est déjà considéré comme nuisible à la santé des animaux.

L'azote nitrique dans les sols s'est également accru avec les doses d'azote. Elle est passé de 13 p.p.m. en sol non azoté, à 72 p.p.m. en sol ayant reçu de l'azote à raison de 560 kg/ha.

L'application d'azote au taux de 336 kg/ha a laissé 23 p.p.m. d'azote nitrique dans le sol et a donné une teneur de 0.10% dans les plantes.

Les forts rendements résultant des doses massives d'azote ont épuisé le sol en potassium échangeable, malgré l'application de K à raison de 336 kg/ha. Les sols non fertilisés à l'azote en contenaient en moyenne, 0.345 mEq. par 100 grammes, après la quatrième coupe, tandis que ceux recevant la plus haute dose d'azote n'en contenaient que 0.063 mEq. par 100 grammes. Les plantes croissant sur les sols ne recevant pas de fertilisation azotée enlevaient du K à raison de 157 kg/ha, tandis que celles croissant sur les sols ayant les plus fortes doses d'azote en soutiraient 278 kg/ha.

L'influence du pH du sol sur l'orge

L'orge a bien répondu au chaulage de trois types de sol, à savoir, l'argile Sainte-Rosalie, le loam limoneux Coaticook et le loam Greensboro. Les pH de chacun des types de sol ont été maintenus aux valeurs suivantes: 5.2, pH original, 6.0 et 6.5.

Sur le premier type de sol, les rendements en grain se sont accrus avec le pH du sol. L'augmentation maximum était de 14%. Sur le loam limoneux Coaticook et le loam Greensboro, on a enregistré des augmentations maximum de 65% et de 188% respectivement. Ces augmentations avaient lieu sur les trois sols à un pH de 6.0. Les rendements en paille ont augmentés avec les pH sur les trois types de sol.

Le phosphore a augmenté les rendements en grain plus que le potassium ne l'a fait. On a noté que l'action du P était plus marquée en sol acide qu'en sol chaulé à un pH de 6.5.

Le phosphore et le potassium ont également augmenté les rendements de paille en loam limoneux Coaticook et en loam Greensboro. Le phosphore était plus efficace en sol acide et le potassium en sol chaulé. Sur l'argile Sainte-Rosalie, seul le phosphore a eu une action bienfaisante sur la croissance de la paille d'orge.

L'effet du pH et de l'azote sur la luzerne en semis pur et en association

Après avoir fixé le pH de trois grandes parcelles à 5.9, 6.3 et 6.9, on les a ensuite subdivisées en trois pour appliquer sur chacune des doses d'azote de 0, 112 et 224 kg/ha. On a ensemencé chacune de ces parcelles avec de la luzerne en semis pur et en association avec du mil et du brome. On a prélevé trois coupes au cours de chaque été afin de comparer les rendements en matière sèche de ces traitements.

Après deux années de récolte, on a obtenu une production moyenne de 10 087 kg/ha. L'établissement de la luzerne a été meilleur, de façon significative, en semis pur qu'en association avec le mil et le brome. Le rendement a été nettement plus élevé à des pH 6.2 et 6.9 qu'à un pH 5.9.

Les effets de la fertilisation azotée étaient variables selon les niveaux d'acidité. L'effet de l'azote sur les rendements a été beaucoup plus marqué avec les pH 6.3 et 6.9 qu'avec un pH 5.9. L'application d'azote à raison de 112 kg/ha a considérablement diminué le rendement sur les parcelles à pH 5.9. Le pH 6.3 a donné une différence significative entre les rendements avec et sans azote.

Le rendement obtenu de la fraction luzerne à un pH 6.9 a été de 6 356 kg/ha en association avec le mil, et de 5 548 kg/ha en association avec le brome. L'azote a diminué le rendement de la fraction luzerne, en passant de 71.1% à 44.4%, respectivement, pour les doses d'azote de 0 et de 224 kg/ha.

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Départs

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INTRODUCTION

En 1969 nous avons franchi plusieurs étapes dans l'élaboration d'un programme de recherches et l'organisation du travail et du personnel de notre Station. Des nouveaux régisseurs ont été nommés aux Fermes expérimentales de La Pocatière et Normandin. L'édifice devant loger notre personnel de Sainte-Foy est en bonne voie de réalisation et nous en prévoyons le parachèvement durant l'été 1970.

Je rends hommage à notre dévoué confrère feu Monsieur J. E. Laplante, décédé durant l'année après une fructueuse carrière de trente-trois années au service du ministère de l'Agriculture du Canada.

Je remercie le Dr. F. M. Gauthier, professeur à l'Université Laval, pour sa généreuse collaboration dans la préparation d'une partie de ce rapport.

S. J. Bourget
Le directeur

LES PLANTES

Pathogénicité des champignons du sol envers la luzerne

Importance du substratum. Les substrats artificiels, tels que les mélanges vermiculite–perlite et vermiculite – sable blanc augmentent de façon significative la pathogénicité des champignons du sol en comparaison avec les substrats naturels. L'importance de l'augmentation de pathogénicité varie avec le pathogène concerné. Les différences dans la pathogénicité peuvent être dues à la température des substrats qui est plus basse dans les milieux artificiels que dans le sol naturel.

Influence des champignons du sol sur le contenu en azote des tiges de luzerne. Les analyses faites à l'aide de l'analyseur Technicon ont démontré que les plants de luzerne inoculés avec *Glicocladium roseum* (Link) Bainier et *Trichoderma viride* Pers. ex Fries contiennent moins d'azote dans leurs tiges que les plants inoculés avec *Rhizobium meliloti* Dangeard et que les témoins non inoculés. Toutefois ces champignons ont une influence moins marquée sur le contenu en azote des tiges provenant de plants de luzerne inoculés avec le *Rhizobium*

Nutrition en carbone et azote de Trichoderma viride. La croissance de trois isolats de *Trichoderma viride* Pers. ex Fries a été étudiée en milieu de culture liquide. Les isolats ont eu leur meilleure croissance sur le glucose, le sucrose, le cellobiose et le mannitol. L'asparagine et le nitrate d'ammonium se sont avérés de très bonnes sources azotées pour les trois isolats. Il n'y a pas de corrélation entre la sporulation et le poids sec des cultures, les quantités de carbone et le rapport C/N.

Morphologie des espèces de *Verticillium*

Une technique simple et très efficace d'impression des conidies a été utilisée pour l'étude de conidies de *Verticillium* spp. Elle consiste à découper un bloc de gélose sur lequel croît le champignon à l'étude et à le placer de façon inversée sur une lame de microscope. Une légère pression permet l'adhésion des conidies à la lame de verre puis le substrat est retiré délicatement. Cette technique permet des études morphologiques et cytologiques de spores provenant d'une même tête conidienne, indépendamment du substrat de croissance, et la comparaison de différentes colonies de champignons.

Résistance de la luzerne à la gelée

Trois variétés de luzerne (Rambler, Vernal, Caliverde) ont été traitées plusieurs fois avec une solution de 2-chloroéthyl triméthylammonium (CCC [Cyanamid]) à 0.1%. À cinq semaines, ces plantes ont été transférées en chambre de croissance et endurcies artificiellement. Elles ont enfin été soumises à un test de congélation. Le CCC semble augmenter la résistance de ces plantes à la gelée, si la période d'endurcissement dépasse 4 semaines.

Une étude du mode d'action du CCC, à l'aide de CCC marqué au ^{14}C, a permis de constater l'incorporation assez rapide de la radioactivité de ce composé dans la phosphatidyl choline. Il se peut que la choline libre ne soit pas un intermédiaire.

Pomme de terre

Résistance à la flétrissure bactérienne. Nous avons déjà montré que l'organisme responsable du flétrissement bactérien de la pomme de terre, *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh., pousse normalement sur un milieu ne contenant que 30 p.p.m. (N) d'asparagine et 2 p.p.m. (N) de méthionine. L'addition à un tel milieu de certains acides aminés tels que la cystine, la sérine, la glycine, la β-alanine et l'acide α-aminobutyrique diminuent la croissance de l'organisme.

L'analyse de la caséine, qui constitue un milieu idéal pour *C. sepedonicum*, indique qu'elle ne contient pas de cystine, d'acide α-aminobutyrique ni de β-alanine comparativement aux extraits d'acides aminés libres des pommes de terre qui sont beaucoup moins efficaces pour la croissance de l'organisme. De plus, l'addition de cystine aux milieux de caséine diminue considérablement la croissance.

La présence de la cystine et de certains autres acides aminés dans les pommes de terre pourrait donc expliquer les progrès plutôt lents de l'agent pathogène dans les vaisseaux de l'hôte et l'apparition tardive des symptômes. Les calculs ont montré que la bactérie met un peu plus de 5 heures pour se diviser dans un milieu de caséine et plus de 9 heures dans un milieu d'asparagine-méthionine.

Dartrose. Après un séjour de 9 ans dans des échantillons de terreau et de loam argileux partiellement stérilisés, *Colletotrichum coccodes* (Wallr.) Hughes, cause de la dartrose des pommes de terre, a pu être réisolé sur gélose. La longévité de ce champignon rend illusoire l'emploi de rotations de 4 ou 5 ans préconisées parfois comme moyen de réprimer cette maladie.

LES SOLS

Étude physico-chimique des horizons indurés

Les mesures de densité apparente de sols à fragipan développés sur till glaciaire donnent des valeurs fort élevées, de l'ordre de 1.9 à 2.0. On observe une légère augmentation de densité au niveau du fragipan (2.0 à 2.1) qui est trop faible pour rendre compte de l'imperméabilité de cet horizon pendant la majeure partie de l'année. Des analyses minéralogiques qualitatives et quantitatives par diffraction de rayons X et par voie chimique ont montré que l'illite est le minéral dominant dans la fraction argileuse. Cependant, la présence d'assemblages minéralogiques distincts au niveau du fragipan, du type chlorite-vermiculite confirme que la pédogénèse est active dans cet horizon qui est par conséquent génétique.

Processus de formation des minéraux argileux

Cette année encore nous avons collaboré avec le centre de recherches de l'ORSTOM, aux Antilles, en étudiant par spectroscopie infrarouge des sols jeunes, dérivés de cendres volcaniques.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes

Écologie

Étude agro-écologique. L'étude écologique entreprise en 1968 dans le comté de Rivière-du-Loup a été poursuivie. À la suite des études préliminaires de 1968, nous avons procédé à un inventaire général de la région. À l'aide de photos aériennes, nous avons groupé les caractères écologiques, pédologiques et physionomiques et nous avons cartographié la région en utilisant le complexe des 3 facteurs ci-haut mentionnés. Ceci nous a permis de définir certaines zones de végétation herbacée qui seront d'ailleurs inventoriées plus précisément en 1970 et 1971 afin de déterminer les groupes écologiques qui seront indicateurs de différentes conditions du milieu (caractères climatiques, édaphiques ou biotiques, ou les trois).

Les céréales

Avoine. Dix espèces d'avoine sur 19 sont présentement analysées pour leur quantité d'ADN (phénotype nucléaire), la masse sèche en gramme des noyaux isolés et le volume des chromosomes. Il y a parmi cet échantillonnage des diploides, tétraploides et hexaploides. On peut tirer cette conclusion: chez *Avena* la variation d'ADN est reliée directement au nombre de chromosomes. Il n'y a aucune différence significative pour l'ADN entre les espèces étudiées pour un même niveau ploidal spécifique et la même chose s'applique pour la masse sèche des noyaux. Cependant, les données du volume des chromosomes ont montré une différence significative chez les tétraploides. Cela pourrait bien être une contribution utile concernant l'évolution de l'avoine commerciale. Les données obtenues soutiennent aussi indirectement l'hypothèse déjà proposée concernant l'évolution de l'avoine cultivée, soit celle des croisements interspécifiques.

D'après cette théorie fondamentale, on peut déduire ce qui suit: la masse sèche du noyau des tétraploides et des hexaploides est relativement plus petite que celle prévue par la simple mathématique. Ces faits ont été déjà remarqués chez le blé et les autres plantes mais avec une technique un peu différente. Dans le cas de l'avoine, nous croyons qu'il y a une réduction de la caryolymphe ce qui indiquerait un nouveau rythme biochimique des polyploides.

Les plantes oléagineuses

Colza. Le groupe *Brassica napus* L. *(colza)* est plus productif (400 kg/ha en moyenne) et plus tardif (20 jours) que le groupe *B. campestris* L. (navette). En semant vers le 15 mai, la tardivité du colza ne présente aucun problème dans le bas St-Laurent. La différence de rendement s'accroît lorsqu'il pleut au début de juin. La navette est moins sensible au manque de pluie durant cette période.

Les plantes fourrageres

Lotier. L'établissement du lotier sans plante-abri à l'aide du labour chimique et mécanique fut complété en 1969. Les échantillons de gazon prélevés dans le comté de Rivière-du-Loup furent placés en chambre de croissance et reçurent l'un des trois traitements suivants: dalapon, 2,4-D ester plus paraquat ou labour mécanique. Les données montrent une relation inversement proportionnelle entre la matière sèche du lotier et celle des mauvaises herbes. Les échantillons dominés par les graminées et traités au dalapon, donnent un rendement plus élevé de lotier que ceux traités au 2,4-D ester plus paraquat, tandis que l'inverse existe pour les échantillons dominés par les mauvaises herbes à feuilles larges. Le labour mécanique se compare très bien au labour chimique dans le cas du rendement en matière sèche du lotier. Vers la fin de l'expérience, le lotier semblait diminuer au profit des mauvaises herbes. On peut soulever l'hypothèse que l'établissement du lotier à l'aide du labour chimique est étroitement lié à la composition botanique du gazon précédant le traitement.

Le rutabaga

On a obtenu 84.6 tonnes/ha de rutabagas en grand champ, soit plus de 9 600 kg de matière sèche. On a ainsi atteint le rendement maximum déjà obtenu en parcelles.

Les loams, loams sableux et même argileux ont bien répondu à tous les taux d'azote (0, 56, 112 kg/ha) et tout particulièrement aux taux de P (0, 45, 90, 135, 180 kg/ha) tant pour les racines que pour les feuilles de rutabagas. Sur les mêmes sols, l'apport de potassium au taux de 56 kg/ha a augmenté les rendements, alors qu'au taux de 112 kg/ha, il a eu un effet dépressif.

Le chaulage du semis n'a pas augmenté les rendements du rutabaga de façon significative et n'a eu que peu d'effets sur le coeur brun durant les années sèches. On a observé qu'une forte pluviosité avait accru les rendements sur les sols de texture légère ou moyenne à pH de 5.0 approximativement. Dans les mêmes conditions d'humidité, mais sur un sol à pH de 5.8, le chaulage a provoqué une carence en bore qui a favorisé le développement d'une grave infection de coeur brun et beaucoup diminué les rendements et le pourcentage de matière sèche des rutabagas. L'emploi de 22.4 kg/ha de borax a empêché le développement de cette maladie et augmenté la teneur moyenne du sol en bore de 217% et celle des rutabagas de 174%.

La pomme de terre

Après 85 jours de croissance au Québec, les semis F 6117 et F 5748 se comparent à Irish Cobbler et à Norland pour leur rendement et leur qualité culinaire. F 5748 et Norland don-

nent de bonnes croustilles à la récolte et après reconditionnement.

Le semis tardif F 6151 se compare en moyenne à la Montagne Verte pour son rendement et sa qualité culinaire, mais il est inférieur à Kennebec pour les croustilles. F 5994 donne un fort rendement de bonne qualité culinaire en sol organique.

Flétrissure bactérienne. La désinfection immédiate du couteau par trempage dans du Kem-Germ (Kem-Sam Products dilué à 31.2 grammes par litre d'eau et dans du Quavo (Dustbane Enterprises Ltd.) dilué à 16.7 et 20.3 grammes par litre ont donné une récolte exempte de symptôme. Le Kem-Germ est également efficace pour les contenants en bois.

L'examen comparatif de frottis de tiges, de stolons ou de tubercules indique que la préparation d'un frottis à la base des tiges d'une même butte est une méthode efficace pour dépister la maladie 100 jours après l'inoculation des tubercules.

L'inoculation par les racines de 224 Solanées a révélé que *S. acaule* PI 320276, *S. megistacrobolum* PI 233124, *S. raphanifolium* PI 310951 et *S. stenotomum* PI 234010 étaient résistantes à la flétrissure. La variété suédoise Elsa était aussi résistante en serre. Les nouvelles variétés: Alamo, Anoka, Aquila, Chieftain, La Route, Lenape, Monona, Norchip, Norchief, Superior et Wauseon sont apparues sensibles à la maladie.

L'addition d'azote aux taux de 112 et 222 kg/ha, dans un sable pauvre, eut pour effet de masquer les symptômes sur le feuillage et les tubercules.

Après inoculation par les racines, on décela la présence de la flétrissure dans la totalité des tiges des variétés résistantes: Saranac et B725-61, cultivées à Franquelin, tandis qu'elles en étaient exemptes à La Pocatière.

Le désherbage chimique

Rutabaga. Les herbicides les plus efficaces sur cette culture pour une durée de 4 ans furent la trifluraline et le vernolate employés en présemis et incorporés aux taux respectifs de 1.1 et 4.5 kg/ha. Le nitrofen utilisé en postémergence a donné un contrôle moyen.

Luzerne. Appliqué à l'automne dans une luzernière, le Kerb (Rohm & Haas Co. [Canada] Ltd.) a enlevé 66 de 66% le nombre de tiges de la luzerne. A la deuxième coupe, en août, la luzerne contribuait pour 90% du rendement en matière sèche contre 70% dans le témoin non traité. Le produit a été employé à 2.4 kg/ha de matière active.

Colza. Le nitrofen et la trifluraline sont très prometteurs pour le contrôle des mauvaises herbes sur cette culture.

*Pomme de terre.*L'*Echinochloa crusgalli* (L.) Beauv. est résistant à la plupart des herbicides employés sur cette culture. L'EPTC (Stauffer Chemical Co.) à 4.4 kg/ha et le vernolate également à 4.4 kg/ha ont réprimé cette plante nuisible à 90% Le mélange dinosèbe-dalapon (4.3-3.6 kg/ha) employé à la levée a aussi donné un bon résultat et produit les meilleurs rendements de l'essai.

FERME EXPÉRIMENTALE, NORMANDIN

Les animaux

Les bovins

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

Indice de consommation. L'ingestion moyenne d'éléments nutritifs digestibles (E.N.D.) par 26 génisses agées de 6 à 8 mois a été de 4.13 kg par kg de gain en poids; par contre, la conversion alimentaire chez trois jeunes taureaux a été de 5.24 kg d'E.N.D. Il a fallu en moyenne 0.52 kg d'E.N.D. pour que 17 vaches produisent chacune 1.0 kg de lait entre le 60^{e} et le 120^{e} jour de leur première lactation.

Épreuve de progéniture. La semence de quatre taureaux a été prélevée régulièrement et 14 géniteurs sont gardés en attendant des données sur le comportement de leurs filles. Un taureau a complété l'épreuve de progéniture de façon satisfaisante en 1969. Sur 105 saillies artificielles effectuées, 44.8% des va-

ches ont été fécondées à la première saillie, 24.1% ont nécessité une deuxième saillie, 12.9% une troisième, 8.6% une quatrième et 10 vaches ont été saillies plus de quatre fois.

Composition du lait. L'analyse de 120 échantillons de lait prélevés à tous les 60 jours de la première lactation de 24 vaches a révélé une augmentation de 0.92% de la protéine du lait entre le début et la fin de la lactation. Le taux de protéine a varié de 2.88, 3.21, 3.33, 3.45 et 3.80% respectivement au 60e, 120e, 180e, 240e, et 300e, jour de production, d'une moyenne de 3.33% durant cette période. Pour le troupeau entier, les solides totaux du lait se sont accrus de 0.95% soit une moyenne annuelle de 12.9% et les solides non gras de 0.71% et 8.72% en moyenne.

Essai alimentaire. Un essai préliminaire a démontré que le chou fourrager, qu'il soit pâturé ou affouragé, permet de maintenir la production laitière quand les pâturages de fin de saison déclinent.

Les moutons

Paissance sur graminées. On a mis en pâturage des agneaux, sevrés à l'âge de 10 semaines, dans trois enclos ensemencés respectivement de pâturin, de mil et d'un mélange mil-brome-pâturin. La production respective de ces enclos en matière sèche, a été de 8 187, 6 979 et 7 387 kg/ha. Les gains moyens journaliers par agneau ont été de 0.105 kg avec le mil, 0.076 kg avec le mélange et de 0.061 kg avec le pâturin.

Chou fourrager comme source alimentaire. Après deux années d'essai, il a été démontré que la paissance du chou fourrager par des agneaux a fait réaliser un gain moyen individuel de 0.204 kg/jour. Le piétinement et les refus ont réduit du tiers la production totale du pâturage. Le hachage du chou servi *ad libitum* a fait accroître la consommation quotidienne par sujet, de 1 kg/jour, par comparaison à la plante entière.

Les plantes

Les céréales

Séchage de l'avoine. La teneur en humidité de grains entreposés durant 2 mois a été abaissée de 2% en aspirant l'air ambiant à travers la masse, grâce à un ventilateur, au taux de 0.05 m^3/hl par minute.

Régie de blé de printemps. Le blé ensemencé au taux de 168 kg/ha dans des rangs espacés de 15.2 cm a produit près de 600 kg/ha de plus qu'un semis au taux de 112 kg/ha dans des rangs espacés de 15.2 et de 22.8 cm.

Orge. Les sélections Q.B. 58.26, Q.B. 40.22 et Q.B. 40.35 ont produit plus que la variété Champlain.

Avoine. La sélection Q.O. 115.15 a donné un rendement d'environ 25% plus élevé que les variétés Glen et Garry; son pourcentage d'écale est relativement faible.

Les oléagineuses

Le colza de type *B. campestris* L. a mis 93 jours pour atteindre sa maturité et le lin 120 jours. Le colza a produit un peu moins de graine que le lin, mais d'une teneur en huile plus élevée de 3.3%.

Les fruits et légumes

Framboisiers. La variété Boyne et la sélection M-541 ont encore démontré une plus grande résistance au froid que la variété Newburg.

Fraisiers. En première année de production, les variétés Veestar, Catskill et Redcoat ont donné des rendements variant de 14 500 a 11 200 kg/ha. Les plus beaux fruits ont été obtenus des variétés Redcoat et Veestar.

Dates de semis du rutabaga. Après deux ans d'observation, les semis de rutabagas effectués vers le 15 juin ont donné 41.6% de plus que les semis du 30 juin; la proportion de rutabagas pour la consommation a été plus élevée avec les semis du 15 juin.

Les plantes fourragères

Régie du chou fourrager. Les semis du 27 mai ont produit 2 174 kg/ha de matière sèche de plus que les semis du 15 juin; le semis tardif a augmenté le rapport feuille/tige. La quantité de matière verte a été augmentée de 12% par deux apports d'azote au taux de 93 kg/ha; la production de matière sèche n'a cependant pas été affectée par cette fumure alors qu'elle le fut par deux apports d'azote au taux de 38 kg/ha.

Conservation des fourrages. Un essai d'une

durée de 4 ans a démontré que le préfanage du fourrage destiné à l'ensilage et le séchage du foin à l'air chaud sont deux bonnes méthodes de conserver la qualité des fourrages. L'essorage a contribué à diminuer la qualité du foin, surtout s'il était exposé à des intempéries après la coupe.

FERME EXPÉRIMENTALE, CAPLAN

Les plantes

Les plantes fourragères

Mil. La variété hâtive Clair s'est avérée la plus productive des 7 variétés à l'essai, après quatre années d'observation. Le mil Climax s'est classé second, suivi de près par Milton et les nouvelles variétés Champ et Bounty.

Lotier corniculé. Les résultats obtenus avec le lotier ont indiqué que la sélection L-6725 et les variétés Empire et Léo persistent beaucoup mieux que Viking. Une première année de récolte d'un nouveau semis de 7 variétés et lignées a fourni une moyenne de 5 300 kg/ha de lotier; dans cet essai, la variété Viking a de nouveau été inférieure aux variétés Empire, Saskatoon et Léo et aux lignées MCY-6, MCF-6 et MCH-6.

Luzerne. À leur première année d'exploitation, 12 variétés de luzerne ont produit une moyenne de 11 000 kg/ha de matière sèche. Les variétés Europe, Haymor, Iroquois et Warrior ont fourni significativement plus de fourrage que Vernal, Alfa, Glacier, Saranac, Narragansett, 525, Beaver et Tuna; cette dernière a été la plus faible avec 9 700 kilos.

Les céréales

Avoine. Le bon comportement de la nouvelle variété Yamaska, semi-hâtive et résistante à la verse, indique qu'elle pourra remplacer avantageusement les variétés Glen et Garry.

Orge. L'orge a continué d'être de meilleur rapport que l'avoine. Les variétés Champlain et Parkland y semblent mieux adaptées que la variété Conquest.

Blé de printemps. Les variétés Opal et Pitic 62, en dépit de leur tardiveté, ont rendu plus que la variété précoce Selkirk.

Seigle d'automne. Des résultats préliminaires indiquent que le seigle d'automne aurait un potentiel de productivité très supérieur à celui des céréales de printemps telles que l'avoine, l'orge et le blé.

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B. Parent, B.A., B.Sc. (Agr.), M.Sc.	Écologie et répression des acariens des pommeraies
J. P. Perron, B.S.A.	Écologie et répression de la mouche de l'oignon
I. Rivard, B.A., B.Sc. (Agr.), M.Sc.	Écologie et répression de la mouche de la pomme

Phytopathologie

L. J. Coulombe, B.A., B.Sc. (Agr), M.Sc., Ph.D.	Maladies des cultures maraîchères
R. Crête, L.S.A., M.Sc.	Maladies des cultures maraîchères

Amélioration des plantes

M. Chiang, B.Sc. (Agr.), M.Sc., Ph.D.	Génétique des légumes
R. Granger, B.A., B.S.A., M.Sc.	Génétique des fruits

Régie des cultures

R. BERNIER, B.A., B.Sc. (Agr.)	Chef, régie des cultures maraîchères

Départ

J. J. CARTIER, B.A., B.Sc., M.Sc., Ph.D. Permuté en avril 1969, Coordonnateur (Entomologie) Direction de la Recherche, Ottawa, Ont.	Nutrition et comportement des pucerons

INTRODUCTION

La Station de Saint-Jean est le principal centre où se poursuivent les recherches horticoles au Québec. Ce rapport donne les résultats saillants des principaux travaux de recherches en cours.

Il convient de mentionner qu'en 1969, on a fait l'acquisition d'une pommeraie de 60 acres et d'un terrain adjacent de 75 acres propice aux cultures fruitières. Ce domaine nous permettra de poursuivre des recherches sur la taille, le rajeunissement et la nutrition des pommiers; les porte-greffes; les pommiers nains; la densité des plantations; l'écologie et la répression des insectes, des acariens et des maladies du pommier. On y poursuivra également de nombreux essais dans le domaine des petits fruits.

On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport en adressant sa demande directement aux auteurs ou à la Station.

A. A. Beaulieu
Le directeur

SOLS ET NUTRITION DES PLANTES

Fertilisants

Taux maxima de fertilisants. Les quantités de fertilisants appliqués pour la production de légumes dans les sols organiques sont généralement plus élevées qu'en sols minéraux. Dans un sol organique bien décomposé, on a ajouté des taux excessivement élevés de N, P et K afin de déterminer le niveau de saturation où on peut déceler des effets nocifs aux pommes de terre. Le phosphore fut appliqué sous forme de superphosphate aux taux de P variant de 0 à 897 kg/ha, la potasse sous forme de KCl aux taux de K variant de 0 à 1 793 kg/ha et l'azote sous forme de $(NH_4)_2SO_4$ aux taux d'azote variant de 0 à 448 kg/ha. Les rendements de pommes de terre ne furent pas diminués d'une façon significative par l'excès de P ou K mais par celui de l'azote au taux de 112 kg/ha. Comme les sols organiques bien décomposés peuvent retenir des quantités excessives de P et K sans affecter les rendements, il devient difficile de déterminer leur taux optimum d'application et d'éviter tout excédant qui ne serait pas compensé économiquement par une augmentation de rendements.

Maïs

Date de semis vs fertilisants. Les rendements en poids de la variété de maïs sucré Seneca 60 n'ont pas révélé de différences appréciables (7 000, 6 580, 6 885 kg/ha) lorsque la date de semis était respectivement le 28 mai, les 9 et 20 juin. Par contre, une application de phosphore a permis de faire la récolte 5, 6 et 0 jours plus tôt respectivement. Le rendement a été augmenté d'une façon significative par l'azote et le phosphore. Aux taux maxima d'application d'azote et de potasse, le phosphore augmenta le rendement de 993 kg/ha et aux taux maxima d'application de phosphore et de potasse, l'azote augmenta le rendement de 240 kg/ha. L'interaction bénéfique des fertilisants et des dates de semis serait surtout attribuable à ces dernières.

Préparation du sol. En recouvrant le sol d'une couverture de plastique transparent au lieu d'employer les méthodes conventionnelles, nous avons hâté la date de la récolte de 3 jours chez les variétés hâtives et de 7 jours chez les variétés tardives. Par contre, chez toutes les variétés, le billonnage à la main fut sans effet ou retarda la date de la récolte. Ces différentes méthodes de culture révélèrent dans les rendements les différences appréciables suivantes: couverture de plastique transparent, 10 370 kg/ha; méthode conventionnelle, 9 650 kg/ha; billonnage, 9 040 kg/ha. Entre les variétés, des différences appréciables de rendements furent enregistrées comme suit: chez les variétés tardives, Seneca Chief, 13 710 kg/ha et Golden Jubilee, 13 630 kg/ha; chez la variété semi-hâtive Queen Anne 363/5, 8 200 kg/ha; chez les variétés hâtives, Earliking, 6 655 kg/ha et Seneca 60, 5 789 kg/ha. Le manque d'interaction significative entre les variétés et les méthodes culturales suggère que ces facteurs sont indépendants l'un de l'autre quant à leurs effets sur les rendements.

Pommiers

Application foliaire du magnésium. Vingt-quatre jours après la pleine floraison des pommiers, des solutions de $Mg(NO_3)_2$ $MgSO_4$ et $MgCl_2$ furent appliquées, à raison de 4.48 et 8.96 kg/ha de Mg, sur le feuillage de pommiers McIntosh âgés de 25 ans et déficients en magnésium. Les pommiers traités ne montrèrent aucun symptôme de déficience de magnésium, contrairement aux pommiers non traités. Les traitements au Mg n'influencèrent pas le rendement d'une façon appréciable, mais à la concentration de 8.96 kg/ha, des brûlures sont apparues sur le feuillage traité au $Mg(NO_3)_2$ et $MgCl_2$. Le feuillage traité au $MgSO_4$ en était exempt.

ENTOMOLOGIE

Bio-ecologie

Tétranyque rouge du pommier. En se basant sur un seuil de 8.8°C, on a calculé, sur une période de sept ans, que *Panonychus ulmi* (Koch) atteignait sa densité maximale après une accumulation moyenne de 1 200 à 1 300 unités thermiques. Ces données permettent donc de prédire le mouvement des populations de ce tétranyque.

Pyrale de la pomme. La pyrale de la pomme, *Carpocapsa pomonella* (L.), est grandement influencée par la température. En se basant sur un seuil de 10°C, à partir du 1er mai, on a observé un début d'émergence des adultes après une accumulation de 50 à 100 unités thermiques et la fin après quelque 600 unités thermiques. Cette période se situe de la mi-juin à la mi-juillet.

Mouche de la pomme. Le piégeage des adultes de *Rhagoletis pomonella* (Walsh) au moyen de balles ou de pommes artificielles en polyéthylène recouvertes de l'enduit gluant Stickem (Michel & Pilton Co.) a démontré que les leurres de couleur foncées (rouge, verte ou bleue) étaient plus efficaces que ceux de couleurs claires (jaune ou blanche). Considérant les différentes variétés de pommiers sous observation, les captures de mouches ont aussi mis en évidence des degrés variés de susceptibilité aux attaques de l'insecte.

Cérèse buffle. Le chalcide *Polynema striaticorne* Girault s'est révélé un important parasite des oeufs d'hibernation de la cérèse buffle, *Stictocephala bubalus* (F.), infestant les jeunes pommiers dans le sud-ouest du Québec. De 1966 à 1969, le taux moyen de parasitisme, établi dans diverses plantations, a varié de 9 à 18%. L'apparition des adultes de *P. striaticorne* ainsi que l'éclosion des oeufs de *S. bubalus* ont pris place, chaque année, principalement durant la première quinzaine de juin.

Pyrale du maïs. D'après les études en cours sur les populations naturelles d'*Ostrinia nubilalis* (Hbn.), la population initiale des oeufs a été de 16% inférieure à celle de 1968. Le taux total de mortalité à la fin de la génération 1968-69 a été de 98.9%; parmi les réductions les plus importantes, nous avons noté un taux de 29% au stade de l'oeuf, 24% chez les jeunes larves avant leur pénétration dans les plantes et 18% chez les larves du printemps (stade compris entre l'hibernation et la nymphose). Durant l'éclosion intensive des papillons en juillet, leur activité nocturne a pris place surtout entre 9 et 10 heures PM et entre 11 heures PM et minuit (heure normale de l'est). Dans les captures alors affectuées, la proportion des mâles a été de 50.5% comparativement à 89% en 1968.

Lutte chimique

Tétranyque rouge du pommier. Des traitements préventifs appliqués avant la floraison ont démontré que les huiles supérieures, particulièrement l'endosulfan-huile 70 sec., étaient très efficaces contre *Panonychus ulmi* (Koch) jusqu'à la fin de juillet. Des traitements curatifs, effectués à la fin de juillet, ont révélé qu'une application de chinométhionat ou d'hydroxide de tricyclohexyltine était plus efficace que deux applications d'hydrochlorure de formetanate, de chlorphénamidine ou de propargite (Omite [UniRoyal Chemical Co.]). D'autres traitements, effectués en août, ont encore démontré l'efficacité du chinométhionat, de l'hydroxide de tricyclohexyltine et du bromopropylate. Concernant le chinométhionat, il n'y a pas eu de différences significatives entre trois applications à 0.22 kg, deux à 0.45 kg ou une à 0.90 kg par 454.59 litres.

Tétranyque à deux points. Parmi certains nouveaux acaricides appliqués en serre contre une lignée de *Tetranychus urticae* Koch résistante aux organophosphorés, particulièrement au parathion, l'hydrochlorure de formetanate, le bromopropylate et Hoe 2969 (Hoechst Chemicals) réduisirent la population de cette lignée résistante de 95 à 98%; l'hydrochlorure de chlorphénamidine de 75% seulement, tandis que les organophosphorés tel que le parathion, le phenthoate et N-4543 (Stauffer Chemical Co.) n'eurent aucun effet de réduction sur cette lignée.

Kermès virgule du pommier. Parmi les traitements appliqués avant la floraison contre *Lepidosaphes ulmi* (L.), éthion-huile supérieure 70 sec. et phosmet-huile supérieure 70 sec. se sont montrés plus efficaces que Lambrol (Montecatini Edison, S.p.A.) et endosulfan-huile supérieure 70 sec. Après la floraison, deux applications, à une semaine d'intervalle, d'azinphos-méthyl ou de méthidathion (Supracide [Fisons, Canada, Ltd.]) donnèrent également une bonne répression.

Mouche de la pomme. Les essais de lutte chimique contre *Rhagoletis pomonella* (Walsh) ont été effectués dans deux vergers différents. Sur la variété McIntosh, les produits carbaryl, formothion, Hoe 2969, phenthoate et dialifor (Torak [Hercules Incorporated]) ont fourni de 95 à 100% de pommes saines comparativement à 89% dans les parcelles non traitées. Sur la variété Cortland, le diméthoate et le phosmet (Imidan [Stauffer Chemical Co.]) ont donné 97% de fruits indemnes, tandis que le carbaryl, le carbofuran, le tétrachlorvinphos (Gardona [Shell Chemical Co.]), le metmercapturon (Mesurol [Chemagro Corporation]) et le phosalone en fournissaient de 87 à 91% comparativement à 75% dans les parcelles non traitées.

Tordeuse pâle du pommier. Les produits diazinon, carbofuran, phosalone, phenthoate, tétrachlorvinphos et phosmet, appliqués le 21 mai sur des pommiers Cortland, ont réduit les populations larvaires de *Pseudexentera mali* Free. dans une proportion de 76 à 100% et ont ainsi assuré une bonne protection des arbres.

Charançon de la prune. Dans la lutte contre *Conotrachelus nenuphar* (Hbst.) infestant les pommiers, les insecticides carbofuran, metmercapturon, tétrachlorvinphos, phosmet, phosalone et dieldrine ont été appliqués le 9 juin, soit immédiatement après la chute des pétales, ainsi que le 17 juin. Tous ces produits se sont avérés efficaces en fournissant de 91 à 99% de pommes saines.

Pyrale du maïs. En 1969, l'infestation du maïs sucré par *Ostrinia nubilalis* (Hbn.) s'est maintenue élevée dans tout le sud-ouest du Québec. Chez une variété précoce, 10 critères biologiques ont été mis à l'essai pour déterminer la date de la première application de DDT contre le ravageur; quatre critères seulement ont donné moins de 7% d'épis infestés. Ce sont: la date prédéterminée du 10 juillet; 5 jours après l'accumulation de 700 degrés-jours; 15 jours après l'accumulation de 525 degrés-jours et l'unique traitement fait 15 jours après l'observation des premières pontes dans le champ. De plus en plus, le nombre de degrés-jours s'avère un critère très valable pour établir annuellement l'époque la plus favorable au déclenchement des applications d'insecticides.

Charançon postiche de la luzerne. Signalé pour la première fois au Québec, dans la région du lac Champlain, en juin 1968, le charançon postiche de la luzerne, *Hypera postica* (Gyll.), est réapparu en 1969 sur un territoire englobant presque tout le sud-ouest du Québec. Dans les essais de traitements insecticides, le carbofuran, sous forme granulée et appliqué dès les premiers développements printaniers de la luzerne réduit sensiblement les attaques de ce ravageur. D'autre part, les pulvérisations de carbofuran, de phosmet ou de malathion, effectuées le 11 juin, lorsque la population larvaire était à sa densité maximale, ont eu une efficacité de 92 à 98%. Le méthidathion et le phorate granulés se sont révélés médiocres au cours de ces essais.

PHYTOPATHOLOGIE

Écologie

La racine noire des betteraves. La saison de végétation de 1969 a été des plus favorables au développement de la racine noire chez les

plantules de betteraves potagères et sucrières. La période propice à l'infection s'est prolongée durant une période d'environ cinq semaines. Comme la plupart des traitements ne peuvent protéger la graine durant une période aussi longue, il en est résulté un très fort pourcentage de plantules malades.

Chez les betteraves potagères, le Dexon (Chemagro Corporation) a enrayé la maladie dans une proportion de 80 à 88%, tandis que l'efficacité des autres traitements a varié de 10 à 30%; ce qui est loin d'être suffisant pour assurer un rendement convenable.

Chez les betteraves sucrières, le Dexon a été également le fongicide qui a protégé le mieux les plantules. Le pourcentage de plantules saines a oscillé entre 40 et 80%, selon les variétés, tandis que, à la suite des autres traitements le pourcentage de plantules saines a varié entre 1 et 34%.

La mosaïque et la gale du concombre. Les variétés de concombre de table Marketmore, High Mark II et Gemini se sont révélées les plus résistantes à la mosaïque du concombre et la quantité de fruits malades chez ces trois variétés n'a pas atteint 1%. Les variétés Marketmore, High Mark II, Shamrock, Gemini, Spartan Valor et Long Vert amélioré n'ont pas donné plus de 0.2 de 1% de fruits atteints de la gale. Par contre la variété Exposition a été très susceptible à la gale.

Charbon de l'oignon. En sol organique, le fongicide endothérapique carboxine (Vitavax [UniRoyal Chemical Co.]), employé comme traitement de semence, donna une meilleure répression du charbon de l'oignon, *Urocystis magica* Pass., que le traitement de semence recommandé au thirame et que le témoin. Le pourcentage de charbon fut respectivement de 10.6, 26.6 et 45.3% tandis que les rendements furent de 41.1, 29.6 et 23.5 tonnes métriques/ha. À la suite de ces expériences, une enquête a révélé que la faible germination de la semence, le charbon, la fonte des semis et la mouche de l'oignon pouvaient contribuer à la perte d'environ 75% du semis.

AMÉLIORATION DES PLANTES

Pommier

Essai de racines porte-greffes. Nous terminons cette année cet essai en cours depuis 1957 à Frelighsburg, Qué. Il consiste à comparer les rendements de pommiers des cultivars McIntosh, Melba et Bancroft sur les porte-greffes *Malus robusta* 5 et East Malling VII. Les rendements moyens cumulatifs de 1962 (la première année de récolte) à 1969 inclusivement pour le McIntosh furent de 11 007 kg/ha avec *M. robusta* 5 et de 7 458 kg/ha avec E.M. VII. Depuis trois ans la qualité du fruit sur E.M. VII fut supérieure à celle sur *M. robusta* 5. Les pommiers avec racine E.M. VII n'eurent pratiquement pas besoin de taille alors que ceux avec racine *M. robusta* 5 nécessitèrent une forte taille à tous les ans. Enfin, les pommiers avec racine E.M. VII durent être attachés à des tuteurs, mais non ceux avec racine *M. robusta* 5.

Évaluation de cultivars, lignées, clones et hybrides de pommes ou de pommiers. Aux 6 lignées prometteuses de McIntosh dans le verger à scions à la ferme satellite de Sainte-Clotilde, nous avons ajouté deux nouvelles mutations de McIntosh dites 'Spur-Types'.

Nous avons cueilli les premières pommes des lignées résistantes à la tavelure. A Frelighsburg en 1969, en dépit des conditions très favorables au développement de la tavelure, aucun symptôme de cette maladie ne fut observé sur les arbres résistants à la tavelure. Cependant, plusieurs de ces lignées furent affectées gravement par la tache ocellée.

Fraisier

Évaluation de lignées et de cultivars de fraisiers. On a comparé 14 lignées de fraisiers provenant d'Ottawa, Ont., aux cultivars Senga Sengana, Guardsman, Redcoat, Grenadier, Sparkle et Cavalier. En 1969 elles rapportèrent respectivement 16 399, 15 949, 13 029, 12 355, 12 130 et 10 782 kg/ha. Une lignée eut un rendement significativement supérieur à celui de Senga Sengana et rapporta 19 329 kg/ha. Sept lignées eurent des rendements significativement supérieurs à ceux de Redcoat et le plus faible rendement fut de 5 840 kg/ha.

Les cultivars Vesper et Fletcher, provenant des États-Unis, donnèrent respectivement 20 442 et 14 286 kg/ha alors que Sparkle et Citation fournirent respectivement 13 023 et

8 057 kg/ha. Dans le même essai, Redcoat rapporta 13 703 kg/ha.

Les cultivars Senga Sengana, Gorella, Guardsman et Midway provenant de Kentville, N-E., eurent des rendements de 18 841, 17 894, 16 438 et 16 114 kg/ha respectivement. Dans cet essai, Redcoat donna 12 812 kg/ha et Acadia et K-62-280 rapportèrent 12 272 et 11 703 kg/ha respectivement.

Guardsman, Vibrant, Catskill, Veestar, Midway, Sparkle et Cavalier provenant de Vineland, Ont., donnèrent respectivement 14 958, 13 026, 12 752, 12 560, 11 585, 11 252 et 10 609 kg/ha alors que Redcoat et Surecrop rapportèrent 9 992 et 8 797 kg/ha. (Dans ce dernier essai, les plants furent endommagés par des produits chimiques.)

Chou

Résistance à la hernie. Nous avons déjà mentionné que la lignée de chou vert 8-41 est presque immunisée contre la race 1, résistante à la race 6, mais susceptible à la race 2 de l'agent pathogène de la hernie, *Plasmodiophora brassicae* Wor. De plus, à la génération F_1 les descendants issus d'un croisement entre la lignée 8-41 et les variétés susceptibles Red Acre et Golden démontrent que la susceptibilité est dominante et la résistance récessive. On note aussi que la progéniture de la F_2 et du rétrocroisement indique qu'il y a deux gènes impliqués. On propose les gènes R_1 et R_2 comme sites de la susceptibilité. Tous les génotypes possédant ces gènes sont susceptibles tandis que le génotype homozygote récessif $r_1r_1r_2r_2$ est résistant.

Regulateurs de croissance

Sur pommiers. Les composés Alar-85 (Uni-Royal Chemical Co.) et chlormequat (Cycocel [Cyanamid of Canada]) furent appliqués à deux concentrations différentes, en juin et à la mi-août, sur le McIntosh Impérial greffé sur *M. robusta* 5 en 1968. L'application foliaire du chlormequat à 500 et 1 000 p.p.m. une ou deux fois durant la saison de croissance n'a pas eu d'effet sur la croissance ou le nombre de branches. Alar-85, à 2 000 p.p.m., a réduit la longueur des pousses annuelles d'environ 50% et à 4 000 p.p.m., il l'a réduite d'environ 70%. Cependant une deuxième application n'a modifié aucunement l'effet de la première.

Effets de Alar-85 sur pommiers adultes. Le composé Alar-85 appliqué à 1 000 et 2 000 p.p.m. sur pommiers adultes et vigoureux des cultivars Melba, McIntosh, Cortland, Spartan et Lobo en 1966, 1967 et 1968 causa en 1969 une réduction appréciable de la grosseur des fruits mais fut sans effet sur la chute et la coloration des pommes. Les applications faites à la mi-juillet 1968 à 2 000 p.p.m. sur des pommiers adultes McIntosh avec racine *M. robusta* 5 diminuèrent significativement la grosseur des fruits, mais cet effet ne fut pas observé sur des McIntosh greffés sur racine E.M. VII.

Alar-85, appliqué à la mi-juillet 1969, à raison de 800 et 1 600 p.p.m., a retardé de 16 et 23 jours respectivement la chute de la McIntosh. Ces traitements ont amélioré, du moins jusqu'au début de janvier 1970, la qualité des fruits. Les pommes ainsi traitées accusèrent une légère diminution en grosseur.

Sur framboisiers. Aucun traitement du composé Alar-85, appliqué en août 1968 à raison de 1 600, 2 400 et 3 200 p.p.m. sur des framboisiers de première année Comet et Latham, n'en a affecté le rendement en 1969; seule la longueur des tiges fut réduite par la plus forte concentration. En 1969, des applications d'Alar-85 à la mi-juin et le prélèvement du bourgeon terminal des tiges ont stimulé une floraison abondante en septembre chez la variété Comet qui donna des fruits mûrs en octobre. Par contre, les mêmes traitements n'ont pas produit ces effets chez les variétés Latham, Newburg et Carnival.

Sur tomates. Pour une deuxième année consécutive, la couverture de plastique transparent, avec ou sans régulateurs de croissance, a augmenté sensiblement le rendement de la tomate. Avec ou sans couverture de plastique transparent, Alar-85 a augmenté le rendement d'environ 20% par rapport aux témoins, mais sans révéler de différence entre des applications à 2 000 et 4 000 p.p.m. Le chlormequat a de nouveau favorisé une augmentation du rendement des primeurs et une réduction du rendement total. Le composé Ethrel (Amchem Products, Co.) a raccourci d'une façon appréciable la période de maturation des fruits, mais son application à 4 000 p.p.m. a réduit le rendement total.

Sur concombres. Des applications du composé Ethrel à 100 et 400 p.p.m. ont respectivement doublé et triplé les rendements des concombres à marinade, augmenté de 44 et 55% deux des concombres de grosseur

moyenne (dill), réduit le nombre des concombres à achar mais augmenté de 24 et 30% les rendements totaux.

Herbicides

Mode d'action des herbicides. Une étude sous verre sur le mode d'action de certains herbicides, employés pour la répression des mauvaises herbes dans les cultures de légumes, a démontré qu'il existe une relation entre leur structure moléculaire et leur sélectivité. Cette étude a été faite avec trois paires d'herbicides appartenant au groupe chimique des urées substituées; le monuron et le diuron, le monolinuron et le linuron, le métabromuron et le chlorobromuron. Sauf pour la position du chlore sur le groupe phényle, les trois paires étaient identiques. Ils ont été comparés sur une plante susceptible, la tomate, deux plantes semi-résistantes, la carotte et le panais et une plante très résistante, le coriandre.

Au cours de l'essai des herbicides appliqués en préémergence, les composés ayant un seul halogène étaient beaucoup plus toxiques aux plantes que ceux qui avaient deux halogènes sur le groupe phényle. Cette différence n'existe pas s'ils sont appliqués en postémergence alors que les monohalogénés sont tantôt plus toxiques ou tantôt moins toxiques que les dihalogénés.

La résistance des plantes à l'action des dihalogénés semble être la conséquence d'une barrière chimique spécifique et sélective qui empêcherait la translocation des dihalogènes dans les racines des plantes. C'est du moins ce qu'ont démontré des études poursuivies avec des herbicides renfermant du ^{14}C. Cette même barrière n'existerait pas chez les plantes susceptibles.

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INTRODUCTION

The main objective of the Station is to improve the quality of flue-cured tobacco to meet current demands and to maintain or improve the yield. Within the past year all segments of the research program have been directed toward accomplishing this objective in the hope that Canadian tobacco will become more suitable for both the domestic and export markets. A smoke-analysis laboratory has been equipped to measure total particulate matter and smoke nicotine in cigarettes prepared from field-grown tobacco under various tests, in order to provide information that will decrease the hazards of smoking.

One main achievement was a significant decrease in total alkaloids that resulted from increasing the proportion of NH_4^+ and decreasing the NO_3^- in the fertilizer N. Also, by increasing the topping height nicotine was decreased without affecting other chemical constituents of the leaf.

Certain fatty alcohols have been found to control sucker growth better than most other inhibitors without affecting quality.

L. S. Vickery
Director

SOIL SCIENCE

Fertilization

Nitrogen. When the proportion of NO_3^- nitrogen in a complete fertilizer was decreased and the proportion of NH_4^+ nitrogen was increased from 0 to 100%, results were a highly significant increase in reducing sugars and a highly significant decrease in total N, total alkaloids, and sand-free ash of the cured tobacco leaves over a 4-year period. A comparison of three rates of N, 22.4, 31.4, and 40.4 kg/ha (20, 28, and 36 lb/acre), showed that each increment of applied N, with NH_4^+ and NO_3^- sources averaged, increased total N, total alkaloids, and sand-free ash and decreased reducing sugars in the leaves.

Time of application. The check treatment, which was the complete fertilizer banded at planting, gave a higher yield of tobacco than when the fertilizer was applied before plowing in each year, over a 3-year period. Applying 50% more N before plowing did not overcome this loss in yield. When all the fertilizer P, K, Mg, and Cl was applied before plowing and N at planting, yield tended to be lower than the check treatment. Applications of 84% of the P and 70% of the K either before or after plowing and the remainder banded at planting time resulted in yield equal to the check treatment. The Cl content of the leaves was much lower than the check treatment in each year when the Cl portion of the fertilizer was applied before plowing and in 2 years when the Cl was applied after plowing.

A survey of soil and plant characteristics. Analysis of soil and tobacco samples taken at 57 locations from 23 tobacco farms throughout the tobacco-growing areas of Ontario showed that high levels of exchangeable K, Ca, Mg, Fe, exchange capacity, total N, and pH were associated with each other. Levels of total N, P, and Ca in the plant were positively related to the forms of these same elements extracted from the soil, but plant levels of K and Mg were not related to soil levels. Total and reducing sugars were negatively correlated with total N, K, and Ca in soil and leaves. Total alkaloids and filling value were positively related to total N and Ca in soil and plant.

PLANT SCIENCE

Frost Control

Clear plastic covers and applications of protein foam protected young transplants in the field from light frosts. Sprays of various antitranspirants and other materials were ineffective. Transplants were set out about 10 days earlier than usual, plastic covers with holes predrilled in them were placed over the

plants set in a trench, and protein foam was applied when low or freezing temperatures were forecast. Thermocouple readings showed that such measures maintained higher temperatures at night around the plants.

Mulches

A paper mulch was applied over previously fertilized rows with a tractor-mounted applicator, and transplants were set by punching through the mulch with a "jack-planter." The transplanting was done in rather warm weather; as a result, many wilted plants were irreversibly damaged on contact with the black surface (polyethylene or wax film) of the mulch. Later in the season fairly dry weather appeared to be more detrimental to the mulched plants than to the check plots, which indicated that the mulched plants did not receive enough water. In the two previous seasons, with higher amounts of rainfall, mulch was beneficial in prevention of leaching. Mulches did not control field horsetail, *Equisetum arvense* L., but they did control other common weeds.

Spacing and Topping

Three varieties of flue-cured tobacco were grown at three plant spacings and topped to three heights for 3 years. Nicotine decreased with increased topping height; it was the only chemical characteristic of each variety that was affected by topping over the 3-year period. Decreased plant spacing decreased nicotine but also decreased total N, sand-free ash, Ca, K, alkalinity of ash, total volatile bases, non-nicotine volatile bases, and water-soluble acids, and increased reducing sugars and the sugar-to-nicotine ratio.

Conditioning Tobacco

Moisture levels of 16 to 20% are optimum for storing tobacco leaves in piles or bales. The following conditions were found to be appropriate for obtaining 18% moisture in 7 hr: 91% relative humidity (RH) at 23.9 C, 86% at 29.4 C, 84% at 35.0 C, and 82% at 40.6 C. Environments necessary to obtain an equilibrium moisture content of 18% were 85% at 23.9 C, 81% at 29.4 C, 82% at 35.0 C, and 79% at 40.6 C. Moisture levels of 12 to 14% are optimum for certain physical tests on tobacco. Environments necessary to obtain an equilibrium moisture content of 13% were 81% at 23.9 C, and 76% at 29.4, 35.0, and 40.6 C.

Sucker Inhibitors

Fatty alcohols (a mixture of 1-octanol and 1-decanol) with a polyoxyethylene (20) sorbitan monooleate surfactant controlled sucker growth slightly better than did fatty esters. Good control was obtained when the fatty alcohols were sprayed before topping without causing injury. Penar was as effective as the fatty alcohols in killing sucker growth, but it caused some injury to the upper leaves. In 1969 bottom suckers were impossible to control with any sucker inhibitor.

PLANT PHYSIOLOGY

Gibberellic Acid

The reducing sugar content of tobacco was lowered significantly by the application of gibberellic acid during the later stages of growth. Initially, gibberellic acid bleached the abaxial (lower) leaf surface when applied to the plants at 2 mg/plant. Lower concentrations of gibberellic acid were effective in lowering reducing sugar content in the cured leaf without bleaching the abaxial surface.

Peat Pots

Tobacco plants grown in several sizes of peat pots responded quite differently to climatic conditions in the field. Large peat pots (7.5 cm sq) promoted earlier flower initiation than did the smaller pots (4.5 cm sq), regardless of season. During long growing seasons, early flowering resulted in fewer marketable leaves and tended to affect quality adversely. However, early maturity promoted higher crop returns during short seasons, because a greater proportion of the crop was harvested from plants propagated in large peat pots than in small peat pots.

Normally, certain periods of stress were imposed on the tobacco throughout greenhouse and field development. Plants propagated in peat pots were not affected to the same degree by low soil-moisture tensions and weather damages after transplanting as were seedbed plants. The leaf plastochron

index showed that reduction of vegetative growth due to stress was less for peat pot plants than for those propagated in seedbeds.

Chemical Changes During Curing

Calcium, known to be immobile in the detached leaf, was used as an index for estimating actual losses and changes of chemical constituents of tobacco during the curing process. Loss of dry weight was also related to the Ca index. Between 30 and 40% loss of actual dry weight for leaves on the lower part of the stalk and on the upper half of the plant were recorded; these losses occurred mostly through respiration. Similarly, losses of total alkaloids as nicotine and total N up to 1.5 and 1.0%, respectively, were observed.

GENETICS AND PLANT BREEDING

Black Root Rot

Varietal reaction to fungus. Black root rot fungus, *Thielaviopsis basicola* (Berk. & Br.) Ferr., stored in frozen silica caused more severe infection on flue-cured tobacco varieties than fungus stored on potato-dextrose agar (P.D.A.). When potato slices were used to propagate the fungus after storage, inoculated tobacco seedlings produced greater vegetative growth but had more severe root lesions than seedlings inoculated with endoconidia produced on carrot slices. Varieties of flue-cured tobacco showed differences in growth under the conditions used in testing seedlings for reaction to black root rot. White Mammoth variety produced heavier seedlings than Hicks Broadleaf during a 6-week growth and 2-week inoculation period, but more severe lesions occurred on the susceptible White Mammoth variety. Therefore, evaluation of root lesions in disease testing was a more accurate criterion of resistance than vegetative weight when the growth period after inoculation was 2 weeks.

Breeding tobacco immune to black root rot. High-yielding lines of flue-cured tobacco carrying the immunity factor of the species *Nicotiana debneyi* Domin. transferred from the variety Burley 49 have been developed. The cured leaf characteristics such as color, texture, and body were satisfactory in most lines. Progeny testing for the immunity factor was conducted under controlled environment and verified under field conditions for each plant selection in the program.

Seed Germination

Soaking seed in water in total darkness longer than a 24-hr period delayed germination by the length of time the seed was maintained in total darkness. Soaking seed at a low temperature of 10 C in the dark caused a similar delay in germination. Soaking temperatures up to 45 C for 4 hr did not reduce total germination significantly when compared to nontreated seed. Tobacco seed, exposed to a 6-hr period of light after 24 hr soaking, germinated satisfactorily in the dark but not as rapidly as seed under constant light.

Induced Mutations

Application of diethyl sulfate, a chemical mutagen, in saturated solution to dry seed of flue-cured tobacco cultivars resulted in a detrimental effect on both the extent and rate of germination, each decreasing with length of seed soaking period. Seedlings from treated seed grew more slowly than controls. The means for plant height and for length of top and middle leaves were smaller, and the means for number of days to flower were higher than those of the controls. The variances and the ranges of variation of all treated populations were larger than those of the controls. Heritability in the broad sense of the treated populations ranged from 27 to 85%.

PLANT PATHOLOGY

Black Root Rot

Tobacco leaf disks were inoculated with *Thielaviopsis basicola* and floated on water or different concentrations of benomyl (Benlate) suspensions. There was gradual reduction in the number of lesions as concentrations were increased from 0.5 to 5 ppm. No

lesions were formed at higher concentrations. Benomyl protected the leaf systemically against lesion formation only if it was applied before the germ tubes penetrated the mesophyll. Fumigation with either chloropicrin or M2680 at 33 and 44 liters/ha, or Vorlex at 112 liters/ha applied in the row at a depth of 15 or 45 cm did not control black root rot in the field.

Benomyl rototilled in the row at a depth of 7.5–10 cm at 2.3, 4.6, 6.9, or 9.2 kg/ha significantly reduced black root rot infection in the field. Similarly, benomyl suspended in the planting water at concentrations of 10–1000 ppm reduced black root rot. Maximum reduction resulted from the highest concentration. The addition of the surfactant Tween 20 to the highest concentration increased the effectiveness of benomyl.

In the greenhouse, a mixture of 6.7 liters of allyl alcohol and 450 g of benomyl applied as a soil drench to 93 m^2 of the bed eradicated black root rot fungus and controlled weeds. Dazomet applied at 890 g per 9.3 m^2 also reduced infection and controlled weeds.

Effect of Fumigation on Yield

Fumigation of sandy soil at 45 cm depth with Telone, M2680, or chloropicrin at 45 liters/ha as well as D-D at 110 liters/ha significantly increased the yield up to 15% as compared with plots fumigated with the same chemical at 15 cm depth. These results could not be explained through the effect of these treatments on the population of *Pratylenchus penetrans* (Cobb) Filipjev & Stekh.

Damping-off

A survey was made on the distribution of organisms causing damping-off in the greenhouse in the tobacco area. Most of the samples of tobacco seedlings collected from 50 farms were infected with *Rhizoctonia solani* Kuhn, whereas a few were infected with *Pythium* spp. Preliminary trials showed that benomyl is effective against damping-off caused by *R. solani*.

ENTOMOLOGY

Cutworms

Biology. Cutworm larvae were attracted by tobacco seedlings set out as trap plants in a rye field. A total of 615 cutworm larvae were collected from 15 traps, consisting of 1 m^2 each, planted with 8 tobacco seedlings from the greenhouse. Three of the larvae collected were identified as the striped cutworm, *Euxoa tessellata* (Harris), and 612 as the dark-sided cutworm, *Euxoa messoria* (Harris).

Chemical control. DDT, carbaryl, Dursban, and AC-47031 were applied at various rates on rye or soil, or both, for control of the dark-sided cutworm attacking flue-cured tobacco in Ontario. All insecticides tested caused significant reductions in cutworm damage in comparison with the untreated check. Dursban at 0.56 kg/ha (0.5 lb/acre) on rye or 1.12 kg/ha (1 lb/acre) incorporated in the soil tended to give better control than DDT at 4.48 kg/ha (4 lb/acre) on soil or a split application of DDT at 1.40 kg/ha (1.25 lb/acre) on rye and 4.48 kg/ha (4 lb/acre) on soil in the large-scale test. Carbaryl and AC-47031 showed less effect than DDT. There was no advantage in the split application of DDT or Dursban on rye and on soil, because each treatment singly provided effective control of this pest. Dursban showed promise as a substitute for DDT for control of the dark-sided cutworm in tobacco fields.

Trichloronat was applied as a soil treatment alone at various rates for control of the dark-sided cutworm in the field. Results showed that a single application at the rate of 3.36 kg/ha (3 lb/acre) incorporated into the soil gave effective control.

Virus control. For control of the dark-sided cutworm in 1969, nuclear virus used as a spray alone or combined with a very small dose of DDT or *Bacillus thuringiensis* Berliner was as effective as DDT applied on the rye at 1.40 kg/ha (1.25 lb/acre) plus 4.48 kg/ha (4 lb/acre) on the soil.

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Departures

H. R. BOYCE, B.S.A., M.S.A. Retired December 31, 1969	Field and forage crop insects
L. F. OUNSWORTH, B.S.A., M.Sc. Transferred to Central Experimental Farm, Ottawa, Ont., December 19, 1969	Vegetables
J. R. RAINFORTH, B.Sc., M.Sc. Transferred to Ontario Department of Agriculture and Food, Vineland Station, Ont., January 2, 1969	Extension Services: Greenhouse and vegetable crops
G. M. WEAVER, B.Sc., Ph.D. Transferred to Research Station, Vineland Station, Ont., October 31, 1969	Tree fruit breeding

EXTENSION SERVICES[2]

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[1]On a transfer of work from August 1, 1968, to June 22, 1969, at the Waite Institute, University of Adelaide, Adelaide, South Australia.

[2]Provided by Ontario Department of Agriculture and Food.

INTRODUCTION

This report summarizes the results of our more important research in 1969. Detailed reports of completed research will be found in journals or reports listed under publications. Reprints are available from the authors.

Important changes in our program included the reestablishment of research on diseases caused by nematodes and the expansion of tests on pesticides used on vegetables to include insecticides.

The most important change was the completion of the new Research Laboratory complex. This includes a two-storey research building interconnected with a single-storey administration wing and three service wings that enclose a courtyard.

L. W. Koch

Director

FIELD CROPS

Alfalfa

Insects. The alfalfa weevil maintained epidemic levels in several areas throughout southern Ontario and Quebec. Heavy infestations were obvious in Essex, Kent, and Lambton counties.

Data from a survey aimed at determining survival of overwintering eggs showed that where there are more than 2,300 heat units/year, the insect can lay eggs in the fall. There appears to be a positive correlation between a decrease in heat units/year and a decrease in number of eggs laid in the fall. The data also showed that no eggs survived the rigors of the 1968-69 winter in Ontario and Quebec.

Data concerning numbers and development of eggs were obtained at Harrow from alfalfa plots cut twice for hay during the growing season.

A chalcid parasitoid and an ichneumonid parasitoid, *Bathyplectes* sp., were reared from weevil eggs and larvae, respectively. The numbers were insignificant.

Burley Tobacco

Harvesting and curing. In 3 years of experimentation it was found that primed Burley tobacco leaf may be cured satisfactorily under special semiartificial conditions. In the best of several test environments, natural air, maintained within a humidity range of 65% to 85% and at a temperature not less than 18 C, was circulated continuously through the tobacco kiln at about six changes per hour for a 6-week curing period. Limiting the maximum relative humidity at approximately 85% by applying the proper amount of heat, when prevailing outside humidity was very high, prevented "barn burn" of tobacco. The yield of tobacco cured in a humidity between 65% and 85% was 4% higher and the grade value was 2% higher than for tobacco cured within a humidity range of 75% to 85%.

Corn

Breeding. Several single-cross hybrids made up of the newer stalk rot resistant inbreds developed at Harrow exhibited excellent combining ability and resistance to stalk breakage in the 1969 Ontario Corn Tests. Two hybrids far exceeded the necessary 10% in yield over the appropriate check hybrids, which made them eligible for licensing after only 1 year of testing.

Other diseases. Two new leaf spots of corn have attracted attention in the past two seasons. Leaf spots caused by a species of *Phyllosticta* occurred from Essex to Northumberland counties. Eyespot, caused by *Kabatiella zeae* Narita & Y. Hiratsuka, occurred again in trials in the St. Thomas and Brantford areas.

Root and stalk rot. From a study of the relative importance of leaves in various positions on the plant it was concluded that groups of upper leaves of resistant hybrids were more effective than corresponding leaves of a susceptible hybrid in maintaining stalks free from rot. Apparently, under stress conditions, the leaves of the resistant hybrid remained more efficient photosynthetically than those of the susceptible hybrid during

the 6 weeks before physiological maturity. A study of pith cells of stalks indicated that ear development may impose greater stress on the stalks of hybrids than on those of the inbreds, and may explain in part why hybrids are often less stalk rot resistant than would be expected from their parent inbreds.

Viruses of corn and cereals. Tests indicate that wheat streak mosaic occurs to a greater extent in wheat and corn crops than visual surveys suggest, because many late-infected plants do not show symptoms. Wheat spindle-streak mosaic (a soil-borne wheat mosaic) was again widespread in 1969 in Essex, Kent, and Lambton counties. When sowing of winter wheat was delayed to mid-October and early November, the proportion of shoots with symptoms of wheat spindle-streak mosaic in the following spring was lower than for September plantings, but yield was reduced. One variety outyielded Genesee and Talbot, although it showed symptoms of the disease.

Oats and Winter Wheat

Insects. The 1969 reports on the cereal leaf beetle purport its presence as far east as Halton County, Ont., and Maryland, USA.

Data from plots of oats and winter wheat at Harrow, and from a plot of oats at Amherstburg, Ont., showed that this pest did not reach large enough population levels to cause immediate concern to production of these crops.

Soybeans

Biochemical genetics. On the basis of thin-layer chromatographic separation of leaf flavonoids, 100 soybean varieties were placed into 15 groups. These groups were differentiated mainly by migration pattern and number of glycosides of the flavonols, kaempferol and quercetin. Varieties with gray pubescence contained only kaempferol glycosides in the leaves and free kaempferol in the hairs, whereas varieties with brown pubescence contained both kaempferol and quercetin glycosides in the leaves but only quercetin in the hairs. This association suggests that the gene *T*, which gives brown vs. gray pubescence, may control the production of an enzyme catalyzing the hydroxylation of kaempferol to form quercetin. Thin-layer chromatography of flavonol glycosides in soybeans will provide an additional aid in variety identification.

Weed control in soybeans. Mixtures of linuron with either alachlor or propachlor gave better weed control than single applications of chloramben, linuron, or metobromuron. Applications of trifluralin with either linuron or metobromuron gave inadequate control of ragweed, a result that was also noted in 1968.

White Beans

Bronzing. A great variation was observed in the occurrence of bronzing, presumably caused by air pollution. Plants showed first symptoms about 10 days after full bloom. Symptom severity was inversely related to crop vigor. It is postulated that depletion of leaves of carbohydrates predisposed them to bronzing.

Sclerotinia rot. Benomyl (Benlate; DuPont of Canada) applied as a single spray at 453 g/378.5 liters of water (1 lb/100 gal) at full bloom directed at the base of the plants controlled the disease. Sprays applied from well above the foliage and after full bloom were ineffective.

Plants in rows oriented in a north–south rather than an east–west direction generally showed a greater likelihood of having the disease. A crop with a heavy canopy of foliage was most susceptible.

Winter Wheat

Five winter wheat breeding lines developed at Harrow continued to perform extremely well in performance trials at four locations in Ontario. One of these selections, 4-71, produced an average yield of 5,242 kg/ha (72.2 bu/acre) over the past 2 years compared with 4,559 and 4,384 kg/ha (62.8 and 60.4 bu/acre) produced by Yorkstar and Genesee over the same 2 years. This selection also demonstrated much better straw strength than Genesee or Yorkstar. It had considerable tolerance to winter wheat spindle-streak mosaic, a disease that is very prevalent throughout southwestern Ontario. At a summer meeting of the Winter Wheat Improvement Committee, it was decided that application should be made to have this selection licensed for use in Canada.

HORTICULTURAL CROPS

Field Vegetables

Potatoes

Green peach aphids on early potatoes. Green peach aphids were counted every 4 days on an unsprayed plot of Irish Cobbler potatoes. The maximum population was only 660 per 50 leaves, compared with 1,900 in 1968. An empirical model developed to predict the count on any occasion from factors measured on the previous occasion correctly predicted the point when numbers started to decline. The results predicted by the model correlated with the actual counts with a correlation coefficient of $+0.775$ ($P = 0.01$).

Verticillium wilt. From 642 isolations attempted from stems of potato (cvs. Irish Cobbler and Kennebec) taken from 65 fields in Essex County, 400 isolates of *Verticillium* were obtained. Of these, 217 were *V. dahliae* Kleb., 44 were *V. albo-atrum* Reinke & Berth., and 139 were *V. nigrescens* Pethybr. The exceedingly wet growing conditions may have given rise to a much higher proportion of *V. nigrescens* among the isolates than that obtained in either 1967 or 1968. Most of the isolates of *V. albo-atrum* were obtained early in the season and from stems showing conspicuous symptoms of wilt. *V. dahliae* and *V. nigrescens* were obtained from plants showing early maturity, but no wilt.

Good evidence was obtained to show that *V. albo-atrum* has a weak capacity for overwintering in field soil in southwestern Ontario. In contrast, *V. dahliae* overwinters readily.

Tomatoes

Nitidulid beetles in tomatoes. A study of the biology and control of *Glischrochilus quadrisignatus* (Say), which infests processing tomatoes, was initiated in 1969. The beetle overwintered as an adult. Oviposition started in early May and continued until July. The only ovipositional sites found were ears of corn that remained in the field from the previous fall. Burial of the ears was an ineffective method of preventing reproduction because all stages of the beetle were found on ears that were several inches underground. Adults fed on all types of rotting fruits and vegetables that were on the ground throughout the summer and fall. Corn kernels damaged by birds also served as feeding sites. There was no evidence of a second generation.

Weed control in tomatoes. Diphenamid was the only herbicide used in a single application on a sandy loam soil which gave acceptable weed control. In contrast, granular chloramben was the only herbicide used on a clay loam soil which provided satisfactory control of weeds. On both soils, applications of either trifluralin or diphenamid followed by solan gave excellent weed control without affecting the yield of tomatoes.

Greenhouse Vegetables

Cucumbers

Control of the greenhouse whitefly. A program of integrated control by chinomethionat (Morestan; Chemagro Corp.) and one release of the parasite *Encarsia formosa* Gahan kept whiteflies at a low level, prevented powdery mildew, and deterred the two-spotted spider mite and the melon aphid. Mass propagation of the parasite is under way and 12,000 were shipped to growers in 1969. The integrated program is harmless to bees.

Pest control. In an experimental greenhouse compartment made as airtight as possible by sealing the connections between the panes of glass, 100% of the active stages and over 90% of the quiescent stages of the two-spotted spider mite were killed when naled was vaporized from heating pipes. Commercial cucumber greenhouses are apparently not sufficiently airtight to confine the naled vapor and only active stages are killed.

Seven hours of continuous ventilation following an overnight treatment failed to remove all traces of naled from the compartment. This may explain the erratic behavior and occasional mortality of honey bees that are released in treated greenhouses after only a few hours of ventilation.

Nematodes in Greenhouse Soils

In a nematode survey involving approximately 25% of the tomato and cucumber greenhouse growers in Essex County, the root-knot nematode, *Meloidogyne* sp., was detected in 50.8% of the houses sampled, and the root-lesion nematode, *Pratylenchus* sp., was found in 13.1% of the houses sampled. The root-knot nematode is the single most economically important plant-parasitic nematode in the greenhouses of this area.

Tomatoes

Trace-element nutrition. Soaking seeds before planting time in dilute solutions of salts of nutrient trace elements has resulted in a small but consistent increase in total yield of fruit. Cu and Zn have been the most effective in this treatment, but other elements have also given positive results.

Whitefly control. A program of integrated control by chinomethionat and whitefly parasites kept whitefly numbers at a reasonable level for 2 months. A higher initial release rate or two releases of the parasite would be necessary for full-season control. Chinomethionat residues on tomato fruit were below 1 ppm, even on the spray dates.

Tree Fruits

Apricots

Breeding. Twenty-one different hybrid combinations were made and 4,950 hybrid seedlings were obtained. The crosses were made to improve winterhardiness, cropping consistency, disease resistance, and fruit size and quality.

Eleven selections from crosses made in 1963 were propagated for widespread second testing in 1971. They varied in ripening date from July 14 to August 12. The fruits were attractive, had good fresh and processing qualities, had good size, and were above average in resistance to peach canker, caused by *Cytospora* spp.; brown rot, caused by *Monilinia fructicola* (Wint.) Honey; and bacterial spot, caused by *Xanthomonas pruni* (E.F.Sm.) Dowson.

A seedling inoculation and rating procedure was developed to screen for bacterial spot resistance in the greenhouse. Progenies from crosses where both parents had the resistant phenotype also had the highest proportion of resistant offspring, resistant × susceptible combinations were intermediate, and susceptible × susceptible combinations had the smallest proportion of resistant offspring.

Microsporogenesis. A degree-hour duration summation technique was used to determine the optimum meteorological threshold temperatures for prediction of meiotic induction and other key stages of microsporogenesis in apricot. The optimum threshold temperature for prediction of meiotic induction using January 1 as the starting date was −2 C, and for differentiation to the tetrad stage either 0 or −2 C were equally suitable.

Tree paints. A new tree paint was developed which prevented southwest injury (winter sunscald), and repelled rodents. The paint contained thiram (75% WP) as the fungicide and rodent repellent, exterior white latex as the light reflectant, and water as the diluent.

Winterhardiness. Scions from six apricot and two peach cultivars were subjected to artificial freezing stresses of −20 and −25 C every 2 weeks from November to March to compare their relative hardiness during overwintering. Flower-bud hardiness of peach and apricot and the cortical stem tissue of peach fluctuated with the outside air temperature, increasing rapidly during cold periods and decreasing just as rapidly during mild periods. In contrast, cortical stem tissue of apricot, once hardened, showed substantially less response to subsequent mild periods.

Peaches

Green peach aphid. In 1969, overwintering eggs of the green peach aphid began hatching on April 11. About 70% of the colonies derived from these eggs were subject to predation by coccinellids and syrphids, but only 30% were destroyed before winged forms were produced. Colonies that survived predation produced about the same number of winged forms as colonies where no predators were seen. Stem mothers collected from peach colonies began producing winged forms late in life, although in other geographic areas a succession of wingless gener-

ations occurs before any winged forms are produced.

Lesser peach tree borer. Two systemic insecticides, Dursban (Dow Chemical Co.) and monocrotophos (Azodrin; Shell Chemical Company), were evaluated for control of the lesser peach tree borer and compared in their effectiveness with the recommended compound endosulfan. These two new materials, which were applied by brush in a band around the tree trunk and on infested areas, gave significant decreases in borer infestation.

Peach canker. Isolations made in the spring from incipient cankers from nodal and internodal regions of twigs yielded mostly *Leucostoma cincta* (Fr.) v. Hohnel, confirming previous reports of its important role in the initiation of perennial canker in Ontario. However, cankers were readily produced by both *L. cincta* and *L. persoonii* (Nits.) v. Hohnel by artificial inoculation of twigs in spring, late summer, and fall, and the latter organism was often isolated from older cankers. It is therefore possible that *L. persoonii* plays a part in the aggravation of perennial canker.

Weed control in peach orchards. Annual applications during a 4-year period of combinations of paraquat with diuron, linuron, simazine, or terbacil were found to have no stimulatory effect on leaf N, tree growth, or fruit yield. The mixture of paraquat and terbacil was the only treatment used that was phytotoxic to newly planted trees, but this injury was not accompanied by a decrease in fruit yield. Mixtures of paraquat with linuron, or simazine, or both, gave inadequate control of crabgrass, but the mixtures of paraquat with diuron, or terbicil, or both, provided excellent annual weed control.

Pears

Breeding. A total of 6,159 pear seedlings, *Pyrus communis* L., representing 46 progenies from controlled hybridization were screened for resistance to fire blight caused by *Erwinia amylovora* (Burr.) Winslow et al. Excellent infection and disease development were obtained. Intraspecific *P. communis* combinations that produced a high proportion of resistant offspring included Mannings Elizabeth × US 446, Bartlett × Tyson, Bartlett × Chapin, and Magness × Starkrimson. Several progenies from interspecific crosses among *P. communis, P. serotina*, and *P. ussuriensis* also produced a high proportion of resistant offspring.

INSECT PATHOLOGY

A long-term field study showed that viruses of the cabbage looper and the imported cabbageworm accumulated in soil following epizootics of the diseases in populations of the host insects. Because the viruses persisted in the soil, residues increased with repeated cropping. In the third year of the test (1969) foliage of plants was contaminated with sufficient virus from the soil to kill all susceptible larvae feeding in the latter part of August, demonstrating the possibility of natural control of the pest insects by virus accumulating in soil from previous epizootics.

Materials to reduce inactivation of insect viruses by ultraviolet radiation, thereby prolonging effectiveness of foliar applications of viruses, were assessed in the laboratory and field. India ink, soy hydrolyzate, and brewers' yeast showed promise.

Plot tests showed that three foliar applications combining viruses of the imported cabbageworm and the cabbage looper protected cabbage from the pests.

SOIL SCIENCE

Soil Fertility

In Fox sandy loam, 3 years after a peach orchard had been removed and the soil planted to two crops of oats, enough N remained to produce a crop of tomatoes, cucumbers, or cabbage. In each of the two

succeeding years cucumbers required 56–112 kg/ha N for maximum yield, and tomatoes and cabbage, 112–168 kg/ha N. At the 168 kg/ha rate, a split in the N application was mandatory for tomatoes, namely, 112 kg/ha at planting time followed by two side-dressings (28 kg/ha) 10 days apart, beginning when the largest fruit were 3 to 4 cm in diameter.

Soil Physics

Irrigation. A project was initiated to study the effects of direct field seeding of processing tomatoes under plastic mulch vs. transplanting, high vs. low plant populations, and the response of two commercial cultivars to irrigation. The much higher than average seasonal rainfall precluded any crop response to irrigation. Tomatoes seeded under black plastic in the field produced a substantially lower yield than regular transplanting methods. However, harvest from both methods of planting was complete in September, well ahead of any frost hazard. Eleven thousand plants per acre produced higher yields than half that number, and the cultivar Fireball produced higher yields than H1350.

Transpiration from a lysimeter where evaporation was eliminated by clear plastic mulch was about one-half of evapotranspiration.

Root extension. Maximum root length and the depth of soil containing 60% of the tomato plant roots were measured at regular intervals throughout the season. Early in August roots had penetrated to a depth of more than 120 cm (4 ft) and seemed quite uniformly distributed, with 60% of the roots in the top 60 cm (2 ft).

MISCELLANEOUS

Control of Vegetable Diseases with Fungicides

Benomyl, a comparatively new systemic fungicide, was remarkably effective in controlling several diseases of greenhouse and field vegetable crops. It was far superior to 19 other fungicides, or combinations of fungicides, in controlling powdery mildew and scab in cucumbers, and powdery mildew and anthracnose in muskmelon. Benomyl was more effective than previously recommended fungicides for controlling botrytis neck rot of onions and cladosporium leaf mold of greenhouse tomatoes. It also ranked with Daconil 2787 (Diamond Shamrock Chemical Co.), captafol (Difolatan; Chevron Chemical Co.), and maneb in controlling septoria leaf spot of celery.

A root drench of an aqueous suspension of benomyl at 4.48 kg/378.5 liters of water (4 lb/100 imp gal) applied to eggplant transplants at the time of field setting delayed the onset of verticillium wilt by 32 days. Although some phytotoxicity reflected in early stunting of plant growth followed, the treatment produced a fourfold yield increase of fruits at first harvest and a doubling of yield for the entire season.

A new proprietary seed protectant RH 893 (Rohm & Haas Co.) was much superior to veteran seed-treating chemicals in preventing seed decay in peas.

Differential Response of Varieties of Canada Thistle to Herbicides

A greenhouse study on Canada thistle, *Cirsium arvense* (L.) Scop., showed that after treatment with dicamba or 2,4-D there was more inhibition of shoot regrowth from the root systems of *horridum* plants than of *mite* plants. However, no differential response between varieties was obtained after treatment with either amitrole or 2,4-DB. All herbicides were applied when the plants were in the full bloom stage of growth.

Herbicide Movement in Soil

A method of determination by gas chromatography for the herbicides Bay-94337 and Bay-86791 (Chemagro Corporation) was developed and successfully employed to analyze soil samples containing these materials.

Selective Phytotoxicity of Dyrene to Varieties of Canada Thistle

Injury to the *mite* variety of Canada thistle treated with Dyrene (Chemagro Corporation) was apparent in less than 3 hr, and vapor from treated plants injured untreated

plants. Regrowth from treated *mite* plants was abnormal.

A second compound found in the commercial Dyrene product proved as toxic to the *mite* variety as Dyrene, but failed to injure the tolerant *horridum* variety.

The metabolic degradation of Dyrene differed for the two varieties. A phytotoxic breakdown product was isolated from the *mite* but not the *horridum* variety. This compound caused severe injury to leaf sections of *mite* but only slight injury to those of *horridum*. Treated leaf sections of both varieties, when floated on water, released compounds into solution which were highly phytotoxic to the *mite* variety.

Verticillium Wilt

Of 104 isolates of *Verticillium* obtained from wilted plants of tomato, strawberry, muskmelon, watermelon, pepper, and eggplant, 101 were *V. dahliae*, 1 was *V. albo-atrum*, and 2 were *V. nigrescens*.

SOIL SUBSTATION, WOODSLEE, ONTARIO

Effect of N on Soil pH and Lime Requirement

Annual applications of N at 326 kg/ha (270 lb/acre) for 15 years resulted in reduced soil pH in the surface 30-cm depth. Soil pH was especially low in the top 15 cm, averaging 4.7, but was also reduced at the 22- to 30-cm depth, where pH averaged 5.1. A lime requirement of approximately 1.2×10^3 kg/ha was required in the surface 15-cm depth to neutralize the acidity resulting from cumulative N applications.

Nutrient Losses from Tile Drains on Brookston Clay

Excessive precipitation in 1969 (total 101 cm), particularly during May, June, and July, resulted in a total annual water flow of 47.5 and 53.7 cm, respectively, from tile drains under corn planted after 2 years of alfalfa, and under first-year alfalfa sod. The lowest annual flow was 16.2 cm under second-year alfalfa. Annual total flows during 1961 to 1968 measured under continuous corn did not exceed 44.5 cm. In 1969 total precipitation was 97 cm with excessive rainfall in June (14.2 cm), and July (18 cm). The N losses were mainly in the form of NO_3-N. The concentration of NO_3-N in water from tile under fertilized corn in rotation was 20 to 25 ppm during June and July, when the corn plants were small, in contrast to 3 to 8 ppm in August, when the plants had reached full height. NO_3-N concentration in water from tile under crops other than corn was generally less than 10 ppm in most years.

Effect of Crop Rotation on Soil Structure and Corn Yield

Soil structure, assessed by pore-space measurement, was maintained at higher levels by grass and legume systems than by monoculture corn. Total pore space on a 4-year rotation of corn–oats–alfalfa–alfalfa was 9% and 6% higher in 1968 and 1969 than pore space after continuous corn. Also, on a 2-year rotation of corn and oats total pore space was 7% and 4% higher in 1968 and 1969 than after continuous corn.

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Ottawa, Ontario

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Departures

F. Gfeller, B.S.A., M.Sc. Retired November 1969	Head of Cereal Section; Winter wheat and peas
L. P. S. Spangelo, B.S.A., M.Sc., Ph.D. Transferred to Research Station, Beaverlodge, Alta., January 1970	Fruits
R. Watkins, B.S.A., Ph.D. Resigned January 1969	Fruit genetics
F. J. Zillinsky, B.S.A., M.Sc., Ph.D. Resigned December 1969	Oats and barley
J. E. Comeau, B.Sc. (Agr.), M.Sc. Transferred to Experimental Farm, La Pocatière, Que., May 1969	Superintendent, Kapuskasing

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C. S. HSU, B.S., M.S., Ph.D., 1968–70	Fruit genetics
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INTRODUCTION

The Ottawa Research Station plays a leading role in cereal, forage crop, fruit, and vegetable research in Eastern Canada and with the associated experimental farms at Fort William, Kapuskasing, and Smithfield carries out research of regional importance for eastern and northwestern Ontario. This report summarizes the main research findings and activities during 1969.

New varieties of winter wheat, forage oats, field peas, orchardgrass, grain corn, apple, raspberry, cucumber, tomato, potato, and *Forsythia* have reached advanced testing stages or have been recommended for licensing. Important results were obtained at Smithfield on the residual effect on apples of Alar stop-drop spray. Research on the application of acrylamide gel electrophoresis techniques to investigate genetic polymorphism and genome relationships was initiated.

A. W. S. Hunter
Director

CEREAL CROPS

Wheat

Breeding winter wheat. The short-strawed Ottawa strain 7453-4-3-3 (a Norin dwarf combined with Genesee and an introduced hybrid) continued to be outstanding. It is more resistant to lodging, mildew, and leaf rust and has a higher weight/bushel than Yorkstar. It is resistant to several races of bunt and should possess some resistance to loose smut. This strain has been further purified for uniformity in height and head density.

Hybrid winter wheat. Gene complexes from three different sources are being used to produce restorer lines: *Triticum timopheevi* (Rf1 and Rf2), Primepi (unknown), and *T. spelta* var. *duhamelianum* (Rf3). Possibly the Primepi complex differs from that of *T. timopheevi.*

About 90% seedset was obtained by cross-pollination in the first and second tillers of the male steriles, but the seedset in later tillers was reduced because the main pollen supply was exhausted. The seed on the male steriles was plump and well formed and equal to that of the self-pollinated parents.

Many F_1 combinations of North American with foreign varieties were tested at normal seeding rates, with fall seeding and with spring seeding after artificial vernalization. The indigenous parents generally gave more heterosis than did foreign varieties in fall seeding, presumably because of their greater winterhardiness. With fall seeding, combining value could not be firmly assessed because of the variability between replicates and between years. Although very little killing occurred, the yield potential of these varieties and their combinations was partly suppressed by sublethal winter injury.

Spring wheat mixtures. It may be possible to use Pitic 62 as a marker in mixture with Opal feed wheat to distinguish Opal seed lots from other commercial varieties. Yield tests of mixtures of Opal and Pitic 62 showed significant yield increases (compared with pure stands of the main contributing variety) with 10% Opal in Pitic 62 and 10 and 20% Pitic 62 in Opal.

Oats

Dormoats. In 1969, as in 1968, increased spring emergence was obtained by subjecting the imbibed seed of certain light-sensitive strains to light outdoors before they were planted in fall. Dormoat-124 and strains having D-124 in their parentage showed outstanding spring emergence. Other fairly promising strains such as D-26 appeared to be insensitive to light and performed best when sown soon after harvest.

A reduction in the number of seeds that germinate in fall was obtained by holding

imbibed seeds at 35 C for 1 week before planting. Induced dormancy occurred in all wild oat and dormoat stocks, even though the seed was capable of partial (20–80% in the various strains) germination at 20 C. The kinetics of this induction process are being studied.

The ability of dormoats to escape serious infection by rusts and septoria, due to early maturity, was again evident in 1969 at Ottawa, Winnipeg, and Brandon.

Common oats. Strain OA123-1 from the Ottawa interspecific program is a good producer of grain and forage in Eastern Canada and is performing well in Western Canada. Other interspecific strains with lodging resistance and large kernel size have been entered in advanced trials and were used as parents in the dormoat program.

Many strains with high seed-protein content have been isolated. Among these, strain OA-123-33 has performed well in the USA both agronomically and in feeding trials with voles.

Daylength insensitivity. When grown in California selection Med. 147, *Avena byzantina* C. Koch, flowers evenly and matures in sufficient time to return seed to Canada for spring planting. The genes for short-day tolerance are dominant, and very promising segregates from the cross Med. 147 × OA123-1 were obtained from the 1968–69 California winter increase. These plants were grown in the summer of 1969, when F_3 segregates were backcrossed to adapted Canadian varieties.

Barley

Strong straw. Forty-one crosses were made between 11 short-strawed varieties of the USDA World Collection on 6 good agronomic varieties. Twenty-one of Shands' short-strawed lines are being introduced in the breeding program to create a large pool of spring-type genetic material segregating for short stiff straw.

Three F_2 populations of winter barley from crosses between cultivars and interspecific strains showed very strong straw, good winter survival, and mildew resistance.

Seed irradiation. In cooperation with Atomic Energy of Canada Limited, seed of Herta and Conquest barley was given 0, 100, 300, and 1,000 rad of gamma irradiation. No significant effect on grain or straw yield of either variety resulted.

New variety. Brock, a six-rowed feed variety, was licensed for sale in Canada. It was developed by the Ontario Project Group from the cross (Jet × Vantage) × York made at Guelph. It is high yielding, has loose smut, mildew, and stem rust resistance, and is well adapted for Ontario conditions.

Field Peas

Two Ottawa strains performed well in 3 years of testing in the Eastern Cooperative Field Pea Test. CD6474 significantly outyielded Stirling in all 3 years. Its seed is larger, is of better quality, and matures earlier than that of Stirling. Strain 7608-13A2-2 yielded equal or better than Century, the leading variety. It has a slightly smaller seed and a shorter vine, and matures 5–6 days earlier than Century.

Pathology

Septoria disease of oats. A high level of resistance to septoria disease is not found in common oats, but there are indications of tolerance. To measure tolerance, selected lines from the USDA World Oat Collection were grown at Ottawa and Charlottetown. Yields were compared from unsprayed plots and plots sprayed with the fungicide maneb. Lack of difference between sprayed and unsprayed plots was interpreted as tolerance. Several diseases occurred at Ottawa, and tolerance to septoria disease could not be determined. At Charlottetown, only septoria was present and five lines showed good tolerance.

In 1969 septoria disease caused an average 16% loss at Charlottetown.

Continuous cropping of barley. Tests with three varieties of barley gave an average 19% reduction in seed yields on land that had grown barley for 3 consecutive years and a 14% reduction on land that had grown barley for 2 years in succession compared with land producing its first crop. Fertility had little effect on yield in the first 2 years, but in 1969 yield increased with fertility level.

FORAGE CROPS

Grass Breeding

Timothy

Under good moisture and fertility conditions Champ produces a denser growth and about 25% more aftermath than hay-type timothies. Histological examination of seedlings showed that Champ establishes more tiller initials and establishes them earlier than the hay-type Bounty.

Male-sterile plants were isolated from Bounty and Labelle and will be used to produce F_1 hybrids for measurement of heterosis. No male steriles were obtained from Champ or its derivatives.

Orchardgrass

Under severe conditions at Fort William in 1968–69 strain K, a vigorous, late-maturing, winter-hardy variety was only 9% winter-killed compared with an average of 30% of all other strains killed in the test. Strain K has been licensed and will be released under the name Kay.

Alfalfa Breeding

Wilt-resistant synthetics of DuPuits and Rhizoma origin have been established in provincial tests for comparison with standard varieties. An experimental cultivar that appears promising for acid soils will be increased for field testing. Studies on F_1 hybrid alfalfas are continuing.

Corn Breeding

A new corn hybrid was released for commercial production. It is adapted to the 2,600–2,700 heat unit zone.

Two sets of three inbreds and the three single-cross hybrids from each were grown at a wide range of densities in systematic spacing arrangements to determine optimum densities for grain yield. Optimum densities varied considerably among both inbreds and hybrids. Some hybrids produced maximum yields at densities double those recommended for commercial planting. Satisfactory yields at high densities were obtained only from hybrids with at least one parental inbred tolerant of high densities. High maximum yields were produced only by hybrids with at least one high-yielding parental inbred, indicating that the maximum yield per acre of an inbred, unlike its yield per plant at wide spacings, may provide an estimate of the yields of hybrids involving that inbred.

Pathology

Effects of organic amendments on growth and survival of Fusarium *species in soil.* The addition of nutrients to soil stimulated germination of chlamydospores and exposed germ tubes, hyphae, and thin-walled spores to lytic action. Lysis was hastened by the application of yeast extract with glucose and asparagine and resulted in a 40% or more reduction in the fungus population. Germ tubes lysed in such soil if asparagine, glycine, glutamine, or nitrogen, alone or in mixtures was added to glucose or sucrose.

Coumestrol production in alfalfa. The cou-

mestrol content of 16 alfalfa varieties, inoculated with a pure culture of the fusarium root rot fungus, *Fusarium oxysporum* Schlecht. and *F. solani* (Mart.) App. & Wr., and grown in the field and in a controlled-environment chamber, varied from 0.4 to 14.4 ppm dry weight. Coumestrol accumulated in response to fungal infection and was associated with tissue necrosis. Coumestrol content progressively increased after the disease developed.

Phytophthora root rot of alfalfa. In a limited survey in 1969, phytophthora root rot, caused by *Phytophthora megasperma* Drechsl., was found in alfalfa fields in 19 counties in Ontario and 2 in Quebec. The disease occurred in low areas and on slopes where drainage was poor. Damage varied from slight to very severe. Under favorable conditions, the fungus may invade and cause damage in a very short time and may become epidemic if the soil remains excessively wet during periods of prolonged heavy rainfall.

Introductions

Some promising introductions were a blue-flowered, compact, hardy alfalfa from Moscow that yielded 48% more green forage than the check variety DuPuits; a yellow-flowered, hardy, leafy alfalfa from Bulgaria that yielded 15% more green forage than DuPuits; a blue-flowered, hardy alfalfa from Leningrad that outyielded DuPuits by 14%. A hairy vetch, *Vicia villosa* Roth, found on a local fence, survived the 1968–69 winter 100% and gave good forage and seed production if the plants were supported by a companion crop. A tall, upright trefoil strain, *Lotus corniculatus* L., from Lithuania outyielded Viking and flowered approximately 2 weeks later. A tall, high forage yielding Ladino, *Trifolium repens* L., from Yugoslavia persisted 3 years without apparent injury. A vigorous, early bromegrass, *Bromus inermis* Leyss., from Hungary yielded 23% more green forage than Redpatch. A perennial rye, *Secale kuprijanovi* Grossh., from Germany produced a good crop of both forage and seed. It starts very early in spring and has an excellent late-fall growth.

The alfalfa weevil, found for the first time in our second-year plots, considerably damaged the alfalfa heads that had been left for seed.

Crown vetch. Varieties of crown vetch, *Coronilla varia* L., from the United States, tested over 3 years, were hardy enough to survive our severe winters. Forage and seed production were good and the varieties tested showed a high degree of tolerance for diseases and insects. Crown vetch is an excellent conservation plant and may be a useful forage species on poor sandy soils.

Foreign forage varieties. Ninety-one unlicensed legumes and 107 grasses are being tested for adaptation and seed production under the Organization for Economic Cooperation and Development plan. First-year results indicate that most foreign varieties were lower in seed yield than our checks, but three timothies and one alfalfa were higher.

CYTOGENETICS

Avena

Regulation of chromosome pairing. Hybrids between *Avena sativa* L. and strain CW57 of the diploid *A. longiglumis* Dur. had 34% more pairing than other *A. sativa* × *A. longiglumis* hybrids. The increase is assumed to be homeologous pairing among the chromosomes of *A. sativa* because of the high frequency of trivalents (mean of 3.1). The CW57 genotype may have the wild allele that suppresses the diploidizing gene of hexaploid *A. sativa*. Strain CW57 should be useful in gene-transfer work to promote recombination.

Somatic association of the homologous chromosomes may precede meiotic pairing. Homologues studied in root tips of diploids and hexaploids were closer to each other than expected from random distribution. The nonhomologues followed the theoretical random distribution.

A constant temperature of 30 C enhanced desynapsis in desynaptic plants of *A. strigosa* Schreb. and induced desynapsis in synaptic

plants. A shock effect was ruled out, because desynapsis increased with the length of treatment. The induced desynapsis was reversed by normal temperatures.

New amphiploids. The following were produced: (*hirtula-barbata*)^2, (*longiglumis-barbata*)^2, (*hirtula-magna*)^2, (*sterilis-magna*)^2, and (*longiglumis-sativa*)^2.

Protein genetics. Analysis of protein extracts from *Avena* seeds by acrylamide gel electrophoresis and the zymogram technique showed that the amphiploids (*hirtula-sativa*)^2 and (*pilosa-sativa*)^2 have an additive spectrum of the parents and are homologous with mixtures of parental extracts. The optical density of the bands from mixtures weighted according to the proportion of the genomes resembles those of amphiploids more closely than 1:1 mixtures.

Protein homologies between species suggest that the diploid *A. ventricosa* Bal. is one of the progenitors of the tetraploid *A. magna* Murphy et Terrell and of the hexaploids *A. sativa* and *A. sterilis* L. A difference between wheat and oat species is shown by the absence in oats of a distinct zonation of protein bands according to genome.

Medicago

The low frequency of quadrivalents at pachytene in six clones of 4n *Medicago sativa* L. (0.89–2.50 per sporocyte) suggests some control of chromosome pairing. The frequency of univalents, trivalents, and quadrivalents increased slightly from S_1 to S_3 in inbred progeny of clone AT171.

Good callus and roots developed from anthers of 4n *M. sativa* cultured on a nutrient medium. Shoot formation did not occur. Segregation data from six trisomic plants showed that none of these plants is trisomic for the chromosome that carries a gene for yellow growing point.

AGRONOMY

Early corn hybrids. Four early flint-dent hybrids (Trojan F75, Trojan TX68, Morden 67, and Morden 88) were compared at Ottawa with four recommended early hybrids (Warwick SL209, United 4, Pride R118, and Belle River 14) at normal and delayed (2 weeks) planting dates and populations of 48,000 and 66,700 plants/ha (19,500 and 27,000 plants/acre), to find out if the flint-dent hybrids had an advantage over the recommended hybrids in late planting situations. The flint-dents matured about 2 weeks earlier than the conventional hybrids, but yielded 1,570 kg/ha (25 bu/acre) less than the conventional hybrids when planted early and 750 kg/ha (12 bu/acre) less when planted late. There were no significant differences due to plant population in either group. Under the conditions of this test at Ottawa, there is no justification for recommending these early flint-dent hybrids when seeding must be delayed for some reason.

Advanced-generation corn hybrids. Ten hybrids and their self-pollinated progeny were grown in paired comparisons at Ottawa. In a growth-room test, differences were small, but in the field the advanced generation yielded up to 30% less than the parental hybrids. In 1968 and 1969 the grain yield of the progeny in relation to their respective parent hybrids averaged 71% for three single crosses, 83% for six double crosses, and 87% for one 3-way hybrid. For silage the relative yields of dry matter were 76, 82, and 87%, which shows close agreement between grain and whole-plant yields.

Early prediction of alfalfa hardiness. Winter injury is a major cause of stand loss in alfalfa. Varieties differ widely in susceptibility, and a reliable rating by field trials may take several years. A method developed at the University of Minnesota has given good agreement with established hardiness ratings in seeding-year tests at Guelph and Ottawa. Twenty-five varieties and strains were seeded in replicated plots of 20 spaced plants each. Vegetative growth was clipped to 7.6 cm stubble height in early September. Regrowth was measured late in October and the data transformed to a regrowth index. The ratings for the control varieties showed that the method should give a highly reliable estimate of hardiness in a single growing season.

Digestibility of sorghum – Sudan grass. Highest yields from four sorghum – Sudan grass hybrids were obtained from early seed-

ing (June 5 instead of June 25), narrow rows (17.8 cm apart instead of 35.5 and 70.0 cm), and moderate seed rate (22.4 kg/ha instead of 45, 11.2, or 5.6 kg). There were only small differences in yield between the four hybrids. The in vitro digestibility of the forage was not affected by row width or rate of seeding, but the digestibility of first-cut material was higher for the later than for the early planting (77 and 68%). This difference did not offset the large yield advantage of early seeding, which produced over 10% more digestible dry matter.

Topdressing cereal crops with nitrogen. Topdressing cereals with N has been recommended to improve yield without the excessive lodging that is usually associated with heavier fertilizer applications. Except on winter wheat, previous experiments at Ottawa consistently failed to produce economic grain yield increases or to materially affect lodging.

In 1969, N was applied at 45 and 90 kg/ha at seeding, or as topdressing, when plants were 15 cm high, to replicated field plantings of Opal, Manitou, and Pitic 62 spring wheat, Keystone barley, and Kelsey oats arranged for combine harvesting. N increased grain yield for only Opal wheat. The increase amounted to 112 kg/ha, which was more than offset by the 3.6% higher grain-moisture content at harvest. Both N treatments slightly increased straw yields of oats and barley but not of wheat. The yield of green forage was not affected in any variety.

A spring application of N at 20 kg/ha on Talbot winter wheat increased grain yield by 10% (400 kg/ha) but gave smaller or no increases on other varieties. Higher rates of N (56 and 84 kg/ha) gave smaller additional increases on Talbot. Straw yield showed similar increases. Fall application of N or various rates of complete fertilizer at seeding did not improve yields.

HORTICULTURAL CROPS

Fruits

Apple

Breeding for scab resistance. Six new seedlings are being evaluated as potential varieties in Ontario and Quebec. Three of these, from the 1962 cross O-521 × McIntosh, fruited in 1969, which is a relatively short juvenile period.

Yield of McIntosh and Quinte on Ottawa clonal rootstocks. Clonal apple rootstocks budded with McIntosh and Quinte were planted in spring 1967. Some combinations produced good crops in 1969. Trees of Quinte on Ottawa 3 outyielded those on M.26. McIntosh yielded equally well on Ottawa 3 and M.26, and on Ottawa 12 it yielded as well as on MM.106. Quinte on Ottawa 12 and MM.106 were equal. McIntosh trees on Ottawa 3 were slightly smaller than on M.26. On Ottawa 12 they were about the same size as on MM.106. Quinte trees on Ottawa 12 were a little larger than on MM.

Apomixis in Malus *species.* The possibility of obtaining true-breeding apple rootstocks from seed prompted a survey of wild apple species for apomixis (asexual seed formation). The facultatively apomictic species *M. sargentii* Rehd., *M. sieboldii* Rehd., and *M. sikkimensis* Koehne gave 21 to 63% apomictic seedlings as determined by use of a leaf color marker gene to identify sexual seedlings. *M. hupehensis* Rehd. gave only apomictic seedlings but was highly sterile. The apomictic seedlings were more uniform than the hybrids. However, the cost of sorting the apomictic seedlings from the hybrids in the same progeny makes it unlikely that apomictic seedlings will replace vegetatively propagated clonal rootstocks.

Raspberry

Breeding. Ottawa 48-26-02 (Muskoka × Trent), a high-yielding winter-hardy selection with short canes and good-quality, medium-red berries, is being increased as a potential new cultivar.

Pathology

Improved indicator for strawberry latent-A virus. F.V. 72, a clone of *Fragaria vesca* L. from the USSR, has been used at Ottawa to detect latent-A virus. A selection from a cross between F.V. 72 and an Ottawa strain of *F. vesca* reacts more strongly than F.V. 72 to latent-A virus and also has thicker petioles, which facilitate the grafting technique.

Vegetables

Cucumber

New breeding lines. Ottawa 66 is a black-spined pickler with a long fruit stem (7–9 cm), a feature likely to increase efficiency of the multiple-pick harvester. It was selected from Ottawa 51 × Wisconsin SMR 12, Ottawa 51 being a long-stem selection from USDA PI 188807 from the Philippines. Ottawa 69, a white-spined slicer, is resistant to bacterial wilt, *Erwinia tracheiphila* (E.F. Sm.) Holland, and was derived from Marketer × USDA PI 200818 from Burma. It has acceptable fruit length, which indicates a break in the linkage between wilt resistance and short fruit. Black-spined and white-spined gynoecious selections are resistant to scab, *Cladosporium cucumerinum* Ell. & Arth., to cucumber mosaic virus, and to powdery mildew caused by *Erysiphe cichoracearum* DC. ex Mérat and *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll. Monoecious selections are resistant to bacterial wilt, scab, and powdery mildew. All selections are resistant to a virulent strain of cucumber mosaic virus isolated at Ottawa in 1966.

Pea

Breeding. A multipodded line from Ottawa 12 × M-129 was equal to M-129 in high level of tolerance, under greenhouse inoculation, to root rot and basal stem disease caused by *Fusarium solani* (Mart.) App. & Wr. f. *pisi* (F.R. Jones) Snyd. & Hansen. Resistance to race 1 of the pea wilt organism *F. oxysporum* Schlecht. f. *pisi* (Linford) Snyd. & Hansen is being incorporated from the variety Puget.

Tomato

Mini-Rose tomato. Mini-Rose, a pink cherry tomato resistant to verticillium wilt and *Phytophthora infestans* (Mont.) de Bary (late blight), was released in 1969. The 1-inch fruit is deep pink and smooth, has good flavor and appearance, and is suitable for use as whole fruit in salads. It is very early ripening and continues to bear throughout the summer. It is derived from Summerland 58-19 × Ottawa 30, the latter selected from PI 198674, a USDA introduction from Mexico.

Skin strength. Skin-puncture tests of fruits from an F_2 population of a cross between Iowa 24-61-1 (radial-crack susceptible) and B.D. 746 (highly resistant) showed an almost normal distribution. Plants producing fruit of intermediate skin toughness occurred most often. However, the population deviated from normal in that 10% of the plants had much greater puncture resistance than the resistant parent. These plants were highly resistant to fruit cracking in the field.

Pathology

Differences in infective periods of strains of cucumber mosaic virus (CMV). Assay tests of three Ottawa isolates and CMV 1 from Wisconsin, using Dixielee cowpea as the local lesion host, demonstrated different periods of maximum activity of the virus within cucumber plants. Two highly pathogenic strains from Ottawa reached their highest concentration in cucumber 14 days after inoculation, but the third reached a maximum concentration in 9 days. The CMV 1 strain reached its peak in 17 days. All four isolates were almost completely inactive 23 days after inoculation.

Variability in the pea wilt and pea root rot pathogens. Cultures of the pea root rot pathogen, *Fusarium solani* f. *pisi*, were isolated from several pea varieties. Although most isolates differed from one another in cultural characteristics and pathogenicity when first isolated, all produced some variants that were identical. Monospore cultures were selected that demonstrated that all of the isolates were basically the same. Variants were also produced in culture and in the host that differed in spore size and shape from the original. Some of these variants possessed characteristics that would place them in the species *F. oxysporum* f. *pisi*. Further investigations are in progress to determine if *F. solani* f. *pisi* and *F. oxysporum* f. *pisi* are forms within a single species, and the effect that this would have on developing disease-resistant pea varieties.

Brassicas

Linkage of male sterility with a seedling marker in B. oleracea. The 5% linkage, reported in 1967, between genes for male sterility (*ms-1*) of green sprouting broccoli and colorless hypocotyl (*c-1*) of curly kale appeared to be associated with a chromosomal

translocation. If this linkage were caused by the translocation its proposed use for producing F_1 hybrid seed would prove technically difficult. However, progeny tests conducted in 1968 and 1969 have shown that the linkage is independent of the translocation. Seed stocks have been distributed to brassica breeders.

Potatoes

Breeding and evaluation for Ontario. The varieties York and Wauseon, described in our 1968 Report, were licensed in 1969. Chieftain, a variety from Iowa, will be recommended for licensing in 1970. It is a red-skinned, high-yielding, main crop variety with smooth, medium-sized tubers, and good table quality. It is adapted to both mineral and organic soil and carries multiple-disease resistance. Other promising varieties are Peconic from New York State, Monona originated by the USDA, and three seedlings from Fredericton, F5647, F6119, and F6151.

Ornamentals

Rose breeding. Diploid roses with yellow flowers are rare, and none is sufficiently hardy to survive Ottawa winters without protection. To develop a winter-hardy, repeatedly flowering rose with yellow flowers, Schneezwerg, a diploid *Rosa rugosa* Thunb. hybrid, was crossed with the relatively hardy, yellow-flowered *R. hugonis* Hemsl. This is the first time this cross has been reported. Eighteen seedlings developed normally and produced flowers in their third year. One of the plants flowered repeatedly and had cream flowers. The *R. hugonis* characters for growth habit, foliage, armature, and flower size were dominant. Petals numbered 5–22 and the flowers were yellow, cream, or white. None showed a trace of pink or red. Seedlings of selfed flowers of Schneezwerg have red, pink, or white blossoms.

Forsythia. The aim of our *Forsythia* program is to improve the flower quality of winter-hardy types. Progenies from the hardy but small-flowered *F. ovata* Nakai and *F. europaea* Deg. & Bald. crossed with the more showy but tender *F. suspensa* (Thunb.) Vahl and *F.* × *intermedia* Zab. all lacked sufficient flower-bud hardiness. Among crosses within and between the two hardy species only *F. ovata* cv. Ottawa × *F. europaea* 01-44-2 showed an improvement over the parents. Most plants of this cross were more vigorous than *F. ovata* and more floriferous than *F. europaea.* These features combined with a high level of flower-bud hardiness produced plants that were showier than either parent.

EXPERIMENTAL FARM, FORT WILLIAM, ONT.

Crop Management

Response of grass species to nitrogen. N was applied in early spring, and as a split application at rates of 84.1–168.2 kg/ha (75–150 lb/acre), to 1-year-old stands of timothy, bromegrass, orchardgrass, and reed canarygrass growing on a well-drained sandy loam soil. In the first test year, the yield of the first cut of timothy was increased significantly by early spring applications at all rates. Reed canarygrass and bromegrass responded to a split application at the lowest rate. The highest yield response of orchardgrass was from a split application of the highest rate.

Yield and feed value of mixed grains. The relative performance of wheat, oats, and barley, sown singly or in mixtures, is influenced by soil-moisture content. Under ordinary conditions highest yield returns are usually obtained from seeding mixtures of three-quarters oats and one-quarter barley or half oats and half barley. Under drought conditions in 1969, barley sown alone or one-third wheat mixed with two-thirds barley were superior, in terms of total estimated feed value per acre, to all other seedings including mixtures containing a high ratio of oats.

Grain corn phenology. In 1969 there were insufficient heat units for the grain of two of the earliest commercial hybrids available to reach full maturity. Kernel moisture in Pioneer PXE-1 was 63% and in United 108 was 80% after the first killing frost. Total heat units from May 13 to September 17 were 1,983, far below the 2,200 heat units considered essential to mature the earliest corn hybrids.

Annual cereals for grain and forage. The grain yield of most varieties of forage-type oats, barley, and wheat was not affected significantly by growing them under high fertility at 7-inch (17.78 cm), 14-inch (35.56 cm), and 21-inch (53.34 cm) row spacings. The one exception was Opal wheat, which, owing to increased rust infection at the widest spacing, yielded significantly less seed. Seed yields of Champlain barley and Dorval, OA123-1, and OA123-5 oats were relatively constant at all three row spacings, but the weight per measured bushel decreased with increased width between the rows. The effect of wider row spacing on forage yield was extremely variable, but Champlain barley and Dorval, OA123-1, and OA123-5 oats yielded more in wider rows and rust reduced the forage yield of Opal wheat at the 21-inch row spacing.

Chemical fertilizers for barley. On sandy loam soil at Fort William, substantial inputs of P are needed to produce high yields of barley. When N, P, and K were applied in different combinations, significant yield increases were obtained from applications of P up to 179.4 kg/ha (160 lb/acre). There was a significant N–P interaction in 1969. N at rates above 67.3 kg/ha (60 lb/acre) or when used with high levels of P depressed seed yields. K had no effect on barley in this experiment.

EXPERIMENTAL FARM, KAPUSKASING, ONT.

Crops

Fertilizer requirements of grasses. Timothy, bromegrass, orchardgrass, and reed canarygrass all responded to a split application of N at 134.5 kg/ha (120 lb/acre). The observation in 1968 that, on the heavy clay soils at Kapuskasing, P and K eventually became limiting elements after high levels of N fertilizer had been used was confirmed in 1969. All grasses responded to P up to 24.7 kg/ha (22 lb/acre). All grasses except reed canarygrass need higher levels of P for efficient use of high levels of N. Applications of K up to 134.5 kg/ha (120 lb/acre) gave significant yield increases in orchardgrass and reed canarygrass. K is necessary for efficient utilization of N by timothy and orchardgrass. Bromegrass gave a slight but not significant response to K. In contrast to results in 1967 and 1968, the only residual effect from N applied after the first cut in 1968 was from orchardgrass. The heavy precipitation in the fall of 1968 may have been responsible.

Cereal crop management. The experiment to compare the interaction between rate of N fertilization, dates and rates of seeding, and varieties of oats, barley, and wheat was repeated in 1969. Cool weather in May and June produced slow growth in the spring and some individual responses different from 1968. However, delaying the seeding date usually reduced grain and straw yields, bushel weight, weight per 1,000 kernels, tillers per plant, number of seeds per head, and weight of grain per head. In oats, N applied to early seedings decreased the percentage of hull, and applied to late seedings increased the percentage. Delayed seeding considerably increased lodging and percentage of hull.

In the spring wheat varieties Selkirk, Opal, and Pitic 62, early seeding (May 1) gave yields up to four times that from late seeding (June 6). When seeded late Opal gave especially low yields. Yields from late seeding can be increased slightly by increasing the seeding rate. At 7-inch row spacing, seeding at 134.5 kg/ha (120 lb/acre) increased average grain yield by 30% over the 67.25-kg (60-lb) rate. In early seedings, 7-inch row spacing gave significantly higher yields. In late seedings, 21-inch rows were best.

In an experiment to compare the effect of within- and between-row spacing on grain and silage yield of Herta barley, OA123-1 oats, and Opal spring wheat, the best grain yields were given by 14-inch and the best

silage yields by 7-inch row spacings. Only Opal responded to distance between plants in the row; yields were highest at 2 seeds per inch (2.54 cm) compared with 1 and 3 seeds per inch. Barley gave the highest grain yield. There were no significant differences between species in silage yield.

Animals

Etiology of nutritional muscular dystrophy (NMD) in beef cattle. The incidence of NMD in the Kapuskasing area is closely related to the Se content of locally grown forages, and species vary in the extent to which they induce the disorder. In a group of pregnant females fed on grass hay, 33% of their calves died from NMD, whereas only 14% of the calves died from females fed on oat hay.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Chemical weed control in transplant tomatoes. Under conditions of low spring temperature and above normal rainfall in 1969, trifluralin at 1.12 kg/ha (1.0 lb/acre) or nitralin at 0.84 kg/ha (0.75 lb/acre) combined with a postplant application of diphenamid at 5.6 kg/ha (5.0 lb/acre) gave excellent weed control and yields equal to weekly hand cultivation. Nitralin appeared to improve plant vigor and fruit size. Of the single-chemical treatments, Bay 943337 (Chemagro Corporation) postplant at 1.12 and 2.24 kg/ha (1.0 and 2.0 lb/acre) gave outstanding weed control, but the 2.24-kg rate was severely phytotoxic and reduced yield. The 1.12-kg rate caused some initial injury but the plants performed well. There was some indication that H-16993 (Green Cross Company) at 3.36 kg/ha (3.0 lb/acre) preplant incorporated in the soil retarded fruit ripening.

Tomato breeding. Smithfield line S67A-13 is early, high yielding, and of high quality, and carries the high-crimson gene. S64B3-B1 is the earliest maturing selection currently available that has both the crimson and the high-pigment genes, but its quality must be improved. The midseason line S67-M1 was the highest yielder in tests in 1969 and had better quality than most selections. S68-D3, also midseason, was lower yielding but had excellent processing quality due to very solid internal structure and the crimson and high-pigment color combination.

Tomato evaluation for mechanical harvesting. Seven varieties were evaluated for once-over mechanical harvesting on September 18, 1969. The most promising were H-1350 56.7 metric tons/ha (25.3 tons/acre), V682 50.4 metric tons/ha (22.5 tons/acre), H-1630 38.5 metric tons/ha (17.2 tons/acre), and H-1706 35.4 metric tons/ha (15.8 tons/acre). These also processed well as juice and whole pack. Fireball was not suitable because of short fruit life on vines.

Residual effects of Alar on McIntosh apple. Alar 85 (*N*-dimethylaminosuccinamic acid) (Uniroyal) applied 50 days before harvest date in 1968 effectively controlled fruit drop in 1968. In 1969, the fruits on these trees were clustered, had short, thick stems, and were smaller. Trees that received Alar at 0, 750, and 1,500 ppm in 1968 had 25.1, 37.9, and 53.9% of the fruiting clusters with more than two fruits in mid-July 1969. Fruit cell size was reduced 14% in July 1969. At 1969 harvest, 35% of the apples from untreated trees and 45% from treated trees were less than 6.88 cm in diameter.

Fruit sampled in early July 1969, 1 year after treatment, contained up to 1.3 ppm Alar. A residue of more than 0.25 ppm in the fruit reduced the normal June drop. At harvest at least 3 ppm must be present in the fruit to effectively control the drop. A balance between drop control and carryover effects must be established by controlling the level of Alar applied.

Phloridzin and phosphorus levels in apple spurs. In Kinkead Red Spy, the level of phloridzin was lower in the leaves but higher in the wood and bark of spurs forming flower buds than those bearing fruit. Spurs with fruit do not form flower buds with this variety.

P levels in wood of spurs forming flower

buds were four times higher than in wood of fruiting spurs. The higher P levels were associated with increased amounts of perchloric acid soluble organic P.

Supplemental N applied to the tree increased the level of perchloric acid soluble and nucleic acid P in spurs forming flower buds. The levels of total P in the leaves and bark were not altered by changes in nutrition or type of spur.

Apples for processing. There has been considerable interest at Smithfield in the apple selections T-392 and T-397, because of their good processed quality and orchard performance. However, T-392 is now known to be highly susceptible to water core, and testing will be discontinued. In 1968–69 T-397 was evaluated by two commercial processors, who found that it cannot be peeled and cored efficiently with common commercial equipment. The fruit tends to be too large (many are over 9 cm in diam), it is asymmetrical and angular in shape, and has knobby stem and calyx ends with large cavities. Approximately 70% of the apples required hand trimming compared with 30% for Northern Spy. These results emphasize the importance of commercial tests to supplement laboratory evaluations.

Fine structure of fruit development in tomato. Fine structural changes in tomato fruit outer pericarp occurred between and within cells throughout the fruit's normal growth cycle on the plant. Changes within cells involved both membranous and nonmembranous components of the protoplasm.

Within 1–2 days after fertilization, most outer pericarp cells had become highly vacuolated and the thin peripheral layer of protoplasm contained all the structures and organelles normally found in mature plant cells of this kind. During the next few weeks, prominent developmental changes included an increase in size of cells and intercellular spaces, reduction in cytoplasmic density, elaboration of the plastid lamellae system, and gradual disappearance of starch granules within plastids. Normal enlargement of intercellular spaces occurred as a result of separation of the cell wall along the middle lamella regions next to intercellular spaces. In senescing fruits, more wall separation was observed, cell size was very large (100–500 μ), the plasmalemma and tonoplast membranes remained intact, protoplasmic organelles were in various stages of degeneration, and some regions of the cytoplasm were devoid of protoplasmic structure.

Several of these fine structural changes can be correlated with developmental and degenerative changes (chemical and physical) known to occur in tomato fruit. The predominantly parenchymatous tissue is typical of many edible plant tissues that are high in moisture content. Our results indicate the potential value of electron microscopy in extending present knowledge of such problems as the processes involved in the onset of senescence, the mechanism of physiological disorders, and the fundamental nature of quality changes affecting the tissue's edible properties.

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Methomyl, tetrachlorovinphos (Gardona; Shell Chemical Co.), and jodfenphos (C9491; CIBA Co. Ltd.) provided as good or better control of the grape berry moth than the currently recommended azinphos-methyl and carbaryl, or the previously recommended DDT.

Spray trials in two pear orchards heavily infested with the pear psylla indicated that the psylla has not become resistant to azinphos-methyl in Ontario. This is in contrast to the situation in neighboring parts of New York State. Carbaryl, which has never given a high degree of control, gave very poor control in 1969.

In an apple orchard in the Georgian Bay area, where the oyster-shell scale has recently increased in several orchards on a DDT spray program, organophosphorus (OP) compounds gave better control than DDT or carbaryl when they were applied in June, when egg hatch was starting. The OP compounds applied at this time were also more effective against the scale than dormant sprays in April of Superior oil or DNOC-sodium salt.

Assessment of spraying practices. A survey of orchard-spraying practices was initiated to determine the level of control achieved with application of pesticides at reduced rates using a variety of applicators in different regions. Forty-two apple orchards were visited and 22 different sprayer models from five companies were examined thoroughly for mechanical fitness. Spray patterns and coverage were checked with fluorescent dye in three areas of the tree in June and August. The chief contributors to poor coverage were poor pruning and excessive driving speed. Trees were much more dense in August and spray penetration was substantially reduced. Control of apple scab and mites was related to volume of spray and amount of chemical applied. Average volumes were 1 kl/ha (107 gal/acre) for the Simcoe area, 0.66 kl/ha (70 gal/acre) for eastern Ontario, and 0.44 kl/ha (47 gal/acre) for the Georgian Bay region. Dodine rates varied similarly: 2.69 kg/ha (2.4 lb/acre) for Simcoe, 1.4 kg/ha (1.25 lb/acre) for eastern Ontario, and 0.84 kg/ha (0.75 lb/acre) for Georgian Bay. Incidence of apple scab on the lower outside of the tree was 0.9% for fruit sampled at Simcoe, 1.9% for eastern Ontario, and 3.0% for Georgian Bay.

Bacterial canker control in sweet cherry. Application of Bordeaux mixture before leaf fall is recommended for the control of *Pseudomonas* canker. To reduce premature leaf fall caused by Bordeaux, crude rapeseed oil was selected as a safener. Bordeaux mixture (4:6:100), with and without rapeseed oil at 2.9 liters (6 pt) and Triton B1956 (Rohm and Haas) at 56 g (2 oz), was applied on the cultivars Schmidt, Vista, Hedelfingen, and Venus on September 18 and October 2, 1968. Weekly leaf-drop counts indicated that rapeseed oil reduced premature drop by 9–16 days in Vista, by 6–12 days in Schmidt, by 12–14 days in Hedelfingen, and by 10–12 days in Venus. Calculations were made from counts taken during periods of 30–70% leaf drop.

Efficacy of reduced rates of dodine and captan for control of apple scab. Dodine 65% WP and captan 50% WP at the recommended rates for dilute application of 0.5 and 2.0 kg/kl respectively kept fruit infection below 1% and leaf infection below 8% in a series of full-season fungicide programs. When these fungicides were applied at half-rates, leaf infection increased to 22% and 20%, and increased further at the quarter rate to 49% and 27% for dodine and captan respectively. The level of fruit infection in the dodine programs increased to 6% and 15% at the one-half and quarter rates and was significantly greater than that in the corresponding captan programs.

The recommended optional reduction to the one-half rate in the latter part of the growing season, commencing with the third cover application, gave adequate control of leaf and fruit infection.

Early season application of high rates of fungicides for control of apple scab. A modified spray program consisting of three sprays applied at green tip, petal fall, and second cover stages of development was compared with a regular eight-spray program applied during the same period for control of apple scab caused by *Venturia inaequalis* (Cke.) Wint. In the regular program, dodine 65% WP and Dikar 80 WP (Rohm and Haas) were used at 0.5 kg and 2.0 kg/kl respectively as dilute sprays. In the three-spray program, the fungicide rates used in the first, second, and third sprays were 4, 2, and 1 times the regular rate.

The modified program allowed 21% leaf

infection by apple scab, compared with 2% in the eight-spray program and 39% in the eight-spray water check, and therefore could not be recommended for commercial use.

The relation between the mortality of European red mites and the distribution and amount of dicofol deposit on peach foliage. Spray deposits of dicofol on peach foliage were investigated by mite bioassay and gas chromatographic analyses to determine the minimum deposit necessary to kill mites and the amount, distribution, and degradation of the deposit in terms of loss of toxicity to mites.

The dicofol was applied at two concentrations by airblast sprayer and at one concentration by hand-operated gun. The minimum deposit on a peach leaf required for 100% mortality of the adult female mite was 0.3 to 0.7 μ g/cm^2, depending on the evenness of the coverage. Mortality decreased very rapidly from the fourth to the seventh day after treatment although the residues detected by chemical analysis decreased at a slower rate. This discrepancy was probably due to the penetration of a portion of dicofol into the leaf tissue where it was not available to the mites.

Survey for mite resistance to dicofol in Ontario orchards. The need to determine the cause of inadequate control of the European red mite reported by a number of Ontario fruit growers led to the standardization in 1968 of a leaf-disc method for detecting and measuring resistance to dicofol. In 1969 a survey was made of the resistance level of the mite to this acaricide in 35 orchards in Ontario where resistance was suspected. Fruit crops sampled were apple, pear, and peach, grown in the Niagara region (15 orchards), Northumberland and Prince Edward counties (6 orchards), southwestern Ontario (12 orchards), and Georgian Bay (2 orchards), representing about 1,150 acres of fruit. Low to high levels of acaricide resistance contributed to inadequate control in half of the sampled orchards. In many cases, however, the lack of control was caused by other than resistance, such as poor timing or inadequate coverage of sprays. A larger percentage of pear orchards had resistant mites probably because dicofol is often used to control the pear rust mite. Generally, resistance was not detected unless dicofol had been applied for at least four seasons.

ECOLOGY OF INSECTS

Fruit Insects

Artificial diets for the oriental fruit moth. An artificial diet containing brewers' yeast was unsatisfactory because of variations in the quality of the yeast from different sources. A modification of the codling moth diet used in Summerland, B.C., made up of alfalfa meal and vitaminized apple juice, was satisfactory for rearing oriental fruit moths and codling moths. Sorbic and ascorbic acids in the original codling moth diet appeared to be toxic to newly hatched oriental fruit moth larvae and inhibited feeding.

Field oviposition behavior of the codling moth. Codling moth females deposited an average of 34 eggs/100 fruit clusters, but only 11 eggs/100 leaf clusters. The number of eggs deposited was larger in the second generation (40/100 clusters) than in the first (23/100 clusters). The distribution of eggs by first-generation females was 64, 25, 8, and 3%, and by second-generation females 45, 42, 10, and 3% on the upper and lower leaf surfaces, fruit, and twigs respectively. In both generations there was little difference between the number of eggs deposited in the upper and lower areas of the tree.

In greenhouse tests there was some indication that ovipositing females selected the cultivar Rhode Island Greening in preference to the cultivars Delicious, McIntosh, and Northern Spy.

Vegetable Insects

Bionomics of the carrot rust fly. Carrot rust fly adults were captured by sweeping during the expected flight period of the second brood in 6 of 22 plantings of carrot and celery in the Holland Marsh in 1968, and in 10 of 15 plantings of carrot, celery, or parsnip in 1969. The insect was most abundant in fields near the borders of the marsh. Sticky-board traps were employed to detect the presence of adults in and around carrot, cel-

ery, and parsnip fields. First-brood adults were most numerous in the week of June 3–10, whereas the second brood was most abundant during the week of August 13–20. Very few third-brood adults were taken in October.

PLANT DISEASES

Fungus Diseases of Vegetables

Pathogenic variation in Ontario isolates of the cabbage yellows organism. Eight isolates of *Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyd. & Hans., which causes cabbage yellows, differed in pathogenicity to cabbage. The cultivars Marion Market and Market Prize showed varying reactions to these isolates 2–3 weeks after inoculation at a soil temperature of 26 C. Early Marvel was completely killed by seven of eight isolates as early as 2 weeks after inoculation. An isolate from Nashville, Ont., caused the most severe infection on Marion Market, whereas an isolate from Cooksville, after it had been maintained in culture in the laboratory for 2 years, showed almost a complete loss of virulence to this cultivar.

Bacterial Diseases of Vegetables

Black rot of crucifers. In the laboratory, larvae of the cabbage looper feeding on cauliflower plants provided infection sites for the black rot organism, *Xanthomonas campestris* (Pamm.) Dowson. Infection through feeding sites occurred whether loopers had fed before or after the plants were sprayed with a suspension of bacteria. Symptoms of black rot appeared on looper-damaged plants at least 7 days earlier than on undamaged plants.

Virus Diseases of Fruit

Strawberry latent ringspot virus (SLRV) in sweet cherry. SLRV was isolated from leaves, flower parts, and embryos of a 16-year-old Bing cherry tree growing in Lincoln County, Ont. The following properties of this virus were determined: dilution end point, 10^{-4}; thermal inactivation point, 56 C; particle diameter, 29–32 mμ (average 30 mμ); sedimentation coefficient, 134 *S*; buoyant density in sucrose, 1.274 g/cm^3; and a nucleic acid content of ca. 30%. The virus was shown to be seed transmissible in *Chenopodium quinoa* L. (range 63–100%) and infected seedlings expressed stunting, deformed leaves, and chlorotic patterns. Peach was infected by approach grafting to *C. quinoa* and Mahaleb cherry by budding from peach. No symptoms developed in either host other than possible stunting.

Seed transmissibility of apple viruses. Over 400 seedlings from three open-pollinated McIntosh trees known to be infected with tobacco mosaic virus (TMV), chlorotic leaf spot virus (CLSV), and tomato bushy stunt virus (TBSV) were manually indexed with *C. quinoa* using 2.5% nicotine for trituration. The range in detections was 0–21% for TMV and 0–17% for TBSV. CLSV was not detected. Apple TBSV was serologically quite distinct from a sweet cherry isolate found in Ontario.

Viruses in wild Prunus. Wild *Prunus americana* Marsh., *P. avium* L., *P. insititia* L., *P. nigra* Ait., *P. pensylvanica* L., *P. serotina* Ehrh., and *P. virginiana* L. in the Niagara Peninsula are being indexed for mechanically transmissible viruses of tree fruits. The necrotic ringspot virus and some unidentified viruses have been detected in a few plants of *P. americana, P. avium,* and *P. serotina.* Because of limited distribution for these species and the low incidence of virus infection, wild *Prunus* species are not considered to be important sources of virus inoculum for infection of commercial orchards.

A sap-transmissible virus associated with diseases in peach and grape. Virus isolates from both peach and grape, partially purified and subjected to density-gradient centrifugation, showed two infectious and serologically active components that sediment at different rates. When these components were isolated and inoculated separately in *C. quinoa* both were reproduced again. Attempts to correlate the formation of such components with the pH of the preparation failed. The ratio of the fast-to-slow migrating form was found not to be related to the age of infection but rather to the age of the inoculated plants. Electron micrographs of the fast component showed isometric particles averaging 29 mμ, whereas that of the slow form was 27 mμ. Cross-absorption tests and the presence of spurs in

the precipitin tests indicated differences in the antigenic constitution of the three isolates studied. One from grape and another from peach were more closely related than two isolates from grape that produced mild and severe symptoms in *C. quinoa*.

Virus Diseases of Vegetables

Pepper viruses. The incidence of natural virus infection in replicated field plots of 15 commercial pepper cultivars varied considerably at sites in Essex, Kent, Waterloo, and Norfolk counties. Viruses were most prevalent in all cultivars in Essex County where the frequency ranged from 5 to 35%. No cultivar escaped infection. By contrast, the frequency of infection among the different cultivars ranged from 0 to 17% in Waterloo and two cultivars remained symptomless.

Differential hosts and serological tests detected cucumber mosiac (CMV), tobacco mosaic (TMV), alfalfa mosaic (AMV), and potato X (PVX) viruses. CMV was most prevalent at all locations. More TMV-infected samples were detected in Essex County than at the other three sites, suggesting regional differences in distribution of TMV. The AMV and PVX viruses were rarely found.

Differential cultivar responses were confirmed by glasshouse experiments. Both CMV and TMV reduced the weight of the aerial parts of plants, particularly when infection occurred early. Generally CMV had a greater influence on yield than did TMV. In some cultivars, however, TMV killed the plants after early infection; in others such as Staddon's Select, Vinedale, and Idabelle little effect on yield was noted. TMV was seedborne in three of five cultivars assayed; 95% of the seed of one cultivar carried TMV and lesser amounts were present in two other cultivars. Trisodium phosphate treatment of seed greatly reduced the incidence of TMV, suggesting that much of the virus is carried on the seed coat rather than in the embryo. No evidence was found to indicate that the other viruses were seed transmitted.

TMV fruit-spotting in tomato. Ripening fruits of Ohio WR-25 tomato plants grown in a greenhouse in southwestern Ontario usually developed superficial white blotches on the blossom end. The symptoms were similar to those induced by tomato spotted-wilt virus, but only TMV could be isolated. This virus induced characteristic spotting on fruit of manually inoculated plants of Ohio WR-25 and Glamor under growth-room conditions. The virus was distinguishable from common tomato isolates by its ability to induce petiole and stem necrosis in *Nicotiana glutinosa* L. and by its failure to induce necrotic lesions in *Petunia hybrida* Vilm.

Studies of mode of transmission and control of Canadian cucumber necrosis virus (CNV). Little CNV was detected in CNV/*Olpidium cucurbitacearum*-infected roots that were air-dried for 60 days, and none was found after 90 days. The chytrid lives at least 90 days and becomes virus-free after 60 days. Virus-free *Olpidium* cultures were consistently obtained from infected roots air-dried for 3 months. Resting spores from CNV/*Olpidium*-infected roots survived treatment in acid for 2 hr or 20 min in 20% trisodium phosphate. Both treatments inactivated the virus in the inoculum and prevented transmission. The virus is not carried internally in the resting spores and the liberated zoospores are virus free on release. However, they eventually become infected with virus released from the roots. The pH of the zoospore suspension had no effect on the transmission of CNV. Zoospores from *O. cucurbitacearum* appeared to be more sensitive to centrifugation than those of *O. brassicae*, the vector of TMV. Captan (0.5 g active material per liter of soil) controlled *O. cucurbitacearum*, prevented virus transmission, and only induced a mild toxicity to the plants.

NEMATODES

Nematode Control

Mode of action of nematicides. The respiration rates of nematodes exposed to sublethal concentrations of two halogenated hydrocarbon nematicides were determined with a Warburg respirometer. Third-stage larvae of *Caenorhabditis* sp. suspended in a 0.53×10^{-2} M solution of ethylene dibromide (EDB) showed a respiration rate of about 22 μl O_2/mg dry wt per hr, an increase of 130% over that of the controls. By contrast, *Aphelenchus avenae* Bastian showed no increase in respi-

ration when exposed to various concentrations of EDB. Neither of these animals showed any significant changes in respiration when exposed to 1,2-dibromo-3-chloropropane (DBCP). There was no correlation between the time required to reach the maximum internal concentration of EDB and the respiration response of *Caenorhabditis* sp. Because EDB and DBCP penetrate quite readily into both *A. avenae* and *Caenorhabditis* sp., it is evident that both the type of chemical and the specific nature of the metabolism of these animals must be considered in explaining the mode of action of halogenated hydrocarbon nematicides.

Host-Parasite Relationships

Root-knot nematodes on forage legumes. In greenhouse pot studies, the northern root-knot nematode, *Meloidogyne hapla* Chit., at populations of 1,100, 2,200, and 11,000 larvae/kg of soil caused moderate to heavy galling of roots of Vernal alfalfa, Canadian commercial birdsfoot trefoil, Merit Ladino clover, and Canadian double-cut red clover. The clovers were more severely galled than alfalfa or birdsfoot trefoil. Fresh root weights of clovers were reduced by 12–46% in the presence of 1,100 or 2,200 larvae/kg of soil; birdsfoot trefoil root weight was reduced 35% at 2,200 larvae/kg but unaffected at 1,100/kg; alfalfa root weight was reduced 14% at 1,100/kg but unaffected at 2,200/kg. Fresh and dry top weights of clovers were reduced by 27–45% at the above population levels and birdsfoot trefoil top weights were reduced by 4–16%, whereas alfalfa top weights were reduced 8–22% at 1,100 larvae/kg of soil.

Interactions

*Interaction of root-knot nematodes (*Meloidogyne *spp.) with* Fusarium oxysporum *f.* conglutinans *on cabbage.* Early Marvel cabbage grown in tanks where the soil temperature was controlled at 22 and 26 C was killed within 4 weeks by *Fusarium oxysporum* f. *conglutinans*, regardless of the presence or absence of *Meloidogyne hapla* Chit. or *M. incognita* (Kof. & White) Chit. Conversely, cultivar (cv.) Market Prize was almost completely resistant under the same conditions. Marion Market was moderately susceptible to the fungus, but was more rapidly infected and exhibited more severe disease symptoms in the presence of either nematode, especially at 26 C.

Interaction of root-lesion and root-knot nematodes with Verticillium dahliae *on pepper.* Controlled-environment studies showed that both the root-lesion nematode, *Pratylenchus penetrans* (Cobb), and the northern root-knot nematode, *Meloidogyne hapla* Chit., parasitized pepper plants, cv. Vinedale. In one experiment, when the nematode and the fungus *Verticillium dahliae* Kleb. were added simultaneously, both *P. penetrans* and *M. hapla* protected the pepper plants against the fungus to a significant degree as measured by plant height, top and root weights, and wilt rating. Attempts are in progress to confirm that both nematodes are capable of reducing the damage caused by the fungus.

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INTRODUCTION

Although the research results are reported by scientific section, an increasing proportion of the research program is multidisciplinary in nature, with scientists from several sections participating in the study of a common problem. This emphasis toward team research increases the probability of making substantial contributions to the animal industry. By concentrating our efforts in fewer program areas, and by increasing the breadth and depth of research programs in each of these areas, our research should be more productive.

The scientists working on swine nutrition at Nappan were transferred to this Institute. Their program is being revised and facilities are being provided for their work.

All the dairy and beef cattle, poultry, and sheep research animals are located at the new Animal Research Institute Greenbelt Farm, 10 miles from our offices and laboratories, which are still at the Central Experimental Farm. Only the swine and some laboratory animals remain on the central farm. A publication describing the new facilities at the A.R.I. Greenbelt Farm is available.

R. S. Gowe
Director

BIOCHEMISTRY

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

Normal lactating cows were infused with free fatty acids (FFA) and triglyceride, but this treatment did not increase blood ketone concentration. It was concluded that normal cows have a high capacity for metabolizing fat without the production of excess ketones. Phlorhidzin infusion, which lowered the blood glucose concentration, resulted in a transient ketonemia. Fasting ketosis was induced in lactating dairy cattle by restricting feed intake 3 weeks postpartum. Antiketogenic and gluconeogenic effects of selected 3- and 4-C precursors were tested in these animals to evaluate the function of reducing equivalents in gluconeogenesis, and to test the possibility that transamination may be rate-limiting in the conversion of free amino acids to glucose.

Studies are continuing on the role of carnitine in clinical ketosis and on the possibility of utilizing carnitine for the mobilization and removal of neutral fat from the liver. It was discovered that bovine milk contains acetyl-carnitine as well as free carnitine. During ketosis, the concentration (and total daily secretion) of acetyl-carnitine increased, whereas free carnitine decreased, and the net result was a twofold increase in total carnitine secretion.

During the studies on the factors controlling the hepatic oxidation of fatty acids, it was observed that carnitine esters of fatty acids were hydrolyzed by liver. The enzyme located in the microsomal fraction was solubilized and purified. The enzyme specifically hydrolyzed long-chain fatty-acid esters of L-carnitine and had no or negligible activity on a number of other esters. The enzyme might be involved in controlling hepatic levels of long-chain fatty-acid esters of carnitine. β-Ketopalmitic acid, β-hydroxypalmitic acid, and *trans* α,β-unsaturated palmitic acid were chemically synthesized and characterized. These fatty-acid derivatives are presumed to be intermediates in the β-oxidation of palmitic acid by mitochondria. The L-carnitine esters of these fatty acids were oxidized by liver mitochondria to carbon dioxide and acetoacetate more rapidly than the free acids. Mitochondrial long-chain acyl-carnitine transferase converted the carnitine esters to the corresponding CoA esters efficiently. Carnitine is thus required for the oxidation of these fatty-acid derivatives also.

Etiology of Nutritional Muscular Dystrophy in Farm Animals

Selenite, selenate, selenodicysteine, selenomethionine, and selenocystine, the forms of Se normally ingested by animals, provided comparable protection against nutritional muscular dystrophy (NMD) and exudative diathesis when administered orally to chicks fed a vitamin-E-deficient fat-free diet. When

lard was fed, the same protection was provided against NMD and exudative diathesis by all Se compounds, but unexpectedly only selenite and selenate provoked the onset of encephalomalacia. In contrast to previous results obtained with chicks, the oral administration of linoleic acid to beef calves or lambs of dams fed low-Se dystrophogenic hay did not promote a higher incidence of NMD or inhibit Se protectivity. No NMD occurred in rabbits that consumed the low-Se hay unless linoleic acid was incorporated into the diet. Se did not prevent the disorder in rabbits. In rabbits and chicks, NMD results primarily from a vitamin E deficiency made worse by dietary linoleic acid. Dystrophy in calves and lambs, which develops under field conditions, is primarily a Se-deficiency condition unaffected by the linoleic acid intake.

Studies in Bone Mineralization

Microzone-electrophoretic studies of mucopolysaccharides (MPS) from cartilage confirmed our previously reported finding that there is no discernible difference in the type of MPS isolated from cartilage in various states of calcification. Study of cartilage lipids showed that the steroid fraction was the fraction that differed most consistently with the state of calcification. Our metabolic investigations of cartilage showed that Se, whether supplied as SeO_3^{2-} or SeO_4^{2-}, will not replace S as an MPS metabolite in cartilage. When growing chicks were made hypocalcemic either by feeding them rachitogenic diet or by parathyroidectomy, changes in the composition of epiphyseal cartilage were characterized in the state of rickets by lower levels of MPS components and increased levels of collagen components; parathyroidectomy effected only increased levels of collagen constituents. An important side product of the studies of chicks in the hypocalcemic state is the discovery of medullary bone structure in their tibiae. Previously, medullary bone had been observed only in bones of egg-laying hens. Structural identification of this bone is in progress; preliminary findings indicate the presence of $CaHPO_4$ in medullary bone from hypocalcemic chicks.

Studies on Energy Utilization in Animals

Electron micrographs showed that the matrix space of the inner membrane of mitochondria from heart, liver, and skeletal muscle expands markedly during the swelling process. Such energized matrix expansion was prevented by the inclusion of Mg^{2+} in the medium. However, the crystal membranes themselves showed energy-dependent configurational alterations even in the presence of Mg^{2+}. In the presence of ATP and Mg^{2+}, the membranes appeared ribbonlike, whereas in the presence of respiratory substrate and Mg^{2+}, they assumed a twisted-tubular appearance. A transition from twisted-tubular to ribbonlike appearance occurred upon addition of either ATP or ADP to respiring mitochondria. This transition required Mg^{2+} and apparently involved the same mechanism that brings about reversal of matrical swelling. The prevalent concept is that the configurational changes of membranes observable in electron micrographs actually represent the intermediate of energy coupling.

Studies on Hormone Action

Recent studies have demonstrated that increased gluconeogenesis (observed in rats after the administration of glucocorticosteroids) depends on increased activity of the enzymes unique to the process. Glucocorticosteroids suppress ribonuclease activities in the liver, and the kinetic studies of these changes indicated that the stimulating action of these hormones can be partly explained on the basis of protection of messenger RNA from degradation by suppression of ribonuclease. It has been found that chicks do not respond to glucocorticosteroids. Chicks, unlike rats, cannot convert aspartate, alanine, glutamate, and pyruvate into glucose via the gluconeogenic pathway. Like rats, they can use lactate, glycerol, and malate as substrates for glucose production. In chicks activities of aspartate and alanine aminotransferases and phosphoenolpyruvate kinase are not significantly affected by fasting, as has been found in rats.

GENETICS

Poultry

Performance of two meat-type control populations. The Ottawa meat-type control population that was synthesized from four meat-type strains has been reproduced yearly since 1958, from approximately 80 sires and 240 dams. Over the same period of time, the USDA has independently bred a replicate of this strain at their Southern Regional Poultry Breeding laboratory at Athens, Ga., and each year has reciprocally exchanged test stock with the Institute.

Of a large number of traits measured, a few showed significant ($P < 0.05$) changes over the generations studied. Analyses have indicated, however, that only the regression coefficients for fertility and hatchability differed significantly between the two replicates. The trait shell color, which was measured in the latest generation only, was the only egg-quality trait that showed a statistically significant difference between replicates. The frequency of rose and pea combs differed between the lines, but this difference, which was established early in the history of the lines, remained stable over the later generations. Analyses substantiated that these control populations were relatively stable over the 10 generations studied.

Genetic parameters of egg production control strains. Analyses were recently completed on the genetic parameters of a series of production traits of two White Leghorn control strains. One strain (05) has been random-bred since 1950 and is in the 19th generation of relaxed selection. The other strain (07) was synthesized from two- and four-way crosses of four commercial stocks in 1958 and 1959 and subsequently it has been random-bred in each generation. There were differences between strains in the heritability of some traits. In general, the heritabilities based on sire components of variance (additive genetic variance) were higher for these control strains than for strains that had been under selection for several generations. This was particularly true for the trait hen housed egg production, where the heritability was considerably higher in both control strains than for selected lines at Ottawa or other selected lines reported in the literature.

Hatching-egg storage and postembryonic performance. Conflicting findings have been reported in the literature of the effects of preincubation storage on subsequent postembryonic performance in the chicken. One possible reason for the conflicting reports are the egg weight changes associated with the extended period of time over which hatching eggs are accumulated for incubation. Multiple regression analyses of data in which both egg weight and storage length were included as independent variables indicated that egg-weight differences were not sufficient to explain the adverse effect of storage on postembryonic performance.

Sex dimorphism and genetic differences in weights, carcass yields, and commercial grade scores of market geese. In a study involving a wide range of weights and genotypes, market geese exhibited sexual dimorphism for live, dressed, and eviscerated weights, for eviscerated yield relationships with dressed and live weights, and for fleshing and dressing grade scores, but not for fat or conformation grade scores. Genetic differences were found for the three weights and for fleshing and fat grade scores. An interaction between sex and genotype was found for dressing grade scores, but not for any of the other traits. The observed sexual dimorphism for eviscerated yield relationships was dependent on the statistical model used for analyses. Dimorphism was not demonstrated for the commonly used model, namely, regression through the origin.

Serum esterase and sexual maturity. The relationship between age at first egg (AFE) and serum esterase activity was studied in six lines of meat-type hens. Birds were bled at 158 to 160 days of age and the resulting serums were used for determining esterase activity and esterase genotype. The correlation between esterase activity and AFE for 1,399 hens was 0.481 and was significant at the 1% probability level. By taking the effect of line and genotype into account in a regression analysis, it was found that a unit increase in serum esterase activity meant a 0.23-day delay in AFE for hens that had not yet laid their first egg when the blood was collected. Birds that had laid their first egg before blood collection showed very little variation in esterase activity and no relationship between esterase activity and AFE. The frequency of three esterase alleles was determined in five egg strains and seven meat

strains. In general, the frequency of EsA was higher in the egg strains, and the frequency of EsB was higher in the meat strains. The EsC allele was of very low frequency in all strains.

Genetic resistance to Marek's disease. Experiments on Marek's disease have indicated a wide range in inherent susceptibility among strains that have not been selected for resistance or susceptibility when these strains are artificially exposed by inoculation with the disease agent. A Leghorn strain, designated 0404, had 11.8% and 7.0% mortality due to Marek's disease in two 8-week experiments, whereas a New Hampshire strain had 53.9% and 42.5% mortality in the same two experiments.

Dairy Cattle

A new mating plan for progeny testing of bulls. A new mating plan has been developed that will increase the rate of genetic improvement over that attainable by mating plans currently in use in the dairy industry. It will also provide a measure of the improvement made on the selection applied. The plan is most suitable when only a limited number of bulls can be tested and where herd size requires a minimum of eight males per mating season. A group of yearling bulls is selected from matings of the best bulls to the best cows each year, and each such group of bulls is used for 2 years. The resulting concurrent use of yearling and 2-year-old bulls on representative females enables the annual genetic progress to be measured by comparing the progeny. Semen from each bull is stored, and the bulls are discarded after 2 years of use. The semen from the best progeny-tested bull(s) is used to inseminate the best cows and so produce a future group of yearling bulls for testing. Repeating this process assures a short generation interval and intensive selection, which are the two factors that determine annual rate of genetic improvement.

Selection for milk solids yield. In a 15-year breeding experiment, 180-day milk solids production was used as the only trait for evaluating and selecting breeding stock in two breeds, Holsteins and Ayrshires. The selection intensity achieved for dams of young bulls was close to its theoretical value, but the selection intensity among progeny-tested bulls was only about half its theoretical value. The main factor that reduced selection differentials for progeny-tested bulls was death of some bulls before the progeny-test information became available. The actual rate of genetic improvement was estimated at 1.06% and 1.30% per year for 180-day milk solids yield for Holsteins and Ayrshires respectively. The heritability for yield was much higher in Ayrshires (0.734) than in Holsteins (0.237). Percentage of fat and solids-not-fat increased significantly by 0.003 and 0.0016 percentage units/year respectively for Holsteins. Percentage of protein did not change significantly in Holsteins and no significant changes in milk composition occurred in Ayrshires. It was concluded that selection for total solids yield does not result in any undesirable changes in milk composition or its main components, protein, lactose, and fat. The experiment also provided evidence that the testing and selection methods now being attempted by artificial insemination (AI) units are of major economic importance to the dairy industry.

Age and herd adjustment of Record of Performance records. Recent studies have indicated that appropriate within-herd adjustments for age differences between cows are quite different from the adjustments required for these differences between herds. Herd differences in average age at first calving, partly identified as differences in heifer-rearing practices, appear to affect milk yield during the first lactation independently of feeding and management procedures during lactation.

Mice

Preweaning growth in mice. Diallel matings of three inbred strains of mice were made and litters were adjusted at birth to either six or eight mice. Litter size had a significant ($P < 0.01$) effect on the weight of dried, defatted mammary glands (DDMW) of mothers, but had no effect on average 12-day weight of progeny.

The within-litter size - mating class correlation between 12-day litter weight and DDMW was +0.58. It was concluded that the weight of mammary glands accounted for 34% of the variation in 12-day weight, which is commonly used as an indirect measure of milk production.

Intensive Sheep Breeding

Implications of artificial rearing for sheep improvement. Single-born lambs gained 18% more weight than twins when they nursed their dams to 70 days of age, whereas twin lambs weaned at 2 days of age and reared artificially made gains equal to those of contemporary single lambs. Mortality was 10–15% higher in artificial rearing. As litter size increases through selection and the use of such breeds as Finnish Landrace, artificial rearing will provide a potential means of assuring adequate nutrition for all lambs. The elimination of environmental effects due to variable litter size and maternal ability of the dam should increase accuracy in assessment of growth rate for selection purposes.

Breed and cross response to artificial and natural rearing. There was evidence of a shift in rank of breeding groups in performance on the artificial and natural rearing systems. In a crossbreeding study involving Shropshires and Suffolks and their reciprocal crosses, the crosses did not differ in growth under artificial rearing, but on the nursing regime the cross from Suffolk ewes was superior to its reciprocal from Shropshire ewes, reflecting the better traits of the Suffolk breed. Suffolks surpassed Shropshires in growth rate under both artificial and natural rearing. Heterosis was consistently expressed at all ages from birth to 140 days of age on both systems of rearing, the crosses averaging 6% to 12% above midparent values in several measures of growth.

Introduction of Finnish Landrace for increasing reproductive performance. Eight Finnish ewe lambs, imported and bred in November 1968, gave birth at an average age of 12.5 months to 19 lambs, including a set of quadruplets. All the lambs except two in a set of triplets were alive at birth. The Finnish purebreds will be crossed with established breeds to form the base stocks for the female lines to be developed for hybrid lamb production in confinement.

NUTRITION

Cattle

Milk replacers for calves. The bactericide nitrofurazone, consumed at a daily rate of 30 mg/kg liveweight, produced paralysis in growing calves within a few days. A daily intake of 14 mg/kg liveweight depressed growth rate and feed intake and induced nervous disorders within 3–5 weeks. A lower intake of 7 mg/kg liveweight had a marginal effect on weight gain and feed intake. The adverse effects of the drug could not be related to blood metabolites.

A milk replacer containing 25% protein and 20% fat produced higher rate of gain and more efficient feed utilization than did diets containing 20% protein with 16% or 20% fat, or 25% protein and 16% fat.

There was little difference in growth rate or efficiency of feed utilization between calves given a skim-milk powder that had been preheated during the drying process in manufacture (3.7 mg serum protein N/g dry milk powder) and those given a nonheat-pretreated powder (6.8 mg serum protein N/g dry powder).

Sorghum-sudangrass silages for dairy cows. Sorghum-sudangrass was ensiled in tower silos (3.66 × 12.2 m) by the following methods: (i) wilted to 29.3% dry matter (DM); (ii) direct cut 22.9% DM; (iii) direct cut plus 1.0 liter of a 45% solution of formic acid per 100 kg; and (iv) direct cut plus 3.5 liters of a 50% solution of molasses per 100 kg. The silages were fed to 16 cows on a multiple-changeover experiment consisting of four 56-day treatment periods with 7-day intervals. All silages were well preserved and had low pH values, high lactic acid content, and low ammoniacal N. Formic-acid silage had lower content of lactic and acetic acids and higher ratio of protein N to nonprotein N, indicating a more restricted fermentation. Mean DM intakes were 10.0, 9.1, 9.2, and 9.5 kg/day for silages (i) to (iv) respectively. The formic-acid-treated material had lower digestibility of DM (58.6% vs. 62.2% for (i)), and gave higher molar proportions of acetate and lower molar proportions of propionate than the other silages; acetate-to-propionate ratios were 2.66, 2.45, 2.97, and 2.58 respectively. Conservation method had no significant effect on yield or composition of milk or on body weight change.

Swine

Caffeine in diets for growing pigs. Further experiments confirmed the earlier finding at Nappan that caffeine mobilized body fat of pigs and made them leaner. A series of five experiments was conducted to determine the rate at which caffeine was metabolized by pigs and the residual levels in the carcass. Caffeine was rapidly metabolized, with a biological half-life of about 12 hr. When optimum levels of caffeine (1 to 1.5 g/kg feed) were given from weaning to market weight, a withdrawal period of 2 days before slaughter was sufficient to ensure that caffeine levels in liver, muscle, kidney, and backfat were below the minimum detectable of 1 μ g/g.

Poultry

Protein nutrition of the laying hen. In phase-feeding studies it was found that during the first half of the laying year 15% crude protein (CP) was as effective as 17% in supporting maximum egg production; during the second half of the laying year 13% CP was as effective as higher levels provided that 15% or 17% was given during the earlier period. There were no interactions between first- and second-period diets. Coincident comparison of three strains of birds showed marked strain differences and significant strain × diet interactions.

Studies on protein requirement in relation to protein quality showed that when all the dietary protein was supplied by grain, a mixture of wheat and oats was better than wheat alone and a wheat–buckwheat mixture better than a mixture of wheat and oats. The superiority of buckwheat over other grains as a protein source is probably due to its higher lysine content. In 'all-grain' diets there is a marked response to supplementation with lysine, but very little with methionine. The better the protein quality of the grain fraction of the diet, the less the amount of protein supplement required.

Protein metabolism in chicks. Methods are being investigated for assessing protein requirements and evaluating protein sources by short-term measurements of protein metabolism in chicks. The effect of ad lib. feeding vs. a regulated pattern of 8-hr access to feed and 16-hr fast on levels of blood ammonia and plasma uric acid was studied by sampling the blood of chicks (cardiac puncture) at regular intervals over 48-hr periods. Uric acid and ammonia contents during the feeding periods were markedly different from those during fasting periods; within 1 hr of access to feed, blood ammonia decreased but uric acid increased to new levels, which persisted until feed was removed; then within 1 hr both began to return to prefeeding levels. In the birds fed ad lib. the blood metabolite levels fluctuated widely and there was no circadian periodicity. Intake of feed and therefore of protein of the controlled group was greater during the 8-hr period when both groups had access to feed, but total consumption per kg body weight was similar for both.

In a subsequent experiment, increasing the protein intake by adding protein to the diet increased blood ammonia as well as plasma uric acid.

Sheep

Nutritional muscular dystrophy. Administration of vitamin E to pregnant ewes fed dystrophogenic hay was ineffective in preventing NMD in lambs, whereas direct administration of vitamin E to the lambs themselves prevented the disease. Measurement of radiotocopherol administered orally or intramuscularly in body tissues of wethers showed considerably greater uptake from the injected compound.

Available energy from steam-heated poplar wood. Following the finding that steam treatment substantially increased the dry matter digestibility (DMD) of poplar wood in in vitro tests, in vivo studies indicated that growing lambs readily consume diets containing up to 70% treated wood (steamed at 165 C for 1.5 to 2 hr) and 30% hay. DMD of steam-treated wood was 50–55%; more than 70% wood in an all-roughage diet resulted in markedly reduced intake. Sheep given diets containing 45% steamed wood and 55% concentrates had daily gains and carcass grades identical with controls given 45% alfalfa hay (51% DMD) and 55% concentrates.

PHYSIOLOGY

Reproduction

Steroids—general. By computation of extensive data obtained from the gas–liquid chromatography of some 200 steroids, the law governing variations of retention time with temperature has been established. Structure-dependent parameters independent of temperature and carrier-gas flow rate (retention constants), and a simple method for their determination were established. Under any condition, such constants allow an accurate prediction of retention time to be made for steroids of given structure. Consequently, their use, alone or in combination with mass spectrometric data, is of considerable help in steroid identification. This investigation has also been applied successfully to a large number of animal, plant, and bacterial sterols.

Steroid hormones—progesterone. A method, based on competitive binding with receptor proteins, has been developed for measuring the concentration of progesterone in peripheral blood of domestic animals using a 1-ml sample of plasma. The sensitivity of the method is 1×10^{-10} g progesterone. By use of this method, the level of progesterone in peripheral blood has been determined through the normal estrous cycle and during pregnancy in the cow and in the sheep. This method also applies to a study of progesterone levels in the sow and in the hen.

Pregnancy test. A very early pregnancy diagnosis test has been developed for the cow and the ewe. This test is based on measuring the progesterone concentration in peripheral blood. It is performed on 1 ml of plasma collected on the 19th to 22nd day after breeding for the cow, and on the 15th to 17th day for the ewe. Both tests can be carried out before the animal would normally return to estrus if fertilization has not occurred. This test would work equally well in the sow tested on the 19th to 22nd day after mating.

Biological Membranes

A comprehensive theory of membrane structure accounting for static and dynamic functions has been evolved on the basis of the large sum of relevant data now available.

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INTRODUCTION

This report records the highlights of our progress in research during 1969. Detailed information is available in the published papers, listed at the end of the report. Reprints are available from the Institute.

Exciting new developments include: some understanding of how myxin acts on inhibited bacterial cells, demonstrations that mycoplasma cells are the causal agents of clover phyllody disease of aster plants and others, isolation of a new low-molecular-weight fungal tyrosinase, electron-microscopic confirmation of intracellular membranous structures as the most likely seats of reactions associated with frost resistance, new insights into the chemistry of host-specific toxins, and the demonstration of aerial infrared color photography as a powerful and accurate tool in the estimation of losses from plant diseases in the field.

R. M. Hochster
Director

BIOCHEMISTRY

Mode of Action of Myxin on Bacterial Cells

Although the antibiotic myxin inhibited the synthesis of new DNA in bacteria, the host cells were capable of supporting the synthesis of T_4 phage components even after a delay of 50 min. The formation of intracellular phage particles was blocked after the cells were exposed to myxin for only 90 min.

The bactericidal effect of myxin was not primarily due to an inhibition of energy transfer.

By use of a very sensitive biological system of lysogenic phage induction as a measure of interference in DNA synthesis, it was found that as little as 0.5–1.0 μg/ml of myxin induced K_{12} cells to produce a large quantity of lambda phage, indicating the low level of the antibiotic that manifests interference in DNA synthesis.

The enhanced inhibitory effects of myxin on both DNA and RNA synthesis in the presence of chloramphenicol, an inhibitor of protein synthesis, suggests the presence of some specific protein whose synthesis during exposure of the cells to myxin is important in ameliorating the bactericidal action of myxin. For controlling bacterial growth, myxin and chloramphenicol used in combination were much more effective than either used alone.

By following the degradation of DNA in the presence of myxin, when both strands were labeled with different isotopes or where one of the two strands was double-labeled at different segments along the length of the strand, we found that myxin attacks at more than one point in the DNA chain. The breakdown of DNA was random and nonspecific and both strands were degraded simultaneously. This result corroborates the evidence of a multiple-hit type survival curve found previously by means of viable cell titrations. Myxin must, therefore, interact with more than one site inside each cell to achieve its biological effect.

Biological Oxidation in Plant-pathogenic Fungi

Dihydroorotate dehydrogenase has been solubilized from fungal mitochondria and purified 10-fold. The oxidation of the pyrimidine precursor, dihydroorotate, was found to involve ubiquinone as an obligatory electron acceptor. The role of ubiquinone in fungal mitochondrial electron transport still requires elucidation.

The role of mitochondrial nonheme iron proteins in fungal metabolism is considered to be a problem of major importance. Chemical methods for the determination of such proteins in crude mixtures have been developed. Redox proteins of this type may be purified by ion-exchange chromatography.

A method has been developed which is diagnostic for the involvement of the reduced form of oxygen in enzymatic oxidations. This method involves the use of catechols as scavengers for the free-radical form of oxygen (superoxide anion). This intermediate is thought to act as an electron carrier in the reduction of cytochrome *c* by certain flavoproteins as well as in the oxidation of

plant-growth hormones such as indoleacetic acid.

Comparative and Ontogenetic Studies of Fungal Enzymes and other Proteins

A low-molecular-weight dopa-catalytic isoenzyme of tyrosinase (8,000–10,000 mol wt) has been isolated from the fungus *Agaricus hortensis* by electrodialysis, ultrafiltration, and Sephadex chromatography. This entity moved electrophoretically as a single band in acrylamide gel and reassociated partially to larger catalytic units (ca. 30,000 mol wt) on freezing and thawing and by altering the molarity of the buffers. Reassociation was prevented by 6 M urea. Unlike the larger unit, the small unit was unable to catalyze catechol. A similar small isoenzyme of tyrosinase was isolated recently also from McIntosh apples.

A protein inhibitor (ca. 600 mol wt) of tyrosinase activity has been isolated from the fungus *Agaricus hortensis*. This entity has a sulfhydryl group (–SH) and no disulfide linkages. It reacts positively with ninhydrin and iodine vapors and behaves similarly to glutathione (612 mol wt) on thin-layer chromatography in two solvent systems. The inhibitor has been demonstrated electrophoretically in five Basidiomycete species of fungi and was obtained recently also from McIntosh apple tissue.

Disc-electrophoresis of Specific Enzymes of *Arthrobacter*

Improvements were made to the polyacrylamide disc electrophoretic technique for the characterization of bacterial enzymes. Location of the enzymes in the gels was by coupled reduction of *p*-nitro blue tetrazolium. By use of Triton-X-100 as an uncoupling agent, and also by incorporation of 25 μg $MnCl_2$/ml in the developing solution, gels without nonspecific background diformazan deposit were obtained. This new and now clean technique, which was used successfully for the study of a number of dehydrogenases, may aid in future taxonomic studies of the genus *Arthrobacter*.

CRYOBIOLOGY

Frost Hardiness

Electron-microscopic studies of cytological changes in phloem parenchyma cells of the living bark of the black locust, *Robinia pseudoacacia* L., indicated that seasonal fluctuations in total protoplasm, including mitochondria, lipid bodies, and membrane-bound vesicles derived from invaginations of the plasmalemma, are closely related to the seasonal cycle of frost resistance. These cellular components increase in autumn during the development of hardiness, remain at a high level throughout winter while frost resistance is at a maximum, and decrease in spring with the decline in hardiness.

The structural organization of the endoplasmic reticulum also varies seasonally. In summer it is present as long cisternae-like units, which during autumn and winter appear to be replaced by a vesicular form of endoplasmic reticulum. Starch content does not appear to be too closely related to initiation of the hardening process, although nearly all the starch disappears from the cells before development of maximum frost resistance in autumn.

Hardiness tests and lipid analyses in autumn of bark tissues (i) of young locust trees held at constant temperature in growth rooms, (ii) of tree sections isolated by girdling or by severance in summer and maintained outdoors and in cold rooms in the dark, and (iii) of completely excised bark held in cold rooms in the dark have provided strong evidence for the existence of a light- and low-temperature-independent conditioning process in the frost hardening of the black locust, which might be inspired by endogenous rhythms.

Commercial development of foams by the cooperating company, and of machinery for its application by growers and farmers, has progressed fairly well. Preliminary tests have been performed to determine if foams can be used to protect blossoms against frost.

CYTOLOGY

Cytological Effects of Myxin on Membrane Synthesis in *Escherichia coli*

Incorporation studies were undertaken to supplement previous cytological observations that high concentrations of myxin allowed the continued synthesis of cytoplasmic membrane in *E. coli* 15T⁻. Techniques were developed (lysozyme–EDTA) for the isolation of cell envelopes of *E. coli*. The envelope fractions contained, in addition to the cytoplasmic membrane layer, the lipoprotein–lipopolysaccharide outer wall layer of the cell; the envelope accounted for approximately 7.5% of the cell protein. Incorporation of acetate-1-C^{14} into whole cells and into cell envelopes of *E. coli* 15T⁻ and *E. coli* 15T⁻MYX^r (myxin resistant) was studied over a 45-min growth period. Acetate was incorporated preferentially into the envelope fraction in both the presence and the absence of 5 μg/ml myxin. Specific activity in the envelope fraction was approximately four times that of the whole cell. In general, similar incorporation pictures (both in cell envelopes and in whole cells) were noted for *E. coli* 15T⁻ and *E. coli* 15T⁻MYX^r in the presence and absence of myxin. Growth of *E. coli* 15T⁻ in the absence of myxin and of *E. coli* 15T⁻MYX^r in the presence or absence of the antibiotic proceeded normally. In these cases the continued synthesis of cytoplasmic membrane is required for normal growth and division. With *E. coli* 15T⁻ in the presence of myxin, there is no further growth (no increase in cell numbers or total mass), although acetate is incorporated into the envelope layer at a rate similar to the unaffected cells. It is believed that the continued synthesis of cytoplasmic membrane in *E. coli* 15T⁻ in the presence of myxin results in the intercellular ramifications of the membrane previously observed in the cytological studies.

MICROBIAL ECOLOGY

Bacteria

The protein band patterns of a number of coryneform bacterial isolates were analyzed by a simple numerical method in which observed *E* values were treated as a unit character. The results were unsatisfactory because patterns derived from replicates that were visually similar were usually quite dissimilar when analyzed. In a second analysis only major bands were considered and small variations in the *E* values of the chosen bands were disregarded. This subjective editing was required to satisfy a minimum criterion that replicates be recognized as such by the analysis. It was concluded that without a means of identifying and estimating the variation in *E* value of each band, electrophoretic band patterns of soluble proteins are likely to be of only limited use in microbial taxonomy.

Fungi

Chitin amendment of soil causes substantial increases in microbial populations, particularly those of actinomycetes and bacteria. A stimulation of fungi also occurs, but increases in their numbers tend to be more modest than for actinomycetes and bacteria. After an initial lag of 4 weeks, a steady increase in fungal numbers was recorded for chitin-treated soil. By the end of 16 weeks a 10-fold increase in the fungal population had occurred and remained relatively stable during the period between 16 and 21 weeks after amendment. Thereafter, a gradual decline in numbers toward the original population level was observed. During the period of increase a change in the nature of the fungal flora occurred and was accounted for mainly by two species that became predominant, *Paecilomyces marquandii* and *Trichurus spiralis*. At the same time, species of *Cephalosporium* that were common in the unamended soil were rarely isolated.

Taxonomic and Ecological Studies

A two-stage principal component (P.C.) procedure was applied in a comparison of the nature and properties of 85 named cultures of *Arthrobacter, Agrobacterium*, and *Rhizobium*. These cultures were characterized in terms of their reaction to a set of 63 tests. Deoxyribonucleic acid was isolated from 48 of the cultures and the percentage of guanosine plus cytosine (% GC) determined by ultracentrifuge methods. As a result of the numerical analysis nine clusters of cultures

were recognized. Although there were some marked similarities between the genera represented, they were clearly separated in the test space of the P.C. vectors. Morphological, symbiotic, and pathogenic attributes were not used in the characterization of these cultures; thus it is significant that it was possible to recognize the individuality of these genera without reference to the attributes that are traditionally regarded as important in classification. Generally, the GC results were consistent with those of the numerical analysis. The % GC of the 'typical' arthrobacter cultures ranged from 60.1% to 66.3%. Inclusion of the 'atypical' arthrobacter brought the range to 72.0% GC.

Bacteriophage

Sixty-four phage isolates lytic to the f. spp. of *Xanthomonas translucens* have been isolated from 82 seed samples of wheat, oats, barley, rye, and other grasses. Results of approximately 6,000 tests demonstrated that barley seed samples produced the largest number of lytic filtrates and indicated that barley is the primary reservoir of both the pathogen and phage isolates. No active filtrates were acquired from oat seed samples.

PHYSIOLOGY

Host-specific Toxins

Enough of the chemical structures of the host-specific toxins of *Helminthosporium victoriae* and *H. carbonum* were worked out to confirm that these unusual compounds possess structures previously unknown in natural products. The *H. victoriae* toxin is a sesquiterpene–peptide complex, whereas the *H. carbonum* toxin has dehydroamino acids and ester linkages in its molecule.

It was demonstrated that different species of pathogenic fungi are able to form hybrids in culture. A certain number of these hybrids were found to have a wider host range than either parent. A comparative study was undertaken of the metabolism of two species of *Cochliobolus* that produce host-specific toxins and that can form hybrids. It was found that pathogenic strains of each species were able to produce similar, but not identical, amines that may be precursors of many different toxins.

An inhibitory substance that covers the surface of fern spores plays an important role in the sexual reproduction of ferns. This inhibitor keeps spores that are destined to form the male gametophytes from germinating until the hormone antheridogen is secreted by female prothalli.

Growth Control—The Rest Period

Two distinctly different types of proteins were found in the flowers of resting *Rhododendron* flower buds. One was distributed uniformly throughout the cells of the petals, the second was found only in the epidermal and subepidermal cells and was present as rather discrete spherical or elliptical bodies. The second protein body was resistant to proteinase degradation unless the central portion of the body was exposed to the enzyme. This indicated that the outer shell of the body is composed of an enzyme-resistant protein or of a different material such as lipid or polysaccharide. This outer shell is probably extremely important in permitting the maintenance of a source of storage proteins for subsequent growth of cells after the rest period is terminated.

Comparative analysis of growth regulators involved in the rest period of higher plants has led to the identification of scopoletin, a biologically active substance hitherto unreported in *Rhododendron* tissues.

An indole compound other than indoleacetic acid, but endowed with growth-promoting activity, has been isolated from dormant *Rhododendron* flower buds. A study of its characterization is now in progress.

PHYTOPATHOLOGY

Effect of Seed Infection on Yield

Yield losses from planting barley seed heavily infected with the common root rot organism *Cochliobolus sativus* were not significant. Infection of the seed by this organism reduced seedling emergence by as much

as 40%, but the reduction in the number of plants per row had to be over 50% before significant yield losses occurred. Treatment of the seed with mercury fungicides eliminated the reduction in emergence and also provided an additional increase in protection from soil-borne organisms, but there was no yield improvement.

Estimating Disease Loss from Aerial Photography

Three factors are required for disease loss estimates: the identification of the disease by infrared aerial photography, the yield of the crop, and the percentage of the crop infected. To determine this percentage infected areas of a field are traced from the photographic negative onto cellulose acetate coated with Krylon. From these ink tracings a camera-exposed high-contrast line negative is produced. From this a vacuum-frame contact is exposed on high-contrast film to produce a film positive with the same tonal relationships as the original ink tracings but on a transparent base. These autopositive copies are cut and placed together to show the various areas of the field as are the copies of the infected areas. The black images are placed on an IBM drum scanner. The scale of the photograph permits the area examined to be ascertained easily and the percentage of infection to be determined by use of the positive and negative readings from the computerized information. Field areas of less than 1 sq ft can be scanned in this manner.

Field Surveys and Disease Loss Estimation in Ontario

Winter wheat. A survey of 300,000 acres of winter wheat for estimating the incidence of foliar diseases showed that mildew, caused by *Erysiphe graminis* DC. ex Mérat f. sp. *tritici* Marchal, was the most common fungus disease but that the severity of infection was low. The consequent economic loss in yield would probably not warrant the application of a fungicide. Two disease-causing viruses, the soil-borne virus that causes spindle streak, and barley yellow dwarf virus, were found to have infected approximately 50% of the fields inspected.

Peach canker. To estimate the incidence and severity of peach canker in the Niagara Peninsula, approximately 2,000 peach trees in 100 orchards were surveyed. The project was a joint program with the Research Station at Vineland Station, Ont. Canker was found to affect 98% of the trees inspected. An effort to estimate the dollar losses over the next few years is expected to be based on Dominion Bureau of Statistics data for peach yields/tree.

Early blight of tomatoes. An experimental determination of losses from early blight of tomatoes was carried out by comparing yields of completely or partially fungicide-protected and naturally or artificially infected plants grown under similar field conditions. The results showed that in the particular field plot employed the average yield of disease-free plants was equivalent to 6.3 tons/acre ± 2.6%, assuming 3,000 plants/acre. With the above amount considered as normal yield of the crop, naturally infected plants suffered 8.4% loss in quantity (number and weight of ripe fruit) and 9.9% loss in quality (visibly infected fruit). The combined loss was 17.4%. An artificially created epidemic caused 26–42% quantitative and 40–42% qualitative loss. Protection during the month of July reduced the quantitative loss to zero and fruit infection to the 2.6% level. Protection for July and August reduced the quantitative loss to zero and the qualitative loss (fruit infection) to 0.5%. Plants protected throughout the season suffered no loss.

Assessment keys. A manual of disease assessment keys, with instructions, was developed and distributed to pathologists in the Branch in an attempt to standardize disease-assessment methods in Canada. Diagrams were prepared with the aid of a new technique, an electronic scanner designed to measure small irregular areas accurately.

Systemic fungicide. Milstem (containing ethirimol; Chipman Chemicals) a new systemic fungicide for controlling powdery mildew of cereals, was tested in greenhouse and field experiments. The fungicide was applied as a seed dressing, and significant increases in grain yield resulted if the epidemic was severe enough. The technique was used to study the relationship between the severity of mildew and reduction in yield.

Pathogen Survival in Soil

Studies on the survival of the *Ascochyta*-like fungi inciting foot rot and blight of field and garden peas have shown that these fungi produce thick-walled chlamydospores that

can survive in natural soil under field conditions at Ottawa for at least 16 months. Pycnidiospores, by which the diseases are spread in the field during the growing season, were unable to survive this period in soil, and they probably do not play an important role in perpetuating the pathogens from one season to the next. Therefore, recommendations for the control of these diseases must now be amended.

VIROLOGY

Vector-Virus Relationships

Wheat spindle streak mosaic. Wheat spindle streak mosaic, formerly referred to as a soil-borne virus disease of wheat, infected 37% of the wheat fields in Ontario in 1969 compared with 47% in 1968 and 0–65% in the preceding 10 years. For the first time, severe symptoms developed at Ottawa but only in plots in which wheat was grown at least six times in the last 15 years. The disease developed in winter wheat sown in infective soil from August to late October, but not in wheat sown in early November when the soil was so cold that the seed did not germinate until spring. Field experiments confirmed that heavy applications of poultry manure and other N fertilizers reduced infection of plants. Rideau wheat was less susceptible than other commercial varieties tested on infective land.

The zoosporic fungus *Polymyxa graminis* was found in the roots of most samples of mosaic-diseased wheat examined and is suspected to be a vector.

Particles that appear to be the infectious units of the virus are long, slender filaments 12 mμ thick by 2,000–3,000 mμ long. Concentrates from diseased plants contain particles 200–1,000 mμ long, which appear to be fragments of the infectious units.

Clover phyllody disease. Pleomorphic bodies resembling *Mycoplasma*, ranging from 75 to 1,100 mμ in size, were found in the sieve elements of vascular tissues of roots, stems, leaves, pedicels, and foliaceous structures of phylloid flowers of clover-phyllody-affected aster plants. Such mycoplasma cells were also found in affected leaves of barley, a monocotyledonous host of the disease. In some sieve elements the extrusions of mycoplasma cells were observed inside the sieve pores, suggesting that cell-to-cell movement of the organism takes place through these pores. Mycoplasma cells similar to those observed in plants were found in the intestine and salivary glands of infective leafhopper vectors.

All mycoplasma cells had a single-unit membrane and contained ribosomelike granules, and cells that were larger than 210 mμ also showed a nuclear area with DNA-like fibrils. Four forms of mycoplasma cells were recognized on the basis of their size, shape, and structure, and probably represented the developmental stages in the growth cycle of the organism in vivo.

Symptom development in the plants was suppressed if diseased plants were left in a solution containing 100 ppm of chlortetracycline HCl for 24 hr. Also, the development of disease could be stopped if aster plants were treated with the antibiotic before they were inoculated by infective leafhoppers. The results suggest that clover phyllody disease is caused by an organism resembling *Mycoplasma* and not by a virus as assumed in the past.

Unidentified clover disease. A yellows-type disease of clover was discovered in the Ottawa area. The causal agent is transmitted by the leafhopper *Aphrodes bicincta* (Schrank). Attempts to identify this disease with known leafhopper-borne diseases have been unsuccessful and it is suspected that the disease may not have been described before. Acquisition experiments showed that nymphs were much more efficient in transmitting the causal agent than were adults.

Wheat striate mosaic virus. A method of purifying wheat striate mosaic virus from infected plants was developed. The procedure involves infiltration of infected leaves with a buffer, adsorption of the sap with charcoal powder, passage of the juice through a celite pad and sepharose column, density-gradient centrifugation, and density-gradient zonal electrophoresis. The final preparations contained virus particles that were bacilliform in shape and 250 × 70 mμ in size.

Vector biology. The leafhopper *A. bicincta*

has one generation per year in the Ottawa area. The egg overwinters, and the nymphs emerge at the end of May or in early June. Early-instar nymphs can be found on strawberry, red clover, alsike clover, plantain, shepherd's-purse, and fleabane. Adults begin to appear in early July. Laboratory studies showed that eggs rarely hatched if held continuously at room temperature. When the eggs were kept cold (7 C) for 4 weeks or more, they hatched in as short a time as 14 days after they were returned to room temperature.

Barley yellow dwarf virus (BYDV). In further work on the mechanism of persistence of BYDV in its aphid vector *Macrosiphum avenae* (Fabricius), serial passage of the virus from aphid to aphid using hemolymph as the inoculum was unsuccessful. The virus could not be recovered from the gut of aphids that had been injected with a massive dose in their body cavity; therefore the movement of virus between the gut and body cavity may be unidirectional. Serologically, the virus was detected only in the gut and hemolymph. Most aphids transmitted the virus for their entire life after a 24-hr acquisition feed; after shorter periods, the inoculativity was lost gradually. The persistence of inoculativity of aphids was correlated with the dose of virus received either by injection or by an acquisition feed. It is evident that the gut plays an important role in the persistence of inoculativity after an acquisition feed. The aphids continued to accumulate virus in their guts during an acquisition feed of 96 hr. However, assays of virus content of the guts of aphids during the period following a 6-hr acquisition feed showed a continued depletion of virus content to a very low level after 96 hr. The above evidence is against multiplication of BYDV in aphids, but favors the hypothesis that the ingested virus persists in an infective state and that its quantity determines the length of persistence of inoculativity.

Tomato spotted wilt virus (TSWV). The virus was found causing a severe disease of tomatoes (incidence 5–8%) and dahlias at Picton, Ont., and of dahlias and geraniums at Ottawa. A vector of the virus, *Frankliniella fusca* (Hinds), was collected for the first time in Canada near Trenton, Ont. The dahlias found infected with TSWV at Ottawa, every year for the last 3 years, may be carrying a European strain of TSWV in their tubers from year to year, as the tubers for the propagation of these varieties were imported from Europe where TSWV and its vector *Thrips tabaci* (Lind.) are common. The TSWV isolated from tomatoes at Picton was transmitted efficiently by *F. fusca.* Many individual viruliferous *F. fusca* transmitted the virus as long as they lived. *T. tabaci* did not transmit this isolate of the virus, but was able to transmit the isolate collected at Ottawa from dahlias. *F. fusca* proved to be a very inefficient vector of the dahlia isolate. *T. tabaci* has never been reported to transmit the strain of TSWV found in Canada and eastern and central United States, nor has *F. fusca* for the European TSWV. Existence of vector-specific strains of the virus is evident from these observations.

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D. P. PIELOU, B.Sc., Ph.D.	Ecology

VISITING SCIENTISTS

L. J. BOTTIMER, B.S. Research Associate	Taxonomy of Bruchidae

National Research Council postdoctorate fellows

H. V. DANKS, B.Sc., Ph.D., 1968-70	Biology of overwintering
A. SMETANA, M.U.Dr., Cand. Sc. Biol., 1967-69	Taxonomy of Staphylinidae
A. N. VERMA, B.Sc., M.Sc., Ph.D., 1967-69	Experimental ecology

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[3] Honorary Research Associate.
[4] Retired in 1969, now Honorary Research Associate.
[5] Seconded from Department of Fisheries and Forestry.
[6] Seconded from Department of Fisheries and Forestry.

INTRODUCTION

The Entomology Research Institute provides a national identification service on insects, arachnids, and nematodes. To fulfill this responsibility the Institute maintains custody of the Canadian National Collections of Insects, Arachnids, and Nematodes. Extensive research in biosystematics is conducted in order to describe and understand the content, origin, and biological significance of the Canadian fauna.

During the year Dr. G. P. Holland retired as Director and was succeeded by Dr. W. B. Mountain, formerly Director of the Research Station, Vineland Station, Ont. Dr. Holland was Director of the Institute since its formation in 1959, and for 10 years before that had been in charge of Insect Systematics within the Department of Agriculture. Following his retirement as Director, Dr. Holland accepted a research position in the Institute to work on Siphonaptera.

Also in 1969 Dr. O. Peck and Mr. G. S. Walley retired, but they are still working full time as honorary research associates. Dr. C. M. Yoshimoto was seconded to our staff by the Department of Fisheries and Forestry to work on the Chalcidoidea, and Dr. L. Masner and Dr. J. R. Barron joined the Institute to work on biosystematics in Hymenoptera.

A thorough review of the Institute, its internal organization, research goals, and identification service was undertaken by a group of the Institute's scientists during the latter half of the year. The new sectional organization is given in the list of professional staff in this report. However, the report is arranged according to the previous organization.

W. B. Mountain
Director

TAXONOMY

Surveys, Collections, and Museum Trips

Field collecting in Chiapas, Mexico, by a scientific party added approximately 26,000 Diptera, 26,000 Lepidoptera, 20,000 Hemiptera, 10,000 Hymenoptera, 100,000 Acarina, and 50,000 Coleoptera to the Canadian National Collection. Surveys in southern Idaho and Nevada yielded about 10,000 Noctuidae; in the Mackenzie River area about 6,000 Diptera; and in Ontario and Quebec about 2,000 Diptera and 3,000 Chalcidoidea (Hymenoptera). Malaise traps in Alaska, in the Mackenzie River area, and throughout the year in Missouri contributed additional Hymenoptera. Specialized collecting in Switzerland and Scandinavia added another 5,000 Diptera, and in the West Indies, more Coleoptera.

Three collections of Diptera were purchased: 500 specimens from Ceylon, 6,500 from New Zealand, and 18,000 from Argentina. Most of the specimens from Argentina were collected in high altitudes.

Two specialists in Diptera visited various European museums; one scientist examined type specimens of 2,000 nominal species of Syrphidae, the other studied the classification of world Tachinidae.

During June many soil and plant samples were collected in a survey of nematodes of the agricultural and forested areas of northern Ontario.

Identification and Information Services

During the year, 751 shipments of insects and other arthropods consisting of 37,500 specimens were received for identification. The Department of Agriculture submitted 185 shipments (24%) with 7,386 specimens (20%) and the Department of Fisheries and Forestry submitted 181 shipments (24%) with 10,835 specimens (29%).

Over 32,700 specimens were identified and returned during 1969. The accompanying table shows the number of specimens identified, their various sources, and the distribution within insects and other arthropods.

A total of 131 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 1969

	Coleoptera	*Diptera*	*Hemiptera*	*Homoptera*	*Hymenoptera*	*Lepidoptera*	*Siphonaptera*	*Other insects*	*Acarina*	*Other arthropods*	*Others*	*Totals*
Canada												
Department of Agriculture	521	1,372	338	334	436	841	1	1,517	327	30	4	5,721
Department of Fisheries and Forestry	3,307	1,154	120	675	4,701	2,316	22	86	135	36	–	12,552
Other federal departments	–	20	–	–	23	–	–	–	–	102	–	145
Provincial departments	56	17	1	142	80	93	10	–	28	5	–	432
Industry	51	–	10	–	–	12	–	–	24	–	–	97
Universities	187	1,706	38	59	419	74	28	92	86	–	–	2,689
Private inquiries	607	49	40	83	169	68	23	110	88	59	20	1,316
United States												
Government departments	105	475	–	–	865	210	482	–	12	–	–	2,149
Universities	303	1,831	–	10	30	2,194	432	6	29	–	–	4,835
Private inquiries	28	39	–	–	–	327	3	–	6	–	–	403
Others	991	20	–	–	272	223	–	–	–	–	–	1,506
Mostly European	1	389	–	39	25	292	52	–	100	–	–	898
			547	1,342								
Total	6,157	7,072	1,889		7,020	6,650	1,053	1,811	835	232	24	32,743

Taxonomic Investigations

Acarina. A review of Holarctic tarsonemid mites parasitic on the eggs of bark beetles, and descriptions of four new species of *Tarsonemus* associated with bark beetles were published. A review of the genus *Heterotarsonemus* and an article on the relationships between mites and insects in forest habitats were completed.

Coleoptera. Two revisions were published: the New World Oxyporinae, a subfamily of *Staphylinidae*, including 16 species, 2 of which are new; and the scolytid genus *Pseudohylesinus*, recognizing 12 species and subspecies.

Descriptions and biological data of three new species of Bruchidae were included in two papers, and the results of a brief study on *Coenonycha*, a genus of Scarabaeidae, were also published.

Diptera. Manuscripts on 31 families and 400 drawings are now ready for inclusion in the proposed Manual on the Genera of North American Diptera.

Among studies completed were: keys to about 100 species of Syrphidae; a key to six species of *Lonchaea* that prey upon bark beetle larvae; the larvae of *Glutops rossi* Pech., which were found in a semiaquatic habitat in Alberta and whose characters show that the genus should be transferred from Xylophagidae to Pelecorhynchidae; and a study on fossil puparia from Alberta that records for the first time the existence of blow flies in the Mesozoic.

Papers were prepared on species of *Prosimulium*, a memoir on *Prosimulium* is in press, and a paper on the genus *Lipoptena* of the Hippoboscidae was completed. Some work was done on new species of Nycteribiidae.

Hemiptera. In the Miridae, a description of

a new genus *Scalponotatus*, including nine new species, was published; descriptions of four new species of *Trigonotylus* are in press; and a revision of *Platylygus*, including 31 species, 26 of which are new, is almost completed.

In the Aphididae, reviews of the genera *Tuberculoides* and *Cepegillettea* were published, and one on the Palaearctic species of *Iziphya* is in press. New Canadian species in *Drepanaphis, Betulaphis*, and *Cepegillettea* were described.

Hymenoptera. Publications included descriptions of: a new genus and three new species of Ceraphronidae; chalcidoid parasites of the alfalfa leaf-cutter bee in Canada; Muesebeckiini, a new tribe of Braconidae; Nearctic species of the *onitis* group of the ichneumonid genus *Trieces*; and a note on a scelionid wasp that has survived unchanged since the Tertiary period.

Studies on the ichneumonid subfamilies Metopiinae and Pimplinae, parasitic on forest Lepidoptera, were completed and the results were given to the Department of Fisheries and Forestry to be used in compiling seasonal and distributional records.

The chalcidoid parasites of insects inhabiting white spruce were studied and compared with those of the European fauna.

Lepidoptera. In the Noctuidae, a generic revision of the Heliothidinae was completed, resulting in a redefinition of the subfamily and a reduction in the number of genera from 28 to 14. According to material sent in for identification, the European cutworm, *Cerapteryx graminis* (Linn.), a potential pest of grassland, appeared not to have increased greatly in numbers since first recorded on this continent from Newfoundland in 1966.

In the Pyralidae, additional contributions to studies on the Pyraustinae of Temperate East Asia and on the American species of *Dioryctria* were published.

Three unusual discoveries were made in the Microlepidoptera. Specimens of an unknown family, near Eriocraniidae, were obtained from material collected in Northern India. Parthenogenesis was observed to occur in three leaf-mining species, two of which are European introductions. A small larval head capsule found in Cretaceous amber from Alberta is the first fossil evidence of Lepidoptera before the Tertiary period.

An aegeriid larva, of most unusual interest because it feeds on scale insects instead of boring in its host plant, was described (in press), and descriptions of larvae in Baltic amber and of Tortricidae in the Canadian Arctic were published.

Trichoptera. A comprehensive revision of the Stenopsychidae was published, and three species of *Hymalopsyche* were recorded from Russian Turkestan.

Nematoda. Three new plant-parasitic species of the genus *Tylenchorhynchus* Cobb were named from Ontario, British Columbia, and Lake Hazen, N.W.T., five species of *Tylenchus* Bastian from the Canadian High Arctic, and a new genus and species of the family Neotylenchidae from the Lake Hazen area, N.W.T. Studies of a new species of *Dactylotylenchus* Wu justified erection of a new subfamily, Dactylotylenchinae, to accommodate those tylenchids with a digitate labial framework. The subgenus *Ottolenchus* was given generic rank based on information gained from studies of a small, previously undescribed tylenchid from Canada.

Comparative studies of topotypes of *Cephalobus persegnis* Bastian and their progeny established the presence of labial probolae that vary widely in form, which has clarified taxonomy of *Cephalobus* Bastian and expedited identification of species occurring in Canada. Morphological study of three new Canadian species of *Teratocephalus* de Man revealed new characters of taxonomic importance, which provided the basis for a more effective key to identification of the species.

Preparatory to a taxonomic revision of the genus *Plectus* Bastian in Canada, the generic composition of the Plectinae in contemporary classifications was analyzed and changes suggested for the removal of some genera. Propositions for nomenclatorial changes and amendments in other nematode groups, which include the genera *Parasitylenchus* Micol., *Rhabditis* Dujardin, and members of the Diplogasterinae, were also made.

New information from studies of 16 species of marine nematodes collected from the Minas Basin – Scots Bay area of Nova Scotia resulted in the description of one new species, reestablishment of a genus, revision of a poorly defined genus, and transfer of

several species to other genera. A new genus and nine new species were described from the Biscayne Bay area of Florida. Detailed examinations of the number, type, and distribution of hypodermal pore complexes and lateral punctate pores in eight new species of cyatholaimids suggest that these characters are of taxonomic importance.

BIONOMICS AND PHYSIOLOGY

Bionomics of Bees

A fatty acid was isolated from pooled pollen. This acid was found attractive to foraging honey bees. It was identified as octadeca-*trans*-2,*cis*-9,*cis*-12-trienoic acid. It could be a precursor of *trans*-2 acids important in nutrition and social biology of honey bees. The characteristic odor of honey bee larvae killed by *Bacillus larvae* White is a composite of low molecular weight mercaptans and pungent lipid compounds. Infections with this bacillus are normally initiated with spores of undetermined origin. A mutant strain, which produces flagellar bundles with a microscopically visible contracted helical form, was found infective. The contracted helix occurred both in culture and in infected larvae. Growth and reproduction of *Nosema apis* Zander, an obligate parasite of adult bees, is suppressed by fumagillin. Studies on the best use of this antibiotic show it to be stable for long periods of storage in syrup; it is most effective when fed in liquid (syrup) form, rather than in dust or candy; it is not inhibited by other antibiotics or drugs fed in combination with it. Kalafungin, steffimycin, dipentene dioxide, and thiadiazole were negative against nosema. Nosema spores contained several sugar compounds, which tend to point toward the metabolic pathways of the spores.

Life Cycle and Energetics of the Armyworm

The temperature limits for the immature stages of the armyworm, *Pseudaletia unipuncta* (Haw.), were found to be about 31 and 10 C. Development was fastest at about 29 C. In all instars except the first, the width of the larval head increased as the temperature rose, and under unfavorable conditions an additional molt often took place. When larvae consumed food at a high rate, they were able to accelerate development and to attain a larger size and a high reproductive potential. When food intake was low, the rate of development, size, and fecundity were reduced for the sake of survival.

Population Studies on Crop Insects

Studies on the imported cabbageworm have shown that the capsule virus that determines generation survival is soil-borne. The virus winters in the soil and is spread to new foliage by wind and water action. The virus can build up to epizootic levels in about 3 years.

Analysis of 63 life tables reaffirmed that adult survival and fecundity are the key factors for population change in the diamondback moth. Fecundity declines as the season progresses, and there is a linear relationship between fecundity and the N content of the larval food.

In *Hylemya brassicae* (Bouché) field populations are overdispersed and conform to a negative binomial distribution. Three transformations were adequate to stabilize the variance of field counts and a statistically sound sampling was developed.

Diversity in Insect Communuties

The bracket fungi *Polyporus betulinus* (Bulliard) and *Fomes fomentarius* L. have yielded over 400 species of arthropods from approximately 100,000 specimens. The collections of the former species were from DDT-free and DDT-sprayed forest areas of New Brunswick, and the effect of DDT on the structure of the community is becoming more complex than expected.

The theoretical concepts regarding association and coexistence of species, developed from these studies, are being extended to the aphid fauna of species of goldenrod, *Solidago*, a common genus of weeds.

Bionomics of Blood-sucking Diptera

The midge *Corethrella* was found to have mandibles and maxillae with fully developed skin-cutting armature, and, independently, in Florida, individuals with mammalian blood in their stomachs were discovered. Consequently, another family, Chaboridae, has been added to the list of biting flies; all genera except *Corethrella*, however, are nonbiting, probably in adaptation to their cool temperate habitat. In the snipe flies (*Symphoromyia*: Rhagionidae), autogenous species with reduced, nonbiting mouthparts were demonstrated for the first time.

A comparison of autogenous and anautogenous females of *Aedes atropalpus* (Coq.) has shown that autogeny is associated with a lengthening of the developmental period and an increase in weight at emergence. The difference in weight is due mainly to a larger fat body. The protein content of the fat body and hemolymph changes as the eggs mature, and the changes differ in the two forms.

Biology of Overwintering

Larvae of chironomids in arctic ponds were markedly freezing-tolerant, but near Ottawa many species are killed by freezing, although some have short-term resistance. Resistance to inoculation by ice is limited and thus they are not protected by supercooling, but the freezing point of the blood is lowered slightly as winter approaches. Most of the mud on the bottom of the pond, however, remains unfrozen, owing to a higher water level and the insulating effect of the snow cover.

A marked difference in subcellular organization has been demonstrated between certain freezing-resistant and freezing-tolerant insects. Freezing-resistant forms such as larvae of *Cyphophora eloisella* Clem. (Lepidoptera) and *Eurosta solidaginis* (Fitch) (Diptera) undergo a marked reduction in membrane systems and organelles, which is characteristic, to a lesser extent, of diapause and metamorphosis. In freezing-tolerant insects (larvae of arctic chironomids) the cells have a nearly normal organization, they apparently dehydrate during freezing and then return rapidly to a normal functional state.

Hormones and Life Cycle

A comparative study of hormonal and environmental control of diapause in noctuid moths has been initiated. A complex network of nerves arising from the corpora cardiaca and extending to all the major cephalic sensory nerves has been discovered. These nerves may provide a direct sensory input to the corpora cardiaca and so affect the production of hormones. The development of these nerves in other families is under investigation.

The Insect Egg Shell

The fine structure of the egg shell and egg membranes has revealed many interesting adaptations. In the endoparasite *Aphaereta pallipes* (Say), the endochorion is extremely thin (0.05 μ), layered, and folded, and permits a great increase in size by intake from the host's blood during embryogenesis. The thick granular exochorion provides an adhesive layer. By contrast, the eggs of *Dahlbominus fuscipennis* (Zett.), a parasite that oviposits externally, have a thicker (0.5 μ) rigid endochorion and a fibrous outer layer. The micropylar apparatus and the aeropyles have distinctive features in many insect eggs. The aeropylar system, in particular, is of taxonomic significance in nine genera of Noctuidae.

Insect Blood

The basic difference in the blood cells between the older and the more recent families in the Dictyoptera is that the species from primitive families lack the well-developed spherule cells that are present in the modern groups. Also, morphological distinctions occur in the granular hemocytes of certain species within the modern complex. Although these distinctive characters are obvious in some cases, e.g. in *Diploptera punctata* (Eschscholz), where granular hemocytes show considerable diversity, their measurement for comparison continues to be a problem for study.

Sex Ratio and Sperm Structure in Hymenoptera

A scanning electron microscope study of the micropyle of *Dahlbominus fuscipennis* (Zett.) showed that the duct through which the spermatozoa pass into the egg is coiled dextrally with the same gyre as that of the

sperm head. The sinistrally coiled sperm become trapped in the micropylar opening and male offspring are produced from the nonfertilized eggs. The order in which the sex of the eggs was laid was shown to be random, indicating randomness in the availability of dextral and sinistral during fertilization.

An intracellular rickettsial organism was discovered in the gonads and ganglia of *Dahlbominus*. The organism has no cytopathic effect, but appears to be a hereditary symbiont, transmitted transovarially. The rickettsia is present also in the spermatocytes, but does not show a polar distribution and is unlikely therefore to be the cause of the dimorphism in the sperm.

Insect Morphology

The work on the morphology and evolution of the insect thorax was completed and submitted for publication, and the companion project on the insect abdomen has been started. The first part, an investigation of the developmental patterns of the abdominal appendages, has led to many new proposals of homologies between different taxa, and appears to necessitate a refinement of the homology concept in general.

Biology of Nematodes

A microsporidian infection of a marine nematode was found for the first time. All tissues of *Metoncholaimus scissus* Wieser and Hopper, except esophageal, were found susceptible to attack at any season of the year.

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CHEESE QUALITY

Milk-clotting Enzymes

A world shortage of rennet has directed interest to other milk-clotting enzymes. Of these, pepsin and a 50:50 mixture of commercial rennet and pepsin were investigated. Pepsin was found to be inactivated quickly by high pH (> 6.5) when diluted with hard water at temperatures likely to occur in the cheese plant; this might explain occasional problems in coagulating milk with pepsin. In hard water samples from two cheese factories, inactivation occurred very quickly at 30 C and significantly at 20 C over a 10-min period. Rennet, however, was relatively stable under these conditions. Alkalinity of the water contributed more to pepsin inactivation than did total hardness.

Passive indirect hemagglutination and hemagglutination inhibition tests have been developed for the detection of coagulating enzymes in cheese because chemical methods for differentiating between rennet, pepsin, and microbial enzymes are imprecise. Serological methods that have high sensitivity and specificity for rennin and for *Mucor pusilus* and *Endothea parasitica* enzymes were developed and tested. Pepsin is only weakly antigenic and is not easily measured by this method.

Cheddar Cheese Flavor

Volatile flavor components. Further progress was made in developing techniques for separating volatile components by gas chromatography. An important problem to be overcome is the masking of minor components by major ones. The minor components can be detected by their odors, the intensities and characteristics of which indicate that they are likely to be essential contributors to the aroma of Cheddar cheese. Many of the volatiles, however, may be converted to trimethylsilyl derivatives, which are more easily separated by gas chromatography. Initial trials established the presence of traces of heptanoic acid in Cheddar cheese.

Bitter and astringent flavor defects. Bitterness in cheese extracts was adsorbed by active carbon and recovered by hot alkaline alcohol extraction of the carbon. The adsorption appeared to be nonspecific because the recovered fraction contained all the peptides present in the original cheese extract.

Preparative high-voltage paper electrophoresis, followed by elution of zones by 80% alcohol, yielded two basic peptide fractions that tasted bitter. In samples of Cheddar cheese ranging in bitterness from mild to extreme, intensity of bitterness was related qualitatively to concentration of basic peptides.

The astringent taste of components, isolated from Cheddar cheese, was evident at acid or neutral pH but not at alkaline pH. Ionization of phenolic groups in the peptides at alkaline pH, as measured by ultraviolet spectra, correlated with loss of astringency.

MICROBIOLOGY

Byssochlamys nivea

More evidence has been obtained to demonstrate the presence of *Byssochlamys nivea* in Canada. Samples of British Columbia canned fruit juices and fruit pie fillings were examined for the presence of heat-resistant molds. Suspected *Byssochlamys* contamination was found in 3 of 37 samples examined. All 3 positive samples were grape juice products, which constituted 9 of the 37 samples.

Grapes in the Niagara area were examined because grapes seem to be a main source of *Byssochlamys* spoilage in the USA. Thirty-one percent of the 82 samples analyzed showed possible *Byssochlamys* contamination, but there was no indication that contamination was confined to any section of the Niagara district.

The respiratory pattern of germinating *B. nivea* ascospores was reexamined to confirm that peak oxygen uptake occurs 16 to 20 hr after germination begins.

Lactic Streptococci

Investigations on the reduction of pH by *Streptococcus lactis* grown in skim milk (10% T.S.) with and without 2% malate or succinate indicated that these additives moderate the lowering of pH over a 5-hr growth period. This may explain in part their effec-

tiveness in increasing the survival of lactic starters in frozen storage.

Several starter culture strains have been induced to a state of defective lysogeny for homologous bacteriophage. Phage protection against three races of phage has been introduced into one single strain culture by this technique.

In a cooperative experiment with Coopérative Agricole de Granby, five cows were immunized with homologous bacteriophage for a starter culture. Four of the cows produced immune milk that was effective at a dilution of 1/50 in protecting the starter culture against phage. Further experiments will be conducted in an attempt to increase the effective titer.

Carbohydrates of *Nosema apis* Spores

As a result of sublethal heat treatment, spores of *Nosema apis* an obligate protozoan parasite of the honey bee, *Apis mellifera*, released material that on fractionation by ion-exchange chromatography and gas-liquid chromatography yielded D-fructose, < 1%; D-glucose, 2%; D-sorbitol, 11%; D-*glycero*-D-*gluco*heptitol, 2%; and α,α-trehalose, 64% (determined as tri-*O*-methyl silyl derivatives); and D-gluconic acid, 7%. With the exception of D-fructose, all these sugars were obtained as crystals or were characterized by the isolation of crystalline derivatives.

The actual significance of these compounds in the composition and physiology of the spores remains to be determined. However, the observations are most significant because α,α-trehalose is the storage carbohydrate of the honey bee and is present in the hemolymph of many other insects. This disaccharide, in conjunction with certain endocrine extracts, is claimed to promote good cell growth in silkworm tissue culture, and when added to cultures of noninfectious trypanosomes renders them infective. Present results suggest a similar important role for α,α-trehalose in the metabolism of *N. apis*.

SENESCENCE OF FRUITS AND VEGETABLES

Stimulation and Inhibition of Ethylene Production from Bean Hypocotyl

The stimulation of ethylene evolution from the stem sections of beans by applied 3-indoleacetic acid (IAA) served as a convenient model for the study of ethylene production and inhibition. The evolution of ethylene was observed over a 24-hr period by use of gas chromatography. Various metal ions had a stimulating effect on ethylene production: Fe^{3+} (50 ppm), Mn^{2+} (150 ppm), and Ag^{+} (3 ppm) doubled the rate of ethylene production, whereas Cu^{2+} increased the evolution by four times. In the absence of added IAA, Cu^{2+} increased the evolution of ethylene eight times and Ag^{+} twice, whereas the other ions had no effect.

Partial suppression of the ethylene production promoted by added IAA was attained by the simultaneous addition of substances known to react with aldehyde and ketone oxygen and with acetylenic and ethylenic bonds. Almost 50% reduction in ethylene evolution was attained with phenylhydrazine and with semicarbazide, each used at 500 ppm. Similar, and lesser, concentrations of hydroxylamine hydrochloride, hydrazine, and various acids and salts of the latter compound were more effective. When hydrazine was added 24 hr before the introduction of the IAA, the inhibitory effect was reduced.

Apple Mitochondria Activity

Apple peel mitochondrial preparations have yielded valuable data on the biochemistry of senescence. Virtually all previous work had been done with Cox's Orange Pippin, a variety not common in Canada, and therefore a study of the suitability of McIntosh apples for such experiments was made.

Mitochondrial preparations from McIntosh consistently showed very low or zero activity when the methods used with Cox's Orange Pippin were employed. In apples, the red pigmentation is mostly due to the anthocyanin pigments, and published data suggested that active mitochondria were readily obtained from apples low in red anthocyanin pigments. This hypothesis was supported when active mitochondria with good respiratory control were prepared from Golden Delicious and Newtown apples, both varieties low in anthocyanin pigments. Addition of Golden Delicious mitochondria to McIntosh

mitochondria resulted in loss of respiration of the mixture, indicative of an inhibitor in the McIntosh mitochondrial preparation. The addition of a commercial preparation of anthocyanidin to Golden Delicious mitochondria also caused complete inhibition. It therefore appears that the red anthocyanin pigments are responsible.

A small increase in the McIntosh mitochondrial activity was found by doubling the polyvinylpyrrolidone concentration and adding dithioerythritol to the isolation medium.

Polyvinylpyrrolidone does not appear to be as efficient a protector against anthocyanin pigments as it is against other phenols found in apples. Unless a potent protector against the inhibitory effects of the anthocyanin pigments toward mitochondrial activity can be found, McIntosh apples cannot be recommended as a source of mitochondria for the study of senescence in fruits.

FOOD PROCESSING

Microwave Applications

Wiener processing. The previously reported microwave process for cooking wiener emulsions was investigated to determine its effect on microorganisms. The process significantly reduced the number of live microorganisms in inoculated beef wiener emulsions. Coliforms, lactobacilli, and yeasts were reduced to an insignificant level, whereas streptococci exhibited some resistance.

Microwave and gamma radiation of wieners were studied for complementary effect. Gamma irradiation of surface-contaminated, microwave-processed wieners disclosed coliforms, yeasts, and lactobacilli to be least resistant and the streptococci most resistant. The coliforms, yeasts, and lactobacilli were absent, or in very small numbers, after 0.3 Mrad of radiation, whereas 0.5 Mrad was required to reduce the streptococci to a similar level. At these treatment levels, no microbial growth occurred during 3 weeks of storage at 5 C. Sensory evaluation tests showed that bland wieners could be irradiated at levels up to and including 0.6 Mrad without a detectable flavor difference being produced.

Wheat flour α-amylase inactivation. Wheat flour containing high α-amylase activity was exposed to microwave radiation to determine its effect on enzyme activity and the functional properties of the flour. Preliminary results showed that exposures of 60 sec in a 2 kW, 2,450 MHz microwave oven produced adequate inactivation of the enzyme without undue loss of moisture or reduction in water retention of the flour, gassing power, or dough development.

Rapeseed Flour and Meal

A procedure for the production of thioglucoside-free flour and meal from rapeseed was developed. Thioglucosides are removed from crushed enzyme-inactivated seed by aqueous extraction at ambient temperature. The present batch-type procedure, however, results in approximately 17% solids loss, and further reduction in water requirement and solids loss is being investigated. Following aqueous extraction, the solids are dried and extracted by conventional methods to recover the oil. The defatted meal is bland and contains 46% protein. Air classification of this product yields a hull-free, whitish flour (55% to 60% protein) and a hull-rich meal (30% to 35% protein). These products are being evaluated for human food and animal feed. Current data show the protein efficiency ratio of rapeseed flour to equal that of casein, whereas the meal quality was slightly lower.

FOOD QUALITY AND COMPOSITION

Eating Quality of Two Basic Breeds of Broiler Chickens and Their Crosses

Relative eating quality of male and female chicken broilers from pure lines of White Rock and Cornish breeds and their reciprocal crosses was assessed. Flavor and tenderness were evaluated by the paired comparisons method. Shear force was measured by the modified Warner-Bratzler shearing device.

The panel preferred the flavor of the

males and found them more tender than the females. No flavor differences were detected among the four crosses. The Cornish male on White Rock female cross and the pure White Rock breed were rated more tender than the White Rock male on Cornish female cross.

There were no appreciable differences in shear values between sexes or among crosses.

The results of this study support the current practice of commercial poultry breeders using Cornish and White Rock as the basis of their male and female foundation stock respectively.

Ascorbic Acid in Fruit and Leaves of Red Raspberry

The possibility of using analyses for leaf ascorbic acid content as a guide to plant selection for obtaining higher ascorbic acid in the fruit was examined in a collaborative study with the Ottawa Research Station. Results from 30 clones showed no consistent relationship at different harvest dates, although the levels in the clones tended to hold the same relative positions at the same dates in two successive years. There was an indication that the concentration in the leaf is inherited in the seedlings. The ascorbic acid content of the fruit ranged from 21 to 36 mg per 100 g fresh weight and that of the leaf from 215 to 480 mg per 100 g.

Composition of Canadian Honeys

Honey produced in six provinces of Canada was studied to detect differences in composition. This work was done in collaboration with the Plant Products Division of the Production and Marketing Branch, and the Food and Drug Directorate of the Department of National Health and Welfare. The analysis of 95 samples showed very little variation in honey composition despite a variety of nectar sources, beekeeping practices, and local environmental conditions. Also, Canadian honeys were shown to meet the provisional FAO/WHO Standards for moisture, reducing sugar, sucrose, hydroxymethylfurfural, and diastase activity.

Performance Evaluation of Rapeseed Oil Products

The performance of plasticized shortenings, salad and cooking oils, and margarines containing mainly rapeseed oil was compared with that of similar products based on a wide variety of edible oils. A sensory evaluation panel of eight judges assessed the quality of the products.

The flavor of the products made with rapeseed oil compared favorably with that of other products. In a few instances, textural characteristics of the products made with high rapeseed shortening rated lower than some of the other products. These differences were probably due to minor components of the shortening rather than to the oil itself.

These results indicated that shortenings, salad and cooking oils, and margarine containing rapeseed oil perform satisfactorily in typical household applications.

POTATO QUALITY

Cell-wall Polysaccharides of Potato

In a further examination of potato cell-wall polysaccharides in relation to French fry texture, 80% ethanol-insoluble material was extracted from Netted Gem potatoes grown in four eastern and four western locations. Reproducible extractions were easily obtained, and there are promising indications that yields of 80% ethanol-insoluble material are better correlated with texture than with specific gravity. In 1968, however, the textural superiority of western over eastern potatoes noted in previous years was not present. The yield of 80% ethanol-insoluble material, on a fresh weight basis, increased with tuber maturity, but reached a plateau close to normal harvesting date.

Use of amylolytic and proteolytic enzymes (HT-1000) that operate rapidly at high temperatures (63 C) improved the procedure for isolation of starch-free cell-wall polysaccharides. Possible relations between French fry texture and the yields of cold-water-soluble, hot-water-soluble, and water-insoluble cell-wall materials are being examined. Acid hydrolyses indicated that the cold-water-soluble polysaccharide is mainly an arabinogalactan.

The water-insoluble material (ca. 2% on a fresh weight basis) showed, approximately, N, 5%; ash, 7%. Pronase digestion reduced the N content by 70%. On enzymic and acid hydrolysis, the water-insoluble material disclosed the presence of major components of uronic acid, galactose, glucose, arabinose, and xylose and lesser amounts of deoxysugar. The cell-wall fractions were obtained starch-free, as indicated by failure to stain with iodine.

Potato Starch Viscosities and French Fry Texture

In a comparison throughout the storage season of two lots of Netted Gem tubers, one of which yielded good French fries and the other poor, consistent differences were found in the viscosities of pastes made from isolated starch. In fractions prepared by sieving the dry starches, the higher viscosities of one set of fractions were consistently associated with the poorer texture. The heating times required to reach maximum viscosity were slightly lower in the fractions from tubers yielding poor French fries, and the rates of breakdown (thinning) of the pastes were higher. In both lots of tubers, the viscosity and swelling power (percentage of water absorbed on heating) of the starch increased with decrease in particle size. The viscosity of each fraction remained relatively constant through five examinations of the stored tubers.

PROTEINS

The Multiple Myoglobins of Beef Muscle

As previously reported, myoglobin consists of at least three electrophoretically resolvable fractions, the slower anodic-migrating forms being convertible into faster-moving fractions. To study the conversion reactions the fractions must be measured immediately after resolution in the gel. To this end, the disc electrophoretic system of Davis and Ornstein for polyacrylamide columns was adapted to gel slabs to enable the comparison of up to eight samples under identical electrophoretic conditions and to regulate temperature. Isoelectric-focusing with polyacrylamide gel to stabilize the pH gradient was also applied to the charge-separation of the myoglobins and yielded the best isomer resolution yet attained. Densitometric analysis using a Soret band light filter on unstained gels gave the required sensitivity.

Sampling muscles before rigor mortis onset or preventing the glycolytic fall of muscle pH with iodoacetate had no effect on the relative distribution of the three myoglobin fractions. Variation in the protein load in the gels was also without effect.

Milk Protein Sulfhydryl Groups

A simple and rapid modification of Elman's assay for sulfhydryl groups was devised for nonfat dry milk. By this procedure, the unmasking of sulfhydryl groups in milk was shown to start in 2 M urea and to be complete in 5 M urea. Maximum exposure of the masked groups occurred in the presence of 3 M guanidine hydrochloride. By using sodium borohydride as reducing agent and a mixture of acetone and HCl to destroy excess reductant, the disulfide content of milk could be determined.

Milk Protein Gels

Milk gels were prepared by heating highly concentrated skim milk slurries at 100 C and higher. As the protein concentration of the slurries was increased from 13.5 to 20.5%, gel strength increased from 70 to over 700 arbitrary units. Within the range of 5-60 min, heating time had little effect on gel strength.

Gel structure was affected by the presence of other ingredients such as cysteine (lighter color, greater strength), $CaCl_2$ (an extremely high strength), EDTA or H_2O_2 (a very low strength). Addition of some other edible components such as fat and plant protein in proper ratios improved the structure of milk gels with respect to elasticity and susceptibility to heating.

During heat-induced gelation, sulfhydryl groups were unmasked for only a very short period of time; the higher the temperature, the shorter the life of the free sulfhydryl group.

Leaf Protein

In cooperation with industry, some effects of solvent extraction on a crude protein coagulum obtained from alfalfa were evaluated. Solvents such as alcohol, acetone, chloroform, isopropanol, hexane, trichloroethylene, and ether, alone and in various combinations, were tried. Two characteristics emerged: water-miscible solvents were required first to remove as much as possible of the water present in the coagulum; color, taste, and texture were all subsequently enhanced by further extraction with solvents possessing little or no solubility in water. Satisfactory dehydration, color removal, and improvement in taste and texture were obtained with acetone followed by hexane, or ethanol followed by ether. The solvent extraction process yielded products varying from 60% to 69% protein (DMB) compared with 36% protein (DMB) in the unextracted product.

RAPESEED COMPONENTS

Rapeseed Carbohydrates

Large-scale extraction of coat-free, oil-free rapeseed (3,164 g) with boiling 80% aqueous ethanol gave a soluble fraction that, after removal of bound lipids (methanol/chloroform/water partition), yielded a lipid fraction (168 g) and an oligosaccharide fraction (454 g). Paper chromatography of the latter fraction (butanol-pyridine-water 10:3:3) showed, in addition to glucose, galactose, fructose, sucrose, raffinose, and stachyose, four nonreducing components ($R_{sucrose}$ values 2.1, 1.9, 0.73, and 0.43). Work on the quantitative composition and characterization of these oligosaccharides is progressing. Extraction of an 80% alcohol-insoluble residue (6,554 g) with hot water, after clarification with ethanol (0.3 vol), yielded soluble polysaccharide material (131 g: N, 7.03%; ash, 23%; moisture, 3.6%). A portion (123 g), after phenol/water partition (90% phenol) and precipitation of the phenol-free aqueous phase with ethanol, gave two polysaccharide fractions. The 70% alcohol-insoluble fraction was deionized with Rexyn 101 ($H\pm$), reprecipitated with ethanol (3 vol), dialyzed and freeze-dried to yield material (9.4 g) that showed N, 0.86%; ash, 1.3%; and moisture, 3.2%. The 70% alcohol-soluble fraction (7.1 g), recovered similarly, showed N, 0.3%; ash, 1.5%; and moisture 6.6%. Both the polysaccharide fractions on acid hydrolysis showed the same sugar components, namely, galactose, glucose, arabinose, and xylose, along with small amounts of mannose and galacturonic acid.

To date the various fractionation procedures have indicated that the water-soluble polysaccharides of rapeseed consist essentially of two types of polysaccharides, the so-called amyloid ones, which are characterized by their iodine-staining properties and formation of gel-like precipitates on addition of ethanol or glacial acetic acid to their aqueous solution. The second or the hemicellulose type consists primarily of an arabinogalactan.

Rapeseed Tannins

Preliminary investigation on the tannins of rapeseed, *Brassica campestris* cv. Echo, disclosed that these substances were strongly bound to the dark seed coat. After removal of simple phenols, the tan-colored residues, when boiled with acidic butyl alcohol, turned red and this pigment was extractable in the alcohol. Chromatography of the pigment indicated the presence of cyanidin and possibly pelargonidin. It may be concluded from these results that a large portion of the polymeric tannin of the seed coat is condensed tannin, consisting of a number of leucocyanidin and leucopelargonidin (flavan 3,4 diol) molecules. Other phenols identified in rapeseed extracts were quercetin and sinapine. Because unknown phenolic acids were detected in rapeseed extracts, hydrolyzable tannins may be present as well.

Residual Lipids of Rapeseed Meal

The lipids of two commercial meals and four meals prepared by different processes in the Food Research Institute were very similar. The "free" lipid class distribution of residual lipids was similar to that of the hexane extract of mature seed, almost entirely triglyceride. A larger number of components were found in the "bound" residual lipids than in the polar lipids of the hexane extract. There were differences in the glycolipids;

more sterol glycoside and esterified sterol glycoside were found in the residual lipids, whereas more mono- and di-galactosyl diglyceride had been found in the polar lipids of the hexane extract. The polar lipids of the hexane extract of mature seed and the "bound" residual lipid of the meals had similar phospholipid fractions. In both, phosphatidyl choline was the main component, whereas phosphatidyl ethanolamine was also present in appreciable quantity.

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S. J. HUGHES, B.Sc., M.Sc., D.Sc.	Fungi Imperfecti, Hyphomycetes
K. A. PIROZYNSKI, B.Sc., M.Sc., D.P.P., M.I.B., Ph.D.	Pyrenomycetes including Fungi Imperfecti
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E. SMALL, B.A., B.Sc., M.Sc., Ph.D.	Ecophysiological biosystematics

Departures

L. A. CABANA, B.A., L.S.A. Retired September 1969	Plant physiology
G. D. DARKER, B.A., M.A., Ph.D. Seconded from Department of Fisheries and Forestry; retired 1969	Hysteriaceae and Hypodermataceae
M. K. NOBLES (Miss), B.A., M.A., Ph.D., F.R.S.C. Retired June 1969	Wood-inhabiting Hymenomycetes
L. C. SHERK, B.S.A., M.Sc. Resigned May 1969	Native plants
K. WILSON Resigned July 1969	Superintendent of Operations

VISITING SCIENTIST

M. C. COLIGADO, B.S.A., M.S. ARDA Climatological Contract 1968-69	Agroclimatology

INTRODUCTION

After being separated for 10 years, the National Mycological Herbarium, the Vascular Plant Herbarium, and the Botanical Library were brought together again in the William Saunders Building in October. This consolidation forms one of the most important botanical research centers in the service of agriculture.

A revised edition of *Weeds of Canada* was completed. The new edition incorporates taxonomic changes that resulted from weed research in the Taxonomy Section, and includes 25 species not recognized as important Canadian weeds in previous editions.

The new Department Publication *Wild-rice* will fulfill an important need for a wide range of readers. A well-illustrated manual, it deals with the taxonomy, biology, culture, and utilization of this increasingly important specialty food.

During 1969 the activities in agrometeorology were concentrated on the practical application of research results for interpreting weather and climate in terms of plant responses, crop zonation, soil classification, and land use.

Intensive efforts were made to determine the causes of premature wilting of cut roses. It was found that a gradual reduction in the rate of water uptake was correlated with the deposition of unidentified materials in the conducting vessels of the stems.

Studies on the developmental morphology of the flowering apex of wheat have yielded important information and led to the development of techniques in support of cereal-breeding programs. These new concepts of yield potentials have been received with enthusiasm by cereal breeders and could make significant contributions to the development of more efficient varieties.

Our mycology staff made important contributions to the Symposia and the Nomenclature Sessions of the International Botanical Congress and at the highly productive Kananaskis Workshop on Classification of Fungi Imperfecti.

Dr. Mildred K. Nobles retired June 6, and appreciation is expressed for her meticulous work in the development of a system of identification of wood-rotting Hymenomycetes and for the concomitant revisions in classification. At the XIth International Botanical Congress, Dr. S. J. Hughes was awarded the Jakob Eriksson Medal in recognition of his far-reaching taxonomic research in Hyphomycetes. Dr. J. H. Craigie, formerly Chief of the Division of Botany, was the first winner in 1930 and is the only other Canadian to be awarded this international recognition.

Allan Chan
Director

AGROMETEOROLOGY

Crop-Weather Model Development and Application

Increasing use has been made in Canada and abroad of crop–weather models developed in this Section. The usefulness of estimated soil moisture, evapotranspiration, and parameters of crop responses including the rate of crop development and crop production has been demonstrated in various applications.

Weather Modification and Agriculture

National survey. Several staff members contributed through their research to an investigation of weather modification in relation to agriculture. It was prepared for the Canada Committee on Agricultural Meteorology. Basic information on the possible impact of weather modification on the agricultural industry in Canada was collected in a national survey and evaluated as a background for research planning.

Wheat yields. Studies were made on the use of wheat–weather relationship equations for estimating probable effects of induced increases in monthly growing-season rainfall on prairie wheat production. Over selected areas, a 10% increase in rainfall during June and July would raise prairie wheat production by 2.5% and a 30% increase would raise production by 5.5%. The equations can also

be used for assessing production losses resulting from unfavorable weather or severe damage by insects and diseases.

Irrigation requirements. Computer experiments with synthesized daily rainfall augmentations indicated that such modifications would supply at best 30% of the irrigation requirements in an arid climate. Economic benefits of rainfall augmentations were estimated to range from $12 to $69/ha through the potential crop production revenue from irrigated lands.

Agroclimatology

Days with snow cover. The winter survival of perennial crops is greatly influenced by characteristics of the snow cover, particularly its depth, duration, and continuity. Prediction equations were developed for estimating the normal number of days with snow cover in Eastern Canada from macroclimatic data.

Soil temperature. A Canada-wide study was begun to estimate monthly soil temperatures at six depths from variables related to air temperature, rainfall, snowfall, soil-temperature estimates for the preceding month, and a soil-texture parameter.

Agroclimatic Data Analysis

Climatic index. In order to obtain estimates of probable irrigation requirements and dates of the occurrences of critical freezing temperatures, analyses were carried out at 59 localities. Data from these analyses have been used to integrate the effects of several climatic factors into a climatic index that approximates the percentage of the total amount of water required by crops that precipitation during the growing season supplies.

Mapping. These analyses of long-term weather records have also provided data for determining relationships to be used in estimating frost dates, water deficiencies, and climatic indices for the 700 localities in Canada for which climatic normals have been determined. The estimating techniques minimize the effects of local siting differences, and the results are therefore helpful in land and soil classification.

MYCOLOGY

Taxonomic Research

Phycomycetes. Physiological and morphological studies of soil isolates of *Rhizophydium* and *Phlyctochytrium*, including four new species, were described. Similar studies were completed on *Hyphochytrium catenoides* Karling and *Phlyctochytrium reinboldtae* Piersal. A study was made of zoosporic fungi found on wheat infected with wheat spindle streak mosaic virus. *Polymyxa graminis* Led., *Lagena radicicola* Vanterpool & Led., *Olpidium brassicae* (Wor.) Dang., and *Rhizophydium graminis* Led. were found on wheat or other Gramineae in Ontario and their role as virus vectors is being assessed.

Basidiomycetes: rusts and smuts. A paper on the interrelationships of *Ledum* species in North America, developed in part from studies of their rust parasites, was published. It recorded the occurrence of a hybrid rust of hybrid *Ledum* plants in the Rocky Mountains of Alberta. A paper on the ecology and evolution of the rust fungi and their hosts was prepared for a symposium at the XI International Botanical Congress. Studies on the rusts of Cardueae are well advanced.

In Alberta, inocula from 18 sources representing 9 *Gymnosporangium* species were used to infect susceptible hosts and yielded taxonomically important data on aecium development time for western species.

Basidiomycetes: Hymenomycetes. Two papers were published recording the microscopic characters of types of 38 species names that have been proposed for *Merulius* in North America; of these 18 were synonyms, 10 were excluded, and 3 were rejected. Details of cultures and basidiocarp structure established that *Plicatura nivea* (Fr.) Karst., which occurs on *Alnus* is distinct from *Merulius*. The role of other fungi in the natural control of infection by *Fomes annosus* (Fr.) Karst. was described in a symposium for the Canadian Phytopathological Society.

Rigidoporus research consisted primarily of comparison of types.

The interpretation of DNA analyses of named cultures supplied to colleagues at Rice

University and the University of Texas indicated that the guanine-cytosine content may have taxonomic application in Hymenomycetes.

Cultural studies on the *Sistotrema brinkmannii* aggregate suggest that in this complex of species, which seem to be indistinguishable in the perfect state, the imperfect states produced by some members of the aggregate will be useful in characterizing several species.

The herbarium specimens in the genera *Galerina, Gymnopilus*, and *Pholiota* were revised in the light of recent monographs of these genera.

Ascomycetes: Discomycetes. A study of the comparative morphology and taxonomy of the genus *Encoeliopsis* was completed. A similar study of species of the illegitimate genus *Crumenula* Rehm was completed and the new name *Crumenulopsis* proposed.

The study of species of the genus *Phibalis* and related forms was continued. Descriptions and drawings of 17 species have been completed.

The study of species of the genus *Pezicula* was continued. It is thought that this genus may contain 60 to 70 species; detailed studies have been carried out on approximately half.

A revision of the section Discomyceteae—Operculatae in the National Mycological Herbarium was completed to bring it into line with modern concepts of classification and nomenclature.

Studies of life histories, sexuality, taxonomy, and morphology in the Sclerotiniaceae were continued. Studies of two species of *Ciboria* in Canada, *C. alni* and *C. rufo-fusca*, were completed. The host range in the latter species was found to include cone scales of *Pseudotsuga* and *Picea glauca*. Life-history and cultural studies of *Streptotinia caulophylli*, which established that the fungus was hermaphroditic and self-sterile, were published.

Ascomycetes: Pyrenomycetes. A study preliminary to a monograph of the Diatrypaceae, based on observations on more than 300 type specimens and including notes on over 1,000 published exsiccati, was completed. A paper was prepared on some Meliolaceae and Asterinaceae parasitic on conifers in Canada.

Preparations for microscopic study were made from 265 type or critical specimens in the Fries Herbarium, Uppsala, and illustrations have been made from most of these. The long-term project of providing illustrations of diagnostic features of pyrenomycetes in DAOM has passed the halfway mark. An account of the comparative development of ascocarps of *Aithalomyces* sp. and *Metacapnodium juniperi* (Phil. & Plowr.) Speg. was prepared.

Fungi Imperfecti. Antennaria Link non Gaertn., based on *A. ericophila* Link, has been used in many senses and is a *nomen ambiguum. Antennaria pinophila* Nees is redescribed and included in *Antennatula* Fr. ex Strauss (syn. *Hormisciella* Bat.). The genus *Hyphosoma* Syd., based on *H. hypoxyloides*, is shown to include three species of *Antennatula* and two other species; it is regarded as a *nomen confusum*. One of the form genera to which the name *Antennaria* was erroneously applied is described as a new genus *Capnobotrys*, type species *C. neesii* n. sp. Two form generic names are thus established for conidial states of sooty molds common in North America, Europe, and the Pacific Basin.

The genus *Trichocladium* Harz was reviewed and a new species *T. novae-zelandiae* was described. Twenty species of setose hyphomycetes from south India including two new species of *Beltrania, Beltraniella* and *Circinotrichum*, and a *Codinaea* were described. A new *Phaeoseptoria* on *Pinus contorta* from Alberta was described. For the Kananaskis Conference on Fungi Imperfecti three chapters were prepared: on methods of development of asexual spores (or sporangia) in Phycomycetes, Ascomycetes, and Basidiomycetes; on annellophores and percurrent proliferations; and on characters of conidiophores as taxonomic criteria.

ORNAMENTALS

Evaluation of Ornamental Plants

New cultivars and seedlings of ornamental plants evaluated included 1,084 taxa of woody plants, 636 kinds of herbaceous perennials, 287 different bulbous, cormous, and tuberous plants, 461 garden annuals and related plants, and 61 outdoor chrysanthemum cultivars.

The groups of annuals selected for intensive testing in 1969 were China asters, impatiens, and salvias. All showed considerable improvement in the range of colors now available, in form, and in extended flowering periods.

Caragana × *prestoniae* 'Golden Sprite', a selection from the interspecific hybrid *C. frutex* × *aurantiaca*, was propagated and distributed to nurserymen through the Canadian Nursery Trades Association during 1969.

Deterioration of Cut Roses

Experiments with the rose cultivar Forever Yours have indicated that cut blooms often wilt prematurely because of a gradual reduction in the rate of water uptake. This decline was found to be associated with a decrease in the diffusion pressure deficit of the tissues and with an increase in the water flow resistance of the stem. The increase in resistance was attributed to the correlated deposition of an unidentified material, which plugged the vessels.

Keeping Quality of Cut Flowers

Absorbents saturated with mercury perchlorate were used to remove ethylene from flower storage rooms or containers and thus extend the life of cut carnations, roses, and snapdragons. The protein breakdown that accompanied aging in flowers was studied by acrylamide gel electrophoresis. It was found that senescence-inducing chemicals such as ethylene hastened breakdown, whereas kinetin hindered this process. Aging in flower and leaf tissue induced changes in cell-membrane permeability. The changes were confined to small molecules of salts, sugars, and amino acids. Senescence was accompanied by a decrease in active uptake and in incorporation of amino acids, and by an increase in 'free space' and in leakage of solutes.

Salt Tolerance of Turf Grasses

The chloride content of leaf tissue is related to the salt tolerance of turf grass. In the field, where winter applications of road salt did not visibly damage the grass, the chloride content of tissue was less than 4 mg Cl/g dry wt. In the laboratory, turf species were able to withstand applications of chloride either by foliar sprays or by high-chloride nutrient solutions to the soil when the chloride content of blade tissue ranged from 10 to 20 mg. However, all species were seriously injured and recovery was poor when the chloride content of tissue was more than 30 mg Cl/g dry wt.

Chemical Growth Regulators

The effect of plant growth regulators (TIBA, naphthylphthalamic acid, Morphactin) on phototropism and geotropism was explained by their effect on spatial distribution of auxin and amyloplasts in tissues. Naphthenic acid and related compounds increased growth and hastened flowering of some ornamental plants.

Winter Survival of Ornamentals

The chemicals B-9 and Amchem 68-240 induced earlier autumn maturity of roses and this may be important in winter survival. The extent of defoliation in the fall was used as a measurement of seasonal maturity. Treatments with DMSO, CCC, MH-30 (maleic hydrazide), and ascorbic acid did not induce earlier maturity. Treatments with Amchem 66-329 and Maintain proved to be deleterious to roses but not to evergreens. No difference in seasonal maturity was found between the two dates of application, August 20 and September 25, 1969.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Amchem 66-329	Amchem Products Inc.
Amchem 68-240	Amchem Products Inc.
B-9 (Alar)	UniRoyal Co.
CCC (Cycocel)	American Cyanamid Co.
DMSO (dimethyl sulfonide)	Crown Zellerbach Corp.
Maintain	U.S. Borax
Morphactin	U.S. Borax

PLANT GROWTH AND DEVELOPMENT

Growing Plants in Controlled Environment

Growth-room experiments on the effects of CO_2 level and light duration on the growth and development of Michigan Ohio hybrid tomatoes were conducted at 3,000 ft-c of light, 26 C air temperature for the light periods, and 17 C for the dark periods. With atmospheric air (350 ppm of CO_2), extending the light periods from 12 hr to 15 and 18 hr increased the plant dry weights after 4 weeks' growth from 3.5 g to 6.0 and 9.8 g respectively (a 179% increase); when CO_2 was supplied at 1,200 ppm, the plant dry weight increased to 11.3 g (a 221% increase). The differences in plant dry weights were less after 6 weeks' growth so that extending the light periods gave a 75% increase and raising the CO_2 level gave a 125% increase. Extending the light periods from 12 to 18 hr reduced the time to flowering from 38 to 34 days and the time to first ripe fruit from 96 to 91 days. Raising the CO_2 level to 1,200 ppm gave no further reduction in time to flowering, but decreased the time to fruiting to 81 days.

Developmental Morphology of the Flowering Apex in Wheat Varieties

Marquis, Manitou, and Neepawa were highly daylength sensitive and initiated spikelet primordia early in the elongation phase of the apex, ultimately at the apparent expense of the foliar primordia. This initiation resulted in the cessation of apex elongation and a lowering of the total number of spikelet primordia. The Mexican variety Pitic 62 was daylength insensitive, and apex elongation continued over a long period. Numerous foliar primordia were laid down before an almost synchronous differentiation of spikelet primordia began. The result was a long ear in which development of spikelets was extremely uniform.

The German variety Opal was daylength sensitive, and spikelet formation was readily induced. Opal did not rapidly produce florets with their attendant sexual organs, but developed an abundant floral envelope of large glumes and lemmas; the glumes often fused to form a single leaf-like organ of remarkable size. The apex continued to elongate, and an exceptionally long ear was produced.

When transferred from an inductive to a noninductive photoperiod at the time of spikelet initiation, Marquis developed leaf-like appendages at the base of the spike, but showed little change in spikelet formation. Pitic 62 developed long spikelets and the head resembled the larger-flowered brome grasses.

Studies on Leaf Inflorescence and Grain Growth and Development in Wheat

Studies were continued on the developmental pattern of inflorescence and leaf formation in contrasting wheat varieties as influenced by photoperiod and mineral nutrition. Cvs. Marquis and Pitic 62 were grown under 8-, 12-, 16-, 20-, and 24-hr photoperiods and at two N levels (low N 1/10 high N) in the 12- and 20-hr treatments. Marquis was highly responsive to photoperiod over the 8- to 16-hr range in terms of apical development rates, and spikelet and leaf numbers. Response of Pitic 62 was substantially less,

but was roughly constant with each photoperiod increase from 8 to 24 hr. Hence Pitic 62 was more responsive than Marquis over the 16- to 24-hr range. Pitic 62 was extremely sensitive to variation in N level. Total grain dry weights per main-shoot ear were reduced by approximately 25% in Marquis with the reduction in N level, whereas the reduction in Pitic 62 was about 80%. This effect was mediated through a 50% reduction in spikelet number, and a 50% reduction in spikelet fertility. At the high N level Pitic 62 greatly outyielded Marquis in all photoperiods. Main-shoot (and tiller) ears of Pitic 62 carried a higher number of grains that Marquis (more spikelets/ear and higher spikelet fertility) and showed a higher mean dry wt/grain.

Growth Efficiency of Cereals

Maximum growth rates of plants and organs of Marquis wheat were similar, but low growth rates under limiting environmental conditions revealed organ priorities in utilization of assimilates for growth. Kinetics can pinpoint morphogenic changes such as those found when the rate of growth of the main stem changed from half the plant's rate during tiller production to the full plant rate when double-ridge formation (floral development) appeared in the apex of the main stem. Rates of grain filling were examined as a function of photosynthetic source. Unlike growth, it is a zero order process. The rate constant for the growth of the germinating embryo was several times the maximum for photoautotrophy. The kinetic basis of that growth is different because the rate was independent of endosperm supply.

The Physiology of Dormancy and Winter Survival of Cereal Seeds

Variable proportions of overwintered seeds of "dormoats" fail to emerge in spring. Studies were made to determine why these seeds do not emerge, and the factors in the fall and winter environment that control dormancy and survival of the seed.

Studies on two strains of dormoats of the 1969 crop showed that germination at 4.5 C on the soil surface was greater with continuous high soil moisture than with intermittent high moisture. Germination was stimulated by alternating temperatures (10 C, 8 hr day; 2 C night). Ungerminated seed from all treatments showed little dormancy (15–30%) when tested at 20 C.

In the field during the fall of 1969, germination of various strains was inversely related to spring emergence values of other years.

Imbibed dormant seed samples of various strains varied in resistance to controlled freezing stress. The relative freezing resistances corresponded closely to the previously observed spring emergence pattern of the strains.

TAXONOMY OF VASCULAR PLANTS

Major Taxonomic Studies

Systematic studies on the wind-pollinated genus *Atriplex* are continuing. Accounts have been completed of the variation and distribution of four native western North American species: *A. argentea* Nutt., *A. truncata* (Torrey) Gray, *A. powellii* Watson, and *A. dioica* (Nutt.) Macbr. A distinctive feature detected in the first three of these species is the unusual 'Kranz' type of leaf venation, which is associated with the recently discovered Hatch-Slack type of photosynthetic pathway. By comparison, *A. dioica* and the *A. patula* group of species, on which work is now under way, have 'normal' venation and presumably exhibit the regular Calvin type of photosynthetic pathway. At least two of the species in this group, which occur on the Atlantic coast, have not previously been recognized in North America.

Work on the oat genus, *Avena*, has been largely concerned with the analysis of observations made on 5,000 samples of oat cultivars and strains grown in Ottawa. This has been done to produce a classification of oat cultivars on a world-wide scale, by use of the techniques of numerical taxonomy. Micromorphological studies have provided more information on fatuoids in *Avena* and have made possible the discrimination of fatuoids, heterozygous fatuoids, and *A. sativa* – *A. fatua* F_1 hybrids in cultivated oats. It was discovered that the occurrence of fatuoids is greater in cultivars with *byzantina* type of

oats in the parentage. The first step toward the production of a register of oat cultivars with pedigrees was taken in the publication of a provisional list of pedigrees and other basic data for about two-thirds of the 1,134 listed cultivars.

Taxonomic studies of the clover genus, *Trifolium*, are continuing. An account of the *T. longipes* Nutt. polyploid complex was published and work on the perennial *T. eriocephalum* Nutt. group is nearing completion. Work continues on the important problem of infrageneric classification in this large genus, and data on pollen morphology is being assembled for many of the species.

Studies of the tribe Cardueae (Compositae) have been concentrated on *Cirsium* and *Centaurea*. A key has been published to the 26 native and introduced species of *Cirsium* that occur in the eastern half of North America, and an investigation is under way on the status of the many reported natural hybrids in this genus. Biosystematic studies on the 23 native and introduced species of *Centaurea* in Canada and the United States have been completed. As a result of a survey of chromosome number and morphology in *Centaurea*, it has been possible to develop a hypothesis regarding the evolution of chromosome numbers within this diverse genus.

A more detailed knowledge of pollen-grain micromorphology has been obtained by the use of the scanning electron microscope, and this has been applied to the classification of taxonomic and biosystematic problems in, for example, *Ambrosia, Tamarix, Clarkia, Trifolium*, and the family Chenopodiaceae.

Biosystematic studies were continued on the family Cruciferae with particular emphasis on the genus *Draba*. A manuscript that includes *D. arabisans* Michx. ($2n = 96$), *D. glabella* Pursh ($2n = 64$ and 80), *D. borealis* DC. ($2n = 80$), *D. longipes* Raup ($2n = 64$), *D. incana* L. ($2n = 32$), and *D. norvegica* Gunn. ($2n = 48$) is being prepared for publication. A new mustard species, *Lesquerella calderi* Mulligan and Porsild, was described.

Floristic Studies

A further part of the Flora of the Prairie Provinces was published during the year. A Flora of the Continental Northwest Territories is being prepared in collaboration with the National Museum of Natural Sciences.

Systematic treatments of the legumes of Canada and of the grasses of Ontario were in preparation during the year.

Weeds

The breeding systems of 80 weedy species were studied during the summer of 1969. A very high percentage of these species proved to be self-compatible and there was a direct correlation between polyploidy and both self-compatibility and the annual habit.

The editing and printing of a new edition of *Weeds of Canada* was completed during the year. This recognition manual describes 230 weed species and has 101 plates that illustrate the species by means of complete or partial line drawings.

Wild-rice

The taxonomy, biology, culture, and utilization of the Canadian native and cultivated species of *Zizania* were described in a Department Publication entitled *Wild-rice*. Wild-rice is in increasing demand as a speciality food.

Reproductive Biology

The factors that affect the overall success of reproduction of wild plant species, including breeding system, pollination biology, competition of flowers of different species for insects, production of pollen and nectar resources, behavior and reliability of pollinators, and spectral characteristics of flowers, are being studied. Reproductive biology is directly relevant to the productivity of many kinds of agricultural crops where pollination is required for seed or fruit production.

Herbarium, Index Seminum, and Plant Identification

The vascular plant collection contains 570,141 mounted herbarium specimens, a growth of 8,472 during the past year. Loans of 4,444 specimens were made to 25 cooperating institutions.

Some 7,000 packets of seed of native and adventive plants were sent to other research centers through the Index Seminum program, and in return approximately 5,000 samples were received for scientists and extension

workers in various organizations across Canada.

Approximately 2,900 plant identifications were made by the research staff of the Taxonomy Section this year. This service is performed for scientific and governmental agencies as well as the general public in Canada.

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Cartography

J. G. ROBERTS	Chief cartographer

Departure

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INTRODUCTION

This is a report of the work carried out by the Soil Research Institute in 1969.

The main concerns of the Institute were investigations of the chemical, physical, and biological factors that control the availability and supply of nutrients and moisture in soils. These studies were made to provide the basic and applied information necessary for the improvement and maintenance of the productivity of Canadian soils.

The Institute has continued work on the correlation of Canadian soils and on the taxonomic and interpretive classification of soils. It cooperated with provincial institutions in Nova Scotia, Ontario, and Alberta in soil survey programs. The Cartography Section prepared and published soil maps as well as soil capability and computer input maps for the Canada Land Inventory.

Dr. P. C. Stobbe, Director of the Soil Research Institute since its formation in 1959, retired on November 1, 1969.

J. S. Clark
Director

PHYSICAL CHEMISTRY OF SOILS

Amorphous and Crystalline $Al(OH)_3$

Because aluminum hydroxide in an amorphous form is more soluble than gibbsite, the Al concentration in the soil solution is highest at any given pH when these amorphous forms are present. Extensive work has been done to determine the conditions under which amorphous forms of Al can be transformed into less soluble crystalline aluminum hydroxide. By the use of methods developed in this laboratory, which were reported earlier, two distinct forms of amorphous aluminum hydroxide were found. Under conditions that exist in soils, one of these forms was transformed into one of the crystalline solid phases of $Al(OH)_3$. The other, however, persisted in the amorphous form unless the system was seeded with gibbsite. This apparently more stable amorphous $Al(OH)_3$ maintained a total Al concentration in true solution as high as 10^{-3} M (27 ppm Al in solution) at pH 6.0. Under these conditions most of the Al in solution was present as polynuclear hydroxyaluminum cations.

Sulfate Reactions

In the presence of basic aluminum sulfates with chemical composition close to that of basaluminite, $Al_4(OH)_{10}SO_4.5H_2O$, the value of the ionic product $(Al)(OH)^3$ was greater than that for gibbsite. The reasons for this metastability were investigated. It was found that a plot of $(2pH + pSO_4)$ against $(pAl + 3pOH)$ gave a straight line with slope equal to −4 and this corresponded to the formation of $Al_4(OH)_{10}SO_4$ according to the following reaction:

$$4Al(OH)_3(S) + H_2SO_4(S) = Al_4(OH)_{10}SO_4(C) + 2H_2O(L)$$

where S, C, and L denote solution, crystal, and liquid. The experimental values obtained were close to the value of $10^{-117.30}$ reported for the solubility product of basaluminite at 25 C. When the ion activity product $(H)^2(SO_4)$ was less than $10^{-9.3}$ the basaluminite was metastable with respect to gibbsite. Seeding with gibbsite induced the dissolution of the basic aluminum sulfate and the formation of additional gibbsite. Hydrolysis of the basic aluminum sulfates did not appear to take place and the decomposition of the solid-phase sulfates occurred simply by dissolution and the subsequent formation of $Al(OH)_3$on the surfaces of gibbsite.

Phosphate Solubility Measurements

In order to make solubility measurements to test for the existence of dicalcium phosphate dihydrate (DCPD) and dimagnesium phosphate dihydrate (DMPD) in soils containing K, Ca, Mg, H_2PO_4, HPO_4SO_4, and Cl ions, corrections must be made for the soluble complexes $CaHPO_4$, $MgHPO_4$, $CaSO_4$, and $MgSO_4$. Methods for computing the corrections that are needed for complexing were developed and evaluated by calculating the solubility products of DCPD and DMPD in pure preparations. The computations are being used for solubility studies in soils. This work was carried out in cooperation with the Department of Soil Science, University of Manitoba.

SOIL MINERALOGY

Crystalline Basic Aluminum Sulfates and Basaluminite

The X-ray diffraction patterns, differential thermal analysis, differential thermogravimetric analysis, and dehydration properties of synthetic basic aluminum sulfates were compared with these characteristics for samples of natural basaluminites. Between 100% and 0% relative humidity, which was equivalent to one interlayer of adsorbed water, basaluminite $Al_4(OH)_{10}SO_4.5H_20$ was shown to have a reversible expansion and contraction of its layer structure. These observations indicated that basaluminite was the crystalline phase formed by partially neutralizing $Al_2(SO_4)_3$ solutions in the presence of montmorillonite. In the absence of the clay another crystalline solid phase was formed.

Sand and Clay Mineralogy of Some Nova Scotia Soils

The mineralogy of some reddish brown soils from Nova Scotia was consistent with previous findings on Podzol and other soils of the province. There was marked weathering of mica and chlorite in the Ae horizons of Podzols, intermediate weathering in Degraded Brunisols, and weak weathering in the Ae horizons of Luvisols. The weathering of the clays in Gleysolic soils showed no consistent pattern.

Potassium Release

The relationship between the rate of K release when micaceous clay minerals were extracted with solutions containing sodium tetraphenyl boron or were leached with 0.1 N $BaCl_2$ and the nature of the mica layers in a series of interstratified clay minerals was investigated. The rate of K release from the minerals was lower when the calculated Si/Al^{IV} ratio of the mica component layers was close to that of muscovite, but was higher when this ratio was intermediate between muscovite and pyrophyllite. These findings supported a recent hypothesis that the composition and structure of the mica component layers may vary in different interstratified minerals of similar total composition.

Effect of Anions on Gibbsite Formation

Studies made to determine the effect of anions on gibbsite formation showed that a considerable amount of Cl was associated with the precipitate formed during the titration of $AlCl_3$ solutions with NaOH. The Cl/Al mole ratio of the solid decreased with decreasing Cl concentration and with increasing percentage of neutralization of the solution. The rate of gibbsite formation decreased markedly with increasing Cl concentration. At 0.6 N Cl, an aluminum hydroxychloride, $Al(OH)_{2.5}Cl_{0.5}$, was formed instead of gibbsite. The experiments indicated that NO_3 reacted much like Cl except that NO_3 was less strongly associated with the solid phase and therefore did not decrease the rate of gibbsite formation to the same extent as Cl. The anion ClO_4 did not appear to be incorporated in the solid and had no apparent effect on the rate of gibbsite formation.

HUMIC ACID CHEMISTRY

Alkanes in Fulvic Acid

Normal and branched-cyclic alkanes accounted for 0.16% of the weight of fulvic acid. Only 3% of the total alkanes could be extracted without methylation, but 97% yield was obtained after methylation and adsorption on Al_2O_3. About one-third of the total alkanes were *n*-alkanes between C_{14} and C_{36} and the remainder were branched-cyclic hydrocarbons. Evidence was obtained that two groups of *n*-alkanes were present. The first group made up 60% of the mixture and consisted of C_{14} to C_{23} *n*-alkanes with a C-odd to C-even ratio of 1.0. The remainder were C_{24} to C_{36} *n*-alkanes with a C-odd to C-even ratio of 1.1. The higher molecular weight alkanes were apparently retained less tightly by the fulvic acid than were those of lower molecular weight.

Fulvic Acids From Different Geographic Locations

To obtain information on the nature of fulvic acids from different locations, the acid was extracted from the B horizons of Podzols obtained from nine different locations.

Chemical and spectroscopic analysis of the purified materials from the different locations were alike in gross structural features and in functional groups, and all contained stable free radicals and increased root initiation in segments of bean stems.

Biological Decomposition of Soil Humus

A detailed study of the enzymatic degradation of Podzol Bh fulvic acids by a particulate fraction of the *Poria subacida* led to improvements in techniques so that degradation increased from 10% in 4 hr to 25% in 2 hr. Attempts to isolate the degradation products from the system as well as from controlled whole-cell cultures are being continued as a means of characterizing the fulvic acids.

Fairy Rings

The decomposition of humic acids and fulvic acids by the fairy ring mushroom, *Marasmius oreades* Fr., was less when the cultures were well aerated than under stationary conditions. Therefore improving soil aeration may be a potential means of controlling the fairy ring fungus.

SOIL BIOCHEMISTRY

Phenolic Compounds in the Extractives of Soil Humus

The phenolic compounds removed by two reagents commonly used for the extraction of organic soils were studied. The pyrophosphate or Dawson reagent was found to dissolve a variety of phenolic compounds from organic soils. Among the compounds dissolved were several phenolic acids that had been previously identified as the alkaline hydrolysis products of humus, for example, *p*-coumaric acid. In addition, *o*-protocatechuic acid, phloretic acid, and dihydroferulic acid were isolated. Evidence was also obtained for the presence of condensed tannins in the extracts.

Some of the phenolic compounds dissolved by aqueous $Ca(OH)_2$ solutions were identified. These compounds included the phenolic aldehydes and ketones found in earlier studies in this laboratory and also several *o*-dihydroxyphenyl carbonyl derivatives. Lime extraction, because of its stabilizing effect, appeared to facilitate the isolation of the labile catechol type of compounds from humus.

Amino Acid Composition of Plant Roots

The free amino acid content of the soil immediately around roots (rhizosphere) of oats grown in fertilized soil was two or three times greater than the content of unfertilized soil. Increasing soil temperature had no consistent effect on amino acid content. Serine was the most abundant amino acid. The amino acid content of the rhizosphere was highest at the third-leaf and heading stages and lowest at the fifth-leaf stage. The close relationship between the amino acid content of the rhizosphere and plant growth characteristics, such as carbon-to-nitrogen ratios, height of plant, and dry weight of tops, indicated that plant growth and physiology or metabolism have a major role in determining the amino acid content of the rhizosphere.

Soil and Soil-water Pollution From Animal Wastes

Monitoring of tile-drain effluents, wells, and piezometers was undertaken to assess the extent of soil and soil-water pollution near manure piles and on land that receives heavy applications of animal wastes. This work was carried out at the Ottawa farm of the Research Branch.

The P and K content of a small stream entering the farm was low and was not changed as it passed through the farm, but the NO_3-N content increased from between 0.1 and 0.2 ppm to values between 1.3 and 2.4 ppm. These NO_3 contents were above the minimum required for growth of algae, but owing to the slow rate of flow (0.28 m^3/sec) the amount was not considered to constitute a pollution hazard for the Rideau River.

More NO_3-N was found in the tile-drain effluents from fallow fields than on land under grass or from cornfields that had received heavy applications of N fertilizer.

Little NH_4 or NO_3 was found at depths of 120 or 270 cm in piezometers near a manure pile situated directly on the soil. Both forms

of N were high at depths of 120 and 270 cm near a manure pile on a concrete base, but after the manure was removed the NH_4-N and NO_3-N contents of the water at 120 cm decreased. There was no evidence that the manure affected the N content of the water of wells and tile drains in the vicinity.

Urea Transformation in Soils

Urea fertilizer was rapidly converted to NH_4 and the latter converted more slowly to NO_3. There was little evidence that N moved downward in a sandy soil even when heavy applications (336 kg/ha) were made to an uncropped plot. When the upper 110 cm of the soil was sampled 4.5 months later, most of the applied N was not accounted for as either NH_4-N or NO_3-N. It is not known if the applied N was lost by leaching, was denitrified, or was fixed by a chemical or biochemical process.

SOIL PHYSICS

Moisture Distribution

Progress was made in developing physical principles and computational methods for predicting moisture distributions when soils that had been partially dried were rewetted, and when water was evaporated from the surface of soil columns.

Experiments on rewetted soils involved comparisons of computed and measured soil-moisture distributions in soils that were carried through second and third cycles of infiltration and redistribution. In order to obtain acceptable agreement, the hydraulic conductivity had to be reduced to about one-half the value used for freshly packed soil. The independent domain theory was found satisfactory for providing wetting tension data during the brief infiltration period. Redistribution profiles could not be computed accurately if the soil in the transmission zone became saturated during infiltration.

When estimates are made of evaporation from soil based on the "isothermal" model, the flux from moist soil is normally assumed to be comparable with potential evaporation, and when the surface dries, subsequent evaporation may be computed on the assumption that the surface moisture content is in equilibrium with the humidity of the air. A more flexible computation (for zero insolation) was developed in which evaporation depended on air temperature and humidity and on a transmission coefficient related to wind speed. This computation was also carried out in reverse in order to determine conductivity (liquid plus vapor) as a function of moisture content, given measured evaporative fluxes at a drying surface under steady conditions of temperature, humidity, and wind speed.

Gamma-ray Measurement of Soil Moisture

A specifically designed ionization chamber for gamma-ray detection was compared with a scintillation detector for use in the gamma-attenuation measurements of the water content in soil columns. The ionization chamber system was found to be more stable and to have potentially greater accuracy. When combined with the transducer-tensiometers, the system was particularly suited to following rapid changes in water content and potential such as those that occurred during infiltration. The ion chamber and its associated picoammeter readout were very simple; thus two desirable features are the simplicity of operation and the low cost. The chamber itself was not commercially available but was constructed locally.

SOIL FERTILITY

Potassium

Because the efficient use of K fertilizer may depend mainly on its reactions with the clay component of soils, work is in progress on the fixation of added K in relation to the mineralogy of clay in some horizons of Canadian soils. Clay separated from four of the samples fixed over 90% against extraction with 1 N NH_4OAc, and the amount for one

of these was 99.7%. Another clay fixed only 28.7% of the K added, whereas values for six other samples varied from 66.1% to 78.4%. The amounts fixed against extraction with 0.1 N $CaCl_2$ agreed with the results obtained with NH_4OAc. The clays that exhibited high K fixation contained vermiculite-beidellite clay minerals, whereas the clay with the lowest fixation capacity contained a mixture of muscovite and chlorite. The mineralogy of the clays and of the release of the so-called fixed K is being investigated further.

Organic Phosphorus

Continuing studies of the organic P component of soils have shown that samples from manured plots in long-term fertilizer trials contained higher amounts of inositol phosphate esters (particularly inositol penta- and hexa-phosphates) than did the control or fertilized plots. Although hot 3.0 M NaOH was a more effective single extractant than hot 6 N HCl, hot concd HCl, or aqueous acetylacetone plus ultrasonic dispersion, the mild nature of the acetylacetone method provided an opportunity for determining the distribution and recovery of various phosphate esters, particularly those of inositol, prior to hydrolysis treatment. Recoveries in neutral NH_4 formate from Dowex-1 resin for three soils ranged from 11% to 78% of the total recovery after hydrolysis; these results indicated that there were marked differences in the form and nature of the organic P – organic matter association with soil. Fractionation of acetylacetone extracts of another group of soils on Sephadex columns revealed that a large part (> 50%) of the extracted organic P was found in molecular-weight units of over 50,000. The neo-, DL-, scyllo-, and myo-isomers of inositol were identified in all NH_4 formate fractions of the soil examined, but other P compounds could not be identified positively.

Soil Temperature

When seeded early and when, after the early boot stage, the soil moisture level was maintained at less than 50% available moisture, the new Mexican wheat variety, Pitic 62, yielded more grain than the Canadian hard spring variety, Manitou. At 50% to 100% available moisture the straw yields of both varieties were increased, but not the grain yields. At a soil temperature of 30 C, the difference in grain yield was negligible. When they were seeded late in cool soil, the yields, however, of the two varieties were the same (2,242 kg/ha), but in warm soil (30 C) the leaf growth of Pitic was heavy (5,605 kg/ha), maturation was slow (128 days), and the grain yield was lowered by 560–1,460 kg/ha. Under moderate moisture conditions there was a marked residual fertilizer effect from previous soybean, pea, and brome crops in the warm but not in the cool soil.

Fulvic Acid and Nutrient Uptake

Fulvic acid applied to a soil increased the amounts of readily extractable Fe, Mn, and Zn and of exchangeable Ca and Mg. Although the available P level in the soil was not affected, the uptake of the element by bromegrass and alfalfa was increased, and therefore the effect of fulvic acid on P uptake was a plant and not a soil effect.

Fulvic acid – iron phosphates were a poor source of P for corn grown in cultures. Combining fulvic acid, Mn, and P resulted in increased yields and a better utilization of P by plants. Fulvic acid increased the growth of the plants, but it was not known if this was due to an ion entry or to a direct stimulatory effect.

Selenium

Preliminary studies have shown that the total Se in some Gray Luvisolic soils from the Kapuskasing district and Podzols from eastern Quebec and New Brunswick was lower than in most of the soils of eastern Ontario. Because Se determination by the usual methods was difficult, a modified method was developed which has given satisfactory results with soils low in Se.

Fertilization of Potatoes

In a field experiment, the yield of potatoes was increased from 9,820 kg/ha on the control plots to 29,325 kg/ha when 134 kg N, 147 kg P, and 279 kg K were applied per ha. The site, which was in sod until recently, had pH 6.1, 0.09% total N, 7.2 ppm $NaHCO_3$-soluble P, and 0.09 meq exchangeable K/100 g soil. Where the rate of P was reduced to 49 kg/ha and K to 93 kg/ha, the yields were 28,316 and 27,240 kg/ha, respectively. The yields were alike when KCl or K_2SO_4 was used and when the P and K were applied by drilling near the seed or by broadcasting. The yields decreased, however, when

the drilled applications of N exceeded 67 kg/ha and the broadcast applications were over 134 kg/ha. Earlier work on this soil had demonstrated a higher N requirement than in the present trials where a yield of 22,734 kg/ha was obtained without additional N. Possibly N was released during the decomposition of the sod.

SOIL CLASSIFICATION AND GENESIS

Correlation and Classification

Inventory and classification of soil resources in Nova Scotia, Ontario, and Alberta have continued as cooperative programs with provincial organizations. Soil correlation work on Organic, Gleysolic, Brunisolic, and Podzolic soils was carried out on a national basis to evaluate the Canadian soil classification system and to obtain samples for laboratory study and for the evaluation and development of diagnostic criteria. A handbook, *The system of soil classification for Canada*, was prepared under the auspices of the Canada Soil Survey Committee. The selection of "benchmark" soils was completed and a program for the description, sampling, and analysis of the soils was established. A soil climatic study of Canada was started in cooperation with the Agrometeorology Section of the Plant Research Institute as part of the development of the soil map of Canada.

Soil Genesis

Studies have shown that organic-complexed Fe, amorphous inorganic Fe, and crystalline Fe oxides in soils can be distinguished approximately by selective extraction. The organic-complexed Fe was extracted with pyrophosphate, the amorphous inorganic Fe was the difference between Fe removed with oxalate and that extracted with pyrophosphate, and the crystalline Fe oxide was the difference between the dithionite and oxalate Fe. Podzol B horizons had the highest organic Fe contents of the horizons tested. Goethite or hematite was detected in a large number of the soils that had a high crystalline Fe oxide content.

Soils in New Brunswick and Nova Scotia that have light gray Ae horizons overlying reddish brown B and C horizons and that were formerly classified as Textural Podzols or Podzols were found to lack the Bf horizon and clay mineralogy of Podzols. According to present criteria, 3 of the 10 soils studied were Gleysolic (Aquepts or Aqualfs), 3 were Podzolic (Spodosols), and 2 were Brunisolic (Spodosols). Although taxonomically different, all the soils had leached, acid, and weathered sola and reddish brown B and C horizons with a bulk density of approximately 2. These soils constitute much of the agricultural area of southeastern New Brunswick and northern Nova Scotia.

Nova Scotia Soil Survey, Nova Scotia Agricultural College, Truro

The field survey of soils in Cumberland County was completed along with the necessary laboratory work. The preparation of the soil report is in progress. The resurvey of Colchester County was started. A report and map of the detailed soil survey of the Musquodoboit floodplain was completed.

Ontario Soil Survey, University of Guelph, Guelph

The detailed field survey of Waterloo County was completed and an additional 24,700 ha were surveyed in Brant County. The reconnaissance soil survey work was completed in northern Ontario and soil capability ratings were made on an additional 549,990 ha. Soil capability maps for agriculture have been prepared.

Alberta Soil Survey, University of Alberta, Edmonton

Approximately 307,395 ha were surveyed in the Medicine Hat map sheet, 73L. Soil capability maps were prepared for map sheet 82J, 82B, and 83A; they cover an area of approximately 3,645,000 ha.

CARTOGRAPHY

During the year the Cartography Section prepared 14 soil maps; 4 were published. Also, 39 Canada Land Inventory capability maps and 17 miscellaneous multicolored maps for the Canada Land Inventory were printed. There were 1,337 detailed computer land capability maps prepared for the Canada Land Inventory computer program geoinformation system. For other institutes and divisions within the Department, 9 miscellaneous multicolored maps were prepared and published.

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Research Institute
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H. G. WYLIE, B.A., D.Phil.	Host-parasite interactions

Departure

J. F. GRANVILLE, B.A. Resigned in 1969	Administrative Officer

VISITING SCIENTISTS

F. M. CHUTTER, M.A., M.Sc., Ph.D. National Research Council postdoctorate fellow, 1969	Fecundity of black flies
T. R. NEW, B.Sc., A.R.C.S., D.I.C., Ph.D. National Research Council postdoctorate fellow, 1969–70	Biological control of weeds
S. YAZGAN, B.Sc., Ph.D. Sponsored by University of Ankara, Turkey, 1969–70	Development of synthetic diets for beneficial insects

INTRODUCTION

The function of the Research Institute, Belleville, Ont., is to discover and develop ways of reducing damage caused by pests, and to do this with the least possible use of persistent pesticides. The components of a pest's ecology, behavior, and physiology that can be manipulated in selective control programs are identified and understood. Processes receiving particular attention towards this end are fecundity, mortality or stress imposed by biotic agents and physical or chemical factors, host selection and food preference, and stimuli that cause aggregation of pests.

During 1969, field trials in collaboration with the Research Station, Delhi, Ont., showed that application of virus and bacteria gives protection against cutworms and hornworms on tobacco equal to that given by the recommended treatments of DDT and carbaryl. The continuing search for compounds that serve to attract insects in nature has revealed that certain pheromones are many times more effective when combined than when used singly. The discovery of a chemical that induces certain parasitic insects to lay eggs in their hosts constitutes an encouraging step toward the long-standing goal of propagating parasites on artificial media.

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 has performed this service since its establishment at Belleville in 1919. The Institute also provides liaison with the Commonwealth Institute of Biological Control to sponsor surveys and research needed by Canada in foreign countries.

This is the seventh report, and the fourth annual report, to be published from the Institute.

Philip S. Corbet
Director

REPRODUCTIVE PHYSIOLOGY AND BEHAVIOR

Ovary Development and Antimetabolites

Certain amino-acid analogues were found to impair reproduction of the larviparous fly *Pseudosarcophaga affinis* when fed to female adults in the diet. The effects of ethionine on ovary development differed from those of imidazole, canavanine, and fluorophenylalanine. Ethionine suppressed follicular growth even in the first cycle, impaired oviposition, and inhibited hatching of eggs and depositing of larvae. It has been confirmed, by the use of radioactive amino acids, that two major proteins are actively synthesized by the hemolymph during yolk deposition, and that treatment by ethionine reduces the rate of synthesis by 50%.

Fecundity of Biting Flies

Field studies have established base lines for egg production of local pest species.

More than 800 females of *Aedes trichurus*, a snowmelt mosquito, trapped after they had fed on a donkey, were observed in the laboratory. They matured an average of 55.4 eggs/female but laid less than one-third of these eggs in captivity. Females that oviposited laid an average of 38.4 eggs/female (range 1–114). About 10% of the females survived to take a second blood meal and to mature a second batch of eggs. Some females were infected with the fungus *Coelomomyces* and, though some of these matured a few eggs, most did not.

In local populations of the black flies *Cnephia dacotensis, Simulium decorum*, and *S. vittatum* fecundity (expressed as the number of developing follicles in the ovary) is positively correlated with adult size and therefore, by inference, with larval nutrition. In the populations studied, fecundity was usually greatest in females that as larvae had existed at intermediate densities.

Factors Controlling Egg Development

Laboratory experiments showed that ovary development in an anautogenous strain of the mosquito *Culex pipiens* is initiated by the nutrient composition of the gut contents and not, as has been widely assumed, by gut distension per se. The nutrient composition

of the meal also determines the number of eggs that subsequently mature.

In the mealworm *Tenebrio molitor* mated females lay more eggs than do unmated females, though both begin to lay at the same time after adult emergence. Repeated mating by a female is necessary to replenish her supply of spermatozoa and to maintain a high rate of egg laying.

PHYSICAL AND CHEMICAL CONTROLS

Antitanning Agents

Tanning (i.e. hardening and darkening) of the cuticle after a molt is a process unique to arthropods. Compounds that can prevent or interrupt this process (antitanning agents) may have potential as relatively specific insecticides. Treatment of fully grown larvae and newly formed pupae of the house fly, *Musca domestica*, and other insects with the aromatic decarboxylase inhibitor α-MDH was found to prevent tanning of the cuticle and cause eventual death.

Autocidal Control of Mosquitoes

The feasibility of applying the sterile-male technique to mosquitoes that have already been localized by other means continues to be examined in the field and laboratory.

Oviposition attractants. Capric (decanoic) acid is repellent to ovipositing females and is an effective larvicide; but after a few days it can make treated pools more than 100 times as attractive as untreated pools to ovipositing females of *Culex restuans* in the field. Capric acid apparently provides some of the nutrients required for a complex of bacteria to grow in the water, thus making the pool an attractive oviposition site. Capric acid or its derivatives no longer kill organisms in a pool that has been made attractive in this way. Certain bacteria that digest capric acid have been isolated.

In the laboratory, females of *Culex tarsalis* have been found to prefer to oviposit next to natural egg rafts rather than next to artificial rafts or on water alone. The chemical responsible for the attraction is ether-soluble and heat-stable.

Aggregation of larvae. Responses of larvae and pupae of *Aedes aegypti* to colored light and to electric field were studied in the laboratory. Neither type of stimulus was promising for aggregating aquatic stages of mosquitoes in the field. Responses of larvae to blue, yellow, and red light varied with instar and light intensity. The positive phototaxis was strongest to blue and red in instar IV, and to yellow in instar III. Pupae were strongly negatively phototactic to all the colors at all intensities tested (approx 1–170 ft-c). All aquatic stages reacted negatively to very low intensities of shortwave (2,537 A) ultraviolet light. Responses of larvae in a d-c electric field varied with instar, voltage, and current. In general, larvae were attracted to the positive end of the field but the effect was not marked.

Chemosterilization of males. Two-day-old male adults of *Culex pipiens* treated topically with measured amounts of tepa, an alkylating agent, were sterile and yet competed successfully with untreated males for females. Emerging males were effectively sterilized by forcing them to ascend a cylinder coated with tepa, but their competitiveness varied. The timing and duration of exposure to tepa are critical for the production of sterile males that are competitive.

Ant Control by Pheromones

The possible control of carpenter ants by manipulation of their alarm pheromone is being investigated. In the three species studied, *Camponotus americanus, C. herculeanus,* and *C. pennsylvanicus*, the mandibular glands were vestigial and contained no chemicals detectable by gas-chromatographic or mass-spectrometric analyses. The dufour's glands, however, were well developed, had a bilobed structure typical of *Camponotus*, and produced a secretion that was more than 98% undecane and contained traces of decane, dodecane, tridecane, and two other chemicals that have not yet been identified.

Bioassays of undecane and formic acid (the secretion of the poison gland in *Camponotus*) with *C. pennsylvanicus* showed that undecane is a mild attractant, and formic acid is an attractant and a releaser of alarm behavior. A 1:1 mixture of these two chemicals, however, produced an attractant that

was four times as effective as formic acid and seven times as effective as undecane alone. Also, this mixture produced an active response for 1 hr and a passive response for up to 12 hr; that is, if disturbed, the ants would regroup within the first hour but not afterwards, and if left undisturbed they would remain at the site of the mixture for periods of up to 12 hr.

PREDATORS

Regulatory Effects of Predators

In the field, greenhouse, and laboratory, temperature controlled the effectiveness of the mite *Typhlodromus fallacis* as a predator of the mite *Tetranychus urticae* infesting alfalfa. During four consecutive years the density of both species of mite varied with the average day and night temperatures, the prey being a pest only during the warm growing season. In greenhouse populations the predator limited the prey increase only at constant temperatures above 70 F. In plant-growth chambers, simulations of day and night temperatures characteristic of a cool and of a warm season showed that in the field it was not warm enough during the 4-year period for the predator to be effective. The principal variables modified by temperature were rate of increase, dispersion, and synchronization of the predator population in relation to that of the prey. Therefore these factors will need to be manipulated if *T. fallacis* is to be an effective control agent.

Coccinellids

Attempts to manipulate the density of coccinellids continued. In the field, coccinellid pupae were more numerous on pickets of *Juniperus virginiana* than on adjacent plants of sweet corn var. Seneca Chief. In the laboratory, an absolute ethanol extract of *J. virginiana* was more effective as an oviposition attractant for *Coleomegilla maculata lengi* than was the wood.

PARASITES

Mirid Parasites

A new species of the braconid genus *Euphoriana* was associated with the pest mirid *Lygus lineolaris*. A population study continued of *Leiophron* parasitizing *Slaterocoris atribibialis* and *S. stygicus* on *Solidago*. The mortality inflicted by this highly specific braconid genus was sufficiently great that inoculative release of adults may offer promise for the control of certain mirids.

Parasite-Host Interactions

Females of the parasite *Phygadeuon wiesmanni* from Austria, Poland, and Switzerland were found to differ in their response to the apple maggot, *Rhagoletis pomonella*, in the laboratory. Parasites from Austria attacked the pupae and were able to complete development on the new host; those from Poland attacked the fourth-instar larva at the time of puparium formation and did not complete development; and those from Switzerland did not attack the apple maggot.

Living material of *Phryxe vulgaris*, a common parasite of the European skipper butterfly, *Thymelicus lineola*, was obtained from Europe for host-selection studies. It was found that this material could be reared readily on larvae of *T. lineola* or of *Pieris rapae*, though the strain of *P. vulgaris* already in Canada has not yet been recorded from *T. lineola*. Since the European species attacks both these hosts, it should be easy to establish in Canada.

Laboratory experiments with three hymenopterous species, *Nasonia vitripennis, Muscidifurax raptor*, and *Spalangia cameroni*, that parasitize fly pupae showed that females of *N. vitripennis* preferred to lay in unparasitized hosts, and they laid less readily in hosts attacked by *S. cameroni*, infrequently in pupae parasitized by *M. raptor*, and seldom in those attacked by its own species. The order of preference by female *N. vitripennis* for the three types of parasitized hosts is directly related to the probability of survival of her larval offspring: these often mature on hosts parasitized by *S. cameroni*, infrequently on hosts attacked by *M. raptor*, and seldom on

pupae attacked by *N. vitripennis*. Larval survival of *N. vitripennis* on the three types of parasitized hosts is inversely related to the rate of development of the competing larvae already on the host: those of *S. cameroni* develop slowly, those of *M. raptor* more rapidly, and those of *N. vitripennis* most rapidly.

A chemical factor that induces oviposition by the ichneumonid parasite *Itoplectis conquisitor* was discovered in the hemolymph of one of its hosts, *Galleria mellonella*. Chemical and physical tests indicate that the factor may be a glycopeptide. It was isolated from the hemolymph by chromatography, using Sephadex, and by boiling under reflux. Bioassays have shown that the factor occurs in Lepidoptera, Hymenoptera, Coleoptera, Hemiptera (Homoptera), Trichoptera, and Odonata (Zygoptera). It also induces oviposition by *Pimpla turionellae*, a closely related parasite. Discovery of this factor may make it possible to induce parasites to lay eggs in artificial media.

PATHOGENS

Cutworms on Tobacco

Field trials conducted at Delhi, Ont., confirmed 1968 reports that nuclear virus sprays on the rye cover crop can control damage to tobacco seedlings by the cutworm *Euxoa messoria*.

A dose of virus the same as the medium dose used in 1968 gave protection to seedlings equal to that given by the recommended treatment of DDT when the virus was combined with a sublethal dose of DDT equal to 1/40 of the total application or when followed by one or two sprays of *Bacillus thuringiensis*. The bacteria were formulated at Belleville from a special strain that inhibits feeding by cutworms.

Trap plants of tobacco set out in a field of rye attracted cutworm larvae from a distance of 6–8 m and increased the density of cutworms in the trap area by more than 100 times the mean density. Such efficient trapping offers possibilities for estimating population densities, collecting larvae economically, and controlling cutworm larvae in rye fields.

Hornworms on Tobacco

Sprays of *Bacillus thuringiensis* controlled hornworm larvae, mainly *Manduca quinquemaculata*, on tobacco as effectively as did carbaryl, the recommended insecticide. The bacteria used were formulated at Belleville from a special strain and were obtained commercially as thuricide. Thuricide is expected to be available in Canada in 1970 at about the same price as the insecticide.

INSECT-PLANT RELATIONS

Biological Control of Weeds

Studies continued on the control of noxious weeds by liberating, after screening, weed-feeding insects from abroad.

Carduus nutans and C. acanthoides. An introduction from Switzerland, the *Rhinocyllus conicus* that attacks *Carduus* flowers, survived on *C. nutans* in Saskatchewan. It was less promising on *C. acanthoides* in Ontario, but a bivoltine strain from the USSR may be more closely preadapted.

Cirsium arvense. A colony of the weevil *Ceutorhynchus litura* in Ontario increased in area fivefold to cover about 700 sq m, and invaded a separate thistle infestation 70 m from the release site. The density and vigor of the thistle, however, have not yet been affected. In their native Europe, these adult weevils seek hibernating sites before midsummer, but in Ontario they remained active until early October. A method was devised and tested for producing radioactive eggs of the beetle *Altica carduorum* to enable its predators to be detected in the field. For successful laboratory culture of the gall-forming trypetid *Urophora cardui* the number of ovipositions per plant must be restricted by limiting the time that plants are exposed to females.

Euphorbia cyparissias. A threefold increase of larvae of *Celerio euphorbiae* at

Braeside, Ont., confirmed that this moth has become established there. Authority has been requested to release another moth, *Chamaesphecia empiformis*, against spurge in North America.

Hypericum perforatum. Cage releases of the beetles *Chrysolina hyperici* and *C. quadrigemina* were made in Ontario to determine which species is the more suitable. *C. hyperici* was also released in Nova Scotia.

Senecio jacobaea. A cytoplasmic virus and a microsporidian disease caused some mortality of the moth *Hypocrita jacobaeae* in British Columbia. Neither disease was found in Nova Scotia or Prince Edward Island. The moth and the defoliation of *S. jacobaea* continued to increase in all three provinces. Larvae of *H. jacobaeae* were distributed to combat the weed in Nova Scotia by provincial weed inspectors and in British Columbia by interested farmers.

NUTRITION

Effects of Antibiotics and Mold Inhibitors on Insects

Experiments to determine the proper use of antimicrobial compounds in artificial diets for insects continued. Compounds tested in diets on axenically reared larvae of the fly *Pseudosarcophaga affinis* were: Aerosporin, Albamycin, Aureomycin, Bacitracin, Bradosol, Chloromycetin, Erythrocin, ethanol, Formalin, Gantrisin, Kantrex, methyl-*p*-hydroxybenzoate, mycifradin sulfate, penicillin G potassium, potassium sorbate, sodium benzoate, sodium propionate, streptomycin sulfate, Terramycin, Tetracyn, and Vancocin. For each compound the concentration causing least impairment of survival or development was determined. To complete this work these optimal levels will be tested to see whether they protect the diet against microbial infection.

Food Selection and Nutrition

Within a certain range of nutrient composition, larvae of *Pseudosarcophaga affinis* select the diet that is nutritionally superior, as measured by larval growth rate, size, and survival. This relationship holds good up to the point where amino acids constitute 1.125% of the diet. Beyond this point, even though diets are mildly inferior nutritionally, larvae exercise no obvious preference, showing that the range of dietary imbalance that they can tolerate is wider than previously supposed.

INSECT IMPORTS AND EXPORTS

The service function of procuring information and living insects from abroad for research establishments of the departments of Agriculture, and Fisheries and Forestry was continued. Four agricultural, eight weed, and seven forest-insect projects were serviced. About 133,000 living insects were imported from eight foreign countries and 31,000 beneficial insects were shipped to six Canadian provinces for use against the insects *Adelges piceae, Neodiprion sertifer, Psylla pyricola,* and *Rhyacionia buoliana*; and the plants *Carduus acanthoides, Cirsium arvense, Convolvulus sepium, Euphorbia cyparissias, Hypericum perforatum,* and *Linaria vulgaris.* Shipments to eight foreign countries totaled 7,576 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.

Adelges piceae (Ratzeburg)	balsam woolly aphid
Aedes aegypti (Linnaeus)	yellow-fever mosquito
Aedes trichurus (Dyar)	mosquito
Altica carduorum (Guérin-Méneville)	beetle
Bacillus thuringiensis Berliner	bacterium
Camponotus americanus Mayr	carpenter ant
Camponotus herculeanus (Linnaeus)	carpenter ant
Camponotus pennsylvanicus (DeGeer)	black carpenter ant
Carduus acanthoides Linnaeus	plumeless thistle
Carduus nutans Linnaeus	nodding thistle
Celerio euphorbiae (Linnaeus)	European spurge hawkmoth
Ceutorhynchus litura (Fabricius)	weevil
Chamaesphecia empiformis Esper	spurge root borer
Chrysolina hyperici (Foerster)	beetle
Chrysolina quadrigemina (Suffrian)	beetle
Cirsium arvense (Linnaeus) Scopoli	Canada thistle
Cnephia dacotensis (Dyar & Shannon)	black fly
Coleomegilla maculata lengi Timberlake	ladybird beetle
Convolvulus sepium Linnaeus	hedge bindweed
Culex pipiens Linnaeus	mosquito
Culex restuans Theobald	mosquito
Culex tarsalis Coquillett	mosquito
Euphorbia cyparissias Linnaeus	cypress spurge
Euxoa messoria (Harris)	dark-sided cutworm
Galleria mellonella Linnaeus	greater wax moth
Hypericum perforatum Linnaeus	St. John's-wort
Hypocrita jacobaeae (Linnaeus)	European cinnabar moth
Itoplectis conquisitor (Say)	parasitic wasp
Juniperus virginiana Linnaeus	eastern red cedar
Linaria vulgaris Miller	toadflax
Lygus lineolaris (Palisot de Beauvois)	tarnished plant bug
Manduca quinquemaculata (Haworth)	tomato hornworm
Musca domestica Linnaeus	house fly
Muscidifurax raptor Girault & Sanders	parasitic wasp
Nasonia vitripennis (Walker)	parasitic wasp
Neodiprion sertifer (Geoffroy)	European pine sawfly
Phryxe vulgaris (Fallén)	parasitic fly
Phygadeuon wiesmanni (Sachtleben)	parasitic wasp
Pieris rapae (Linnaeus)	imported cabbageworm
Pseudosarcophaga affinis auct. nec Fallén	parasitic fly
Psylla pyricola Foerster	pear psylla
Rhagoletis pomonella (Walsh)	apple maggot
Rhinocyllus conicus (Froelich)	weevil
Rhyacionia buoliana (Schiffermueller)	European pine shoot moth
Senecio jacobaea Linnaeus	tansy ragwort
Simulium decorum Walker	black fly
Simulium vittatum Zetterstedt	striped black fly

Slaterocoris atritibialis (Knight)	plant bug
Slaterocoris stygicus (Say)	plant bug
Spalangia cameroni Perkins	parasitic wasp
Tenebrio molitor Linnaeus	yellow mealworm
Tetranychus urticae Koch	two-spotted spider mite
Thymelicus lineola (Ochsenheimer)	European skipper butterfly
Typhlodromus fallacis (Garman)	predatory mite
Urophora cardui (Linnaeus)	fruit fly

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INTRODUCTION

The highlights of the Institute's activities for 1969 are summarized here. Research continued on the mode of action of toxicants (fungicides, herbicides, and insecticides) and biologically active material such as toxins associated with plant pathogens, insect attractants, and phytoalexins. The search for these materials, their characterization, and their utilization requires a multidisciplinary approach. This has increased within the institute and with other establishments in the Branch and elsewhere. The current pressure to replace the persistent pesticides has made the search for alternatives even more important. However, the need to determine any deleterious side effects and to improve efficiency is equally critical.

E. Y. Spencer
Director

BACTERIOLOGY

Structure and Composition of the Insecticidal Parasporal Body of *Bacillus thuringiensis*

The development of a milder method for dispersion of the parasporal body of *Bacillus thuringiensis* permitted fractionation of the material. Assay against the corn borer indicated greatest toxicity in certain fractions, which are being studied in greater detail.

BIOPHYSICS

The Physical-Chemical Nature and Functioning of the Cytoplasmic Membrane

For toxicants to be effective they must be transported through membranes to target sites. From a number of possible mechanisms studied the data obtained support the theory based on the possibility of transport resulting from conformational changes in a protein within the membrane. Such changes have only recently been established. In the study of membrane composition, solubilization resulted in the release of particles that may be lipoproteins or simply lipid micelles. The significance of these particles to membrane structure and activity is being examined.

FUMIGATION

Absorption and Metabolism of Fumigants by Insects

The amount and rate of phosphine absorbed by insects varies with species. The granary weevil and the confused flour beetle reacted differently to successive sublethal doses. However, from the standpoint of insect control, these repeated sublethal exposures may be expected to be lethal to the insects. Labeled phosphine ($^{32}PH_3$) was used to demonstrate the presence of phosphorus residues in wheat, flour, insects, and cystine after treatment with phosphine. However, the residue was largely water-soluble, mainly hyphosphite and phosphite.

Concentration-Time Mortality Data

Experiments on the granary weevil with methyl bromide are being used in collaboration with the Statistical Research Service to make a mathematical model. The model is expected to show the relationship of concentration and time to absorption and toxicity.

With the cooperation of the United Kingdom Ministry of Agriculture, Fisheries, and Food, tests have been made on the feasibility of using dichlorphos for the control of infestations in empty cargo ships destined to load Canadian grain for foreign markets. The results from a grain shipment look promising. Meantime, a gas-chromatographic method for analysis has been developed for use with air samples and grain.

Fumigant-resistant Insects

A phosphine-resistant strain of the granary weevil has been tested against a number of other fumigants and has shown no apparent difference in response to that of a phosphine-susceptible strain.

INSECT PHYSIOLOGY AND TOXICOLOGY

Electrophysiological Studies on Insect Visceral Muscle

In the study of insecticide mode of action and selectivity, a number of electrophysiological studies have been made elsewhere on the central nervous system of the insect, but none on the insect gut muscle. Studies on the latter were undertaken here, and these studies have shown that the electrophysiological activities resemble those of some vertebrate smooth muscles.

Pharmacologically Active Substances in Insects

In the search for alternative insect toxicants, a study of the properties and identification of a new neurotransmitter substance isolated from the gut of the roach may give useful leads. None of the phenylethyl amines examined showed stimulatory action remotely approaching that of the transmitter substance. Studies with other stimulatory substances indicated that the sites of action are clearly distinct from those of the unknown compound. Meantime, isolation of the material is under way by extraction from whole insects. Simultaneously a detailed study of the fine structure of the longitudinal muscles is being made with the electron microscope.

Mode of Action of Photoperiod in Determining Growth and Development in Insects

In the study of factors that affect diapause maintenance or termination in insects, the physiological changes to photoperiodic response are currently under investigation. An attempt has been made to correlate certain cyclic fluctuations during different photoperiods, such as neurosecretory cell size, trehalose, Na^+, and K^+ in the hindgut. Ca^{2+}, Mg^{2+}, protein, and fluorescence showed no fluctuation. Morphological changes have been examined with the light microscope, and more recently in greater detail with the electron microscope. A number of cyclic changes have been observed including the appearance of lipid droplets, which are being specifically characterized.

Isolation and Identification of Insect-feeding Stimulants and Attractants

In cooperation with the Research Institute, Belleville, Ont., the isolation and identification of chemical substances, which determine host selection by the phytophagous insect *Celerio euphorbiae* (Linnaeus), European spurge hawkmoth, continued. From the leaf wax of *Euphorbia cyparissias* Linnaeus ceryl alcohol and a mixture of long-chain aldehydes were isolated. The latter occur in only a few plants, including grape leaves, and were found in the cuticle wax of *Euphorbia esula* Linnaeus and *Lythrum salicaria* Linnaeus, on which the spurge moth feeds. Callus tissue cultures of *E. cyparissias* and *E. esula* were eaten reluctantly, which suggests that they lack the specific feeding stimulant. This possibility was confirmed by the absence of ceryl alcohol or the aldehydes in the tissue; however, β-sitosterol was found.

In collaboration with the Research Station, Winnipeg, Man., the monounsaturated triglycerides isolated from the mycelia and spores of the storage fungus *Nigrospora sphaerica* (Sacc.) Mason, which cause aggregation of *T. confusum*, were further characterized. Several triglycerides were synthesized, and the most active were triolein and 1-palmityl-2,3-dioleyl glycerol.

A more economical method for the synthesis of octadeca-*trans*-2,*cis*-9,*cis*-12-trienoic acid was developed to prepare quantities of this honey bee attractant for field studies.

Glycogen Synthesis in Insects and Mammals

As part of the program to elucidate detailed differences in vertebrate and invertebrate glycogen synthesis for ultimate use in selective inhibition, liver glycogen synthetase was investigated further. With the recent development of a greatly improved method for the isolation of synthetase, it has been possible to demonstrate the presence in liver of a factor that is required for the high overall activity and characteristic high affinity of the *a* enzyme for substrates. The factor is dialyzable and unstable on dilution.

Acetylcholinesterase

Because acetylcholinesterase is the prime target for organophosphorus and carbamate insecticides, a detailed examination of the enzyme from various sources may aid in developing selective inhibitors and in explaining anomalous toxicities. Work on substrate hydrolysis by fly-head acetylcholinesterase is nearing completion. It has been shown that the enzyme contains two anionic sites, and all observations can be explained if both are in the active center.

Mechanism of Oxidative Phosphorylation

The interference with the major source of cellular energy, oxidative phosphorylation, could be an effective form of control of the organism. During the study of the mechanism, a factor was found in the thoracic muscles of the fly that prevents the rapid decline of mitochondrial respiration and of partial reactions of oxidative phosphorylation. Subsequent purification of the factor has resulted in the identification of two distinct ninhydrin-positive spots, which are not amino acids.

Mode of Action of Organophosphorus Insecticides

With the discovery that isomers of some vinyl phosphate insecticides are differentially detoxified, attention has been extended to another insecticide in commercial use, phosphamidon. In preparation for biochemical studies, the separation of the isomers is being investigated by liquid countercurrent distribution.

FUNGAL PHYSIOLOGY AND TOXICOLOGY

The Mode of Action of Dithiocarbamate and Related Fungicides

The application of nonenylsuccinic acid, its monomethyl ester, Dexon, methylmercuric dicyandiamide, and cycloheximide showed a marked reduction in both root pressure and total amino acid synthesis. Minor variations in levels of individual amino acids were found except after cycloheximide treatment, where a significant reduction in glutamine and an increase in proline and especially gamma-aminobutyric acid was noted.

Mode of Action of the Toxin from *Bipolaris sorokiniana* and Other Dialdehydes

A large part of the action of the toxin, helminthosporal, and the monoacid on the germination of intact barley and wheat seeds may be ascribed to an inhibition of electron transfer and oxidative phosphorylation in the mitochondria of the aleurone cells. Also, the respiration of the embryo and its synthesis of gibberellin substances may be blocked. The net effect is an inhibition of amylase synthesis and other hydrolytic enzymes in the aleurone cells, resulting in a limited supply of sugar and amino acids for embryo growth and germination.

Physiology of Plant Pathogenic Psychrophilic Fungi

During a transfer of work to Zurich to extend the understanding of psychrophilic organisms, a research scientist demonstrated the psychrophilic nature of the ascomycete *Hypoxylon diathrauston* from *Pinus* and the necessity of freezing temperatures to initiate spore germination. A large number of filamentous fungi, yeasts, and bacteria were isolated from glacial soils. Their psychrophilic nature and the effect of temperature and light on their physiological and morphological responses were studied.

To aid in elucidating the source of hydrogen cyanide produced by a low-temperature basidiomycete, a method for the synthesis of

the required isoleucine-2-C^{14} was devised in a three-step procedure from glycine-2-C^{14}.

Abnormal Metabolites of Rust-inoculated Resistant Wheat

In cooperation with the Research Station, Winnipeg, further spectroscopic and chemical work on the abnormal metabolites from a rust-resistant wheat variety resulted in the identification of the ferulic and *p*-coumaric acid amides of 2-hydroxyputrescine. This is the first known report of the occurrence of 2-hydroxyputrescine in nature.

Metabolites of *Alternaria solani* and Other *Alternaria* Species

In tests at the Cell Biology Research Institute one of the pigments of *Alternaria solani,* whose structure has been determined, alternsolanol A, was shown to be active against gram-positive bacteria. Meantime more pigment is being produced for more extensive testing.

Owing to the reported toxicity of certain *Alternaria* species and reports of food contaminated with this fungi, alternariol, a metabolite of a number of these species and recently isolated here, was tested on chicks by the Animal Research Institute. However no toxic symptoms were produced at the levels used.

Phytoalexins

The hypothesis that when a plant is invaded by a fungus it produces an antifungal inhibitor, phytoalexin, is being reinvestigated. Antifungal components were found in green peppers. Work on their isolation is in progress.

PLANT PHYSIOLOGY AND TOXICOLOGY

Auxin-induced Conjugation Systems

In the study of growth-regulator-triggered synthetic processes, the induction of acylasparate synthesis was adapted to provide a specific biochemical test for auxin activity, and can be used as a rigorous test of growth-regulator action theories. A highly sensitive and specific assay for indoleacetic acid was developed, based on its conversion to a strongly fluorescent indole-α-pyrone.

Control of Enzyme and Protein Synthesis by Plant Growth Regulators

A dual-labeling technique was developed for detecting relatively short-term changes in the pattern of protein synthesis induced by growth regulators. To determine specific binding sites of these regulators, a special affinity adsorbent was synthesized.

Indoleacetate oxidase was chosen for a detailed study of the effect of plant growth regulators on the synthesis of important enzymes. Results have shown that there is an interaction of different types of growth regulators on one enzyme.

Metabolic Root Pressure and Uptake of Triazine Herbicides

In the dark, control plants transpired approximately seven times the quantity of water that would be supplied to the shoots by metabolic root pressure. The amount of atrazine found in the shoots of the plants correlated more closely with the quantity of water moving under the influence of transpiration than with metabolic root pressure. In the light, at higher rates of transpiration, similar relationships were found.

PESTICIDE BEHAVIOR IN SOIL

Interaction of Soil Microorganisms with Herbicides, Fungicides, Insecticides, and Nematocides

The potential effects on microbial populations in the soil are considerable and could lead to a decrease in fertility or an increase in crop losses from disease owing to changes in the microbial balance. Studies have been initiated with various herbicides and fungicides and a wide range of fungi, bacteria, and streptomycetes. Results indicate a great range in sensitivity, which could appreciably alter the microbial balance. Atrazine was found to inhibit many fungi, to have no effect on other

fungi, and to stimulate some. Fungicides also displayed selectivity toward various bacteria. Nabam, in contrast with other fungicides examined, did not inhibit rhizobia bacteria.

Four nematocides showed inhibitory effects on bacteria in the first week; fungal populations were depressed for 4 weeks, but they subsequently recovered to the level of the control. Ammonification of the native organic matter in the soil was inhibited in most cases. Fumigants retarded microbial activities in the soil also, but only temporarily.

In collaboration with the research stations at Vineland Station and at Delhi work was extended to a study of the effect of applications in fall and spring of some organophosphorus and carbamate insecticides and of some fumigants on microbial populations in tobacco soils. In samples taken in July, the heterotrophic bacteria had decreased from all treatments, whereas in most samples taken in June, August, and September the bacterial population had increased from treatments with the fumigants at all levels.

Microbial degradation of heptachlor was investigated with water extracts from sandy loam soils in contrast with the previous studies on pure cultures. The reductive pathway to chlordene predominated, whereas there was much less chemical hydrolysis to 1-exohydroxychlordene than with single species incubations. Oxidative products were not found until 10 to 12 weeks after the start of incubation.

Influence of Soil Type and Climatic Conditions on the Effectiveness of Soil Insecticides

Studies with lepidopterous insects have shown that larval tolerance to insecticides increased with each instar. The most susceptible stage of the dark-sided cutworm or the onion maggot was either the egg or the first-instar larva, depending on the material used.

Because residues of chlorinated hydrocarbon have been found in many soils, joint-action behavior studies with organophosphorus and carbamate insecticides are in progress. All shades of interaction from antagonistic through to synergistic have been found. The greatest effect was shown by a sixfold increase in toxicity with a mixture of DDT and the carbamate carbofuran.

To determine if there is any movement of insecticide residues from the soil, a study was made of the vertical distribution of organochlorine insecticides in soil. The results showed that with the possible exception of light mineral soils it is unlikely that residues will contaminate subterranean water supplies. Sheet erosion of topsoil is a more likely source of contamination.

During the past 3 years a four-step program has been devised for screening insecticides for insect control in soil and on vegetables. The program includes primary and secondary screening in the laboratory, a microplot trial, and large-scale field trials. Emphasis is on the development of more adequate control measures for the dark-sided cutworm and on an integrated approach for the control of insect pests of cruciferous crops. In the search for replacements for organochlorine insecticides, a few organophosphorus and carbamate candidates have been found. However, they are not complete replacements, because some are less effective under dry conditions, others are toxic to bees, and some have a serious effect on some of the nontarget soil invertebrates.

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National Research Council postdoctorate fellow

J. DOKLADALOVA (Mrs.), M.Sc., Ph.D., 1968–70	Pesticide residues

INTRODUCTION

The Analytical Chemistry Research Service has cooperated directly with Research Branch personnel in many of their projects and in addition has continued to provide expert knowledge, advice, and assistance to Branch establishments in analytical chemistry as required for the solution of agricultural problems.

A new pesticide residue chemist reported for duty in March and we have been able to continue a team approach in pesticide residue work and to extend it to include organophosphorus compounds, their metabolites, and breakdown products in soil and animal tissues.

The purchase of a mass spectrometer and the provision for the purchase of nuclear magnetic resonance equipment will provide us with the nucleus for an instrument center that should be of great value to Branch establishments in the Ottawa area.

R. B. Carson
Director

INORGANIC CHEMISTRY

Selenium in Biological Materials

The valence states of certain trace metals are known to have marked effects on biological activity. Through studies on its responsiveness for alleviating deficiency diseases such as nutritional muscular dystrophy in calves, lambs, and pigs, Se has been categorized as an essential dietary element for farm animals, but its high toxicity continues to be of grave concern. It would be helpful to be able to establish the form or forms of Se that afford optimum responses during animal treatment, but result in the lowest Se residues in the tissues.

A scheme of analysis allowing for partitioning of total Se in the nanogram range into Se^{VI} (selenate), Se^{IV} (selenite), amino-acid Se, and other organically bound Se has been developed and found to be valid for such systems as rumen juice, urine, and water extracts of agricultural materials where the form of the Se is not altered by the necessity to ash the material.

Inorganic Se is separated from organically bound forms on ion-exchange columns composed of specially purified resins. Se^{IV} is separated from Se^{VI} by complexing with diaminonaphthalene and extracting with cyclohexane. Amino-acid Se can be recovered quantitatively from the columns and other organically bound Se held on the column is determined by wet digestion of the ion-exchange resin.

The micro method for Se in biological materials has been modified to avoid the fluorescing interference that may be obtained from some materials and by increasing the amount of EDTA to allow full recovery of Se from large samples of dried blood or powdered coal.

Multielement Analysis

The requirements for multielement analysis for such mineral and trace elements as Na, K, Mg, Ca, Cu, Fe, Zn, and Mn are being met through the development of reliable procedures using atomic absorption spectroscopy for the final estimation step. Sample preparation, which has always been difficult for agricultural and biological materials, remains the limiting factor in taking full advantage of the time saving offered by atomic absorption analysis.

Conventional methods of sample preparation call for either dry or wet ashing. Although complete destruction of organic matter is essential for either colorimetric or gravimetric methods, it seems possible that the high temperatures generated in atomic-absorption burners would be capable of giving quantitative results on samples that are simply dissolved or dispersed in acid.

Concentrated HNO_3 has previously been used for the dispersal of animal tissues prior to certain radioactive measurements. This "pseudo wet digestion" was considered to offer the best possibility for atomic absorption applications because HNO_3 is an excellent medium for dissolving mineral and trace elements.

Work to date has established that "pseudo wet digestion" can be used for multielement

analysis on a wide variety of agricultural samples. The technique, which is still being refined, should result in a considerable saving of time and holds out the possibility of dispensing with the need for perchloric acid hoods for many applications.

ORGANIC CHEMISTRY

Pheromones of the Honey Bee

More than 50 esters, ranging in molecular size from methyl formate to octyl butyrate, were tested on bees for the production of alarm reaction. A correlation with their infrared spectra is being attempted.

Fluorine

A micro analytical method has been developed for the determination of fluorine in organic compounds following oxygen-flask combustion and using a fluoride ion specific electrode.

Chemotaxonomy

In cooperation with Dr. T. Rajhathy, of the Ottawa Research Station, a genetic study is being carried out on varieties of oats using thin-layer chromatography of the phenolic fraction extracted from the leaves.

Coumesterol

A thin layer chromatographic fluorometric method for screening of coumesterol-type compounds in clover has been developed in collaboration with the Ottawa Research Station.

PHYSICAL CHEMISTRY

Fulvic acid is a typical humic material occurring widely in nature, including soils. It is important because of its ability to form complexes with metal ions. The work described below was undertaken to elucidate the complexing mechanism and to permit quantitative measurements to be made of complexed metal ions in soils and large bodies of water.

Complexing of Cu^{2+} by Soil Organic Matter

Cation-exchange experiments have been completed for the measurement of the Cu^{2+} – fulvic acid chelation equilibrium. A Cu^{2+} – Dowex 50W-X8 ion-exchange calibration curve was prepared by fitting 51 data points from four sets of experiments to a straight line by the method of least squares. Two sets of ion-exchange chelation experiments were carried out.

A Job's Continuous Variations experiment, which employed a solid state Cu^{2+} electrode, has demonstrated a 1 to 1 mole ratio of Cu^{2+} to chelating sites in the Cu^{2+} – fulvic acid chelate.

Complexing of Fe^{3+} by Soil Organic Matter

Sufficient Fe^{3+} – H^{+} – Bio-Rex 70 ion exchange data have been obtained, both with and without fulvic acid, to permit estimates of the Fe^{3+} – fulvic acid chelation equilibrium. An attempt is being made to consolidate these data with further experiments.

Fulvic Acid Titration Curves

The calculation of metal ion – fulvic acid chelation equilibria requires a knowledge of the types, numbers, and ionization equilibria of the fulvic acid functional groups. The potentiometric and conductometric titration curves obtained for this purpose have disclosed typical polyelectrolyte properties. This fact must be taken into account during the calculation of titration end points and of Ka values.

PESTICIDE RESIDUES

Soils

The second year of the check sample program for pesticide residues in soils of the Canadian Committee on Pesticide Use in Agriculture has been completed. Six soil samples were circulated to federal, provincial, private, and industrial laboratories in Canada. The program was extended to include organophosphorus compounds and more emphasis was placed on the positive identification of compounds. Polychlorinated biphenyls and chlorine containing organophosphorus compounds were added to extracts to see what problems, if any, would be encountered by the analyst. From results received to date it would appear that if a phosphorus detector is not used electron-capturing organophosphorus compounds can be misidentified. Thus ronnel, diazinon, parathion, and ethion were identified as aldrin, lindane, *p,p'*-DDE, and *p,p'*-DDT respectively on a DC-200/QF-1 column even though thin-layer chromatography was used as a confirmatory test. The results for the past 2 years are being analyzed to see if any conclusions can be drawn regarding the performance of individual laboratories. The third year's program is in the planning stage and it is hoped that it will be possible to include some herbicides among the samples.

Trichloroacetic Acid Residues in Crops and Soil

A modified method for the determination of trichloroacetic acid residues in soil, vegetables, cereals, and milk has been developed. The original procedure, developed in this laboratory, employed a microcoulometric – gas chromatographic procedure (J. Ass. Offic. Anal. Chem. 49:341. 1966). This detector system is expensive and not many laboratories have facilities for microcoulometric analysis. Earlier attempts to utilize the more common electron capture detector failed, but use of an XE60 or a Poropak Q column has overcome solvent interference problems. In collaboration with laboratories from Regina, Brandon, Lethbridge, and Taber trichloroacetic acid in wheat, oats, barley, corn, potatoes, sugar beets, and soil have been determined. The method is now being extended to dicofol and other pesticides that yield chloroform on decomposition.

Nicotine Residues in Pigs

A method for the determination of nicotine residues in pig's liver and carcass has been completed. This work was undertaken because experiments in the Branch had established that nicotine incorporated into the diet of pigs had a beneficial effect on growth. The procedure is limited by the background level of "apparent nicotine" of 0.3 ppm for liver and 0.5 ppm for carcass. Interfering materials are encountered by both spectrophotometric and gas chromatographic procedures. Attempts to reduce this background level by various cleanup procedures, e.g. ion-exchange, column, and thin-layer chromatography, partitioning, steam distillation, and chemical derivatization all failed. An examination of the literature disclosed that although many biogenic amines are present in liver few have been identified. Degradation of nicotine by liver was, however, known to be rapid. Experiments using fresh pig liver homogenates confirmed these results and indicated that nicotine residues in liver were unlikely to be a problem.

Pesticide Residues in Poultry

A new project has been initiated with the Animal Research Institute that involves the effect of feeding low levels of a mixture of organochlorine, organophosphorus, and herbicide pesticides to poultry. Analytical techniques for the determination of these materials in such things as eggs, poultry tissue, fat, and feathers are being developed where needed.

Dicofol Residues

Under alkaline conditions dicofol was hydrolyzed to chloroform and estimated by electron capture gas chromatography. Eggplants from a soil containing 0.4 ppm dicofol had residues of 0.03 to 0.45 ppm.

Thin-layer Chromatography of Urea and Triazine Herbicides

The thin-layer chromatography of linuron, neburon, siduron, fenuron, diuron, monuron, propazine, prometon, atrazine, and simazine was studied. Silica gel and alumina oxide layers were used, together with more than 20 solvent systems and two detection methods. Optimum conditions were determined for the

separation of either urea or triazine herbicides.

Organophosphorus Residues

A start has been made on a study to compare the efficiency of extraction of organophosphorus pesticides from soil. Complete recovery of diazinon was obtained from a sample of clay loam soil containing lindane, heptachlor, aldrin, dieldrin, *o,p'*-DDT, and *p,p'*-DDT to which 10 ppm of diazinon had been added.

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INTRODUCTION

The continuing need for improved mechanization and efficiency in agricultural production, for increased accuracy and greater facility in conducting scientific research, and for controlling some aspects of the environment in which man and animal must live gave impetus to the research and development activities of the Service.

Cooperative projects using the systems concept were conducted in dryland pasture renovation and in animal waste disposal, with special attention to soil, water, and air pollution.

New plans were designed and developed for the Canada Farm Building Plan Service in swine and dairy housing systems that incorporated recent research results.

An experimental plot harvester, typical of mechanized equipment that facilitates field research, was developed and evaluated.

Spectroradiometers for studying the effect of radiant energy on apple quality and coloring and an automatic data logging system used in animal physiology studies are typical of special instruments and facilities developed to increase flexibility and efficiency of scientific studies.

The periodical ERDA, through its four regular issues and supplements, published a wide range of results of engineering research and development activities in Canada and other countries.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

Most of the developmental work outlined here was carried out in cooperation with federal and provincial government agencies, universities, consulting engineers, and agricultural industries. The staff provided advisory service by conducting three seminars on environmental control in farm buildings, and by assisting in the preparation of the *Canadian Code for Farm Buildings 1970.*

Developmental Research Program

A project was initiated in cooperation with the Research Station, Lethbridge, Alta., to optimize dryland pasture renovation. To determine the best conditions for utilizing the native pasture while new grass becomes established, alternate strips of various widths of native grass and tillage seeded to Russian wild ryegrass were established. A rotary cultivator was successfully used for the strip tillage.

Work continued in cooperation with the National Capital Commission and the Animal Research Institute on the design and development of a handling and storage system for liquid wastes of dairy cattle. Design of a low-cost storage structure was completed.

A small monitoring network was established in cooperation with the Soil Research Institute to make a preliminary study of the pollution potential from fertilizers and animal wastes.

Two studies were completed on the development of systems to reduce odor and pollution potential when animal liquid wastes are applied to cropland. In cooperation with the Animal Research Institute, a study was made of the feasibility of applying liquid manure from vacuum tankers in a strip on the soil surface or immediately burying it by plowing it in. The second study concerned the establishment of an experimental oxidation ditch in British Columbia for the partial aeration of swine wastes to control odor. Construction of the unit was completed in 1969 at the National Hog Enterprises Limited Farm in cooperation with the British Columbia Department of Agriculture and the University of British Columbia.

An investigation was conducted into the requirements of a product standard for corrugated plastic drainage tubing, and in cooperation with personnel from the Ontario Government and the manufacturers of plastic tubing a tentative standard was prepared for the Ontario Farm Drainage Association.

Studies of ventilation systems were con-

ducted in controlled-environment animal buildings at the Animal Research Institute. For a high-density caged poultry brooder building, the best ventilation for summer was obtained from fresh air inlets with 72% of the air coming from holes discharging horizontally near the ceiling, and 28% from slots discharging down the wall. Winter ventilation, by means of the adjustable inlet holes only, was not completely satisfactory, and further work is needed.

Wood is being conditioned for evaluation of rotational resistance of roof truss joints. A test apparatus has been designed and built. The effects of large-diameter nails on the tensile strength of plywood truss gusset plates were evaluated.

A project is under way for the development and testing of insulation systems most suitable for use in controlled-atmosphere storage buildings. Model structures with sprayed-on polyurethane insulation are subjected to a wide range of temperatures and vapor pressures in order to evaluate adhesion and moisture problems.

Canada Farm Building Plan Service

Results of research on building structures and on environmental control were applied directly to plans and information prepared for use by provincial extension engineers and the agricultural industry. The Swine Housing Committee progressed with development of systems for integrated swine production especially suited to the Canadian climate. Planning was also initiated on dairy housing systems and fruit and vegetable storage.

RESEARCH SERVICE

Besides the work that has been described, assistance was given to other government agencies, universities, and industry in solving a wide range of technical problems. During the year the Service workshop completed 170 fabrication orders.

Equipment for Mechanization of Plot Experiments

A mechanical harvester for chufa, *Cyperus esculentus* L., an oilseed crop, was completed. This machine was constructed to develop the lifting, topping, elevating, threshing, and sieving mechanisms required for commercial harvesting of this new crop.

A cereal harvester with a vacuum-blower to gather and partly thresh the cut material was constructed for two-row experimental plots. This harvester reduced the labor required by blowing the harvested material directly into a bag.

A thresher was developed to increase the efficiency of stripping stems from lamina of experimental tobacco samples.

Several commercial machines for seeding, harvesting, and threshing experimental or small-scale farm crops were tested. Recommendations were made for application of these machines, and details of required modifications were forwarded to the manufacturers.

A sprayer was completed for applying nonselective herbicides on the soil between plot rows. Low-pressure driftless spray heads were used to generate preselected spray patterns by vibration.

Environmental Apparatus

A differential thermal analysis technique was developed for the characterization and identification of complex protein mixtures. An inexpensive but sensitive apparatus was then produced.

An environmental cabinet was constructed for the study of insect–environment–insecticide interactions. The working volume (45 × 45 × 30 cm high) was controlled within ± 1 C and ± 5% relative humidity from 4 C to 50 C and from 15% to 95% relative humidity at light intensities up to 2,000 lumen/m^2.

A liquid-nitrogen-cooled cabinet was developed for studying the supercooling of insects in overwintering biology. A linear cooling rate to –70 C was achieved.

For the study of seed germination and winterhardiness of plant material a 50-cm-long temperature gradient bar was developed. A linear gradient of 11 C to 33 C

controlled within ±0.5 C could be selected within -20 C to 20 C.

Instrumentation

A paddle type of dough mixer was developed for evaluating baking properties of wheat breeders selections by using only 10 g of flour. Techniques were established to obtain repeatable results and to record and evaluate dough development curves by computer techniques. Two 100-g mixers used in cereal baking tests were modified to record test dough development so that it can be mixed for the optimum time.

Two instruments were completed for measuring tobacco filling value by compressing a shredded sample in a cylinder. One was designed for industrial quality control, and the other for research into the rheological properties of tobacco.

A study of the airflow around shelters for alfalfa leaf-cutter bee hives was made in a water-flow visualization tunnel. A modified shelter design, limited to the addition of flat plywood sheets, reduced turbulence at the shelter entry.

Two systems were assembled for automatically recording the weight of hay in drying experiments.

Electronics

An electronic system was developed for counting tobacco seeds at 240 seeds/min with a 1% error.

A portable spectroradiometer was completed for recording radiant energy at eight wavelengths ranging from 4,400 to 7,300 Angstrom. The 60-sec output of each photodiode was integrated simultaneously and stored by an electronic memory. A similar instrument was developed for continuously recording total energy at three selected wavelengths.

A study of automatic data logging systems was completed to examine the advantages of small on-line computer systems. It was concluded that for studies on animal physiology the increased flexibility and efficiency obtained offset the increased cost.

Apparatus was developed for detecting viable larvae of the alfalfa leaf-cutter bee so that they can be selected for commercial sale by measuring the dielectric constant.

Equipment was developed for detecting and recording biopotentials during the salivation process of aphids.

TECHNICAL AND SCIENTIFIC INFORMATION

In its service to engineers and research scientists of the Branch this section maintains an expanding technical and scientific collection of information on agricultural engineering. This section has cooperated with research personnel in the preparation of reports and scientific articles, and in conducting surveys.

Scientific information is exchanged with other government departments, and service has been provided to universities, provincial departments of agriculture, and to the agricultural industry.

A list of current agricultural engineering research and development projects in Canada was compiled and published in ERDA Supplement 2.

The engineering periodical ERDA informs agricultural engineers on new developments and practices, and acquaints agricultural engineers outside Canada on the progress of research in this country.

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Statistical Research Service
Ottawa, Ontario

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M. R. Binns, M.A., Dip. Stat.	Design of experiments, sampling
D. J. Clark, B.S.A.	Systems and programming
C. R. Fahie (Mrs.), B.Sc.	Systems and programming
M. E. Gibson (Mrs.), B.Sc., M.Sc.	Design of experiments, multivariate techniques
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L. P. Lefkovitch, B.Sc.	Quantitative ecology, numerical taxonomy
C. S. Lin, B.Sc., M.S., Ph.D.	Quantitative genetics
A. Petrasovits, B.Sc., M.A.	Bioassay, organoleptic tests
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I. D. Richardson, B.Sc., M.Sc.	Analysis coordinator
C. S. Shih, B.Sc., M.Sc., Ph.D.	Design of experiments
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Departures

P. K. Hill (Mrs.), B.A., M. Math. Resigned Nov. 1969	Biometrics
E. C. Pielou (Mrs.), B.Sc., Ph.D. Resigned Feb. 1969	Quantitative ecology
G. J. Rowlands, M.A., Dip. Stat. Resigned May 1969	Head of computer science section; design of general programs
M. A. Wightman, B.Sc., B.Ed. Resigned Nov. 1969	Systems and programming

VISITING SCIENTIST

M. Fazil Sabir, West Pakistan Canadian International Development Association trainee

INTRODUCTION

The Statistical Research Service provides advice and assistance on statistical problems that arise in the research programs of the Department and carries out the associated research on statistical methodology. The unit also develops and maintains a computer library of general statistical programs, which is used to analyze data from experiments and surveys.

During 1969 a large amount of time was devoted to the analysis and interpretation of data from complex experiments, often with the use of multivariate models. An example of one of the experiments that caused considerable difficulty was an investigation in which complications arose from the unbalanced split-plot type of design, which had unequal subclass numbers, variances changing with age, treatments effectively changing as the experiment progressed, and possible competition and other behavioral effects.

The analysis of this and other complicated experiments was greatly facilitated by the use of our library of general statistical programs. During the year new programs were developed and older ones modified and expanded to meet new demands. New programs mentioned in this report are referred to by their library reference number in parentheses, for example (S105). As more versatile and powerful programs become available, new dimensions are added to the biological research, resulting in requirements for additional mathematical and statistical treatment.

Investigations into different methods of optimizing various functions have provided valuable experience, and resulted in the development of a powerful set of computer routines. The success or failure of the different optimizing techniques in converging to an optimum depends on a number of factors, and therefore care and mathematical insight are necessary in selecting the appropriate method, or combination of methods.

Other research has been concerned with problems arising in ecological work, particularly with the sampling of insects and other pests in orchards, and the subsequent mathematical and statistical treatment of the data. Because of the complexity of these problems greater emphasis is being placed on these aspects of our work.

The programming courses, started in 1967, were continued in the early part of the year. These courses were designed to introduce scientists in the Department to the general potential of the computer. Complementary courses to discuss the capabilities of our general programs and to provide some practice in using them were planned in the summer and will be given as soon as conditions allow.

P. Robinson
Director

BIOMETRICS AND COMPUTER SCIENCE

Statistical Ecology and Population Dynamics

Progress was made in finding a mathematical link between age-structure and stage-structure models of population growth. Some further insight was obtained into the length of a generation: distinction is made between the stable generation length and the current generation length; the former is a special case of the latter. Both measures of generation length may be defined in terms of the mean age of mothers of newborn offspring, and also in terms of the invariants of population growth.

Various problems related to sampling in orchards and subsequent data analysis were handled during the year. These included advice on the design of an experiment for testing a complex hypothesis on the distribution of insects in an orchard, and advice on the type of information needed for testing the hypothesis.

Work continued on the study of mite populations, and the interactions between phytophagous and predator mites. Studies on the relationship of numbers of *Euxoa* spp. to environmental factors continued.

Food Research

A number of taste-panel experiments were designed and analyzed during the year. These experiments included work on poultry,

eggs, beef, cheese, and tomatoes, and problems that arose in the Food Advisory Services Section of the Production and Marketing Branch as well as in the Research Branch.

The availability of computer programs for analyzing data from more complex experiments has resulted in the use of more efficient designs and analyses in trials based on subjective assessments. For example, a general program was prepared to handle paired comparisons from two-factor experiments; the program provides for up to 25 treatment combinations, and allows for ties (S040). Another program (S050) was used to analyze multivariate data from paired comparisons.

Bioassay

Bioassay problems of many different types were handled. These included ordinary probit lines, planes and hyperplanes for quantal assays, time-response assays using procedures newly available in a program developed during the year (S105), quantitative assays for hormones and herbicides, and applications of the new general multivariate program (S104) for complex quantal assays.

The bioassay model for polychotomous responses was applied to the classification of apples for different degrees of deterioration in storage, in order to assess the suitability of the currently used scoring system.

Data from an investigation on the absorption of fumigants by insects and on the subsequent metabolism effects on those insects were analyzed by using a combination of quantal and quantitative bioassay methods.

A new computer program (S106) was used to analyze quantal data from a mixed population of relatively susceptible and resistant individuals.

Breeding and Quantitative Genetics

A computer system (S559-64, 569, 585-6) was developed for maintaining an up-to-date register of oat cultivars and all available information on the ancestors of each cultivar. The computer generates an alphabetical list of cultivars, provides cross-references for synonyms, and draws pedigree charts in a form for direct reproduction.

Programs in the system may be run independently. The total system, or parts of it, may have application in other areas of crop breeding. The possibility of using some of the programs for registered breeds of farm animals is being explored.

A computer system (S557, 567, 851) was developed for preparing monthly summary tables of economic returns and other data from various treatments in a poultry experiment. The system also provides summaries for selected periods.

Numerical Taxonomy and Classification of Methods

As the number of individuals in a group subjected to taxonometric methods increases, the requirements for computer storage also increase, but storage requirements increase much faster. Therefore, existing programs can only deal with relatively small numbers of individuals. Progress has been achieved in the use of a new method for selecting a reference set of individuals with respect to which those remaining may be grouped.

Efficiency is important in numerical taxonomy programs, because of the large amount of data manipulation required. Newly acquired and developed programs are more efficient than our earlier programs and they have eased the demands on computer time. One of these programs (S014), a modified version of a program obtained from Rothamsted Experimental Station, England, performs a single-linkage cluster analysis; another (S018) obtains monothetic divisions by the use of those characters that have the highest multiple correlation with the remainder.

Possible agreement between groupings obtained from numerical taxonomic methods and groupings based on genetic relationships is being explored.

General Statistical Programs

Initiated in 1968, the system for standard input to general programs has been enthusiastically received. The data can be read in any specified format, without the need to recompile, and specifications of the design and the required analyses are given in a simple standardized form.

These procedures have proved to be far less error-prone than our earlier procedures; scientists and technicians find them easy to learn and use; and they satisfy requirements for versatility in an environment covering a

broad spectrum of different types of statistical analysis.

Many of the older programs have been converted to the new system, and all new general programs are written to accept specifications in the new form. The input to the new version of MINFAC (S022), for example, permits specification of complex designs with mixed nested and crossed classifications, and allows pooling of specified sums of squares.

In addition, many of our programs have been modified and extended in the light of experience and as improved techniques are developed or become available in the literature.

A teletype terminal has been installed, which permits connection with a number of commercial facilities. Experience is being gained on the use of the terminal for development of programs for running in batch mode, and on its use in applications in conversational mode.

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Research

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Research Station
Brandon, Manitoba

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INTRODUCTION

This report describes progress in long-term experiments and the main research findings in 1969. Research at Brandon emphasizes animal breeding and physiology; plant breeding, physiology, and management; and soils–agronomy research on fertility, cultural practice, crop rotations, and weed control.

Dr. R. I. Hamilton joined the staff in forage physiology and management and this research program has been expanded. Dr. G. W. Rahnefeld, a geneticist in animal breeding, returned to the Station after completing a postdoctorate transfer at the Genetics Section of CSIRO, Sydney, Australia. Mr. L. D. Bailey, a specialist in soil fertility, continued on educational leave.

Highlights for the year included the initiation of research with European breeds of cattle and the approval of a new variety of malting barley for licensing.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Foreign germ plasm. Six Limousin bulls and four heifers were imported by the Department for the Station. These animals will form the nucleus of the breed, which will be studied for its potential for beef production. The cattle have responded favorably to the Canadian climate, and their growth rate has been normal. On arrival the bulls averaged 409.1 kg at 14 months of age, and 10 months later, 681.3 kg. The heifers averaged 347.2 kg at 14 months of age and 480.8 kg at 24 months.

The bulls were mated by artificial insemination with Hereford, Aberdeen Angus, and Shorthorn cows. The F_1 hybrids will be evaluated on their growth, feedlot performance, and meat production.

Semen characteristics of Limousin bulls. When the six Limousin bulls averaged 21 months of age and 630 kg in body weight, semen was collected from each bull as single ejaculates at 48-hr intervals. The average semen composition was as follows: semen volume, 2.2 ml; sperm concentration, 1,688 million/ml; motility, 67%; total sperm per ejaculate, 3.94×10^9; and motile sperm per ejaculate, 2.77×10^9. Wide variation was observed among the six bulls, but all were easy to handle and showed good sex drive.

Response to selection. Eight years of single trait selection for yearling weight in Shorthorn cattle resulted in an estimated average genetic gain of 2.9 kg per year. Correlated responses in weaning weight and birth weight produced average gains of 0.68 and 0.20 kg per year. In the same period, improved management and other environmental factors produced improvements of 5.1, 0.34, and 0.10 kg per year in yearling, weaning, and birth weights.

Meat quality in bulls and steers. Hips of beef from bull and steer half-sibs were compared for fat and lean content, fat cover, and individual muscle components in Brown Swiss × Shorthorn crossbreds and two Shorthorn lines (selected and control). Bulls had a higher percentage of lean meat and a lower percentage of fat than steers. There was little difference in intermuscular fat (marbling) and nearly all the difference was in fat cover. Crossbreds had the highest percentage of lean meat, followed by straightbred Shorthorns selected for growth performance and control-line Shorthorns.

In steers the inside thigh muscles (semimembranosus, sartorius, and gracilis) form a higher percentage of the hip than in bulls. The situation is reversed in the outside thigh muscles (semitendinosus and biceps femoris).

Swine

Influence of sire on litter size. In 277 Yorkshire and 356 Lacombe litters sired by 131 and 163 boars, the sire showed a significant effect on the total number of pigs born, the number born alive, and the number weaned.

Development of the reproductive tract in Yorkshire boars. To study the development of the reproductive tract Yorkshire boars were killed in groups of 5 at 1.4, 12, 29, 39,

48, 56, 65, 75, and 84 kg of body weight. Over this weight range some simple correlation coefficients were: body weight with testicular weight, 0.86; with epididymal weight, 0.87; with seminal vesicle weight, 0.60; and with bulbourethral weight, 0.83. Correlations of age with these components were 0.82, 0.84, 0.59, and 0.80. Spermatozoa were observed in the tail of the epididymis as early as 110 days of age.

Effect of low temperature on litter size. When gilts were subjected to temperatures as low as –40 C during breeding and pregnancy there was no adverse effect on litter size. Gilts housed in a heated piggery averaged 9.3 fetuses after 60 days of pregnancy, compared with 9.6 fetuses for gilts maintained outside with only a wood cabin for shelter.

Effect of nutritional level on litter size. Gilts individually fed a maintenance ration carried larger litters after 60 days of pregnancy than gilts individually fed a ration permitting a gain of 0.27 kg per day (10.3 vs. 8.7). Ovulation rates were equal in both groups, but embryonic mortality was 18.8% for the group fed maintenance rations compared with 31.0% for those fed a liberal diet. The fetuses, ovaries, and corpora lutea were heavier where the gilts received liberal feeding.

Embryonic survival in sow litters. When Yorkshire and Lacombe sows, subjected to different feeding levels (1.8 and 2.7 kg per day) and different breeding periods (first or second postweaning estrus), were sacrificed after 66 days of pregnancy, the number of fetuses was the same in both breeds (10.6) and similar for both levels of feeding. However, sows bred at the second postweaning estrus averaged 11.8 fetuses and sows bred at the first postweaning estrus, 9.8. This difference was influenced by a slightly higher ovulation rate and a significantly higher embryonic survival in the sows bred at second estrus.

Poultry

The effect of environment on selection. Four generations of selection for hen-day rate of egg production to 273 days of age produced increases of 8.6% when birds were reared under full feeding on a standard growing ration to 21 weeks of age (full-fed environment) and 5.1% when the ration during the growing period was restricted to 70% of full feeding (restricted environment). Corresponding increases at 497 days of age were 11.8% and 5.0%, which indicates a strong genetic correlation between the 273- and 497-day rates of egg production per hen day in the first four generations. There was no change in age at maturity in the full-fed strain, but there was a distinct trend toward earlier maturity in the restricted strain. These observations suggest that the environment in which selection is practiced has an influence on the relationship between these traits.

The economics of heterosis. The crossing of Leghorn strains resulted in improved performance over the parental strains in characteristics such as egg weight and feed efficiency, whereas rate of egg production tended toward the mean of the parental strains. When returns over costs were used as an index of heterosis, the reciprocal crosses were much superior to both parental strains. This difference was greater when the pullets were reared on a high-fiber diet rather than on the standard growing ration.

Chick response to cereal varieties. There were marked differences in growth response when Leghorn cockerels were fed five varieties of barley and three varieties of wheat. The grains were supplemented with essential minerals and vitamins, but the rations were not balanced for protein or energy. Growth was slower than on a standard growing ration, but the differential response suggests that chicks may be used as indicators of varietal differences in feed quality. Daily gains on the barley varieties ranged from 5.1 g per day with Conquest to 3.9 g per day with Keystone, and the same performance trends could be observed in measured shank length and feed efficiency. Within wheat varieties there was little difference in the growth response, which averaged 30 g per day. Thatcher was more efficient than Manitou or Pitic 62, but all wheats were much lower than barleys in feed efficiency.

PLANT SCIENCE

Cereal Crops

Malting barley improvement. A new six-rowed barley, Bonanza, was approved for licensing and distribution. It is the third malting variety released by this station in the last 5 years. Bonanza, which contains both Conquest and Parkland in its pedigree, is adapted to the Park belt of Western Canada, where it has outyielded both Conquest and Paragon. Also, in Manitoba it has outyielded the recommended feed types. This new variety is resistant to stem rust, loose and covered smut, and it has shown field tolerance to some of the diseases that cause leaf blotch. Bonanza is intermediate in maturity between Conquest and Paragon, and has good malting and brewing qualties.

Progress was made in breeding for earlier maturity and shorter straw. Malting quality is being evaluated for about 100 selections that have shown favorable combinations of these characteristics and yields comparable with later-maturing taller types.

Feed barley breeding. Advanced selections were compared in replicated yield tests. A cross of Keystone and Dickson had the most outstanding segregates combining the yield potential of Dickson with the straw strength of Keystone. Galt and crosses including Galt were not outstanding, but a few selections showed promise.

Forage Crops

Characterization of bromegrass clones. First- or second-year data were as satisfactory as third-year data in characterizing bromegrass clones for leaf height, head height, seed yield, hay yield, rhizome extension, spring vigor, resistance to lodging, and leaf-to-stem ratio. Seasonal conditions modified the various characters but did not change rankings according to merit.

Sweetclover screening. Seedlings and roots of *Melilotus infesta* Guss., which is resistant to the sweetclover weevil, were found to be lower in phosphorus content and higher in sodium than other susceptible *Melilotus* varieties.

Dry matter yield in hay and pasture. After 3 years of production from comparable stands, dry matter yields per acre were 10% greater from hay than from pasture. However, protein yields were 37% greater from pasture swards. This was influenced by the stage of plant growth and the legume-to-grass ratio. In the hay stand the alfalfa-to-grass ratio was 1:1 and in the pasture area alfalfa dominated the ratio 1.5:1.0.

Bromegrass response to fertilizer N. When bromegrass stands were fertilized with 84, 168, and 252 kg/ha of N, dry matter production per kg of N was greatest at the 84 kg/ha level and the best response occurred in the first cut after application. The higher rates of N were more efficient than 84 kg/ha for dry matter production at second cutting and in the year following application. Applied N was used more efficiently by stands 4 to 6 years old than by younger stands.

Dry matter yield of corn and cereal forage. Corn, Morden 67, seeded June 3 attained maximum dry matter production at 12.3 metric tons/ha on October 6 (125 days maturity). Row spacings at 51, 76, and 102 cm and plant populations of 54,400 and 69,200 plants/ha did not affect yield significantly. At 92 days maturity comparative yields of barley and oats (total plant) were 8.6 and 6.4 metric tons.

Horticulture

Monarda polyploids. In the subgenus *Monarda* the native varieties are diploid, but, as a result of work at Brandon, tetraploids have been produced and the occasional triploid has been found. These tetraploids are more attractive, shorter, and have broader leaves and larger flowers than the diploids, but they are less tolerant of dry conditions. Because the first recognized triploid was a very vigorous plant, attempts were made to pollinate selected diploids with controlled crosses of tetraploids. From these crosses a number of exceptionally vigorous selections were identified, and these are currently under test. Other variants among *Monarda* include one probable hexaploid and one probable octaploid.

SOILS AND AGRONOMY

Soil Fertility

Relative placement of seed and fertilizer N. The practices of clump seeding and clump application of fertilizer N were studied in relation to the standard procedure of row seeding and applying fertilizer in rows with the seed or by broadcasting. When "no fertilizer" was compared with 50 and 100 kg of N/ha applied in continuous rows, in clumps at 15-cm intervals, or broadcast on spring wheat seeded in rows and in clumps (about 8 seeds/clump) at 15-cm intervals, it was found that wheat seeded in clumps produced more grain than row seeding, regardless of the fertilizer level. Without fertilizer N, clump seeding gave 125 kg/ha more grain than row seeding, but with fertilizer N the maximum difference was 463 kg/ha. The largest yields were obtained where wheat was seeded in clumps and the fertilizer N was placed either intermittedly between the seed clumps or in a continuous row with the seed clumps. Broadcasting the fertilizer gave about 10% less yield than near-seed placement.

Form and time of applying fertilizer N. Ammonium-N and nitrate-N at 45 kg/ha was applied to wheat at seeding, at heading, and at both stages using ammonium sulfate treated with a nitrification inhibitor and calcium nitrate as fertilizers. N and P were applied with the seed at seeding, and, when used at a later stage of growth, fertilizer N was broadcast between the rows. The grain yield without fertilizer N was 1,830 kg/ha. Yield was increased 925 kg/ha by supplying 45 kg of N/ha as ammonium sulfate at seeding and it was increased 760 kg/ha when calcium nitrate was used. The largest yield was obtained when 90 kg N/ha in the form of ammonium was applied half at seeding and half at heading. The percentage of protein in grain was highest when nitrate N was applied at heading. Without fertilizer N, the percentage of protein was 11.1%; when nitrate N was applied at 45 kg N/ha at heading and when 90 kg of N/ha was applied half at seeding and half at heading, the percentage of protein was 16.0%.

Phosphorus formulations on wheat. In a comparison of phosphorus formulations, unfertilized plots yielded 2,260 kg/ha. Formulations, each supplying 50 kg of P/ha, increased yields as follows: ammonium polyphosphate, 720 kg/ha; triammonium pyrophosphate, 530 kg/ha; urea orthophosphate and urea polyphosphate, 440 kg/ha; and ammonium orthophosphate, 305 kg/ha. Grain produced without added fertilizer P contained 8.3 kg P/ha, and where ammonium polyphosphate was used the largest content was 12.0 kg P/ha.

Response of rapeseed to fertilizer at The Pas, Manitoba. Rapeseed fertilized with five levels of N and three levels of P showed a yield response to both elements. Without added N the yield was increased from 775 to 1,090 kg/ha with 15 kg/ha of added P; and to 1,420 kg/ha with 30 kg/ha of added P. Without added P the yield was increased from 775 to 990 kg/ha with 34 kg/ha of added N; to 1,135 kg/ha with 68 kg/ha of added N; and to 1,325 kg/ha with 135 kg/ha of added N. When P at 15 kg/ha was added a similar response curve to added N was obtained over these levels of added N. At higher levels of N the increase was lower or negative. When P at 30 kg/ha was added the response to N fertilizer was erratic.

Response of winter rye to fertilizer. Various combinations of N-P-K fertilizers were tested, and the greatest return per dollar invested in fertilizer was obtained with N at 67 kg/ha and P at 34 kg/ha, although maximum yields were obtained when N at 101 and 135 kg was applied with P at 67 kg/ha. P at 67 kg/ha produced a linear yield response with each increment of N: from 967 kg of rye/ha (with N at 34 kg/ha) to 2,511 kg of rye/ha (with N at 120 kg/ha). N at 67 kg/ha and P at 34 kg/ha applied with K at 56 kg/ha produced the same effect as adding an extra 34 kg/ha of N.

Nitrogen for wheat. N in liquid (28-0-0) and granular (34-0-0) formulations applied at the two-leaf stage to Manitou wheat gave significantly better yields (+269 kg/ha) than preemergence treatments. Significant increases of 538, 1,009, 1,345, and 1,412 kg/ha of grain were obtained with applications of N at 22, 44, 66, and 88 kg/ha at the two-leaf stage. Untreated check plots produced 1,547 kg/ha of grain.

Nitrogen in combination with herbicides for barley. Postemergence applications of N at 22, 44, and 66 kg/ha in combination with

herbicides at recommended rates significantly increased yields of Conquest barley by 323, 1,022, and 1,345 kg/ha. Untreated plots produced 2,206 kg/ha and plots treated with the herbicide alone yielded 2,363 kg/ha. The best results were obtained with N at 22 and 44 kg/ha in combination with bromoxynil and MCPA ester at 560 g/ha and with 2,4-D amine at 560 g/ha. All plots were fertilized with 11-48-0 at 112 kg/ha applied with the seed.

Weed Control

Wild oats in wheat. Increased yields (+740 kg/ha) of Manitou wheat and 68% control (good) of wild oats were obtained with a new herbicide, Shell W.L. 17731 (Shell Canada Ltd.), applied at 3.4 kg/ha in oil to wheat at the four-leaf stage, in comparison with untreated plots that yielded 1,480 kg/ha. This product also produced good results when applied at rates from 1.1 to 5.6 kg/ha at the five-leaf stage.

Residual effect of atrazine on flax and cereals. Average yields of flax, wheat, oats, and barley were not significantly affected when these crops were grown on plots treated with atrazine the year before to control weeds in corn. However, since the atrazine had been applied in a 30.48-cm band over the corn rows, only one-third of the total area was subject to the residual effects of atrazine. In rows on treated soil the cereals were susceptible to injury, and substantial yield reductions were found where atrazine was applied at 1.1 and 2.2 kg/ha. Compared with similar rows on untreated soil, these reductions were 10% and 25% for wheat; 18% and 34% for oats; and 32% and 55% for barley. Flax yields were not affected by the previous atrazine treatments.

Control of green foxtail in corn. Harrowing before and after emergence followed by interrow cultivation as required gave 81% control of green foxtail in corn planted in 0.9-m rows. Yields of dry matter were 5.18 metric tons/ha compared with 2.02 metric tons/ha for untreated plots and 5.87 metric tons/ha for hand-weeded plots. Similar results were obtained from these cultural treatments on corn planted in 0.45-m row spacings. Promising results were obtained with early postemergence application of prometryne mixed with atrazine, or prometryne mixed with TCA, where yields were 84% to 89% of those on hand-weeded plots.

Factors affecting green foxtail control with TCA. Temperature and light intensity appear to be critical factors in determining the effectiveness of TCA for controlling green foxtail. At 10 C, TCA failed to control foxtail when applied at 0.56, 0.84, 1.12, 1.68, and 2.24 kg/ha. At 22 C, all levels of TCA except 0.56 kg/ha suppressed the weed growth, but at 27 C only the two highest levels were effective.

At light intensities of less than 2,700 luxes, TCA at five rates from 0.56 to 2.24 kg/ha did not control green foxtail. When light was increased to 8,100 luxes all rates were effective, and at 19,900 luxes all rates except 0.56 kg/ha controlled the weed. Therefore warm, sunny weather and rates of over 0.8 kg/ha appear necessary for effective control of green foxtail.

Effect of TCA on N metabolism in wheat and oats. When wheat and oat seedlings were treated with TCA at 0.56 kg/ha the total N in the wheat plant was increased by 23%, and at 2.24 kg/ha by 40%. These increases were closely associated with TCA injury and the resulting yield reduction. In oat seedlings total N decreased 10% with TCA at 0.56 kg/ha and 13% at 2.24 kg/ha. Neither treatment produced injury, and the yield decreases were slight.

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INTRODUCTION

At the Research Station, Morden, the emphasis is on research in horticulture and special crops. Accomplishments in 1969 that merit special mention include: naming the first double-flowered ornamental crab apple that is adapted to the Prairie Provinces; completing the final stages in development of a selection of field peas, and a selection of soybeans; licensing a Russian variety of sunflowers; and continuing encouraging work in preconditioning potatoes.

Eric D. Putt
Director

SPECIAL CROPS

Buckwheat

Breeding. The Morden project of varietal testing was expanded to six locations in Canada. CD 7274, a selection from a Russian introduction, continued to yield well. Tests of intervarietal crosses indicated heterosis for yield.

A leaf variegation, apparently due to instability of genes controlling chlorophyll production, arose spontaneously in buckwheat.

Date of seeding. In experiments on date of seeding, buckwheat planted in the first half of June produced the highest yields.

Disease. Pyrenochaeta terrestris (Hans.) Gorenz, Walker & Larson was isolated from roots of buckwheat at Morden. This is the first record of buckwheat as a host for this fungus.

Field Peas

Breeding. In the past 5 years a small-seeded yellow pea selection from the cross Chancellor × Weibulls 700 has outyielded Chancellor by 9% in six Canadian locations and by 15% in Manitoba locations. An application to license it with the cv. name Trapper will be made in 1970.

Quality. In a cooperative study with the NRC, Prairie Regional Laboratory, Saskatoon, Sask., the protein content in over 500 introductions of peas varied between 22% and 32%. Differences between years and locations were significant. No significant relationship between protein content and yield, maturity, or seed size was found.

Ascochyta blight. In 1969 *Ascochyta pinodes* L.K. Jones, causal organism of ascochyta blight, was prevalent and generally quite severe. Eighteen of 112 introductions retested showed some tolerance. Individual plants were selected for tolerance or susceptibility to the disease, and progenies of these plants appeared to retain the respective disease reactions.

Flax

Breeding. In the 1969 Flax Cooperative Tests the USDA variety Nored produced the highest yield of all varieties. It is tolerant to pasmo, caused by *Septoria linicola* (Speg.) Garass., and is a selection from irradiated stocks of a line from the same cross that produced Redwood. The high incidence of pasmo in 1969 may explain the good performance of Nored. F.P. 497, which again equaled Redwood 65 in yield, is of interest because it has a different gene for resistance to rust, caused by *Melampsora lini* (Ehrenb.) Lév.

Nineteen introductions that showed promise as parents in breeding for higher seed yield were tested further. Four yielded 15% to 26% more than the check varieties. Others are possible new sources for resistance to rust.

Oilseed quality. Individual fatty acids are not uniformly distributed in the cotyledons or among the seed components, therefore appropriate corrections must be made when microsampling is done. Genotypes with iodine values of 147 to 212 have been selected. Of the fatty acids, 13% to 45% are oleic, 6% to 21% linoleic, and 33% to 67% linolenic.

Disease. Seven imported accessions, reputed tolerant to pasmo in Argentina, all showed resistance to pasmo at Morden. Their disease scores varied from 2 to 14 on a scale of 100. Four check varieties scored from 31 to 63. Simulated lodging of flax consistently increased disease scores.

Pyrenochaeta terrestris and *Phoma* spp.

were isolated from stem bases and roots of flax in several Manitoba fields. The presence of each of these fungi on flax constitutes a new record for Manitoba.

Sunflower

Culture. Krasnodarets, an open-pollinated oil-type variety introduced from the USSR and licensed in 1969, comprised 40% of the acreage in Manitoba. First-year results from a date-of-seeding test indicate that Peredovik should be seeded in early May for maximum yield and oil content. Krasnodarets yielded best when seeded 10 days later. In later plantings of both varieties the content of linoleic acid was greater and oleic acid less. For two seasons in plots of 1 row, of 2 rows with both harvested, and of 3 rows with the center row harvested, the yield of Armavirec was 31.6%, 42.5%, and 49.3%, respectively, of the amount of Valley. Armavirec is shorter and earlier than Valley.

Male sterility. A genetically male sterile line planted 0.5 and 0.75 mile from a large field of Peredovik set 14% and 18% seed, respectively, indicating that insects cause more outcrossing than has been suspected. A cytoplasmically male sterile line from France proved sterile in both the field and growth cabinet. Search for a fertility restorer is under way.

Oilseed quality. Diverse fatty acid compositions in the following ranges are now available: 8% to 26% saturated, 9% to 41% oleic, and 44% to 83% linoleic acid.

The growth retardant B-995 applied at 5 $\times$ 10^3 ppm to sunflowers every third week starting at the fifth-leaf stage caused 40% reduction in height but no apparent effects on seed quality. This retardant will aid growing sunflowers under glass.

Weed control. After a preplanting treatment of trifluralin or EPTC at low rates for control of green foxtail, a single postemergence spike tooth harrowing greatly improved the control of broad-leaved weeds. In one test, there was a fivefold reduction of broad-leaved weeds.

Corn

Breeding. The Station has developed several new corn hybrids, which may be licensed in 1970. One yielded 11.3 q/ha more grain than the mean of four checks at Morden. Another exceeded its nearest rival by 6.3 q/ha at Kentville, N.S.

Population study. The performance of corn inbreds under high populations differs considerably. Three of 14 inbreds yielded an average of 68% more grain at 217,500 plants/ha than at 52,500 plants/ha. Four other inbreds yielded an average of 60% less at the higher population than at the lower population.

Soybeans

Breeding. Application will be made in 1970 to license the soybean selection CM 30, as cv. Morsoy. It yields 2.7 q/ha more than Altona, and as it bears only a few pods in the lower 10 cm of the plant, it contributes to a reduction in seed losses at harvest.

In a study of gaps in the rows the yield of soybeans in test plots was affected significantly only when the gaps were longer than 50 cm.

ORNAMENTALS AND FRUIT CROPS

Apple Breeding

Eleven apple selections were made in 1969. In 10 of these the cv. Goodland was one parent and the other parent was an unnamed seedling (Kerr $\times$ Melba). One selection MM-7-5 (Wealthy $\times$ Lobo) was placed in the final evaluation trials as number M-382.

Fruit of 42 seedling selections was examined by the Prairie Cooperative Fruit Breeding Committee. Nine were chosen for final replicated trials at Brooks, Alta.; Melfort, Sask.; and Morden and Portage la Prairie, Man. The 1969 selections bring the total selected to 43. First plantings at each site were made in 1968.

Apple Stembuilders

Several apple stembuilder selections, besides the four originally recommended, show increasing yields as they mature. Among these are Kerr, *Malus prunifolia* (Willd.)

Borkh. #1, and an Antonovka seedling 5035-B27.

Raspberry Breeding

Fifty-seven selections were made, in 1969, from among 1,528 controlled-cross raspberry seedlings derived from 27 different crosses that include the cultivars Asker, Boyne, Canby, Chief, Early Red, Killarney, Lake Geneva, Madawaska, Muskoka, Ottawa, Taylor, and Willamette.

One of three selections from native annual-bearing species was successfully crossed with Fallred and 100 seedlings were started in 1969. All other crosses failed to set seed. Failure may be due to ploidy.

Weed Control in Strawberries

A test showed that when strawberries were treated twice in the first and second years with simazine at 1.68 kg/ha the bed required only a little time to weed and contained few perennial weeds in the third year. Total yields were closely correlated with weediness.

Breeding and Selection of Ornamentals

A double-flowered crab (*Malus* ×*adstringens* Zabel) was named Kelsey in 1969. It resulted from a controlled cross of two Morden selections (*M.* #6011 × *M.* #5908) of the hybrid species *M.* ×*adstringens*. The tree is upright in habit, at present 5–6 m high. The branches are slender and the bark is reddish brown on young twigs, grayish brown on mature wood. The leaves are comparatively small, bright red when young, green at maturity, and they have a trace of red pigment along the veins. The flowers, produced annually, are approximately 5 cm in diam, semidouble with 10 to 16 broad petals, strong purplish red (Munsell: 6RP 7/8), except for a small white mark at the base of each petal. The fruit is bright, dark red, covered with a waxy bloom, approximately 2 cm in diam, oblate and slightly ribbed. Preliminary tests indicate that Kelsey is hardy to Zone 2b in Manitoba. (Zones of plant hardiness are found in *Map of Plant Hardiness Zones in Canada*, Can. Dep. Agr. 1967.)

Kelsey is the first cultivar from a series of double-flowered crab apples developed at Morden. In the series, 22 selections are being evaluated, 14 with reddish bloom and 8 with white flowers. One is an open-pollinated seedling of an Ottawa numbered selection from *M.* ×*adstringens* 'Cowichan' × *M.* ×*scheideckeri* (Spaeth) Zab. 'Dorothea'. The other 21 are from Morden intraspecific hybrid selections of *M.* ×*adstringens*.

Selections in 1969 from the programs in ornamentals include: 5 *Chrysanthemum*, 5 *Fraxinus*, 5 *Malus*, 1 *Philadelphus*, 3 *Prunus*, 18 *Rosa*, and 2 *Salix*.

Taxonomy

Collections from over 700 taxa of woody plants, most of them from the Morden Arboretum, were added to the herbarium during 1969.

Arboretum

One hundred and thirty new woody accessions were added to the Arboretum in 1969. A new block was started for the *Salix* collection. Outstanding among the newer plants were: *Betula occidentalis* Hook. received as *B. fontinalis* Sarg., *Caryopteris* ×*clandonensis* Simmonds 'Kew Blue', *Clematis* × 'Blue Bird', *Clematis* × 'White Swan', *Hydrangea arborescens* L. 'Annabelle', *Lonicera xylosteum* L. 'Nana', *Philadelphus* × 'Galahad', *Prunus padus* L. var. *commutata* Dipp. 'Dropmore', *Populus tremula* L. 'Erecta', *Rosa* × 'Cuthbert Grant', *Sambucus racemosa* L. 'Goldenlocks', *Spiraea* ×*arguta* Zab. 'Grefsheim', *Spiraea* × 'Fairy Queen', *Syringa meyeri* Schneid. received as *S. palibiniana* Nakai, *Tilia* × *flavescens* A. Br. 'Dropmore', *Viburnum trilobum* Marsh. 'Compactum', and *Viburnum trilobum* 'Garry Pink'.

VEGETABLES

Potato Storage

Preconditioning, or treatment of potatoes with high temperature at harvest, first proposed at Morden in 1967, continued to be effective. The treatment hastens the completion of maturity in the tubers and tends to stabilize good chipping quality. Preconditioning studies on commercial potato storage

gave good results in 1968 and 1969. Two lots of 454 metric tons of Kennebec, one of which was very immature at harvest, were used. During preconditioning, internal tuber temperatures reached 27 C, probably because of accelerated respiration. Relative humidity was maintained at 90% or more, and the rate of air exchange was high. Chips from weekly samplings showed progressively lighter color. The Hunterlab L values increased from below 45, the minimum level for acceptable chip color, to above 55 in 4 weeks of preconditioning. Tuber spoilage was minimal.

Other studies suggested varietal × temperature interaction. Kennebec at 8 C produced dark chips but F5889 at 8 C produced light chips.

Carrot and Parsnip Root Discoloration

In Western Canada surface discoloration of parsnips often occurs. This condition was found to be caused by enzymatic oxidation of phenolic compounds. Study showed that the brown pigments, similar to those observed in our work with carrots, were caused by enzymatic oxidation of chlorogenic acid. The parsnips had an active monophenolase and polyphenolase enzyme system and a moderately high phenol content. Chemical and cultural methods of controlling browning in carrots and parsnips are being studied.

Weed Control in Onions

Linuron at 0.56 kg/ha and prometryne at 1.12 kg/ha each in combination with benzadox at 3.36 kg/ha killed onions when applied at the loop stage of growth. Nitrofen at 2.8 kg/ha caused little injury even when applied at the loop stage, but this herbicide did not control wild mustard or stinkweed and did not reliably control green foxtail.

A gas chromatographic method was developed for determining the herbicide allidochlor in soil solutions. The method was used to determine the adsorption of allidochlor on soil containing 6.3% organic matter, at soil-to-solution ratios varying from 1:10 to 4:1. Essentially the same adsorption isotherm (at 18 C) was obtained over the whole range.

Germination and Growth of Irradiated Cucumber Seed

Exposing dry cucumber seed to 10, 20, 40, and 80 thousand rad of gamma irradiation caused differences ($P > 0.01$) in germination of eight cultivars. Viability of the seed of NK-805, Marketmore, Burpless, and SMR-58 was not affected by any dosage. Reduced emergence in SMR-18 and Snappy occurred only at 80,000 rad. Emergence of Tablegreen-65 and Early Fortune was significantly reduced at 20, 40, and 80 thousand rad. At these levels the germination of Early Fortune was 56%, 15%, and 2%, respectively. The number of dwarfed or malformed plants was similarly influenced. At 80,000 rad flowering was delayed, especially in the slicing cultivars.

Germination and Seedling Growth of Sweet Corn

In field and growth-room tests of field and sweet corn noted for vigor of spring growth, the field corn cultivar OX-351 exceeded all others in rate of emergence, green weight of plants, and plant height 47 days after being sown. Sweet corn pregerminated on filter paper emerged sooner than that sown by the conventional method. Seed of poor quality emerged more quickly and in greater numbers, and the green weight of seedlings was greater when the seed was sprouted on filter paper than when it was given any other treatment. Pregermination followed by application of gibberellic acid gave the most rapid emergence. Also, pregermination with phosphate added to the growing medium produced the largest seedlings.

Heading in Cole Crops

The green sprouting broccoli cultivar Harvester produced uniform heading and appeared adapted to once-over mechanical harvesting. The chemical *N*-dimethylaminosuccinamic acid applied to plants of Brussels sprouts in early August produced heads that matured earlier than those of check plants and plants pruned by hand.

Rhizoctonia on Potatoes

In 1969 canker, caused by *Rhizoctonia solani* Kühn, occurred on shoots and stolons of potato plants in each of 28 fields examined. Canker was usually more severe on shoots than on stolons. The number of sclerotia on

tubers collected in mid-September from eight of the fields was positively associated with the severity of the cankers on the shoots and stolons. Potatoes planted in two fields for the first time showed little canker or sclerotial formation, whereas those in fields repeatedly planted to crops susceptible to *R. solani* had more of the disease.

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Departures

M. S. BOWMAN (Mrs.), B.Sc., M.Sc. Resigned October 31, 1969	Plant biochemistry
W. J. CHEREWICK, B.S.A., M.Sc., Ph.D. Retired February 14, 1969	Smuts

[1] On leave of absence to Food & Agriculture Organization of the United Nations, Rome, Italy, October 1, 1969, to September 30, 1970.

[2] On leave of absence to Plant Breeding Station, Njoro, Kenya, East Africa, December 1, 1969, to December 31, 1970.

[3] On transfer of work to Department of Industrial & Scientific Research, Lincoln, N.Z., August 1, 1969, to May 1970.

VISITING SCIENTISTS

University of Manitoba fellows

W. J. R. BOYD, Ph.D.	Plant breeding
S. S. CHANG, B.Sc., M.Sc.	Entomology
A. JACKSON, B.Sc., M.Sc., Ph.D.	Plant biochemistry

National Research Council postdoctorate fellows

R. A. FULLERTON, Ph.D.	Plant pathology
J. PESEK, Ph.D.	Genetics
W. A. SHIPTON, Ph.D.	Plant pathology
Y. TAMAKI, Ph.D.	Biochemistry

Graduate students

M. DOLINSKI, B.S.A.	Entomology
B. HALSTEAD, B.Sc.(hon.)	Virology
F. G. KOSMOLAK, B.Sc.(hon.)	Plant biochemistry
R. NOWAK, B.Sc., M.Sc.	Plant biochemistry
M. QUINONES, B.Sc., M.Sc.	Plant pathology
G. ROWLAND, B.Sc.(hon.)	Cytogenetics

Other scholarships

J. E. M. H. VAN BRONSWIJK, Doctorandus Biologie (Nijmegen) Canada-Netherlands exchange scholarship (Canada Council)	Entomology
M. A. HAGGAG, B.Sc., M.Sc. Egyptian Government scholarship	Plant breeding

INTRODUCTION

The release of the hard red spring wheat variety Neepawa and of the durum wheat variety Hercules represents significant progress in the achievement of the main objective of the Research Station, that is, the development of cereal varieties suitable for production in the Prairie Provinces. Neepawa is markedly superior to other commercial varieties in yield and resistance to lodging. Hercules has excellent quality, is early maturing, is resistant to rusts and smuts, and has short strong straw.

This report outlines the highlights of the research completed in 1969. None of the research is described in detail. Results of the completed research are contained in the publications listed, and reprints may be obtained by writing to the author concerned. The research scientists or the technical liaison officer will be pleased to provide additional information.

A. E. Hannah
Director

BREEDING, GENETICS, AND CYTOGENETICS

Plant Breeding Methods

Correlations among some agronomic and quality traits in spring wheat were found to change from year to year owing to the effects of environment. Differences in time to maturity appeared to be a main source of heterogeneity of correlation coefficients.

Computer simulation studies in self-pollinated species indicated that index selection would result in a greater increase in the genetic worth of selected lines than the presently used tandem selection.

A method of calculating selection indices was developed that eliminated the need for assigning economic weights in the traditional manner. The relative importance of the various traits was incorporated into the index by taking into consideration the gain that the breeder would want in each trait.

The Finlay-Wilkinson regression method was found inadequate for the study of genotype–environment interaction in wheat. Linear regression coefficients accounted for less than 10% of the variability due to the interactions of genotypes with environments.

Barley Breeding and Genetics

The reaction of the cultivars Jet (C.I. 967) and Milton (C.I. 4966), and their derivatives, to selected cultures of *Ustilago nuda* (Jens.) Rostr. was used to identify genes for resistance to loose smut. This technique replaced the older method in which identification was carried out by determining genetic interactions between host and pathogen. Jet was shown to have two genes for smut resistance, *Un3* and *Un6*, and Milton one gene, *Un8*. Derivatives from Jet with only *Un6* were distinguishable from those with genes *Un3* and *Un6*.

Disease-resistant stocks were developed that have genes for loose smut resistance from Jet and Milton combined with: the *Mla* gene for resistance to powdery mildew, *Erysiphe graminis* f. sp. *hordei* Marchal; a gene from C.I. 5791 governing resistance to net blotch, *Pyrenophora teres* (Died.) Drechsl.; and a gene from C.I. 4439 controlling resistance to septoria leaf blotch, *Septoria passerinii* Sacc. Seed of these stocks was submitted to the Small Grains Collection, USDA, Beltsville, Md., for increase and distribution.

Work continued on the development of a genetic base for resistance to stem rust and net blotch, derived from hybrids developed at the Station, and these genotypes are being used in combination with the superior agronomic and malting-quality types of Eastern European introductions.

Oat Breeding and Genetics

Backcross strains of Harmon, Kelsey, Rodney, and OT 606, each possessing gene *Pg9* for resistance to race C10 of oat stem rust, were all similar to the recurrent parents in many characteristics, but lacked adequate crown rust resistance. Combinations of genes resistant to stem and crown rust provided the basic material for breeding programs. Heritability of oil content is being determined in these strains. Strains of dormoats were received from Ottawa and planted early in November 1968. They survived the winter,

whereas Kelsey and Pendek failed to emerge. The dormoats were early-maturing and relatively productive.

Common Wheat Breeding

Ten years of intensive breeding culminated in the licensing of the new hard red spring wheat variety Neepawa. Neepawa is a significant improvement over Manitou and Thatcher. The cross involved a full Thatcher backcross,

(Thatcher^{7} × Frontata) ×
(Thatcher^{6} × Kenya Farmer),

and a partial Thatcher backcross,

Thatcher^{2} × (Frontata × Thatcher).

Compared with Manitou, Neepawa is markedly superior in yield and resistance to lodging, and slightly superior in time to maturity and seed size. Neepawa has about the same rust resistance as Manitou.

Approximately 1,900 kg (70 bu) of Breeder seed and 70,200 kg (2,580 bu) of Select seed were distributed to Select growers in the Prairie Provinces in 1969. Ample supplies of seed will be available commercially after the 1970 production season.

Restoration of fertility continues as the main obstacle in the development of hybrid wheat varieties for this area. Genes from the French variety Primépi are being added to those from *Triticum timopheevi* (Zhuk.) Zhuk. to increase the effectiveness of restoration.

Durum Wheat Breeding

The recently licensed variety Hercules was distributed to seed growers for increase in 1969. Hercules possesses early maturity, short strong straw, good resistance to rust and loose smut, and excellent quality. Yields have averaged 98% and 92% of the yield of Stewart 63 in the Black and Brown soil zones of Western Canada, respectively.

Two hundred early-maturing, short-strawed lines from the breeding program were evaluated for yield and quality in comparative trials. Early-generation quality screening ensured that a large proportion of the lines would be of satisfactory quality. Most outstanding in yield were seven lines from one cross; they performed well in 1968 and continued to show high yield potential over a wider area in 1969, ranging in average yield from 112% to 130% of the standard commercial varieties.

Specific breeding programs for resistance to root rot and to the cereal leaf beetle were started during the year. Root rot resistance was derived from the common wheat variety Thatcher and the tetraploid component of Canthatch. Because resistance in Thatcher is simply inherited and located on chromosome 5B, it is possible to transfer this gene to durum wheat. Resistance to the cereal leaf beetle is achieved by transferring genes conditioning leaf pubescence to suitable varieties. A modified backcross program is being used in both instances.

Cytogenetics of Wheat

Preliminary results indicated that seedling resistance to several races of stem rust is determined by one dominant gene in the diploid wheat *Triticum monococcum* L., R.L. 5244. This gene was transferred to Stewart durum wheat, in which it also provided excellent resistance to these races. Since R.L. 5244 is also highly resistant to leaf rust, an attempt is being made to transfer this resistance to tetraploid wheat.

Genes for resistance to leaf rust were transferred to hexaploid wheat from two strains of *Aegilops squarrosa* L. ($2n = 14 =$ DD). Additional resistant varieties of this diploid have been found. However, before an attempt was made to transfer genes for resistance from these into hexaploid wheat, comparative genetic studies were started to determine if different genes for resistance are carried by both *squarrosa* strains.

Analysis of chromosome pairing in several pentaploid hybrids between tetraploid and hexaploid wheats indicated that trivalents formed through AB–D intergenomic pairing are due to homeology rather than to interchanges.

Genetics of Wheat

Lr14, a gene that confers a mesothetic reaction to several races of leaf rust, was isolated from the wheat variety Selkirk. It was also common to a number of other varieties, such as Renown and Hope. Another gene that gives a mesothetic reaction, but only to races virulent on *Lr14*, was isolated from the varieties Maria Escobar and Bowie;

this gene is either allelic or closely linked to *Lr14*. Virulence of the pathogen on the host that contains gene *Lr14* was conditioned by a recessive gene and on the host that contains the gene from Maria Escobar and Bowie by a dominant gene. The virulence genes were inherited independently of each other.

Adult-plant leaf rust resistance in a synthetic hexaploid ($2n = 42$ = AABBDD) derived from *Aegilops squarrosa* L., R.L. 5271, is conditioned by a gene that is linked with the gene for nonwaxy foliage (15.6 ± 2.5%) and the gene for threshability (6.0 ± 1.5%).

Two genes, *Lr10* and *Lr16*, for seedling leaf rust resistance were located on chromosomes 1A and 4A, respectively. *Lr12*, a gene for adult-plant leaf rust resistance, is identical or closely linked with the Chinese Spring gene for adult-plant resistance. This latter gene was identified by Australian workers.

CEREAL RUSTS

Stem Rust of Wheat

Wheat stem rust caused little loss in Western Canada in 1969. The few small plantings of the variety Pitic 62, where slight losses occurred, were attacked late in the season.

Race C18(15B-1L) has predominated since 1964. This race and others that have been common in recent years do not threaten the predominant commercial varieties grown in the rust area. C22(32) and C25(38), two races that were moderately virulent on the varieties Manitou and Neepawa, were not reported in 1969, but two other potentially important races were identified. Race C33, a strain of 15B that resembles C18, was found at five locations in Eastern and Western Canada. At present, it does not threaten the widely grown resistant varieties, but its widespread appearance in 1969 suggests that it could increase in prevalence. Race C35(32-113) was found for the first time in 1969 at five locations in Eastern and Western Canada, mainly on the recently licensed variety Pitic 62. It was virulent on Pitic 62, Manitou, and Neepawa in greenhouse seedling tests. The differential host varieties do not distinguish between cultures of race C35, but tests with the variety Selkirk showed that at least two biotypes were present. For a full evaluation of the potential importance of the new race, further study is needed, but already its widespread occurrence indicates that it is capable of spreading rapidly. If it increases, the adequacy of the adult-plant type of field resistance of the varieties Manitou and Neepawa will be of the utmost importance. In 1969, when rust was scarce, C35 was not found on Manitou in farm fields, or on Neepawa growing near plots of heavily rusted Pitic 62 at Glenlea, Man.

A study of wheat varieties that are resistant to stem rust in Kenya showed that several are highly resistant to North American races, including the new races virulent on seedlings of Pitic 62, Manitou, and Neepawa.

Leaf Rust of Wheat

The commercial wheat varieties Manitou and Neepawa carry the gene *Lr13*, which conditions resistance to leaf rust in adult plants. In 1966 Manitou was resistant to all cultures of leaf rust prevalent at that time. In greenhouse tests in 1968 and 1969, a few isolates of leaf rust were found to be virulent on Manitou. However, resistance is poorly expressed under greenhouse and growth-chamber conditions, and variable results were obtained with the same isolates. It seems certain that virulence on Manitou and Neepawa is increasing in the present leaf rust population.

The wheat varieties Exchange and Chinese Spring carry the gene *Lr12* that conditions adult-plant resistance to leaf rust. However, in 1969 a few isolates of leaf rust were found to be virulent on a backcross line that contains gene *Lr12*.

Stem Rust of Oats

Oat stem rust infections were light or absent in Canada in 1969. The widely distributed and virulent physiologic race C10 comprised 83% of all isolates from Western Canada. In Eastern Canada race C9 and the closely related race C8 continued to predominate. A new source of stem rust resistance from *Avena sterilis* L. was effective against all 186 isolates identified in Canada in 1969. Approximately 90% of all isolates identified

were virulent on plants carrying resistance genes *Pg2* and *Pg4*. All commercial varieties have this type of resistance. Serious losses could result if conditions favored development of these races.

An analysis of the data from physiologic race surveys in Canada extending over 48 years showed that the frequency of virulence genes in the population of the pathogen can be explained only in part by the selection pressure caused by genes for resistance in the host population. Genes for virulence identified on newly released varieties have spread quickly throughout the rust population after initial 'breakdown' of the resistance. The most successful physiologic races carry more genes for virulence than are needed for successful parasitism on the prevalent hosts. Many races carry genes for virulence capable of attacking varieties with types of resistance that have never been used on this continent.

Genetic studies with the parasite have shown that virulence is conferred by a dominant gene corresponding to the resistance gene *Pg8* in the host.

An orange culture of oat stem rust was established from an orange pustule found in a uredial culture that originated on barberry in the greenhouse. Orange and normal reddish brown pustules developed on oat plants inoculated with the orange spores. Repeated attempts to purify the orange strain from single uredial pustules failed, and orange and reddish brown pustules appeared in cultures from single orange urediospores. Isolates from reddish brown pustules were stable. The segregating orange and pure reddish brown cultures possessed the same genes for virulence and avirulence, and they germinated equally well. The available evidence suggests that the method of inheritance of the orange characteristic is extrachromosomally controlled.

Crown Rust of Oats

Populations of oat crown rust from Eastern Canada were clearly distinguishable from those in Western Canada on the basis of their reactions on the differential varieties Landhafer and Santa Fe. Western isolates were virulent on these two varieties, whereas eastern cultures were not. This evidence substantiates the theory of the different origins of these two geographically isolated populations.

Two genes for crown rust resistance, *Pc38* and *Pc39*, isolated from *A. sterilis*, a hexaploid wild oat, were highly effective against Canadian crown rust cultures isolated during the 1968 survey. Both sources of resistance are being utilized in the oat breeding program.

Wild oat collections obtained from the Middle East contained two very promising lines, CW-486 and F158, which provided effective resistance to more than 200 cultures of crown rust. A study of both lines was undertaken to isolate the effective resistance gene or genes for possible incorporation into *Avena sativa* L. background.

A unique form of ameiotic variation in crown rust was observed when isolates of Saia-virulent race 229 were subcultured. Either aneuploidy or cytoplasmic inheritance could account for this variability.

A study of the taxonomic significance of protein patterns of rust species and formae speciales from disc electrophoresis showed that interspecific differences are greater than intraspecific differences. Physiologic race differences in crown rust cannot always be substantiated on the basis of disc electrophoresis.

Physiology of Parasitism

Metabolism of alicyclic acids and phenylpropanoids by rust urediospores. Urediospores of wheat leaf rust did not take up or metabolize exogenous supplies of quinate-U-^{14}C, shikimate-U-^{14}C, *p*-coumarate-α-^{14}C, or ferulate-α-^{14}C. Caffeate-α-^{14}C was converted to an unidentified ether-soluble component that was recovered from the germination medium. Activity from phenylalanine-U-^{14}C and tyrosine-U-^{14}C was recovered from soluble and insoluble spore fractions. No evidence for phenylalanine–tyrosine interconversion was obtained. Glycosides or free and bound esters of phenolic acids were not radioactive. Activity was not detected in free phenolic acids when phenylalanine-U-^{14}C was supplied, but when tyrosine-U-^{14}C was used as precursor, radioactive *p*-coumarate was detected in the germination medium at 20 C, and radioactive *p*-coumarate and caffeate were recovered from the medium kept at 30 C. Cell-free extracts of wheat stem rust and wheat leaf rust urediospores contained shikimate dehydrogenase and tyrosine ammonia-lyase, but not quinate dehydrogenase and phenylalanine ammonia-lyase.

The rusts investigated appear to be the only fungi known to degrade tyrosine but not phenylalanine to cinnamate derivatives, and to possess tyrosine ammonia-lyase but not phenylalanine ammonia-lyase.

The relationship between the metabolism of aromatic compounds of rust sporelings and that of the parasitic rust mycelium is not known. If the metabolisms are assumed to be similar, then most changes in this pathway that occur in the host–parasite complex would have to be attributed to pathogenically induced alterations of the host metabolism, and not to the metabolism of aromatic constituents by the pathogen.

Abnormal metabolites of wheat. The aromatic metabolites first detected in rust-infected resistant wheat leaves grown at 20 C were isolated in milligram amounts. In cooperation with Dr. A. Stoessl, Research Institute, London, Ont., the metabolites were identified as *N*-(*p*-coumaroyl)-2-hydroxyputrescine and *N*-(feruloyl)-2-hydroxyputrescine. These compounds are representatives of a new group of natural products, since hydroxylated polymethylenediamines have not been observed previously in nature. The abnormal metabolites also occurred in rust-infected susceptible wheat grown at 25 C, and in wheat infected with *Pyrenophora tritici-repentis* (Died.) Drechsl. or with virulent or avirulent species of *Pseudomonas*. Small amounts of the abnormal metabolites were detected in wheat leaves treated with necrogenic chemicals or with hot water. Thus, production of the amides in wheat was correlated with chlorosis- or necrosis-producing treatments, and the largest amounts were produced under conditions of sustained stress. Leaves of oats and barley, untreated or infected with virulent and avirulent pathogens, did not contain these 2-hydroxyputrescine amides. Tracer studies on rust-infected resistant wheat leaves indicated that the aromatic moieties of the abnormal metabolites are derived from shikimic acid via phenylalanine and hydroxycinnamic acids. Tyrosine was not an effective precursor. The origin of the 2-hydroxyputrescine moiety is not known, but it apparently does not arise from free putrescine.

Folates in senescent wheat leaves and wheat leaf chloroplasts. When detached leaves are maintained on water, they exhibit metabolic changes similar to those that occur during senescence. Metabolic changes characteristic of senescence are of interest in rust research because similar changes are often observed in infected leaves, depending on infection type and other factors. Preliminary work had shown that detachment of leaves affects their folate content and these drifts were compared with folate levels in freshly harvested leaves and with those in detached leaves floating on solutions of benzimidazole. The latter is known to arrest senescence in excised leaves of monocotyledons and to act as a pterine analogue in other systems. Also, chloroplasts were isolated with nonaqueous solvents from each of these samples and analyzed for folate content and composition.

Total leaf folates increased after detachment, whether or not benzimidazole was present. This overall increase was due mainly to increases of 5-methyltetrahydrofolate and is reminiscent of the folate drifts in leaves after rust infection. In excised leaves floated on water, the concentration of 10-formyltetrahydrofolate increased and that of folate conjugates above the triglutamate level fell below levels observed in freshly harvested leaves. In excised leaves floated on solutions of benzimidazole, the concentration of these components remained unchanged and that of the diglutamate of 10-formyltetrahydrofolate increased. Similar folate drifts were observed per unit weight of chloroplasts isolated from these samples, except that nonconjugated folates predominated in chloroplasts from leaves floated on water, and conjugated folates predominated in chloroplasts from leaves floated on solutions of benzimidazole.

CEREAL DISEASES

Smuts

The ultrastructure of spore walls of dark, wild-type, and hyaline mutants of *Ustilago avenae* (Pers.) Rostr., *U. nigra* Tapke, *U. nuda* (Jens.) Rostr., and *U. tritici* (Pers.) Rostr. were compared. There was little difference in wall structure between species, but there was a distinct difference in the number

of layers in walls of dark, wild-type, and hyaline mutants of the same species. The walls of wild-type spores were composed of five or six layers, but only three or four were present in the walls of hyaline spores. The second layer, which carries the echinulations, and the third layer, which carries pigment and the component responsible for most of the mechanical strength, were missing.

Mitotic recombination occurred often in axenic culture of dikaryons of *U. avenae* and *U. kolleri* Wille as a result of stress after isolation of the dikaryon from the host plant. Mitotic recombination also occurred in the host but very seldom and only in certain dikaryons.

Barley Yellow Dwarf

Methods of assessing yield losses in barley and oats from barley yellow dwarf were developed and used to estimate losses in an extensive disease survey in Manitoba. In an area of approximately 6,993 km^2 north and east of Winnipeg, where an epiphytotic developed on late-seeded crops, barley yellow dwarf caused an estimated loss of 32,200 metric tons of barley and 8,700 metric tons of oats. Two strains of the virus, one transmitted specifically by *Rhopalosiphum maidis* (Fitch) and the other transmitted nonspecifically by three other species of aphids, were chiefly responsible for the epiphytotic. An early migration of the aphid vectors and the prevalence of late-seeded crops contributed to the severity of the disease. A high proportion of cereals in the field was found to be carrying a symptomless infection of barley yellow dwarf. The proportion was highest for barley infected with the *R. maidis*-specific strain.

Four six-rowed varieties of barley grown commercially in Canada were moderately to highly susceptible to barley yellow dwarf when tested in the greenhouse. Losses in seed weight of 79% and 67% in Parkland and Conquest barley, respectively, occurred when they were inoculated in a field trial. Tests in a growth cabinet and in the field with one strain of the virus showed that a variety of barley from Ethiopia (C.I. 5791) was tolerant.

Aster Yellows

An isolate of the aster yellows pathogen infected an average of 70% of Selkirk wheat plants and 33% of Rodney oat plants in the greenhouse when each plant was inoculated by a single six-spotted leafhopper. Aster yellows was more severe on wheat and oats at high temperatures and high light intensities than at low values. Incubation periods for aster yellows were longer than those for barley yellow dwarf, the difference being greatest at low temperatures. Early symptoms were similar for wheat and oats infected with aster yellows or barley yellow dwarf. Subsequently, the disease on plants infected with aster yellows became more severe, but plants infected with barley yellow dwarf usually exhibited partial recovery.

Of the 13 varieties of oats tested against several strains of the aster yellows pathogen, all were susceptible to a noncelery-infecting strain but not to the other strains used. Transmission from oats to aster was low, the pathogen being reisolated from only 12 of 155 infected oat plants.

Bacteria

Bacterial black chaff, *Xanthomonas translucens* f. sp. *undulosa* (Jones, Johns. & Reddy) Dowson, significantly reduced the yield of the wheat varieties Neepawa and Saunders. The correlation coefficient between head discoloration and yield was –0.57 for Neepawa and –0.59 for Saunders. Similarly, the correlation coefficient between bacterial lesioning of the leaves and yield was –0.53 for Neepawa and –0.41 for Saunders. The correlation coefficient between head discoloration and bacterial leaf infection was 0.79 for Neepawa and 0.72 for Saunders, all significant at $P = 0.01$. Symptomatically and by analysis, infection appeared to be unitypic bacterial black chaff.

Regression analysis indicated a 161.4 kg/ha loss of yield in Neepawa and a 43.7 kg/ha loss in Saunders for each 10% of head discoloration to a maximum yield loss of 40% in both varieties. Similarly, bacterial leaf infection caused a 114.3 kg/ha loss in Neepawa and a 25.5 kg/ha loss in Saunders per 10% increase in infection to a maximum loss of 50% in Neepawa and 80% in Saunders. The maximum calculated yield loss in Neepawa was 36% and in Saunders 18%.

Foliage Diseases

Fertile perithecia of *Pyrenophora avenae* Ito & Kurib. were produced on oat seed or oat straw in Sach's agar inoculated with a mixture of cultures from 18 localities. Mature ascospores were produced 9 weeks after inoculation in cultures grown at 16 C in a 12-hr photoperiod. Monoascospore cultures were infertile, but a few matings were fertile or partly fertile when certain monoascospore cultures were paired. The fungus is heterothallic and bisexual.

Seed Treatment

Nineteen seed-treatment fungicides were tested for their effects on the microflora of barley seed naturally infested with *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, *Alternaria alternata* (Fries.) Keissler, and *Streptomyces* species. Treated seed was placed in soil for 7 days at 20 C, and then examined. The wide-spectrum fungicides Ceresan M (DuPont of Canada Ltd.), methylmercuric dicyandiamide (Panogen PX; NOR-AM Agricultural Products Ltd.), and mancozeb (Dithane M-45; Rohm & Haas Co. of Canada Ltd.) provided the best control of *C. sativus*, whereas the more selective fungicides provided little or no control. *A. alternata* was controlled ($P < 0.05$) by all fungicides except SWF 850 and G 696. In contrast, growth of *Streptomyces* spp. was enhanced by Chemagro 4497; F 735 and G 696 (UniRoyal Ltd.); and SWF 860, SWF 800, and SWF 850 (Green Cross Products); the other chemicals had no effect. Because of similar results from soil and filter-paper techniques and the large amount of work involved in the former, the filter-paper technique is best for initial screening of fungicides.

Sixty-eight seed-treatment chemicals were tested for their efficacy in controlling bunt of wheat, *Tilletia foetida* (Wallr.) Liro, covered smut of oats, *U. kolleri*, covered smut of barley, *U. hordei* (Pers.) Lagerh., seedling blight of barley, *C. sativus*, and seed rot of flax, caused by a complex of seed- and soil-borne microorganisms. The best chemical for control of seedling blight was only partly effective. The systemic fungicides usually controlled smut diseases, but oat smut was especially difficult to control. The value of maneb, and to a lesser extent thiram, as broad-spectrum fungicides was indicated. However, the occurrence of a serious outbreak of covered smut of barley in southwestern Saskatchewan in 1969, even when the seed was treated with materials containing maneb, indicates the need for further testing.

Over 1,000 samples of grain were examined for the occurrence of storage fungi, insects, and mites. Storage fungi were much less abundant in undried grain than had been expected.

FIELD CROP INSECTS

Soil Insecticides

Heptachlor granules applied to the seed furrow failed to control the cabbage maggot, 85% of the population being resistant to the insecticide. Rape was effectively protected throughout the growing season where granules of trichloronat (Bayer 37289; Chemagro Limited), fonofos (Dyfonate; Stauffer Chemical Co.), carbofuran (Furadan; Niagara Chemicals), fensulfothion, and Bay 77488 (Chemagro Limited) were applied to the seed furrow at 42.5 g actual per 30.5 m of row. The first three insecticides were also effective as postemergence treatments applied in 10.2-cm bands 22 days after seeding at 71 g actual per 30.5 m of row.

The extent and intensity of the sugar-beet root maggot infestation has increased during the last 3 years. Because it is anticipated that liquid starter-fertilizers will be used to a greater extent in sugar-beet culture, granular insecticides were tested in conjunction with in-furrow applications of phosphoric acid (0-52-0). Four organophosphorus insecticides and one carbamate provided adequate plant protection, but reduced the heavy maggot population (70 maggots per beet in control plots) by only 45% to 55%. The fact that the peak of adult flight was delayed about 10 days does not fully account for the results. It was not determined if the starter-fertilizer influenced the bioactivity or persistence of the insecticides in soil.

Dieldrin, absorbed by growing cereal plants from insecticide-contaminated soil and

translocated into the seed, is reduced to aldrin during storage of the grain. The initial amount of dieldrin (3 ppm) in wheat grain was gradually reduced to a trace during 5 years of storage, whereas aldrin, initially a trace, increased to 0.5 ppm. This reduction process is in marked contrast to the well-known epoxidation of aldrin to dieldrin and was hitherto believed not to occur under natural conditions.

Grasshopper Ecology

When first-instar nymphs of the two-striped grasshopper were fed fresh leaves of dandelion, wild mustard, sow-thistle, stinkweed, and garden lettuce, the survival was between 70% and 80%. The developmental period was shortest on sow-thistle and garden lettuce and longest on stinkweed. There was no survival on either quack grass or brome grass. Survival to the adult stage was between 53% and 67% on dandelion, wild mustard, sow-thistle, and stinkweed and 20% on garden lettuce.

Estimates of the grasshopper population were made in areas in which the dominant plants were *Agrostis* sp. and *Poa pratensis* L. (bluegrass), by use of hardboard panels approximately 2,100 cm^2 in area arranged in pairs, one white and one green. The surface temperature was higher on the green panels. Consistently, more grasshoppers settled on the green panels than on the white ones.

Estimates of grasshopper eggs in the spring of 1969 were lower by about 50% than estimates made in the same areas in the fall of 1968, except in one instance where the spring and fall estimates were equal.

Grasshopper Surveys

In Manitoba in 1969, grasshopper populations were at their lowest level since 1954. Cool wet spring weather delayed and prolonged the hatching period and retarded development.

INSECTS AND MITES IN STORED PRODUCTS

Surveys

Farm-stored grain. Because of unfavorable conditions, much of the grain harvested in 1968 was stored in a tough or damp condition. Periodic surveys revealed that the moisture content of grain declined during the winter. Moreover, with the onset of warmer weather the temperature in these bulks rose at a slower rate than in grain that had been artificially dried. Only a relatively small percentage of the farm grain bulks were infested by economic species of insects.

Merchant grain beetle. Since 1925, the merchant grain beetle has been found in Canada, and is widely distributed as a household pest of processed cereal products, particularly those with high oil content. It was not found in stored grains. The beetle has often been identified as the saw-toothed grain beetle, a species that infests both stored grains and processed cereal products.

Ecology

Chemical control of insects. Extremely high dosages of chloropicrin, 14 and 140 mg/liter, were required to kill 50% of the eggs of the rusty grain beetle and the flour mill beetle, *Cryptolestes turcicus* (Grouvelle), respectively. This is in sharp contrast to results with adult populations of these species, where 50% were killed with dosages ranging from 1 to 2.5 mg of the fumigant per liter. Chloropicrin, however, is effective against the mobile stages of the grain mite, *Acarus siro* L., a common grain pest in the prairies; dosages as low as 0.65 mg/liter induced 50% mortality at 20 C.

The effectiveness of hydrogen phosphide (Phostoxin; Degesch) against all stages of the rusty grain beetle was assessed under field conditions. Eggs of the beetle were resistant to Phostoxin; some survived three pellets/163 kg of wheat for 4 days at 15 C, although the recommended treatment is 2.5 to 10 pellets/900 kg for 3 days at 15 C.

Areas of a concrete floor in a terminal grain elevator were treated at the rate of 1.46 g/m^2 with either malathion or bromophos.

Ten weeks after treatment with either compound, the mortality of adults of the confused flour beetle exposed to the treated areas averaged 85%; after 33 weeks mortalities were still over 75%. The low pH of the surface (approx 6.0) that resulted because grain dust was ground into the concrete probably accounts for the unexpected persistence of malathion.

Reaction to feeding compounds. An antifeeding compound AC-24055 (American Cyanamid Co.) was applied to different kinds of cereal packages to protect the contents from infestation by stored-products insects. Well-constructed plastic or plastic-lined packages treated with the compound were protected for up to 6 months, but cloth bags with large stitch holes, bags made of loosely woven cotton, and paper bags with poorly sealed closures became infested within 2 months even when treated.

Work was continued on fractionation and characterization of components in the fungus *Nigrospora sphaerica* (Sacc.) Mason that induce flour beetles to aggregate or to feed. Several triglycerides were identified, the most active being 1-palmityl-2,3-dioleyl glycerol.

Insect detection. An insect-detection device for use in stored grain, described in 1967, has proved to be a more sensitive detection device and a more efficient trap for collecting insects and mites than the conventional grain samplers.

Bioassay for nutritive value of cereals. The confused flour beetle was used to detect differences in nutritive value among cereal varieties. Varieties to be assayed were finely ground in a ball mill. Because the length of the larval period varies with the fineness of the grind and the effect of particle size on larval development is not consistent among varieties, all material was pelleted before assay. Newly hatched larvae were placed in the medium, and the length of the larval period, in days, was used as the criterion of nutritive value. Personnel at the Research Station, Brandon, Man., conducted feeding trials with chicks to determine whether the beetle's assessment of nutritive value was meaningful for farm animals. Results of these comparative assays with five varieties of barley and three varieties of wheat are in general agreement.

Factor analyses of natural arthropod fauna in bulk grain ecosystems. Interrelationships between natural arthropod fauna and their environment were studied on samples collected from 165 grain bulks from various parts of Western Canada. Principal-component and maximum-likelihood factor analyses were applied to six biotic and three environmental variates, and a three-factor hypothesis on the interrelationships among stored-grain fauna was developed and tested. Of the three factors, two were strongly correlated (correlation coefficient = 0.78 ± 0.15). The final confirmatory factor analysis revealed that the mites *Glycyphagus* and *Cheyletus* were correlated positively with each other, but negatively with the insect Psocoptera; and that the mite *Tarsonemus* was correlated with moisture, dockage, and Psocoptera.

FUMIGANT ANALYSES

Sorption Affinity of Fumigants

A rapid, dynamic method of measuring sorption of methyl bromide by granular or powdered substrates in the parts per billion (10^9) range was developed. The method employs rapid fumigation (1.5–7 sec contact time) with a Teflon gas chromatographic column in which the substrate constitutes the packing. The response (peak height) measured with a hydrogen-flame ionization detector is compared with that obtained with an empty column. Uptake of as little as 5 nanograms of methyl bromide by the substrate can be determined within 22 sec after injection. When column temperatures are raised, chemisorption is indicated if the response is significantly lowered, and physisorption if the response is increased. The substrates tested ranged from ground wheat and wheat products to soils, sand, glass beads, and charcoal. Sorption of methyl bromide varied with substrate; it ranged from 10% to 62% for the foodstuffs, and from 4% for glass beads (15-cm column, 5 g) to 100% for activated charcoal (0.6-cm column, 0.08 g).

The method is analogous to that developed

by Berck and Gunther, in which a gas chromatograph equipped with a flame-photometric detector was used to determine sorption of phosphine by cereal products and other foodstuffs. In both methods N_2 (carrier gas) is used for constant aeration of the flash-fumigated substrate.

PEDOLOGY

Classification and Mapping

The Pedology Section, in cooperation with the Manitoba Soil Survey, surveyed 39,300 ha intensively and 45,800 ha on a low-intensity basis in the southern half of the Virden map sheet area, 62F. Hydrology and salinity studies, in cooperation with the Department of Earth Sciences, University of Manitoba, were continued in the Whitewater Lake basin section of the map area. Approximately 221,200 ha in the Swan Lake map sheet area, 63C, and 800,000 ha in The Pas map sheet area, 63F, also were surveyed at low intensity during the past field season.

Soil Characterization

A study of Al, Fe, and Mn relationships in a sequence of well-drained, imperfectly drained, and poorly drained Manitoba soils indicates that their distribution in profiles is of some value in differentiating Orthic Gray Wooded, Gleyed Gray Wooded, and Eluviated Gleysol soils. Maximum accumulation of Mn occurs in the Ae and Bt horizons of well-drained Orthic Gray Wooded soils, in the Bt horizon of imperfectly drained Gleyed Gray Wooded soils, and in the C horizon of poorly drained Low Humic Eluviated Gleysol soils. Ratios of oxalate-extractable Fe to dithionite-extractable Fe in the B and BC horizons of these soils range from low values in the well-drained soils (0.09) to high (0.9) in the poorly drained soils. Oxalate- and dithionite-extractable Al do not appear to be affected by differences in soil drainage.

In an organic-matter characterization study of a well to poorly drained soil sequence, the proportions of NaOH-extractable humic and fulvic acids and the functional-group content of the humic acids were determined. The results suggested that the organic-matter content of these soils was similar and that differences in drainage had not affected the processes that determined its nature.

In soil classification and characterization studies of the Localized, Discontinuous, and Continuous Permafrost zones in northern Manitoba, it was found that organic soils are dominantly Cryic Fibrisols. In the Discontinuous Permafrost zone the water content of the active layer (that layer subject to annual thaw) was approximately 25% to 32% lower than permanently frozen layers. Exchangeable Ca and Mg content is considerably lower in the active layer than in permanently frozen layers of similar composition. The pH of the frozen layers is significantly higher than the more acid active layer.

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INTRODUCTION

This report outlines the significant results of the research program at the Experimental Farm, Indian Head, for 1969. None of the research is reported in detail. Significant progress on long-term projects is mentioned. Results of our testing program are incorporated in the information on which practical recommendations are made for the guidance of farmers in Saskatchewan for cereal crops, forage crops, fertilizer, weed control, and rotations.

Echo rape was developed at Indian Head and the first seed was distributed to growers in 1964. A survey of acreage seeded to rape in Western Canada in 1969 indicated that well over 50% of the acreage was seeded to Echo. Breeder seed of Echo rape was supplied to 21 Select seed growers in 1969.

J. Roe Foster
Director

FIELD HUSBANDRY

Rotations and Soil Fertility

Rotations. Two cropping systems have been compared for 58 years. In the 9-year rotation, each field was left in a grass-legume mixture for 3 years, manured, broken, and cropped for 3 years, summerfallowed, then sown to wheat and oats. In the other rotation, two crops of wheat were produced after summerfallow. In 1969, wheat on summerfallow in the 9-year rotation yielded 37.5 q/ha (55.8 bu/acre). The soil tested 32.7 kg/ha of available N and 13.6 kg/ha of available P. When ammonium phosphate was applied with the seed in this rotation, yields were not increased, whereas the yield of wheat on summerfallow in the 3-year rotation was increased by 3.4 q/ha (5 bu/acre) and on stubble by 6.1 q/ha (9.1 bu/acre). The soil test in the latter rotation was much lower. For the past 12 years plots have been sown continuously to wheat. They yielded 28.9 q/ha (43.1 bu/acre) this year, and for the 12-year period averaged 14.9 q/ha (22.3 bu/acre). When fertility requirements were met and weeds controlled, continuous wheat outyielded wheat in a 2-year rotation. In another sequence, wheat, oats, and barley were sown after flax and after cereal crops. For a number of years the preceding crop had no effect on the succeeding crop, but in 1969, the yield of each crop following flax was depressed.

Fertilizers

The relationship between soil analysis and the response to an application of N and P was studied on Oxbow and Ryerson loam soils. In 89 tests conducted from 1966 to 1969, the yield of wheat on summerfallow and on stubble increased as the amount of NO_3-N in the soil increased. The response to applied N was fairly uniform, irrespective of the level of NO_3-N in the soil. The optimum rate of application of N in combination with P was 22.4 kg/ha. The response to P was related to two levels of available P in the soil. When the available P was 22.4 kg/ha or less, the optimum rate of application was 19.7 kg/ha. When the available P was higher than 22.4 kg/ha, the optimum rate of P was 9.9 kg/ha.

For the past 23 years, P at 4.4 to 21.1 kg/ha has been applied to test plots on the Experimental Farm. The available P in the soil has increased, particularly where the higher rates were used. Though the soil test for P was high, the greatest increase in yield in 1969 occurred where the heaviest rate of fertilizer was used. For more than 20 years manure has been applied once every third year at three rates to these plots. Available N and P have increased in all plots. In 1969 wheat sown on summerfallow in the check plots yielded 25.4 q/ha (37.7 bu/acre) and on stubble 22.7 q/ha (33.7 bu/acre). The plots that received 20 tons/ha of manure yielded 32.9 q/ha (53.0 bu/acre) and 27.8 q/ha (41.3 bu/acre) respectively. The increases are very much higher now than in the early years of the experiment.

Various rates of N and P in solution were applied to wheat sown on stubble. This fertilizer compared favorably with granular forms. N alone and in combination with P was applied to flax sown on stubble. Yields were increased by 2.7 q/ha (4 bu/acre) with

N at 11.2 kg/ha and by 5.8 q/ha (8.6 bu/acre) with N at 33.6 kg/ha.

Weed Control

Green foxtail. Trifluralin at 1.12 and 1.68 kg/ha was the only preemergence spray of four tested that controlled green foxtail without injuring wheat or barley. Although some of the postemergence sprays at the higher rates controlled green foxtail, all of them injured the crops.

Continuous use of herbicides. Weed infestation was reduced in plots where three formulations of phenoxy herbicides at a light and a heavy rate were applied for 24 years. Weeds were counted before the first operation on the summerfallow and about 2 weeks after emergence in the crop. In 1969 in plots where the heavy rate of 2,4-D was used, weeds averaged 4/sq m in summerfallow wheat, 6 in the stubble wheat, and 5 in the summerfallow, whereas in the check plots weeds numbered 15, 30, and 360. The average yield of wheat this year on summerfallow plots where chemicals were used was 38 q/ha (56.5 bu/acre) and on stubble plots 26.4 q/ha (39.3 bu/acre). These results indicate that no injurious effect was shown from the continuous use of herbicides.

PLANT SCIENCE

Cereals

Evaluation of cereal varieties, lines, and plant breeders' material was made in cooperative and zone tests. Zone tests were sown on six project farms. These tests covered the main crop hazards, drought, rust, and frost. The good crop in 1969 was produced as a result of fall reserve moisture plus a few effective rainfalls in late June and early July. Total rainfall at Indian Head from May 1 to August 31 was 16.10 cm. Maturity was hastened by shortage of moisture in early August. There was no rust to indicate variation in resistance.

Neepawa at 30 q/ha (45 bu/acre) was the highest yielding red spring wheat; Manitou and Canthatch produced similar yields, which were 0.67 q/ha (1 bu) less than Neepawa. Stewart 63 and Ramsey durum produced similar yields, and Hercules yielded 11.2% less, but Hercules had short, strong straw, and matured 5–6 days earlier. Pitic 62 yielded about 18% higher than Neepawa and matured about 6 days later. Fraser was the highest yielding oats at 40 q/ha (105 bu), followed by Kelsey and Garry. Under rust-free conditions Harmon yielded less than Rodney. Yorkton yielded about the same as Kelsey, was later maturing, and had a thin yellow kernel that weighed about 10 g less per 1,000 kernels than Fraser or Harmon. Jubilee was the highest yielding barley, followed by Galt, Paragon, and Bonanza. Redwood 65 was the highest yielding flax, and Noralta, Norland, and Nored produced about 78 kg/ha (1.2 bu/acre) less. The Triticales did not yield as much as the other cereals in this area, and consequently they do not appear to be promising as a feed grain. The following increase of Select seed of new varieties was made: Bonanza barley 11,080 q (5,090 bu) and Trader (MP41) peas 1,278 q (470 bu).

Forage Crops

Because fall moisture reserves in forage crops were low and no effective rain was received until June 22, yields of perennial crops were low in 1969.

Management practices. Ammonium phosphate fertilizer, 11-48-0, at 22.4, 33.6, 44.8, and 56.1 kg/ha applied with the seed of five grasses and alfalfa in 1966 had no effect on herbage yield of grasses in 1969, but significantly increased the yield of alfalfa when applied at 56.1 kg/ha. Alfalfa seeded with grass either in the same row or in alternate rows produced the same yield of dry matter. Clipping Russian wild ryegrass after seed harvest produced no effect on seed yield the following year. A high rate of N (112.1 kg/ha) in the fall increased the seed yield by 170.4 kg/ha, whereas N at 56.1 kg/ha increased the yield by 141.2 kg/ha. The use of grass and alfalfa mixtures in the rotation significantly increased the yield of wheat on stubble in 1969. Grass alone in the rotation had no effect on the yield of wheat on stubble.

Plant breeding. Five and a half q (1,225 lb) of Foundation seed of Magna, a new variety of brome, was distributed to growers

in 1969, and an additional 9.2 q (2,025 lb) was produced in 1969. The Breeder seed plot of Sawki Russian wild ryegrass produced 4.3 q (950 lb). Breeder seed plots of the new varieties Norgold sweetclover and Parkway crested wheatgrass were established; these were sown in cooperation with the Research Station, Saskatoon.

Several oat lines selected for herbage yields showed promise for use as forage; they yielded more seed than Rodney and Garry and produced about 15% more dry matter. Reselecting within Echo rape Breeder seed for increased seed size, oil content, and yield is continuing. Preliminary tests indicate some progress is being made.

SOILS—HORTICULTURAL CROPS

Soil Fertility

Effect of rotation on soil-borne diseases in potatoes. Average data for 1962–69 showed that the first and second potato crops of a 6-year rotation produced marketable tuber yields of 241 and 211 q/ha, respectively. Continuous potatoes and a 3-year rotation produced marketable tuber yields of 209 and 254 q/ha, respectively. The 6-year rotation consisted of potatoes for 2 years, alfalfa and crested wheatgrass hay crops for 3 years, and fallow, whereas the 3-year rotation consisted of potatoes, sweetclover hay crops, and fallow.

Soil moisture level of the various rotations at planting time did not contribute to the higher yield from the 3-year rotation. However, a plant-disease survey showed that wilts and rhizoctonia may affect yields of these rotations. In 1968–69 the average percentage of infected potato plants found in the continuous crop, the 3-year rotation, and the first and second crops of the 6-year rotation were 85, 15, 28, and 44 respectively.

Cross-feeding of applied fertilizer by potato plants from adjacent rows. Soil NO_3-N levels and root distribution patterns show that cross-feeding of NO_3-N by potatoes in adjacent rows may occur at row spacings of 91 and even 122 cm under irrigated conditions. It was shown that sufficient cross-feeding occurred to significantly increase yields at a row spacing of 61 cm when low or medium amounts of NH_4NO_3 fertilizer were applied and at a row spacing of 91 cm when a high amount of fertilizer was applied.

Cross-feeding of phosphate fertilizer was limited to a row spacing of 31 cm.

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INTRODUCTION

The Research Station, Melfort, serves the agricultural industry of northern Saskatchewan through research aimed at improving the production efficiency of crops and livestock. It specializes in forage production and utilization research, much of which has a broad application to the nutrition of ruminant livestock. Other areas of research are soil and crop management, forage seed production, weed control, animal nutrition, cereal crops, and horticulture.

In 1969 the growing season was one of the shortest on record. The last killing frost was on June 12 and the first on September 17. The cold, dry spring delayed the start of the grazing season until June 10. During the growing season only 13.2 cm of rain fell, 56% of which is the usual rainfall. However, 16 cm of rain fell in numerous showers in September and October, and interfered with harvesting operations.

This report includes a condensation of some of the results obtained in 1969. More detailed results of interest to farmers and extension workers are published in our annual *Research Highlights*, available at no charge from the Station.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Evaluation and Breeding of Forage Crops

Sainfoin. Melrose is the first variety of sainfoin, *Onobrychis viciaefolia* Scop., to be developed in Canada. The name was derived from the words Melfort and rose, which refer to the location where early recognition of the variety's potential was made and to the attractive and distinctive flower color.

Melrose is a selection from among a group of introductions received in 1962 from the All-Union Institute of Plant Industry, Leningrad, USSR. These introductions were grown at Saskatoon and open-pollinated seed from the most promising accession was harvested in 1963. This seed was used to establish plots at Melfort, where a large number of vigorous, high-seed-setting plants were selected in 1965. Seed from the selected plants was further increased at Melfort to form the basis of the Melrose variety. Seed from the increase plot at Melfort was used in Regional Sainfoin tests coordinated by the Research Station, Lethbridge, during 1966–69. In these trials Melrose displayed excellent winterhardiness and yield of seed. Sainfoin does not cause bloat because it lacks the 18-S protein fraction responsible for bloat. Melrose will probably be readily accepted by livestock producers in Western Canada.

Forage Crop Production

Nutrition. Yellow sweetclover and bromegrass–alfalfa, without fertilizer, established in the spring of 1969 on newly broken land in the Saskatchewan River Delta, produced 3,366 kg DM/ha. Sweetclover fertilized with N at 29 kg/ha and P at 56 kg/ha and bromegrass–alfalfa fertilized with N at 180 kg/ha and P at 168 kg/ha produced 6,700 kg DM/ha in the establishment year.

Soil levels of K and of several micronutrients (Cu, Zn, Fe, Mn, B, and Mo) appeared to be adequate. Levels of P in the soil were clearly insufficient for high production, especially of legumes. Observations from a test plot in which forages were seeded directly into the unbroken ground in the summer of 1968 showed that the addition of fertilizer enabled cultivated forages such as sweetclover, alfalfa, alsike clover, and bromegrass to suppress native grasses and sedges and to yield 4,400–7,600 kg DM/ha in the year following seeding.

Weed control. MCPB applied at up to 3.36 kg/ha appeared to do little damage to seedling and established sainfoin plants that were under 15 cm high.

Rates of 2,4-DB up to 1.68 kg/ha showed some differential effect between broadleaved weeds and sainfoin seedlings, but damage to the sainfoin became excessive at rates higher than 1.12 kg/ha. Unacceptable

damage was caused to an established sainfoin stand.

A 1:1 mixture of MCPA and bromoxynil defoliated or severely scorched sainfoin at all stages of growth. Seedlings recovered poorly. Established sainfoin, 16 cm high when the herbicide was applied, produced good regrowth but flowering and seed set were delayed about a week.

Applications of 2,4-D at 0.35 kg/ha, or higher, killed both seedling and established sainfoin.

Forage Crop Utilization

Management of steers on pasture. For the third consecutive year four systems of managing steers on bromegrass–alfalfa pasture were compared. 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 soilage; (iii) maintaining a stocking rate as in (ii), but supplementing pasture with rolled barley; and (iv) "put and take" stocking. The results of the four systems, in order, follow. Yields of dry matter, 1,688 (including surplus harvested as silage), 1,957, 1,997, and 1,395 kg/ha; consumption of dry matter, 1,381 (including silage fed), 1,652 (plus 1,414 kg of oat soilage), 1,770 (plus 1,233 kg of rolled barley), and 1,216 kg/ha; average stocking rate, 1.53, 2.77, 2.77, and 1.53 steers/ha; average daily gain, 1.08, 1.17, 1.38, and 1.17 kg/day; gain/ha of pasture, 174, 345, 405, and 189 kg. Results averaged for the first 3 years of the experiment include: yields of dry matter, 3,396 (including surplus harvested as silage), 3,556, 3,461, and 3,035 kg/ha; consumption of dry matter, 2,772 (including silage fed), 3,120 (plus 1,410 kg of oat soilage), 2,936 (plus 1,427 kg of rolled barley), and 2,722 kg/ha; average stocking rate, 2.20, 3.26, 3.36, and 2.30 steers/ha; average daily gain, 1.13, 1.12, 1.33, and 1.14 kg/day; gain/ha of pasture, 268, 406, 504, and 281 kg.

Rate of increasing wheat content. When 318-kg steers were self-fed a 90% ground good-quality hay ration, and the content of rolled wheat in the ration was increased by 10% increments every 8–10 days up to 70% (and several weeks later 80%), performance was excellent and no digestive disturbances occurred. Wheat straw gradually replaced the good forage as the level of wheat was increased. On the average, these steers each consumed 349 kg good hay, 291 kg wheat straw, and 821 kg wheat over the 119-day test; and they gained 1.48 kg daily, required 8.3 kg feed/kg gain, and dressed 56.9%.

When the wheat content of the ration for a similar group of steers was increased by 20% increments, two steers had to be treated for rumen overload and the others developed diarrhea when the level of wheat was increased from 50% to 70% of the ration. The diarrhea cleared up without treatment. On the average, these steers each consumed 195 kg good hay, 327 kg straw, and 885 kg wheat, and gained 1.45 kg daily, required 8.1 kg feed/kg gain, and dressed 56.7%.

After the steers were slaughtered, it was discovered that several steers from both treatments had rumen ulcers, abscessed livers, and abnormal kidneys.

The test showed the value of ground roughage in getting steers safely onto high grain rations, but also indicated that steers should not be fed rations containing too much wheat for too long a period.

Forage quality, fineness of grind, and initial level in wheat-based rations. Roughages of good quality (brome–alfalfa) and poor quality (oat straw) were each ground through 1.27-cm and 2.54-cm screens and the resulting four "products" each fed at levels of 40%, 60%, and 80% of the starting ration. Dry-rolled wheat, a mineral, vitamin A, and an antibiotic supplement made up the remainder of the ration. Each ration was self-fed to six steers that averaged 325 kg at the start of the test. During 8 weeks the wheat content of all rations was gradually increased to 90%.

Average daily gain (kg), daily feed consumption (kg), feed-to-gain ratio, and dressing percentage by the main treatments were: 40% roughage, 1.61, 11.5, 7.1, 58.2; 60% roughage, 1.65, 12.1, 7.3, 57.6; 80% roughage, 1.57, 12.1, 7.7, 57.2; good quality roughage, 1.65, 12.2, 7.4, 60.5; poor quality roughage, 1.57, 11.7, 7.5, 59.6; fine grind, 1.66, 11.8, 7.1, 60.1; coarse grind, 1.56, 12.0, 7.7, 59.8; 62 of the 72 steers graded Canada Choice.

Some digestive problems occurred mainly when good quality roughage was fed at the

50–70% level. One steer fed a ration of 90% wheat content developed a severe case of bloat and required emergency treatment. No deaths occurred. A study of internal organs revealed 9 abscessed livers, 9 abnormal kidneys, and 16 ulcerated rumens, but the incidence of these disorders could not be related to treatments.

Utilizing crested wheatgrass hay in lamb finishing rations. Rations containing 90%, 70%, 50%, and one gradually changed from 90% to 50% crested wheatgrass hay were fed in ground (0.48 cm) and in pelleted (0.64 cm) forms to individually stalled ewe and wether crossbred lambs that averaged 30.5 kg at the start and 45 kg at the end of the test. As the level of forage in the ground rations decreased, the rate of gain increased slightly and feed-to-gain ratio, dressing percentage, grades, and returns increased. The best performance was obtained when the 90% hay ration was used as a starter, and the level of hay was reduced by 5% over 8 weeks to 50%. The rations fed in the pelleted form increased rate of gain and feed efficiency by 47% and 22%, on the average, respectively; the greatest increase (66% and 33%, respectively) occurred with the 90% hay ration.

Pelleting increased in vitro digestibility of the organic matter in the 90%, 70%, and 50% roughage rations by 1.1, 1.8, and 2.7 percentage units, respectively.

CROP PRODUCTION

Cereal Breeding and Crop Evaluation

The oat breeding program that is under way emphasizes nutritional value (fat content) as well as yield and disease resistance. A Rodney × Exeter cross (O.T.613) has a high percentage of plump kernels and a low hull content, and has yielded well in Western Cooperative Tests for 3 years. Several plump-kerneled strains from two crosses, Exeter × O.T.606 and Glen × O.T.606, have performed well on the Black soil zones of Manitoba and Saskatchewan and four will be retained for further assessment. Several (2–5%) albino plants were found in the F_3 progeny of a cross involving, among other strains, Rodney, Beacon, and Roxton.

New crops under appraisal include buckwheat, coriander, and canarygrass.

Crop Management

Soil fertility. Crop production studies in the Saskatchewan River Delta (first year breaking, alluvium soil) revealed significant yield increases when Conquest barley was fertilized with N at 0, 56, and 112 kg/ha and P at 0, 56, 112, and 168 kg/ha. K applied at 112 kg/ha did not significantly increase yields. Maximum yield (4,618 kg/ha) was obtained with N at 112 kg/ha and P at 168 kg/ha (check 2,586 kg/ha). The most economical treatment was N at 112 kg/ha plus P at 56 kg/ha, which yielded 4,349 kg/ha. A treatment consisting of sulfur and the micronutrients Cu, Zn, Fe, Mn, B, and Mo significantly increased yield when applied without NPK, but not when applied with NPK.

Response of vegetables to fertilizer. The application of 11-48-0 at 448 kg/ha to the peat–mineral soil in the Saskatchewan River Delta increased the yield of potatoes, carrots, turnips, and parsnips by 104%, 93%, 176%, and 83%.

When phosphate fertilizer plus N was applied at the tasseling stage, it did not significantly increase yields of table corn grown on Melfort silty clay soil. The average increase from N alone was only 99 dozen ears per ha.

Fertilization effect of organic amendments. Peat, manure, straw, and sawdust were applied at 2.5% of soil weight to Garrick loam (Gray Wooded soil). Peat and manure were applied to Nipawin loam (Dark Gray Wooded soil) and peat was added to Waitville loam (Gray Wooded soil). Canthatch wheat, *Triticum aestivum* L.; Conquest barley, *Hordeum vulgare* L.; a mixture of bromegrass, *Bromus inermis* Leyss., and alfalfa, *Medicago sativa* L.; bromegrass; and Manitou wheat were grown in succession. The experiments were carried out in the greenhouse under irrigation, which kept the soil moisture tension constant, so crusting did not affect establishment of crops. Grain yields were highly related to the amounts of N supplied by the amendments (wheat R^2 = 91%, barley R^2 = 54%). By increasing the C:N ratio of the organic matter of the Garrick soil with straw and applying a moderate

rate of N fertilizer (35 μg N/g soil) maximum yields of alfalfa and bromegrass were produced.

Effect of organic amendments on soil crust strength. Organic amendments (peat, manure, straw, sawdust) at 2.5% of soil weight were applied to three Podzolic soils in the greenhouse. After five successive crops, soil crust strength, as indicated by modulus of rupture measurements, was reduced by the amendment treatments. Modulus of rupture values were highly related (R^2 = 85.4%) by multiple curvilinear regression equations to plant counts of Target rape, *Brassica napus* L., in the growth chamber. Modulus of rupture determinations showed that the effect of soil moisture on crust strength between treatments was negligible. Treatments increased field and available moisture capacities of soils, but had little effect on moisture retained at 0.35 and 15.8 bar tensions.

Forage Seed Production; Management of Pollinators

Effect of temperature and source of food on the reproduction of the alfalfa leaf-cutter bee. Important factors influencing the reproduction of the alfalfa leaf-cutter bee, *Megachile rotundata* F., include temperature, sunlight, and the availability of nectar and pollen. Bee activity is generally limited to periods of bright sunshine and temperatures above 20.5 C. From July 1 to August 25 these conditions of temperature and sunlight occurred 224, 300, 137, and 255 hr in 1966, 1967, 1968, and 1969, respectively. Average cell (cocoon) production per female per year was 6.6, 15.7, 5.0, and 11.1, respectively. Alfalfa was the source of nectar and pollen each year.

To determine if wind or source of food affected the reproduction of *M. rotundata* a standard domicile was strategically located on a field of alfalfa in 1966, sweetclover, *Melilotus officinalis* Lam., in 1967, and buckwheat, *Fagopyrum esculentum* Moench, in 1969, to achieve the greatest possible amount of protection from prevailing winds. At these favorable locations the average number of cells constructed per female from July 1 to August 25 was 12.9 in 1966 on alfalfa and 32.5 in 1967 on sweetclover. In 1969 buckwheat was pollinated from July 22 to August 25. Despite this rather short period, average cell production was 29.1 per female.

Soil and Crop Management

Dates of initial tillage on summerfallow. When broad-leaved weeds are controlled with herbicides, tillage on summerfallow can be started later than usual (May 15–25) in the Melfort area. Results over 5 years show that controlling winter annual weeds on summerfallow with a late fall or early spring application of 2,4-D permits tillage to be delayed until June 1, or even mid-July, without adversely affecting wheat yield, soil moisture supply, or nitrate nitrogen level. The extent of the delay in the tillage operation depends on the germination of cereals and grassy weeds. Delaying the first tillage operation on summerfallow reduces the cost and preserves more trash for erosion control.

Herbicides for replacing tillage on summerfallow. Herbicides have been compared with tillage for controlling weeds on summerfallow for two successive rounds of a 2-year rotation. The herbicides used were 2,4-D, dicamba, and paraquat. These herbicides are used to replace tillage and to preserve the trash cover for erosion control. Four summerfallow treatments were used: herbicides only, tillage only, one tillage operation plus herbicides, and two tillage operations plus herbicides. Four-year average wheat yields were 2,771, 2,684, 2,850, and 2,812 kg/ha, respectively. No significant differences were found in the nitrate-N content of the soil (to 61 cm) or in the amount of spring-stored soil moisture (to 1.2 m) among treatments.

Because of the cost of herbicides required to control grassy weeds one or two tillage operations combined with one or more herbicide treatments is the most practical method of controlling weeds on summerfallow.

Moisture storage and production on summerfallow. Summerfallowing at four sites in northeastern Saskatchewan, Archerwill, Melfort, Parkside, and Somme, over the past 7 years has resulted in the storing of an additional 2.5 to 8 cm of moisture in the top 1.2 m of soil. Well-managed stubble land has produced yields of wheat averaging 74%, 85%, 93%, and 70% of that produced after summerfallowing at the four sites, respectively.

Dates of swathing rapeseed. The results of trials to determine the proper stage at which to swath rapeseed showed that Target, *B. napus* type, and Echo, *B. campestris* type,

produced the highest yield and quality when they were swathed at about 35% and 30% seed moisture content, respectively. These levels of moisture occurred when most of the seeds were in the firm-dough stage and when 35% or more were brown. In 3 years at Melfort, this stage was reached 110 and 93 days, respectively, after Target and Echo rapeseed were seeded. Swathing rapeseed at this stage produced a good-quality product and reduced losses from shattering, wind damage, and untimely fall frosts.

ANIMAL SCIENCE

Medication of rations for newly weaned and newly shipped calves. On arrival from the Lethbridge area, 85 Charolais × Aberdeen Angus calves, averaging 200 kg, were divided into three groups: (i) control, fed good-quality grass ad lib. plus 0.9 kg dry-rolled barley per head daily; (ii) fed as in (i) plus 700 mg chlortetracycline-sulfamethazine per head daily; and (iii) fed as in (i) plus 350 mg oxytetracycline per head daily for 3 days and 75 mg per head daily from days 4 to 28. Average daily gain, daily feed intake, and feed-to-gain ratio for the three treatments, respectively, were 0.95, 1.10, and 0.96 kg; 7.3, 7.2, and 6.8 kg; and 7.7, 6.5, and 7.0. None of the control animals required treatment for shipping fever, but four steers in group (ii) and three in group (iii) required treatment.

Swine Nutrition

Protein levels from 15 to 90 kg liveweight. Two groups of 8-week-old barrow (B) and gilt (G) pigs, separately penned, were fed ad lib., either a 19% (high) or a 16% (medium) crude protein (CP) ration during the rearing period. A finishing ration containing 16% (medium) or 14% (low) CP, respectively, was provided for one B and one G pen as the average liveweight exceeded 36, 45, 54, or 64 kg.

Average daily gains (ADG) for the overall period, 15–90 kg, were high-medium, 0.70; medium-low, 0.64; B, 0.68; G, 0.66 kg; and feed conversion efficiencies (FCE) were 3.54, 4.08, 3.84, and 3.78, respectively.

By prolonging the rearing period overall ADG and FCE were improved. However, when fed high CP the ADG of gilts during the rearing period increased more rapidly than for barrows, whereas on the lower protein ration the converse occurred.

Although the high CP levels significantly increased the percentage of dressing, loin eye area, and percentage of lean in ham face, grades and returns over feed costs were similar for both groups. Optimum performance, grades, and returns were usually obtained with the shortest rearing period for gilts and the longest period for barrows.

Rapeseed meal in rations for market pigs. Rapeseed meal (RSM) at 0%, 5%, 10%, or 15% was included in 16% CP barley – soybean meal rations, with 0% or 0.1% added methionine, for market pigs from 23 to 93 kg liveweight. Daily gains, feed intakes, and efficiencies of feed conversion decreased with increase in RSM level; however, carcass quality and grades improved. Methionine supplementation slightly improved growth performance and greatly improved carcass quality. From average figures for ingredient cost and carcass returns, it was shown that the inclusion of up to 15% RSM was economical.

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INTRODUCTION

This is a report of the work carried on at the Research Station, Regina, in 1969. The Station is the main center for research on the control of weeds in the Prairie Provinces. The objectives of this program are to develop and improve methods for the control of weeds in field crops, to develop and improve methods for the control of weeds on rangeland, to study the physiology of herbicide action, to study the biology of weeds, and to study the effect of herbicides in the environment. Work on herbicides has been intensified so that producers and consumers can be assured that herbicides do not harm crops, wildlife, livestock, and humans, or pollute the environment.

The Station is also the center for production and distribution of seed of new varieties of cereal and forage crops developed within the Research Branch.

J. R. Hay
Director

WEED SCIENCE

Germination of green foxtail. In studies with 5 constant temperatures (4.4, 10.0, 15.5, 21.1, and 26.6 C) and 15 alternating temperatures, which were combinations of the 5 constant temperatures, green foxtail seeds did not germinate in 10 days at a constant temperature of 4.4 C or at alternating temperatures of 4.4 and 10.0 C, operated on a 12-hr cycle. When the constant and the alternating temperatures were increased, the rate and the amount of germination increased markedly. Optimum germination occurred at 26.6 C.

Emergence of green foxtail seeded at 0, 2.5, 5.0, 7.6, 10.2, and 12.7 cm deep was similar in Regina heavy clay, Weyburn loam, and Asquith fine sandy loam. Differences in soil type did not appear to affect emergence if other conditions were the same. The test was set up in a growth chamber with a cycle of 8 hr in darkness at 10 C and 16 hr of light at 25 C. Under these conditions emergence was reduced at depths below 7.6 cm.

Increased persistence of green foxtail in the field was found at increased soil depth. At 0 to 10 cm deep, 6% to 27% of the original seeds were viable and nondormant after more than 3 years in the soil. Variable amounts of dormant seed were also present. Similar results were obtained with another population. After 2 years in the soil the percentage of viable nondormant seeds at depths of 0 to 10 cm ranged from 8% to 37%. At 15 cm deep, 81% of the seeds were alive.

In the laboratory dormancy was induced in nondormant seeds by exposing moist seeds to low temperature (4.4 C) and subsequent drying, by keeping seeds in very moist soil, or by immersing them in water. Short periods of wetting and drying affected the rate of germination, and some seeds with small sprouts withstood 7 days of drying at 22 C and still grew when rewetted.

Apical dominance in quack grass. In 1969, experiments were conducted on the apical dominance of low-N rhizomes and on the influence of the N supply. These studies supplemented earlier experiments on isolated rhizomes from high-N plants. The results follow. Longer rhizomes did not affect apical dominance in low-N plants, but they effectively reduced inhibition as the N supply to the parent plant was increased. When the apex of low-N rhizomes was exposed to light apical growth was inhibited and apical dominance was reduced 50%. High-N rhizomes showed a greater reduction than low-N rhizomes, probably because of their higher moisture content; also, water supplied through the cut end of low-N rhizomes greatly increased the light effect, which eliminated apical dominance. Inhibited buds from rhizomes of high nutritional value increased in dry weight, N, and percentage of moisture within 24 hr of isolation. Buds from lower N rhizomes also increased in percentage of moisture during the first 24 hr, but decreased in dry weight and soluble carbohydrate. The increase in carbohydrate and N content was delayed until the 24- to 48-hr sampling period. Water supplied through the cut end of the rhizome (in darkness) caused a slight reduction in apical dominance. NH_4NO_3 so-

lution had a greater effect, but the most effective treatment was N plus sucrose. These results suggest that apical dominance in isolated low-N rhizomes depends on the availability of critical levels of water, N, and carbohydrate, each of which may limit growth.

Bud development on quack grass rhizomes. The pattern of bud development on decapitated rhizomes of quack grass was similar to that on the seedling shoot. Apical buds developed as shoots, subapical buds as rhizomes, and basal buds remained dormant. As shown for the seedling shoot, environmental conditions determined the portion of buds in each category. Increased temperature extended shoot production to nodes farther from the apical end of the rhizome and reduced the number of buds that developed as rhizomes. Reduced light intensity had a similar but more pronounced effect and considerably increased the percentage of dormant buds. NH_4NO_3 supplied through the cut end of the rhizome caused buds to develop as shoots instead of rhizomes. Therefore the supply of N is an important morphogenetic factor in controlling bud development.

Persistence of diallate and triallate. Electron-capture gas chromatography was used to detect diallate and triallate residues in persistence studies with two soils at various moisture levels. When incubated at moisture levels above the wilting point, 50% of the diallate applied at 2.5 to 2.75 kg/ha (2.25 to 2.5 lb/acre) was degraded in Weyburn loam in 4 weeks. Losses in Regina heavy clay were slightly lower. There was little degradation in either soil at moisture rates below the wilting point. In both soils, about 60% of the triallate was degraded in 3 months, as reported previously.

Triallate was almost completely adsorbed from aqueous solution by four soils, whereas diallate was adsorbed to a lesser extent.

When triallate was mixed with soil, loss by volatility was negligible, even when heated to 50 C for 28 days. Vapor loss of diallate from treated soils was dependent on soil type and temperature.

In field plots, 15% to 20% of the applied triallate was found at the end of one growing season in the top 5 cm of soil. Less than 5% of the initial diallate remained. Negligible residues of either chemical were found at 5 to 10 cm deep.

Both diallate and triallate were very susceptible to alkali and degraded rapidly in solution at pH values greater than 10 with liberation of chloride. In 5% caustic methanol, triallate underwent isomerism with movement of the double bond to yield a white solid with properties different from those of triallate. In methanol or ethanol, at neutral pH, the isomerized compound slowly reverted back to triallate.

Leaching of picloram. Leaching of picloram was measured in several prairie soils that contained 1.8% to 12.5% organic matter and 8% to 70% clay. Organic matter content and water-holding capacity of the soil affected the rate of leaching of picloram. The clay content of the soil affected the leaching of picloram by its effect on the water-holding capacity of the soil. This explains the faster movement of picloram in sandy soils than in clay soils. Neither the rate of picloram application nor the rate of water application affected the leaching pattern in coarse-textured soils.

Persistence of picloram. A gas-chromatographic method was developed for soil residue analysis of picloram for Regina heavy clay. Picloram recoveries of 95% or more were obtained. This method will be used for persistence studies during 1970 to supplement information obtained from bioassay tests.

Adsorption of herbicides by soils. The adsorptive capacity of several prairie soils was established for picloram, linuron, and simazine, and was expressed as the Kd value, μ g of herbicide adsorbed/g of soil. The extent of adsorption of all three herbicides was correlated with organic matter content of the soils. That is, Kd values were dependent on soil organic matter content. The ranges of Kd values for the three herbicides in various prairie soils were linuron, 3.9 to 93.0; simazine, 1.4 to 46.8; picloram, 0.09 to 0.74.

Chemical summerfallow. Several herbicides were applied to seeded wheat in an effort to find a satisfactory control for volunteer wheat and wild oats during the summerfallow year. Herbicides that gave good control included amitrole-T, ametryne, paraquat, mixtures of paraquat, diquat, and 2,4-D, and mixtures of paraquat and bromoxynil. Paraquat applied at the three-leaf stage gave better control than when applied at the two-leaf stage.

Seeding into stubble. A triple-disc seeder with coulters mounted ahead of double-disc furrow openers was compared with a discer-seeder in tests on direct seeding into wheat stubble without seedbed preparation. Regina heavy clay soil was hard to penetrate with the triple-disc seeder, and because of dry spring weather germination was uneven. Both methods gave similar yields of wheat, but owing to the uneven germination, the wheat sown with the triple-disc seeder matured 4 days later than that sown with the conventional discer-seeder.

Periodicity of emergence of green foxtail. No green foxtail emerged before the wheat was seeded on May 8, 1969. The weed emerged on May 26, 1 day after the wheat emerged, and this first flush of emergence continued until early June. Large numbers emerged from late June to mid-August, a period of ample rainfall. No emergence occurred after September 25. The total emergence per square meter was high: 1,074 weeds/m^2 on land being summerfallowed, 304 in wheat on fallow, and 1,574 in wheat on stubble. After 4 years of testing, emergence of green foxtail has been found to be associated with heavy rainfall and warm temperatures.

Chemical control of green foxtail in wheat. In 1969 the effects of herbicides on green foxtail were observed only in the early part of the season, because sharp frosts in mid-June killed the green foxtail without serious injury to the wheat. Benzadox was tested for 5 years at Regina. It usually gave good control of the weed, but has occasionally caused severe initial injury to the wheat. MSMA (Niagara Chemicals), in 3 years of testing, gave similar results to benzadox. In contrast to results in 1968, GS 14260 (Fisons Canada Ltd.) caused severe injury to wheat in 1969. Several other herbicides were tested; some of these will receive further testing. TCA was still present in aerial parts of wheat plants collected 48 days after they had been sprayed for green foxtail. Soil samples collected 96 days after spraying also contained TCA residues.

Control of wild oats. GS 14260 and R 11913 (Stauffer Chemical Co.), which showed promise in controlling broad-leaved weeds, were combined in a preplanting treatment with triallate, a herbicide for wild oats, in order to control more species of weeds. These tests were only partly successful owing to a low infestation of broad-leaved weeds, but the mixtures did not injure the wheat in the crop tolerance tests.

Postemergence mixtures of MSMA and MCPA or bromoxynil gave good weed control. MSMA, however, caused rather severe initial injury to wheat. In tests in the greenhouse the effect of MSMA on wild oats was not reduced at temperatures below 15 C, as it was in field tests. On wild oats, MSMA mainly suppressed growth. Control in the field was not outstanding and a final assessment of MSMA, based on 4 years of field experiments, failed to show significant increases in yield in most of the tests. Consequently, no further work with MSMA for control of wild oats is anticipated.

Persian darnel. Greenhouse and field experiments showed that Persian darnel could be controlled in flax with preplanting applications of diallate, triallate, or trifluralin. Several other chemicals applied after emergence did not control Persian darnel.

Flixweed and stinkweed. Counts indicated that winter survival of flixweed and stinkweed in untreated plots on summerfallowed land was 59% for flixweed and 41% for stinkweed. Spraying in the fall with amine and the ester formulations of 2,4-D gave 100% control.

Crop tolerance tests. Twenty-four herbicides or herbicide mixtures were tested for crop tolerance in wheat. Several tests showed either light or no injury. Wheat was tolerant to fenoprop at 1.1 kg/ha (16 oz/acre). Sodium salt of MCPA applied at 0.84 kg/ha (12 oz/acre) to wheat at the two-leaf stage 1 week after emergence reduced yields by 10%. This treatment was suggested for suppression of green foxtail in wheat, based on some experience in Manitoba. Four experimental herbicides tested on flax destroyed the crop. Crop tolerance tests on sunflowers in the greenhouse showed that C-6313 (CIBA Company Ltd.) and nitrofen applied preemergence caused no injury. Postemergence treatments with nitrofen caused some leaf scorch, but did not retard growth. C-6313 caused severe injury. Sunflowers were tolerant to postemergence applications of barban.

Weed control in irrigation ditches. Irrigation ditches were treated with simazine in the fall of 1968 to control weeds that impeded

the flow of water. Excellent control of weeds was obtained, but high amounts, 0.5 to 1.0 ppm, of simazine were found in the first water that passed through the ditches in the spring of 1969. After 2 hr of flushing only trace amounts remained. These results showed that the use of soil sterilants for controlling weeds in irrigation ditches was dangerous, and therefore should not be continued.

Herbicide drift. For 4 years, studies have been made on 2,4-D that drifted from the target area at the time of spraying. In early tests large amounts were collected in the air 15 min after spraying was completed. In July and August 1969, a large-scale trial was conducted in cooperation with the Saskatchewan Research Council and the Defense Research Establishment at Suffield, Alta., with the use of extensive field trial facilities at Suffield.

Butyl ester of 2,4-D was sprayed and air samples were collected at 2-, 10-, and 30-min intervals at distances to 200 m from the spray swath and at heights to 9 m. Movement out of the target area was even greater and faster than had been anticipated as a result of the earlier studies.

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INTRODUCTION

The Research Station at Saskatoon conducts a broad research program on crop and animal production. Included are the breeding of grasses, legumes, oilseeds, wheat, barley, and potatoes; ecology and control of some of the most important insect pests, plant diseases, and weeds; and ecology and control of black flies and mosquitoes that affect animals and man. Research is also carried out on the epidemiology of western encephalitis, the histophysiology and nutrition of insects, the physiology of drought tolerance in cereals, the characterization and fertility of soils, and pesticide residues in both crops and soils. The accomplishments during 1969, for selected subjects, are summarized in this report.

J. E. R. Greenshields
Director

CROPS

Crested Wheatgrass

Breeding. The synthetic strain S-5565, developed cooperatively by the Saskatoon and Melfort stations, was released as the variety Parkway. This variety is similar to the well-known variety Fairway, but it is slightly higher in yield of forage, grows 5 to 8 cm (2 to 3 inches) taller, and is less subject to lodging. Adaptation is expected to be better in the Black and Dark Brown soil zones than the Brown soil zone. Approximately 544 kg (1,200 lb) of Foundation seed were distributed for Certified seed production.

Legumes

Sweetclover breeding. A superior strain of the yellow-blossomed sweetclover having normal levels of coumarin was developed and submitted for licensing as cv. Norgold. This strain has good seedling vigor and winterhardiness, and above-average forage and seed yields. Approximately 18 ha (45 acres) were established to produce Foundation seed.

A low-level coumarin strain of white-blossomed sweetclover (S-7115) was bred. It is similar to the common variety Arctic but yields 10% less. This reduction in yield is more than offset by the making available of a feed that does not cause hemorrhagic sweetclover disease. As licensing is expected in 1970, 1,588 kg (3,500 lb) of Foundation seed was produced.

To find the effect of the coumarin character on sweetclover performance, sweetclover isosynthetics high and low in coumarin were produced. High-coumarin isosynthetics were consistently superior to corresponding low-coumarin isosynthetics in forage yield, seed yield, seedling vigor, spring vigor, and winterhardiness, and were earlier maturing. The physiological basis for this performance remains unknown.

Oilseeds

Rapeseed breeding. Commercial contract production of a selection of *Brassica campestris* L. high (60%) in erucic acid content was begun to determine its value in the industrial oil market. Two *B. napus* L. F_3 lines from crosses between glucosinolate-free selections and adapted varieties seem to combine the desired characteristics of both parents. Each of the six glucosinolates in *B. napus* seed was found to be controlled by independent genes. The first and only *B. campestris* plant completely free from glucosinolate was discovered in the Echo variety. Outcrossing to other low-glucosinolate selections from other adapted varieties is being given priority. *B. campestris* seeds with yellow seed coats were found to have 1.5% higher oil content and to produce a meal with lower fiber and higher protein than brown seeds of the same variety.

Genetic markers. From mutagen-treated seed of *B. campestris* 53 mutants were isolated for studies on agronomic characteristics and gene action. Some show potential as varietal markers in commercial rapeseed. A genetic analysis showed that the mutant *C*, which causes cotyledon chlorosis, is controlled by a simply inherited partially dominant gene.

ENTOMOLOGY

Alfalfa Leaf-cutter Bee

Effect of mold on emergence. *Megachile rotundata* Fabr. adults emerged from 30.4% of cells that were left in tunnels in laminated fir plywood or polystyrene during most of the winter of 1968–69. Cells stored in this way were badly infested with molds. Adults emerged from 64.5% of cells that were apparently free from mold because the cells were removed from similar nests in the fall and allowed to dry. Similar emergence occurred from cells that were left in soda straws and allowed to dry at 23 to 24 C (73 to 76 F) for 3 to 4 weeks immediately after removal from the field.

Diamondback Moth

Predators. In the laboratory, larval *Chrysopa carnea* Stephens eats eggs and larvae of the diamondback moth, *Plutella xylostella* (L.). However, *P. xylostella* can complete two generations and enter a third, during the time that *C. carnea* completes one and enters a second. This may explain the observation that although adults of *C. carnea* are usually detectable in the field from the start of the active season, larvae are not found on rape, the main host of diamondbacks, until the crop nears maturity. Since the destructive second-larval diamondback generation reaches its peak before this time, naturally occurring populations of *C. carnea* cannot control *P. xylostella.*

Mosquitoes

Abundance of larvae and adults. Thirteen species of larvae and 16 species of adults were recorded during the season in a study area near Saskatoon. Larvae were sampled in three selected ponds; adults were sampled by adjacent light traps. Peak populations of the larvae of *Aedes* spp. occurred in May and preceded peak populations of adults by about 1 month. Peak populations of *Culiseta inornata* (Williston) larvae and adults coincided in mid-July to early August. Peak populations of *Culex* spp. were obscured because numbers were low. *C. inornata* constituted 78% and 86%, respectively, of all adults and larvae taken; *A. flavescens* 8.8% and 3.6%; *A. fitchii* 2.6% and 8.3%; *A. campestris* 3.2% and 0.5%. The other species were taken in lesser quantities. Fifty-four percent of the mosquitoes captured were taken downwind of the ponds. When one pond dried this proportion did not change and there was not much reduction in the total numbers captured. Hence, light traps placed near a pond appear to sample the population of the area in general rather than only the population emerging from an adjacent pond.

Insect Pathology

Melanotic lesions were found in several tissues of larval *Drosophila melanogaster* (Meig.) after treatment with Rous sarcoma virus, or with methylcholanthrene or dimethyl sulfoxide, or both. Similar lesions were found in adults of *Melanoplus sanguinipes* (Fabr.) after injection with sublethal doses of dieldrin. However, a process analogous to mammalian neoplasia was not indicated. The tissue reactions suggest an irritative and necrotizing process followed by deposition of amorphous melanotic masses.

Aflatoxin was fed to first- and third-instar larvae of *D. melanogaster* at a concentration of 10 μg/ml. The first-instar larvae died after they had remained in the first instar seven times longer than the normal period. The treated third-instar larvae remained in this stage three times as long as control larvae and formed puparia. The few puparia that pupated reached a fairly advanced stage of development but did not emerge. Reasons for markedly delayed growth and development in the aflatoxin-fed larvae are not known, but there is probably a severe upset in the normal endocrine balance.

Pesticide Application

Controlled-drop nozzle. A prototype nozzle that produces uniform droplets of any size is under development. Air is drawn in through the gap between a rotating disk and a shroud that surrounds it. Under certain conditions liquid is thrown off the disk in drops of only two sizes, uniform main droplets and much smaller satellites. The small satellites are trapped in the air stream, while the larger drops, having more impetus, escape. At one speed of rotation 95% of the droplets measured between 134 and 143 μ and 100% between 126 and 158 μ.

Insecticide Residue Studies

Soil type and uptake of dieldrin by wheat plants. Six mineral soils containing varying proportions of sand, silt, and clay, and 1% to 6% organic matter and one muck soil were treated with 9 to 23 ppm of dieldrin. Thirty-day-old wheat plants grown in these soils in the greenhouse had 0.003 (muck soils) to 0.09 (sandy loam soils) ppm dieldrin per ppm in the soil. The amount of dieldrin absorbed by the plants was directly proportional to the amount of dieldrin present in the water in the soil during growth. Water can desorb proportionately more dieldrin from a sandy loam soil than from a heavy clay or muck soil. Consequently, there is more uptake from sandy soils than from heavier soils.

Insect Nutrition

Yellow mealworm. In cooperation with Professor J. Leclercq, Faculté des Sciences Agronomiques de l'Etat, Gembloux, Belgium, protein requirements of the yellow mealworm, *Tenebrio molitor* L., were studied for a year. Casein was classified as superior to lactalbumin, probably because of the concentration of protein nitrogen, the mineral composition, and the lactose content of lactalbumin, although work with rats had indicated the reverse. The concentrations of arginine, phenylalanine, and tyrosine in lactalbumin were not adequate for *T. molitor.* Results suggest that this insect is more sensitive than the rat to small changes in constituent amino acid concentrations or in amino acid balance of various proteins.

Chemically defined diets were prepared; the amino acid constituents were based on analyses of casein, lactalbumin, and pupae of *T. molitor.* Growth of the mealworm was the same on each diet and twice as much as on chemically defined diets of previous studies. However, this growth was only about one-quarter of that obtained with casein diets. The diminution is probably due to the low concentration of methionine in the diets.

The year's results provided a basis for the development of a satisfactory chemically defined diet and subsequent determination of amino acid requirements of *T. molitor.* They also provided a basis for interpreting results obtained with proteins of unknown biological values and information for proposed comparative studies in which *T. molitor,* the rat, and man are used.

PLANT DISEASES AND PLANT PHYSIOLOGY

Common Root Rot of Cereals

Disease development. Common root rot followed a similar pattern in barley and in common and durum wheats in field plots in 1969. Most infections occurred in July and August. Disease in plants is usually assessed on the amount of lesioning in subcrown internodes. Lesions may also occur in basal stem and crown tissues. Comparisons of average plants showed that the fresh weight of subcrown internode-lesioned plants was usually less than healthy plants, but the weight of crown-lesioned plants was usually more. Subcrown internode lesions are better indices of disease than basal stem and crown lesions. The magnitude of reduction in fresh weight of subcrown internode-lesioned plants diminished during the season indicating a partial recovery from disease. Good growing conditions prevailed at the test locations. Plants with lesions in the subcrown internode produced lower yields of grain.

Losses. Yield reduction caused by common root rot in wheat was determined by a survey of 55 fields representing all crop districts in Saskatchewan. The estimated average loss was almost 5%, equivalent to 62 million kg (22.5 million bu). In 1969, the level of disease was the lowest and the yield of wheat about the highest ever recorded in the province.

Seedling reactions. Generally, seedlings of diploid species of *Triticum* were more susceptible to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur than tetraploids, which in turn were more susceptible than hexaploids. Isolates of *C. sativus* varied in aggressiveness, but this variation occurred in all the host species used.

Culture filtrates. Germination of Manitou and Cypress was little affected by culture filtrates of *C. sativus.* Germination of 680-11-6 was greatly inhibited, and Ramsey durum showed an intermediate response.

Soil microbiology. Treatment of soil with Panogen PX (Morton Chemical of Canada Ltd.) at 5 ppm of active ingredient and peptone at 0.1%, although nonlethal to spores of *C. sativus*, reduced common root rot in wheat. The treatment promoted growth of such fungi as *Ulocladium atrum* Preuss, *Penicillium citrinum* Thom, and *P. griseofulvum* Dierckx., which are probably harmful to *C. sativus*. The fungi, especially *U. atrum*, were often isolated from surface-disinfected, healthy subcrown internodes.

Diseases of Grasses

Seed-borne pathogens. Selenophoma bromigena (Sacc.) Sprague & A. G. Johnson, the cause of a leaf and stem spot disease of bromegrass, is commonly thought to be seed-borne. However, seedlings from infested seed were found to be not diseased. Crop debris may be the likely source of field infection. *Drechslera phlei* (Graham) Shoemaker, the cause of a leaf spot of timothy, was found on seed from Eastern Canada and from some European sources, but not on seed from Saskatchewan. The leaf spot is seldom important in seed crops in this province.

Diseases of Oilseed Crops

Staghead (white rust) reduced rapeseed yields by 30% in some northern Saskatchewan fields. Seedling inoculation tests with a race from *B. campestris* indicated that *B. campestris* (var. Yellow Sarson and var. Echo) was highly susceptible, *B. hirta* Moench (yellow mustard) was slightly susceptible, *Thlaspi arvense* L. and *Camelina sativa* (L.) Crantz were highly resistant, and *B. napus* (var. Target) was immune.

Drought Resistance in Wheat

Drought avoidance. Field-grown wheat varieties differed in water potential and osmotic pressure, but were similar in water flow when the flow was indirectly measured by determining exact leaf temperatures. These indices of drought avoidance were not definitely related to yields. Plasmic desiccation tolerances of varieties appear implicated.

PEDOLOGY

Soil Survey

Classification and mapping. The Pedology Section, working with the Saskatchewan Institute of Pedology, assisted in the reconnaissance mapping of 1,524,000 ha (3,764,000 acres) in the St. Walburg, Waterhen, Pasquia, and The Pas map sheet areas in the Northern Provincial Forest, and 470,000 ha (1,160,000 acres) in the agricultural region of the Hudson Bay map sheet area. Work toward publishing maps and reports of the soils of the Rosetown and Saskatoon areas was continued. The soil survey of the Indian Reserves within the agricultural area of the province was completed with the publication of eight reports.

Soil characterization. An apparent cycle of erosion and deposition in the development of slopes and soils was observed in studies of the genesis of Black Chernozemic soils. Detailed field examinations and C-14 dating of these buried layers continued to add information about the genesis of these soils.

The relationship between morphological characteristics of Saskatchewan soils and their physical properties as related to plant growth was studied. Undisturbed soil cores of selected soil horizons with varying textures and structures were analyzed at controlled-moisture levels for such physical determinations as air, water, and total porosity, oxygen diffusion rate, soil compaction, bulk density, air and water permeability, aggregate analyses, and mechanical analyses. The data were statistically analyzed to find a relationship between the measured physical properties and soil moisture content and soil texture, and to relate this to soil structure.

EXPERIMENTAL FARM, SCOTT

Potatoes

Coordination of the prairie regional group for breeding and testing. Each year up to 150 potato introductions have been received for increase, preselecting, indexing, and distribution to the 14 cooperating units of the group. The data from each unit are fed back to the coordinator at Scott for compilation and a combined report. In the past 5 years approximately 25,000 seedlings have been grown and screened. A total of 128 of these have entered regional trials.

New varieties. Cariboo, Norgold Russet, and Viking were licensed on the basis of results and support from the prairie group and from other regions. Cariboo may partly replace Netted Gem as a main-crop variety and the others will replace Warba and Norland as earlies. Two red selections, F6087 and FS6339, are in advanced trials at several locations. They score higher in boiling and baking tests than Norland and are 20% to 50% higher in marketable yield. Norchip, Monona, and seedling F5889 are in advanced chipping trials. The latter can be processed directly from 4.4 C (40 F) storage, a characteristic valuable to the chipping industry.

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INTRODUCTION

The climate of southwestern Saskatchewan may be characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on a variety of soils, and cattle are raised in large numbers on natural grasslands and on grass–alfalfa mixtures. Some small areas are irrigated. Research is focused on improving the economy and stability of this production.

Adequate soil moisture at seeding and timely precipitation during June and July produced above-average wheat yields in 1969. Harvesting was delayed by wet weather during October, but was completed during November and December. Otherwise, the season was near normal, except that a minimum air temperature of −5 C was recorded on June 12 and 13. Spring cereals recovered, but fall rye and grass and legume seed crops were seriously damaged. Vegetable crops recovered from the frost, but fruit and ornamentals were severely damaged.

For determining the digestibility of dry forage, Dr. J. E. Troelsen perfected an in vitro method that is sufficiently simple, rapid, and precise for routine analysis of commercial samples. The method has been adopted by the feed-testing laboratories at the universities of Alberta and Saskatchewan. It is expected that it will be adopted by many other feed-testing laboratories.

Mr. F. B. Dyck designed a four-row, self-propelled plot seeder with multiple wheel packing and both single- and multiple-cone seed distribution systems. The unit was constructed and tested during 1969. The seeder performed extremely well, and it is expected that with only minor modification it will be used by most scientists doing crop research in the field in Western Canada.

These and other research accomplishments during 1969 are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report or from individual research scientists.

A. A. Guitard
Director

ENGINEERING

Irrigation

A study was begun to assess the validity of designing irrigation systems for peak water requirement of alfalfa, grass, and spring wheat. The effect on yield of applying less water than the amount needed to meet peak water requirement will be measured by comparing three irrigation treatments: 14-day system, designed to satisfy peak water requirement; 21-day system, designed to irrigate one and one-half times the area irrigated when based on peak water requirement; and 28-day system, designed to irrigate twice the area; and a nonirrigated check. The study will be conducted for several years to obtain comparative yields over a variety of seasons.

Plot Seeders

A self-propelled, four-row seeder was designed and constructed for seeding cereal, grass, and legume plots of various sizes and for placing fertilizer. The seeder is powered by an 18-hp, air-cooled, two-cylinder motor. Power is transmitted through a hydrostatic transmission, which enables shifting from forward to reverse with one lever and allows selection of any speed up to 6.5 mph. Under normal conditions, the seeder operates satisfactorily at a low motor speed, and with an opposed-throw crankshaft it has little vibration. Seed is dispensed through four 17.8-cm cones or through one 25.4-cm cone that feeds a four-way centrifugal divider. The rate of cone rotation can be adjusted for seeding rows 3 to 15 m in length. A foot pedal lifts the cone seed cups, and the operator's hands are free to prepare seed packages for the next plot. A foot pedal is also provided for disengaging the cone drive in an emergency. Seed is placed in the ground through four double-disc furrow openers. A furrow opener is placed immediately behind each of the four front-drive wheels. The main frame is supported by four rear wheels, which are immediately behind the openers. Wheels and openers can be adjusted to seed four rows

22.9 or 30.5 cm apart. Depth of the openers is controlled hydraulically.

The seeder is steered by articulating the main frame about a pivot point located 43.2 cm behind the front axle. Complete power steering makes the seeder easy to turn. It has a 2.8-m turning radius. The design of the main frame of the seeder allows for mounting a second toolbar. This design makes possible the mounting of a second set of openers to side-band fertilizer when grain or forage is being seeded. It also allows for mounting hoe openers in a staggered fashion for direct seeding into stubble. The machine weighs 800 kg, which is adequate for good traction and packing, and it has a low center of gravity for stability. The seeder requires two operators. The tractor operator sits above the front wheels and the seeder operator sits above the rear packer wheels within easy reach of seed packages and cone seed cups. In preliminary trials, the two operators seeded 480 plots/hr. Only 400 plots/hr were seeded by three operators using the standard eight-row seeder.

Plot Combines

Overshot and undershot concaves made of diamond tread plate, pipe, and flat bars were tested with a rasp bar cylinder. Tests confirmed that an undershot, open, flat-bar concave was the most satisfactory for threshing cereals because the long straw was cleared from the straw walkers more efficiently, and the concave cleaned more readily. Of several methods tested for removing the straw from the grain, the sieve was the most suitable.

CEREAL CROPS

Wheat Breeding

Hard red spring wheat. Sawfly-resistant wheats have exhibited high alpha-amylase activity, an undesirable quality in baking. To combine suitable alpha-amylase activity with sawfly resistance, Park and Chris were crossed with Fortuna. In a study to determine the usefulness of primary roots, plants with higher than average numbers of primary roots were selected in four F_3 populations. Root rot resistant lines obtained from the Research Station at Saskatoon were intercrossed to determine whether or not these lines carry different genes for resistance.

Durum wheat. The durum wheat breeding program at the Research Station at Regina was transferred to this station in 1969. In a controlled environment Maliani 8 and Maliani 15 from Italy and Adur from France had a lower incidence of root rot infection than the locally grown variety Pelissier. The new variety Hercules continued to be 15% lower yielding than the presently recommended commercial varieties. However, it is more resistant to lodging and matures earlier.

Rye Breeding

Entries of spring rye from the world collection were screened for height and time to maturity. Suitable parental material was not obtained, and it now appears that the desirable characteristics will have to be transferred from fall rye.

Effect of Time of Harvest on Kernel Phosphorus

It was previously shown that P continued to translocate from the leaves and stems to the kernels of windrowed wheat as it matured in the field and that when wheat was threshed at a kernel moisture content above 20%, the amount of this element in the kernel was low. In 1968, P^{32} was used to trace the movement of P from the leaves and stems of windrowed wheat to the kernels. A treatment solution was applied to the stems immediately after the wheat was windrowed, and counts for radioactivity were made in the threshed grain when it reached 14% kernel moisture. The results showed that P continued to move from the stems to the kernels in generally decreasing amounts as the crop was windrowed at successively later stages of maturity. Rainfall during the test appeared to increase the rate of P movement from the stem to the kernel.

Influence of Solar Radiation and Soil Moisture on Growth and Yield of Wheat

The influence of solar radiation on the growth and yield of Chinook wheat was determined in a 5-year field shading study, and a 1-year 3 × 3 shading × soil moisture lysimeter experiment. In the field, shading with saran mesh reduced solar radiation and wind, but had little effect on air or soil temperature. In moist years, shade maintained soil moisture at a higher level than no shade did. Generally, mean leaf area ratio decreased and mean net assimilation rate and relative growth rate increased linearly with increases in the log of light intensity. There were shading × years interactions in dry matter yield. The efficiency of use of solar energy for grain production increased with shading. The effect of shading on crude protein and soluble sugars in grain was variable.

In the lysimeter shading study, plant height, stem diameter, days to head, number of tillers, weights of grain and of straw, and percentage of cellulose were negatively related to soil moisture stress, but crude protein was positively related. Days to head and crude protein were negatively related to light intensity, but all other characters were positively related. Partial regression coefficients indicated that soil moisture stress had much more influence than solar radiation on the crude protein content of the grain.

Effect of Rate of Seeding on Yield of Wheat

From 1960 to 1968, rates of 22, 45, 67, and 101 kg/ha for seeding spring wheat were compared in a field experiment on a medium-textured soil. Low seeding rates produced significantly more grain than higher rates; the greatest increases occurred during years of severe moisture stress.

Comparison of Yield Components of Cereal Crops

The yield and yield components of several varieties of spring wheat and barley were compared from 1967 to 1969 at two seeding rates and two soil fertility levels. The 3-year average yield of Conquest barley was 1,664 kg/ha and the comparable yield for Cypress wheat was 1,326 kg/ha. The barley variety had only 1.7 mature heads per plant, whereas wheat had 3.0, but a comparable increase in kernels per head and 20% greater 1,000-kernel weight in the barley compensated for the low number of heads. In 1969 the wheat variety Pitic 62 was compared with Cypress wheat and Conquest barley. Again, barley gave the greatest yield; Pitic 62 was very close and Cypress much lower. The yield difference between Pitic 62 and Cypress was almost entirely due to a lower number of kernels per head in Cypress. Floret counts indicated that this difference was attributed to floret sterility and not to fewer florets.

The 2-year average yield from the seeding rate of 20 kg/ha was slightly greater than from the 80 kg/ha seeding rate. The reduction in plant number was compensated for by increases in heads per plant, kernels per head, and 1,000-kernel weight in order of importance. Fertilizer application also increased the average yield by increasing the number of heads. The number of kernels per plant and the 1,000-kernel weight were not affected or were decreased slightly by fertilization. There were no interactions between variety and seeding rate or fertilizer treatments.

Cold Tolerance of Winter Wheat

In freezing tests with Kharkov MC22 winter wheat at the three-leaf stage, glucose increased survival more effectively than sucrose or galactose, and ascorbic acid was not effective. Osmotic potentials (OP) of extracted tissue solution increased as the sugar treatment concentration increased, but transpiration rates decreased. Polyethylene glycol exhibited similar effects to sugar on OP and transpiration rates, but had little influence on tissue sugar levels or cold tolerance. Maleic hydrazide tended to increase cold tolerance and also increased the levels of sugars in the plant. Sugar level appears to be more strongly related to cold survival of winter wheat than is OP.

FORAGE CROPS

Breeding

Alfalfa. Progeny tests from 1966 selections of alfalfa (18-plant diallel) again demonstrated that creeping-rootedness does not express itself in a reliable way until the second growth season after planting. Combining ability for the character was remarkably high between some plants and low between others. The population of approximately 2,000 plants was assessed for seed-setting potential and for leafiness. The seed set in the field when the alfalfa was pollinated by *Megachile rotundata* (Fabr.) correlated fairly well with seed set obtained with hand pollination in the growth room.

When the same clones were grown in the field and greenhouse, there were strong associations between percentages of P, S, Ca, and crude fiber, but percentages of N, K, and Mg were only weakly related. Content of 18-S protein in field-grown clonal lines showed a fairly normal distribution. Because plants of *Medicago falcata* L. background were generally lower in 18-S protein than plants of *M. sativa* L. background, *M. falcata* may provide a source of "low-bloat" alfalfa.

Russian wild ryegrass. Three cycles of selection for increased seedling vigor based on seed size and the capacity of seedlings to emerge from a 6-cm depth of seeding were completed with *Elymus junceus* Fisch. Leaf spot resistant lines that have strong seedling vigor are now being evaluated for production.

Altai wild ryegrass. An uncultivated species, *Elymus angustus* Trin., from Siberia has been evaluated at Swift Current since 1950. The evaluation has established that the species is highly nutritious, cures well, and appears to be especially useful for grazing cattle in fall and winter. However, low seed yield must be overcome before this grass can be used commercially. Breeding nurseries were established in 1969 to develop strains that are more uniform in plant type and produce high yields of both forage and seed.

Seedling Vigor

Compared with such common grasses as bromegrass, tall wheatgrass, Russian wild ryegrass, and crested wheatgrass, Altai wild ryegrass emerged from greater depths in loam, sandy loam, and heavy clay soils. It had the fastest rate of emergence, the greatest percentage of emergence from seedings as deep as 9 cm, and the most top growth during the first 6 weeks after emerging.

A specially constructed chamber with a sloping glass side was used for in vivo observation of preemergence and postemergence seedling growth of these grasses. Failure of the coleoptile to elongate sufficiently for emergence appeared to be one reason for failure of seeded forage grasses to establish.

Row Spacing

The creeping-rooted alfalfa variety Rambler produced the highest dry matter yields when seeded in rows spaced 45, 60, and 90 cm apart, and the lowest yields in rows spaced 30 and 120 cm apart. New plants originating from creeping roots did not appear between the seeded rows until the third growing year. The number of new plants between the rows increased as the spacing between rows increased.

Forage Removal

Stage and height of cutting. Under irrigation the dry matter yield of intermediate wheatgrass, bromegrass, and reed canarygrass decreased with increasing heights of cutting, and increased with advancing maturity at the time of taking the initial harvest. Highest yields were obtained from all species when cut 3.8 cm above the ground during the seed stage. However, this height of cutting caused the most winter injury and stand deterioration. Bromegrass was less sensitive to variation in cutting height than intermediate wheatgrass or reed canarygrass. The application of a regression analysis to the study of significant interactions among management factors and species within a single test proved to be a very useful statistical approach.

Nitrogen fertilizer and clipping frequency. In tests during 1961–62 and 1963–65, the dry matter yield of irrigated intermediate wheatgrass increased with increasing rates of N fertilizer and with longer intervals between clippings. Highest yields were obtained with 375 kg/ha of N fertilizer and an 8-week clipping interval. Fertilizer level did not affect either the basal ground cover of grass or the degree of winter injury. However, fre-

quent clipping reduced ground cover and increased winter injury. Here also, use of a regression analysis for the study of significant interactions among management factors was very useful.

Simulated pasture studies on irrigated land. Rambler alfalfa alone and in mixture with Carlton bromegrass, clipped for the first time in the season on June 1, 4, 7, 10, 13, and 16, and subsequently every 28 days, persisted remarkably well into the fourth crop year under all schedules of clipping. However, in pure stand, the alfalfa plots were invaded by dandelions to a much greater extent than in mixed stands with bromegrass. Even when heavily fertilized with N, bromegrass alone yielded much less than alfalfa alone or in mixture with bromegrass. Apparently these two varieties can withstand abusive defoliation when adequately fertilized and irrigated.

Effect of type of cutter and height of cutting. In the first crop year of an alfalfa–bromegrass mixture on irrigated land, 17% of the forage was produced between 2.5 and 7.5 cm from the ground, 10% between 7.5 and 15 cm, and the remaining 73% above 15 cm. On dry land, 22% of the forage production occurred between 2.5 and 7.5 cm, 45% between 7.5 and 15 cm, and 37% above 15 cm. This study indicates that to harvest most of the growth, close-to-ground harvesting is more essential on dry land than on irrigated land. The study will be continued for several years to establish effects of season and age of stand on these relationships.

Pasture Evaluation

Annuals for pasture. Fall rye pastures grazed in May and June by steers of an average weight of 333 kg produced 287 kg/ha in animal weight gains. When grazed at a rate equivalent to 0.16 ha/animal unit month, they provided 52 days of grazing. Estimated dry matter yield was 2,862 kg/ha. Oat pastures sown in May and July and grazed after 7 weeks of growth produced 134 and 90 kg/ha respectively in animal weight gains. They provided 38 and 46 days of grazing and their estimated dry matter yields were 1,778 and 1,444 kg/ha. Perennial dryland pastures grazed all summer produced 80 kg/ha in animal weight gains.

Evaluation of Altai wild ryegrass and green needlegrass. Altai wild ryegrass, Green Stipa green needlegrass, and Sawki Russian wild ryegrass seeded in rows 90 cm apart in May 1966 were grazed in August, September, and October in 1969 after removal of the seed crops. Seed yields were 15, 16, and 88 kg/ha respectively. Altai wild ryegrass provided 73 days of grazing for yearling cattle, and produced 56 kg/ha of animal gain, Green Stipa 55 days of grazing and 78 kg/ha gain, and Sawki 51 days of grazing and 72 kg/ha gain. Seed yields were greatly reduced by the severe frost in June.

Dry Forage Evaluation

In vitro digestion. A laboratory digestion procedure for prediction of the nutritional value of forage was developed at the Station and introduced for routine use at the Alberta and Saskatchewan feed-testing laboratories. Regression equations relating the in vitro digestibility to voluntary intake (VI) are provided to laboratories that use the procedure. These were established by measuring VI of digestible energy of some 104 different lots of hay by sheep in 416 individual trials during 6 years. The same forages were digested by the laboratory procedure to determine in vitro digestibility of organic matter. The relationship between VI and in vitro digestibility was expressed by one regression for grass hays and one for legumes.

The in vitro digestibility procedure uses the rumen microflora produced by sheep in a controlled environment and fed a constant ration. Rumen liquor is poured out through a fistula in the left side of the dorsal sac, and kept at body temperature with minimal exposure to air and light. Inoculum is prepared by straining the liquor through a 60-mesh wire cloth, diluting the strained rumen liquor with artificial saliva in the ratio of 2:3, and vigorously aerating it with CO_2 while dispensing it through an automatic pipetting machine.

A representative 1-g sample of forage ground through a 1-mm screen in a Wiley type mill is digested at 39 C for 48 hr by 25 ml of inoculum in a 90-ml test tube closed with a vented rubber stopper. The microbial digestion is terminated by acidifying the digest to pH 1.2 by 1 N HCl dispensed by automatic titration, and by introduction of pepsin to hydrolyze the microbial protein. After a further 24 hr of incubation, the digest is filtered to determine the percentage of organic matter digested in the two fermentations. Adjustments are made for digestible

organic matter in the inoculum by analyzing a blank sample of each new batch. Two standard forage samples are used to check for accuracy in replication between batches and between laboratories.

Physical breakdown of coarse roughage. Hay from four growth stages of two alfalfa varieties and four grass species was fed to sheep to determine VI and digestibility. The relationship between VI and digestibility was determined by linear regression within and between varieties and species. The effect of physical breakdown by artificial mastication, as a second independent variable, was detected by a reduction in the standard deviation from regression. No effect was observed within grasses, but between grasses the average thickness of individual particles of masticated hay explained 4.3% to 13.1% of the standard deviation from regression. The rate of physical breakdown and particle length and thickness each reduced the standard deviation within and between the two alfalfa varieties. The rate of breakdown also explained 1.5% to 6.3% of the standard deviation from regression between the alfalfa and the grass.

Criteria of hay. Leafiness, maturity, harvest weather, and digestibility of hay affected the VI by sheep as shown by linear and polynomial regressions. Leafiness explained 84% of the variability in VI of digestible organic matter from 8 alfalfa hays, and 76% of that from 12 grass hays. Stage of maturity explained 77% to 89% of the variability in VI of digestible organic matter from the 20 hays. The effect of harvest weather was expressed by the number of days required to reduce the moisture level to 20% between harvest and baling. In a pooled regression for the 20 days, hay characteristics explained 62% of the variability in VI and harvest weather explained an additional 12%. The relationship between VI and digestibility of dry matter in 8 alfalfa samples and 16 grass samples was shown by linear regression. Digestibility explained 75% of the variability in VI in the alfalfa and 69% of that in the grass.

POULTRY

Feeding Value of Rapeseed Products

Rapeseed gum. The addition of as much as 3% crude rapeseed gum to starter diets did not affect the early growth or feed conversion of chicks or poults. The levels of gum fed were much higher than those normally used in commercial practice.

Rapeseed meal. Diets containing 10% and 20% of either prepress-solvent commercial rapeseed meal or thioglucoside-free Bronowski rapeseed meal were fed to Large White turkeys when they were 6 to 144 days old. The turkeys gained less weight on the 20% commercial rapeseed meal than they did on an isocaloric and isonitrogenous soybean meal control diet. The performance of birds on Bronowski rapeseed meal was equal to that of birds fed the control diet. The turkeys used the diets containing 10% commercial and 10% or 20% Bronowski meal more efficiently when they were 55 to 111 days old than when they were 6 to 54 days old.

Dietary Fat

Changes in fatty acid composition of the carcass fat of heavy male turkeys fed varying levels of saturated palm oil or unsaturated rapeseed oil fats were studied to 24 weeks of age. The similarity between dietary and carcass fatty acids increased as the dietary fat level increased, and was highest before the turkeys were 12 weeks old. The tissue fat of turkeys fed a low fat diet was found to consist mainly of palmitoleic, stearic, palmitic, and oleic acids.

Turkeys fed rapeseed oil had unsaturated carcass fat that became rancid when stored for 10 months at -12.2 C. Carcasses with saturated fat from palm oil were stable at this temperature, as were carcasses of both types when stored at -23.3 C.

Amino Acids

Amino acid balance. A free amino acid diet supplemented with glutamine increased the growth rate of Broad White turkeys to approximately 78% of the rate of growth of 26 g/bird per day obtained on an intact protein

control diet. This growth was achieved with 70% of the feed intake during 7 to 21 days of age. An amino acid procedure that required the use of the gas chromatograph was satisfactory for analyzing the free amino acids in the plasma, muscle, and liver tissues and in feed hydrolysates.

Limiting amino acids in wheat. A valine-supplemented, semipurified diet that contained wheat as the only protein source failed to produce maximum growth in the absence of lysine. Maximum growth was obtained only when both lysine and valine were added.

Nutrient Density

Two strains of Broad White turkeys were fed three nutrient-density levels from 1 day of age to market weight. Nutrient densities 1, 2, and 3 contained caloric densities of 2,780, 3,100, and 3,400 kcal/kg, respectively. Because concentration was the main variable studied, the same nutrient-to-calorie ratio was maintained each week for all nutrient-density levels. Females were marketed at 14, 16, 18, and 20 weeks of age and males at 18, 20, 22, and 24 weeks. If breast and back fat score had been used as a measure of market quality, the females on nutrient densities 1, 2, and 3 could have been marketed at 18, 16, and 14 weeks of age, and the males at 24, 22, and 20 weeks, respectively. Meat yields indicate that this chronological age will provide the turkey producer with the greatest tonnage and return from turkeys on these nutrient-density levels.

Histomonostats for Control of Blackhead

Weight gains and feed conversion of male Large White turkeys to 111 days of age were not influenced by the addition of 0.035% Carbarsone, 0.015% Dimetridazole, or 0.0075% Nifursol to an unmedicated control diet.

SOILS

Fertility

Nitrogen fertilizers for continuous wheat. From 1966 to 1969 the amounts of fertilizer N applied to spring wheat were based on the amount of NO_3-N in the soil in late autumn. Control plots were also maintained. During the 4 years, a total of 105 kg N/ha was applied: 40 kg in 1966, 30 kg in 1967, 20 kg in 1968, and 15 kg in 1969. Soil tests in the autumn of 1969 indicated that no N is required for 1970.

The results showed that the equilibrium NO_3 content of the soil increased when soil-test recommendations were followed. At all sampling dates during the growing season, the NO_3-N content of the tested plots gradually increased over that in the untreated plots. In 1966 the average difference for seven sampling dates was only 6 kg/ha. This difference increased each year until 1969, when it was 36 kg/ha. The maximum difference occurred in the late autumn of 1969, when the fertilized plots contained 62 kg/ha more NO_3-N than the untreated plots. The loss of N must have been small, and a very high proportion of the applied N must have remained in a highly labile form.

Winter changes in soil nitrogen. Cylinders of a loam soil were placed in the field in late fall and were sampled in midwinter and early spring. Soil NO_3 and moisture moved upward during the winter and downward again in the spring. The amount of upward movement was much greater when soil moisture was near field capacity than when it was near the wilting point.

To inhibit nitrification, N-serve was applied in 10 cm of water to field plots in late fall. Other plots received water but no N-serve. Regular monitoring of soil NO_3, exchangeable NH_3, soil moisture, and temperature in the top 90 cm of these plots showed evidence of upward movement of moisture and NO_3 as the soil froze. Large and sudden unexplainable decreases in exchangeable NH_3 occurred following steady fall increases.

Structure

Effect of freezing and thawing on percolation rate. A laboratory investigation of clay and loam soils indicated that the effect of freezing and thawing on the relative rate of water percolation was influenced by the soil texture, the method of drying, and the initial

moisture content. The percolation rate was consistently higher in the clay than the loam. Drying the soils before the tests were made reduced the relative percolation rate. Freeze-drying caused a greater reduction than air-drying. Freezing and thawing of the samples at moisture levels of 0.1 atm caused a reduction in the relative percolation rate regardless of subsequent treatment of the samples. However, freezing and thawing at moisture contents of 15 and 3 atm increased the relative percolation rate.

Effect of snow cover on soil aggregation. When a continuous snow cover was maintained on medium-textured soil, the percentage of fine (< 1 mm) aggregates declined from October to April. This decrease was particularly evident during periods of snowmelt in February and March. When plots were protected from snow by covers that allowed air circulation, the soil surface became very fine and highly erosive. The structure of the soil did not deteriorate when plots were protected from snow by a polyethylene mulch because the surface did not become dry. This finding demonstrates that desiccation by sublimation is important in the process of overwinter destruction of soil aggregates.

Minimum Tillage for Summerfallow

Experiments on various combinations of tillage and herbicides to control growth during summerfallow indicate that herbicides can be used effectively to reduce the number of tillage operations and that they help to maintain trash cover in southwestern Saskatchewan. Starting the summerfallow operation in the late autumn with a 6- to 8-oz/acre application of 2,4-D to control winter annual weeds gave the best results. A second application of 2,4-D in the spring usually kept weed growth under control until midsummer, when tillage had to be used to remove grassy weeds and volunteer cereals. Depending on the growing season, a second tillage operation was sometimes needed in late summer. Again in late autumn a herbicide application was often required to control winter annual weeds. Abundant trash cover and wind erosion protection has been achieved by these methods with no sacrifice in the yield of the subsequent crop and at a cost per acre similar to that of cultivated summerfallow.

Effect of Spring Thaw on Soil Microflora

When soils were frozen and subsequently thawed at low fluctuating temperatures, no significant changes in the level of N or exchangeable NH_3 could be detected. This lack of change in soil inorganic N was found to be caused by changes that occurred in the microbial population of the soil during freezing and thawing. The initial freezing had little effect on the total number of viable organisms, but several days of thawing with a diurnal temperature fluctuation from 14 to 3 C were extremely damaging to certain soil organisms. The first thawing reduced the number of viable bacteria in some soils by as much as 90%. The thawing was generally less damaging to the fungal population and caused only a slight reduction in the viability of soil actinomycetes. The same low fluctuating temperatures did not damage microbial populations when the soil had not been previously frozen; slow freezing apparently rendered the microbial cells susceptible to subsequent inactivation by alternating low temperature.

Alfalfa-sick Soils

The phytotoxicity of alfalfa-sick soils varies greatly from year to year in soils at comparable locations. Soils collected in 1967 were more toxic to alfalfa growth than those collected in 1968. In 1969 none of the soils appeared to be highly toxic. Presumably the heavy precipitation in the fall of 1968 leached the toxic compounds to below sampling depth.

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Research Station
Beaverlodge, Alberta

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INTRODUCTION

The Research Station, Beaverlodge, and its associated experimental farms at Fort Vermilion, Alta., Prince George, B.C., Fort Simpson, N.W.T., and Mile 1019, Alaska Highway, Y.T., comprise the Northern Research Group. Research in soils, cereals, oilseeds, and horticultural and forage crops is aimed at increasing the efficiency of production under northern conditions and assessing the agricultural potential of areas not yet developed.

In 1969, a crab apple cultivar and a hardy shrub rose were named and released. Research supported the licensing, on June 24, 1969, of the chewings fescue variety Highlight. A 5-year study showed the feasibility of producing package bees from colonies overwintered in southern British Columbia. Progress was made on determining the relationship of day length and temperature to the yield of barley. A snow mold, new to the area, was identified.

Dr. A. A. Guitard, Director, became Director of the Research Station, Swift Current, Sask., on Sept. 2, 1969. Dr. L. P. S. Spangelo, Ottawa Research Station, was appointed Director on Nov. 4, 1969.

A. G. Kusch
Acting Director

SOILS

Correlation of soil test values with response of oats to fertilizer. Eighteen tests were conducted on oats grown in Gray Wooded soils in the Upper Peace River region of Alberta and British Columbia. Pendek oats were treated with nil, NPKS, NPK, and PKS at 71.2, 35.6, 35.6, and 17.8 kg/ha, respectively, for N, P, K, and S. The mean yields were 994–2,350 kg/ha. In all tests response to N was shown. In five of the tests without added N, yields were equal to or lower than the nil treatment. Fourteen tests showed yield increases from the application of P. In three tests without added P, yields were equal to or lower than the nil treatment. Six tests showed increased yields from an application of K and eight from an application of S. These increases were less than responses to N and to P.

The Alberta Soil and Feed Testing Laboratory analyzed soil samples taken at the time of seeding, to a depth of 94 cm in successive 15-cm layers, and soil test values were correlated with crop response for each nutrient. There was a strong correlation between soil NO_3-N and response to N fertilizer.

CROPS

Cereal and Oilseed

Effect of liming acid soils on cereal and oilseed crops. In a 2-year study on two strongly acid soils, liming greatly increased the yield of barley, increased to a lesser extent the yield of wheat and rape, but did not appreciably increase the yield of oats and flax. Three varieties of barley and wheat showed various responses, but those of three varieties of rape, oats, and flax were the same. Relative crop yields were consistent for the two soils in both years. Because large amounts of plant nutrients were applied to the soils both years, it may be inferred that yield responses to liming were caused mainly by the decrease in available Al and Mn. Oats and flax were not noticeably affected by available Al and Mn. It was shown that the toxic elements Al and Mn precipitate out at pH 5.5 and cause more plant injury than does the H ion concentration of the soil.

Temperature and day length effects on barley. In the continuing study of the relationship between development and yield in the barley plant, the photoperiod-insensitive cultivar Olli and the photoperiod-sensitive cultivar Vantage were grown in controlled-environment chambers at 13 C and 24 C under 8, 16, and 24 hr of light per day. The high temperature reinforced the effect of the short

day. Internode elongation began after floral initiation, but environmental conditions determined at what stage of apical development the internode elongation began. However, internode elongation and other measurements of vegetative development indicate apical stage. The relationship between apical and vegetative stages was constant over a wide range of cool temperature and long-day conditions, including normal spring conditions in the field.

In the mature plant, an increase in all seed yield components showed that the number of floret primordia formed in the seedlings was increased under short day lengths. This increased yield occurred only when the seedlings were moved to long days after floral initiation, because after initiation, longer day lengths result in higher yields. Under long-day conditions the yield of Olli was more stable than the yield of Vantage. Similar results were found when these cultivars were grown at different latitudes. The high temperature (24 C) reduced the number of days needed to reach maturity to 60% and reduced the yield to 15% of that obtained at the low temperature (13 C).

Preliminary experiments with near isogenic barley lines are in progress to determine the effect that various lengths of developmental stages produce on yield.

Forage Crops

Forage introductions. From a program designed in 1966 for evaluating introduced cultivars of grasses and legumes enough data have been provided to rate about 300 cultivars. A Station mimeograph containing these data was given to the Forage Seed Industry in 1969. Enough data were supplied to support the licensing of the Swedish chewings fescue variety Highlight. This program is continuing, and new seedings are made annually.

Snow molds on lawn grasses. During the spring of 1968 a survey of lawns and lawn grasses in northwestern Canada showed extensive plant injury caused by snow molds. *Typhula ishikariensis* Imai (*T. idahoensis* Remsb.), a species not reported previously in this area, was the most prevalent.

Twenty cultivars of fescue and nine of bluegrass were rated for susceptibility to and recovery from *T. ishikariensis* infections. Highlight chewings fescue showed good resistance to and excellent recovery from this disease.

Stem eyespot of creeping red fescue. In 1969 *Phleospora idahoensis* Sprague was found in most fescue fields in northern Alberta and British Columbia, but not in recently developed fields that were isolated from old seed-production areas. Fewer losses in yield were reported in 1969 than in 1968, because the hot, dry weather in 1969 delayed development of the disease until seed heads had been well formed and were nearly mature.

Northern native species. A genecological collection of northern grasses was made during the past 3 years in the following areas: northern British Columbia, northern Alberta, the Mackenzie River to Inuvik, N.W.T., and the Alaska Highway to Whitehorse, Y.T. The most numerous genera collected and the number of sites where they were collected were *Poa* 848, *Agropyron* 650, *Calamagrostis* 333, *Agrostis* 191, *Elymus* 158, *Bromus* 124, *Festuca* 73, *Beckmannia* 68, *Deschampsia* 65, *Trisetum* 58, *Alopecurus* 57, *Phleum* 40, *Stipa* 31, *Cinna* 29, *Glyceria* 28, and *Danthonia* 26. Of the 3,844 plants collected, 600 died after the first year. Seed is being collected from each genotype, and the individuals are being screened for disease resistance. This collection is used locally for extracting agronomically desirable breeding material, and it is also available to interested scientists for studies on plant physiology and genetics.

Effect of irrigation on hay land. A 5-year-old stand of bromegrass–alfalfa on a Hythe-Esher sandy clay loam was studied for 3 years. An application of 15 cm of dugout water in July increased the second cut only if the extra water exceeded the June to August water deficit (total evaporation less the precipitation). The aim of the project was not to maximize yields by irrigation, but rather to determine the yield of forage that could be harvested by using enough extra water to raise the water level closer to good moisture conditions.

An application of 16-20-0 fertilizer at 300 kg/ha was found to produce a greater effect on unirrigated plots than on irrigated ones. Results showed that to produce economic increases in forage, usually more than the minimal 15 cm of irrigation is needed. A more extensive trial is planned.

Development of white-blossomed strains of red clover as markers for isolation tests. Pure-breeding white-blossomed strains of the red clover cultivars Altaswede and LaSalle were developed as genetic markers for determining isolation distances in the production of pedigreed seed. White-blossomed plants were selected in 1965–66. The plants were open pollinated by honey bees in isolation cages. Plants whose progeny had more than 25% nonwhite blossoms were discarded. A partial diallel of the remaining plants was made, and final selections were based on the blossom color of the progeny.

Fruit Crops

Fieldhardiness of strawberries. A record low mean temperature of -28.9 C in January did not damage Protem or other Beaverlodge selections, but all introduced cultivars showed various degrees of injury. The introduced cultivars, in order of increasing injury, were Agassiz 2, (Cheam, Agassiz 3, and Redcoat), (Agassiz 1, Agassiz 5, and Guardsman), Agassiz, Cavalier, Senator Dunlop, Agassiz 4, and Grenadier. The cultivars listed in parentheses received the same degree of injury.

Laboratory hardiness test for strawberries. The percentage of electrolytes extracted from crowns of RR_4, Protem, British Sovereign, and Northwest after cold stress in early winter was inversely related to recovery in the field and the greenhouse. This method of evaluating hardiness was more suitable than the recovery, resistivity, or ninhydrin methods. The cultivars increased in hardiness during the winter; the least-hardy cultivars showed the greatest increase. By January, RR_4, Protem, and British Sovereign had achieved the same degree of hardiness, and by March, the least-hardy cultivar, Northwest, had reached the same degree of hardiness as Protem had shown in October.

The optimum temperature for differentiating hardened cultivars was -9 C. Temperatures above -9 C did not cause enough injury to show the inherent differences among cultivars, whereas lower temperatures caused complete killing.

Consequently, in the Peace River region early winterhardiness is very important and it can be assessed in October by electrical conductivity tests.

Low-dose gamma irradiation of seed of the strawberry cultivar Protem. Sixteen days after planting, germination increased from 5% in the control to 37%, 36%, 45%, and 55% for doses of 100, 300, 1000, and 2000 rad respectively. After 23 days germination percentages increased to 12, 49, 60, 50, and 67 respectively. After 40 days no further changes occurred.

Arctic Red, a new crab apple. The cultivar Arctic Red was produced from open-pollinated seeds and released by the Station in 1969. It is the hardiest domestic crab apple that has been tested at Beaverlodge. Young trees come into production at an early age, and always produce heavy crops. The trees are upright, spreading, moderately vigorous, and have strong crotches. The fruit is 3–5 cm in diam, and golden yellow almost covered with dark purple red; the flesh is golden yellow, crisp and juicy, and has good flavor.

Winterhardiness in red raspberries. Winterhardiness of several red raspberry cultivars was evaluated for 4 years. All cultivars were severely injured. In Honeyking, the hardiest cultivar, 43% of the buds were growing in early summer, whereas Comet had only 10.2%. Counts of growing buds during the spring and early summer showed that only the number of buds growing in mid-July reflected the relative hardiness. Bud growth during the winter on excised canes indoors showed the relative hardiness and time of injury only 1 year in 4. The cultivars with the slowest rate of elongation in late summer and the earliest leaf drop sustained less injury than the cultivars with higher rates of growth and later defoliation. The relationship between rate of elongation, defoliation, and amount of injury was the same each year, and did not appear to be affected by climate.

Ornamentals

Kakwa, a new shrub rose. This cultivar, produced from open-pollinated seed of *Rosa spinosissima hispida* (Sims) Koehne, was released by the Station in 1969. The bush is shorter and more spreading than normal for the species, and is 60 to 90 cm high. It is very hardy, and suitable for foundation planting on southern exposures in severe climates. The cream-colored flowers are 5 to 7.5 cm in diam, highly perfumed, semidouble with 4 to 6 rows of petals, and have pronounced yellow stamens. The fruits are black.

Vegetable Crops

Evaluation of potato cultivars. Three years of comparative tests at Beaverlodge, Anzac, and Fort Vermilion, Alta., Fort Simpson, N.W.T., Mile 1019, Y.T., and Prince George, B.C., showed significant effects of location, cultivar, year, and location × year interaction on total and marketable yield, specific gravity, and cooking quality. No interaction was shown for cultivar × location, cultivar × year, or cultivar × location × year. Therefore, for early tests on potatoes for northern regions only one location is needed.

Cariboo potato. The recently introduced potato cultivar Cariboo is being well accepted in British Columbia. In 1968, 4.15 acres passed seed inspection, and in 1969 this had increased to 46.85 acres. Of 17 cultivars inspected in British Columbia, Cariboo ranked sixth.

APICULTURE

Wintering colonies in southern British Columbia for production of package bees. In a 5-year study (1964–68) in cooperation with the Research Station at Agassiz and the British Columbia Department of Agriculture, colonies wintered in the Fraser Valley produced an average of 5.5 one-kg packages of bees. Honey consumption averaged 39 kg (86 lb) for 8 months. If queens could be obtained early enough and at reasonable cost, small package bee industries in southern British Columbia would be successful. In the fall of 1969, about 6,000 colonies were taken from Alberta and northern British Columbia for wintering.

Preliminary evaluation of bee queens imported from New Zealand. Queens imported from New Zealand in April 1968 and 1969 compared favorably with queens from California. Honey production of the package bee colonies was 69 kg (150 lb) for the New Zealand queens and 64 kg (141 lb) for the California queens. The New Zealand bees were gentler and easier to manage. Studies are in progress on disease resistance and wintering adaptability.

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RESEARCH STATION, BEAVERLODGE, ALTA.

Research Station
Lacombe, Alberta

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INTRODUCTION

The diversification of the research program at the Research Station, Lacombe, Alta., is illustrated in the brief reports of our findings during 1969. Further details are available on request.

The project on the evaluation of foreign breeds of cattle, started in 1968, has aroused intense interest in the new germ plasm being imported and in crossbreeding in general. We are not promoting these new breeds, but are testing them to ascertain their possible contributions to the Canadian cattle industry.

We were pleased that Dr. Fujishima's postdoctorate fellowship was extended a year, as he has proved to be a very stimulating scientist.

Dr. Cairns, officer in charge of the Substation at Vegreville, spent January to October at the Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest, where work with Solonetzic soils similar to those in Alberta is in progress. He also visited other soil research institutes in eastern Europe.

Dr. Fredeen received a Merit Award from the Canadian Government in recognition of his outstanding contribution to the Canadian livestock industry.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Selection for yearling weight in Shorthorn cattle. The project of single-trait selection for weight at 1 year of age has progressed through 9 years. Performance (mean yearling weight of males and females) of the control herd, a reflection of environment, increased during the first 7 years and decreased during the eighth and ninth years. The superiority of the selected over the control line has increased at the rate of 2.5 ± 0.6 kg (5.5 ± 1.4 lb) per year. The regression of the selected line deviation from control on the selection differential (realized heritability) is 0.33 ± 0.08.

Swine

Breed structure of the Canadian Yorkshire. Over a period of 6 years that ended in 1966, 87,295 Canadian Yorkshire pigs were registered from 2,281 herds. Approximately half the herds and the animals recorded were from the provinces of Alberta and Ontario. Average life-span of the herds was short, 50.9% appearing for only 1 year of the 6-year period. Such herds contributed less than 10% to the total registrations. Herds in continuous production comprised 10.9% of all herds, produced 53.5% of the total registrations, and registered 30.4 pigs annually from an average herd size of 2.8 sires and 8.3 dams. These estimates of herd size were about four times the estimated size of herds that registered pigs only once in the 6 years.

During the period of the study, the number of herds decreased by more than 50% (from 1,501 in 1960 to 737 in 1966), primarily by elimination of small herds. However, of all herds that registered pigs in 1966, 70% contained five or fewer sows and 74% registered fewer than 20 pigs. The average generation interval was approximately 24 months. Record of Performance (R.O.P.) records were not employed to any meaningful degree for culling parental stock or for selecting progeny entered for registration. Pedigree analysis showed little evidence of intraherd breeding.

Inbreeding and relationship for three breeds of pigs. Pedigree sampling techniques were used to study inbreeding and relationship within the Berkshire, Yorkshire, and Tamworth breeds in Canada. The pedigrees sampled were from Volume 71 of the *Canadian Swine Breeders Herdbook*, published in 1963.

The Berkshire is the oldest established breed in Canada, but in terms of genetic relationships it is the youngest of the three breeds studied. Only two of the important ancestors of the breed predate 1939. A high proportion of the inbreeding present in the breed has occurred since 1939, and the major

importations of breeding stock have taken place since 1948.

The Yorkshire, established in 1889, 13 years after the Berkshire, has been markedly less dependent on importations. Inbreeding has progressed at a reasonably steady rate since 1920, and birth dates of important common ancestors of the breed are distributed reasonably uniformly over the period from 1900 to 1940. These two breeds have the same inbreeding (7.0%), but, because of the difference in effective genetic age, inbreeding in the Berkshire has progressed at about twice the rate per generation observed for Yorkshires. Inbreeding of Tamworths has progressed at the same rate as for Berkshires. In terms of generations, however, the breed is essentially the same age as the Yorkshire, and total inbreeding is approximately twice that for the Yorkshire and Berkshire breeds.

The Lacombe breed. The Lacombe breed, the product of a developmental research program undertaken in 1947 by the Canada Department of Agriculture at the Research Station, Lacombe, was released to the public in 1958. The breeding stock distributed was from a population that averaged 6.36 generations removed from foundation stock, carried an average inbreeding of 12.4%, and comprised direct contributions of 56.6, 20.8, and 22.6% from the Landrace, Chester White, and Berkshire breeds respectively.

In 1968, Lacombes comprised 11.9% of all swine pedigrees issued in Canada. Seventy-two breeders contributed to this number. Lacombes tested under the National R.O.P. Swine Testing Program averaged approximately 10% faster in growth rate than Yorkshires and produced carcasses of equivalent merit.

Selective registration based on R.O.P. tests of parents or sibs has been an integral part of the Lacombe Breed Association Bylaws since the Association was formed in 1959. The R.O.P. testing required for registration and the mandatory culling levels (of those failing to meet the performance standards) impose production inputs and costs higher than for other breeds. Although these factors appear to have adversely affected rate of propagation, they have exerted a beneficial influence on herd size.

Lacombes have proven popular for cross-breeding in Canada and have also been widely sought by breeders in other countries. The most recent export was in May 1969 when 40 head of Lacombes purchased from breeders in Saskatchewan and Manitoba were exported to West Germany. Other countries to which Lacombes have been exported include England, USSR, Italy, Spain, Japan, Mexico, Cambodia, Dominican Republic, and Singapore. Production figures from England and the USSR indicate that the breed has established a good record for rate of reproduction and growth.

Carcass Research

Beef carcass research. A comprehensive project on beef carcass evaluation involving 574 carcasses of bulls, steers, and heifers was conducted by the Research Station at Lacombe. One objective of this project was examination of the relative efficiency of lean vs. fat production in beef cattle. The second main objective was the development and evaluation of prediction equations for estimating lean content of a beef carcass. The bulls were provided from the breeding research programs at the Lacombe and Lethbridge research stations. Also, the steers used in the efficiency portion of the study were from Lethbridge. Purchase of 200 head of commercial steers and heifers for the project was financed by the Alberta Department of Agriculture out of the Horned Cattle Trust Fund and administered by the Alberta section of the Canadian Cattlemen's Association.

Measurements included thickness of fat cover on live animals, detailed accounting of killing floor losses, several carcass measurements, and the weight of fat, lean, and bone from each of the cuts. Samples from each carcass were also used for laboratory studies of tenderness, meat color, and chemical composition. Statistical analyses of the data are in progress.

Length and carcass merit in pigs. Detailed analysis of complete carcass cutout data for 5,000 pigs indicated that carcass length was related to both yield and value of the carcass. This relationship was entirely accounted for by the high correlation (+0.82) between carcass length and carcass weight. Regression analyses established that the addition of carcass length as an independent variable, after inclusion of both carcass weight and backfat

thickness, did not add precision to the estimation of yield or value of the carcass.

Yield prediction equation for R.O.P. Complete carcass cutout data for 1,200 pigs produced in the breeding research program at Lacombe were used to develop new carcass-yield prediction equations in which carcass yield was defined in the same terms as those employed by the revised grading standards for commercial hogs. Two breeds, Lacombe and Yorkshire, and two crosses (Hampshire–Lacombe and Poland China – Lacombe) were involved. Analyses established that the breeds and crosses did not differ in the magnitude of sex differences. It was further established that there was no interaction between sex and weight for any of the carcass measurements.

The analysis produced a prediction equation based on actual measurements of the carcass, and sex adjustments were applied to the predicted yield. This revised formula has been adopted by the National Advisory Board for R.O.P. swine.

Weight adjustment of age and live-animal probe. Four hundred and seventy-eight pigs were probed at two weights, 76 and 90 kg (170 and 200 lb), to provide information on growth rate and fat deposition over this 14-kg (30-lb) weight range. Detailed analyses of these data indicated that backfat thickness increases proportionally with body weight, whereas growth rate during the period is a function of the previous growth history of the animal. Formulas were developed for adjusting age and probe to a standard weight. These formulas and quick reference tables developed therefrom have been adopted for use by the National R.O.P. Swine Testing Program.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Random method of oat breeding. Five years evaluation of the random method of breeding oats (advancement of generations at random to virtual homozygosity, then selection for high productivity) indicates it to be highly efficient. In this rather short period an improved variety has been developed and will be considered for license in 1970.

Associated studies with 820 random lines from four crosses showed transgressive segregation for yield, height, time to maturity, kernel weight, and bushel weight. Lack of variation in lodging resistance precluded study of this trait. Correlations between yield and the more visible traits indicated advantages for the random method over the pedigree in breeding for high productivity.

Selection index for higher yield. The weight of five panicles or spikes taken at random from standard rod-row plots of oats and barley was significantly correlated with plot yields (r = 0.275 and 0.640 respectively). This finding could save time and expense when used as an indicator in preliminary screening, particularly in barley. The performance of single plants grown under spaced conditions was not indicative of the productivity of their progeny seeded at normal rates.

Net blotch of barley. Yield reductions with Gateway barley, caused by heavy infection of the leaves with net blotch, were more marked on soils low in fertility than on more fertile soils. Removal of comparable leaves did not depress yields as much as when leaves were diseased, which suggests that net blotch affects the general health of the plant beyond the parts visibly attacked.

Physiological studies. When leaves infected with net blotch were detached, or when light was withheld, a marked increase in peroxidase activity and an accompanying decrease in catalase activity occurred. No clear-cut association between increased resistance and increased peroxidase activity was found, although the latter appeared to indirectly affect the implementation of a defense mechanism in leaves against the net blotch fungus.

Root rot in barley. In keeping with previous findings, barley sown on stubble continued to show less infection with common root rot than that on fallow. A significant decrease in incidence was noted when Gateway barley was grown on soil that received heavy applications of N alone. Other nutrients alone or

in combination with N had little effect on the incidence of root rot.

Forage Crops

Grass varieties. Magna bromegrass, licensed in 1968, has been evaluated for 4 years at Lacombe and has not proved superior to other varieties. Average yields for Saratoga, Redpatch, Carlton, and Magna were 6,009, 5,560, 5,493, and 5,269 kg/ha respectively.

Parkway crested wheatgrass, licensed in 1969, has been evaluated in two separate tests for 2 years. The 4-year average yields for the diploid varieties Parkway and Fairway and the tetraploid varieties Summit and Nordan were 7,780, 7,600, 6,961, and 6,726 kg/ha respectively.

Gray stem canker of sweetclover. Ascochyta caulicola Laub., the fungus causing gray stem canker of sweetclover, caused severe flower drop at Lacombe in 1968 and was reported to have reduced seed production severely in areas north of Edmonton in 1969. The fungus attacks the flowering shoot, infecting the petals, calyx, and rachis, and has caused up to 95% seed loss. Yellow-blossomed varieties, *Melilotus officinalis* (L.) Lam., were more tolerant than white-blossomed varieties, *M. alba* Desr. Six to 30% of the seed from infected varieties carried the fungus, and this was directly related to the susceptibility of the variety and the severity of the infection.

Horticultural Crops

Pickling onions. When harvested 90 days after seeding, White Portugal onions produced the highest yield of pickling grade, followed by Crystal Wax, White Queen, and Eclipse L303. Eclipse L303, a short-topped early-maturing variety, produced the most uniform grade. A seeding test with White Portugal indicated that the rate of 40.4 kg/ha was superior to the higher rates of 49.3 and 58.3 kg/ha.

Continuous cropping of radish. Seeding radish at 10-day intervals from early May to mid-August permits continuous cropping from mid-June to mid-September. The variety Cavalrondo was superior to four other varieties tested.

Reaction of sweet corn to severe frost injury. After a frost of −10 C at ground level, on June 12, a 16% survival of sweet corn was recorded. The surviving plants remained stunted throughout the season and the earliest that cobs were ready for use was 114 days from seeding, approximately 20 days later than normal. Corn reseeded after the frost was ready for use at the same time.

CROP MANAGEMENT AND SOILS

Weed Control

Competition between wild oats and barley. Both wild oats and barley responded to increments of N fertilizer when grown together in growth-chamber and field experiments. The response of barley increased when the competition of wild oats was removed through the use of barban. Seeding wild oats before barley in the growth-chamber experiment resulted in 17% fewer culms of barley and 24% less dry matter, and seeding after barley produced 14% more culms and 18% more dry matter, than when the two species were seeded together. Prior seeding of wild oats in the field produced 5% fewer barley culms and 4% less grain yield, whereas later seeding increased the number of barley culms and grain yield by only 1% and 2% respectively.

MSMA (monosodium methanearsonate). For 3 years and in some 40 field experiments MSMA (Niagara Chemicals) was less effective on wild oats than barban, but was very effective for control of green foxtail. Oats and barley showed fair tolerance, but wheat was rather seriously injured. When barley was treated at the two- or three-leaf stage, the seed did not carry sufficient arsenic residue to be considered dangerous, but it did when the plants were treated at the four- and five-leaf stages. Because of the relatively poor control of wild oats, the variable tolerance of the crops, notably wheat, and the very short time to spray to avoid arsenic residue on the grain, work with MSMA in cereal crops has been discontinued.

Bromophenoxim. In the past 3 years Bromophenoxim (C-9122; CIBA Company) has

shown a very quick and complete selective control of green smartweed, and wild and Tartary buckwheat. However, acceptable control of common chickweed and corn spurry was observed in only a few cases. Wheat, oats, and barley were highly tolerant of dosages up to 4 kg/ha, more than twice the amount needed to control the buckwheat.

Soils

Organometallic interaction in soil. Potentiometric titrations of the humic acid in the presence of added cations showed the formation of metal - humic acid complexes. The order of magnitude of pH drop of the humic acid on addition of metallic cations was found to be $Mn^{2+} < Co^{2+} < Ni^{2+} < Zn^{2+} < Cu^{2+} < Al^{3+} < Fe^{3+}$. The only change in the sequence of the effectiveness of added cations in coagulating the humic acid was the reversal of Al and Fe.

Humic acid fraction of a Gray Wooded soil. Five-year rotation of grains and legumes practiced over 39 years and also the continued application of manure on a Gray Wooded soil of Alberta increased the humic acid fraction of soil organic matter. From 14% to 17% of the N in the surface soil was present in the form of humic acid. The higher C content and greater values of the extinction ratio (E_{465}/E_{665}), neutralization capacity, and carboxyl content of humic acid under a wheat–fallow sequence than under the rotation indicated marked differences in the characteristics of the fraction under the two cropping programs.

Copper and manganese on barley. We mentioned previously (Research Report 1968, page 299) that a soil site in central Alberta was deficient in both Mn and Cu for barley. These deficiencies were confirmed in 1969. Spray treatments with Cu alone on barley at another site also resulted in substantial yield increases, but when Mn was combined with Cu there was no visible beneficial effect. Chemical analysis of the plants from this second site at flowering stage indicated Mn concentrations of 15–27 ppm, which are not considered excessive. The conflicting results with these and other minor elements show that further study is needed.

Effect of sulfur fertilization on the selenium content of forage species. Levels of Se considered to be deficient for animal health (less than 0.1 ppm) were found in timothy, bromegrass, alsike clover, and red clover in west central Alberta. Alfalfa from only two of six sites contained less than 0.1 ppm. Where more than one species was sampled at a site, similar concentrations of Se were found in all species except at two sites where alfalfa contained 15 and 50 times more Se than bromegrass from the same site. The application of S fertilizer at rates of 22 and 44 kg of S/ha had an inconsistent effect on Se concentrations when the level was less than 0.1 ppm. There was either no change or a slight decrease. In all instances where forage contained more than 0.1 ppm a very marked reduction in concentration of Se resulted from the application of S fertilizer. The effect of the S fertilizer appeared to be twofold: a dilution effect due to increased plant growth and a direct antagonistic effect on Se uptake.

Calcium carbonate for alfalfa and sweetclover on Gray Wooded soils. Growth of alfalfa and sweetclover was restricted by N deficiency in two soils with pH values between 5.5 and 5.0 and also by Mn excess in another soil with pH < 5.0. The addition of $CaCO_3$ increased soil pH, reduced the concentration of Mn in the one soil, and improved the soil environment for root nodulation and fixation of atmospheric N by *Rhizobium* in all three soils. It also increased the yield of both crops.

Fertilizer on peat soils. Peat soils in Alberta are highly variable in physical and chemical characteristics and are also variable in response to applications of fertilizer. Bromegrass on a well-decomposed sedge peat, under cultivation for 15 years, responded to P and K but not to N. On a newly cleared, well-decomposed, woody moss peat, the response was to N only. Similarly, on a third site of newly broken, well-decomposed mossy sedge, bromegrass responded only to N.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Salt and water movement into Solonetzic soils. Water containing 0.1 N NH_4^+ or divalent cations penetrated a Duagh soil more than 50 times faster than water alone. Infiltration of water applied after treatment with these solutions varied from 41 to 51 mm/hr, but decreased with time. A field application of these cations could thus cause the Na to move farther down the profile with periodic rainfall. Calculations showed that diffusion of Ca^{2+} into a sodic soil in the absence of viscous flow will not contribute significantly to reclamation of sodic soils.

Movement of precipitation and groundwater in a Solonetz soil. Groundwater often occurs within 100 cm of the surface of Duagh silt loam and is generally 0.2 N with respect to Na_2SO_4. Capillary rise of a simulated groundwater was 84 cm, whereas infiltration of distilled water was 23 cm during the same time interval in soil columns containing A, B, and Csk horizons at the same depths as they occur in the field. The ascending groundwater and the descending distilled water met in the lower B horizon, the region of greatest salt accumulation in the field. Long-term reduction in the salt content of this soil can result only by shifting the equilibrium between the movement of groundwater and precipitation.

Recovery of applied nitrogen by barley seedlings. About 65 ppm N were recovered in the aboveground parts of barley seedlings where 100 ppm of N was applied as NH_4NO_3 to Duagh silt loam, compared with about 175 ppm where 200 ppm was applied. Repeated crops were grown to exhaust the applied N, most of which was recovered in the first cut of the first crop.

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Research Station
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S. DUBETZ, B.Sc., M.S.	Irrigation agronomy
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K. K. KROGMAN, B.Sc., M.Sc.	Irrigation efficiency
L. E. LUTWICK, B.Sc., M.Sc., Ph.D.	Chemistry and genesis
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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)

Departures

T. H. ANSTEY, B.S.A., M.S.A., Ph.D. Transferred to Ottawa as Assistant Director General (Western), April 8, 1969	Director
M. W. CORMACK, B.S.A., M.Sc., Ph.D., F.A.I.C., F.R.S.C. Retired August 15, 1969	Associate Director
L. C. GODFREY, B.Sc. Transferred to Lacombe, February 12, 1969	Assistant Administrative Officer
R. D. CLARK, B.S.A., M.Sc., Ph.D. Resigned August 22, 1969	Dairy cattle breeding
P. C. CHANG, B.Sc., M.S. Retired October 23, 1969	Chemical analysis

VISITING SCIENTISTS

M. D. KRUNIC, B.S., M.S., Ph.D. National Research Council postdoctorate fellow	Forage crop insect pollinators
M. N. MUGOFWA Colombo Plan Trainee, July to August 1969	Water management

INTRODUCTION

The Research Station, Lethbridge, is engaged in research in a wide variety of fields of science related to agriculture, as shown in the list of professional staff. This report highlights the results of some of the research in progress in 1969. More detailed information can be obtained direct from the scientists or from the publications listed in this report.

The Station participated in the Canadian program of aid to developing countries by providing scientists for technical studies in Korea, West Africa, and India. It is taking a leading part in an extensive 5-year research program in soils, agronomy, and agricultural engineering to improve production on nonirrigated land in India.

The accumulated findings of the research program have had a considerable impact on agriculture over the years. The research of Dr. G. A. Hobbs on the use of alfalfa leafcutter bees to increase alfalfa seed production was recognized in 1969, when he received the Merit Award of the Public Service. A feedlot starter ration for beef cattle that was developed here has been adopted extensively by the feed industry.

Research efficiency has been enhanced through the services of a biometrician and a computer programmer in the design of experiments and in the analysis and processing of data.

J. E. Andrews
Director

ANIMAL SCIENCE

Beef Cattle

Feedlot performance. In the first 4 years of a long-term breeding program in which selection was based solely on feedlot gain in a 168-day period, 28 beef bulls sired 894 first-generation calves. About half the progeny of each sire were tested on a ration containing 80% concentrate and 20% hay; the other half were tested on a ration of hay alone. Gains on the first ration were 138 ± 1.0 kg for bulls and 112 ± 1.0 kg for heifers, and on the latter 62 ± 0.7 kg for bulls and 50 ± 0.7 kg for heifers. Both ration and sex-within-ration differences were significant ($P < 0.01$). Although the response of sire progeny groups to the rations varied, the sire × ration interaction effects were not statistically significant.

Starter ration. A complete starter ration containing 50% roughage was formulated, and a successful program for starting cattle on feed was designed. This program eliminates the need for long hay. Use of this ration has made it possible to change feeder cattle from a diet of roughage to a finishing ration in 8 days. Calves started on this ration gained almost as much weight per day in the first 4 weeks (1.1 vs. 1.2 kg) on feed as they did in the succeeding 4-week periods. Therefore, maximum rate of gain was attained without delay.

Protein for wintering calves. Protein intake was more critical than energy intake for steer calves wintered on a mixture of three parts straw and one part grass hay plus 0.4 kg barley per head per day. The average daily gain of calves fed this ration was 0.1 kg, whereas calves fed the same roughage plus 0.1 kg of a 46.6% protein supplement per head per day gained 0.2 kg. However, calves fed roughage and 1.8 kg of barley, or about the same total protein intake as the high protein supplement, gained 0.4 kg per day. Roughage intake was 3.6 kg per head per day for all groups.

Renal clearance of silicic acid in cows. The clearance of inulin (glomerular filtration rate) in cows given alfalfa hay and native range hay was not affected by type of ration, but was affected by level of intake. The clearance of silicic acid paralleled that of inulin, which indicates that a constant fraction of filtered silicic acid was reabsorbed. The amount reabsorbed was 25% of that filtered. Reabsorption may have occurred in the proximal tubule under the influence of a large concentration gradient. It was concluded that diet affects silicic acid clearance only to the extent that it alters the glomerular filtration rate.

Siliceous urinary calculi formation in cattle given excess water. In a previous experiment, the addition of 4% NaCl to a native range

hay diet prevented the formation of siliceous calculi. In a subsequent experiment, a group of calves consuming range hay were given 40% more water than another group receiving water free-choice. The extra water was mixed with milk and was readily consumed or administered by stomach tube. The concentration of silicic acid in the urine and the amounts of calculi in the urinary tracts of the calves given extra water were less than in those of calves consuming normal amounts. The results support the earlier hypothesis that salt prevents the formation of calculi by the diuresis it causes and not by some effect of the salt per se.

Sheep

Heritabilities and genetic correlations. Traits studied in Rambouillet and Romnelet sheep under selection for rate of gain were: weaning weight (WW), total 126-day feedlot gain (TG), feed efficiency (FE), final weight (FW), grease and clean fleece weight (GF, CF), and staple length (SL). Moderate heritabilities were obtained for TG (Rambouillet, 0.23; Romnelet, 0.22); FW (0.26, 0.03); GF (0.31, 0.29); CF (0.23, 0.37); and SL (0.25, 0.39). Low estimates were found for WW (0.13, 0.00) and FE (0.06, 0.18). Genetic correlations were found between FE and TG (-0.44, -1.03); FE and FW (-0.01, -1.71); and FW and TG (0.85, 1.50). Positive correlations were found in both breeds between GF and CF (0.64, 0.93) and CF and SL (0.20, 0.66), but one negative correlation was found between GF and SL (-0.38, 0.70). Positive relationships also were found for GF and CF with TG and FE; however, SL was not related to or had zero-order correlations with TG, FW, and FE.

Poultry Nutrition

Relationship between inorganic P and inorganic Ca in blood plasma. Male broiler-type chickens were fed diets containing graded levels of P from hatching to 4 weeks of age. Plasma inorganic P and plasma inorganic Ca were determined on aliquots of blood plasma samples taken when the chickens were 4 weeks old. The level of plasma inorganic P decreased when the chickens were fed the rations containing low levels of P. Plasma inorganic Ca was inversely related to the plasma inorganic P. Regression equations differed for each of the four dietary P levels, which indicated that a unit change in plasma inorganic P had less effect on plasma inorganic Ca as the P level increased. The sums of plasma inorganic P and plasma inorganic Ca were similar for all groups.

PLANT SCIENCE

Cereals

Wheat streak immunity transferred from Agropyron *to wheat.* A hybrid line derived from the cross *Triticum aestivum* L. cultivar Rescue[3] ($2n = 42$) × *Agropyron elongatum* (Hort.) Beauv. ($2n = 70$) is immune to wheat streak mosaic virus, *Marmor virgatum* McK., has 21 pairs of chromosomes, and hybridizes readily with common wheat. By crossing it with wheat lines ditelosomic for known chromosomes it was determined that *Agropyron* chromosomes have replaced wheat chromosomes 4D, 5D, and 6D in the hybrid. In growth habit the immune line is similar to Rescue, but its long slender spikes, absence of awns, and small, slender, blue seeds resemble *Agropyron.* Since the *Agropyron* chromosome responsible for blue seeds does not seem to be associated with the immune reaction, translocations from only two *Agropyron* chromosomes to their homeologues in wheat are required to produce an immune wheat.

Heterosis in F_1 wheat hybrids. When cultivars of spring and winter wheat, *T. aestivum* were crossed, significant levels of heterosis were demonstrated in F_1 yield trials. Yield increases up to 40% higher than the spring wheat parent were attributed to the crossing of genetically different spring and winter types. This information is valuable in both hybrid wheat and conventional breeding programs. Research is continuing on the practicability of developing higher yielding spring wheat cultivars through the introduction of genes from winter wheat.

Crown depth inheritance in spring wheat varieties, T. aestivum. Inheritance of crown depth was studied in crosses between the spring wheat cultivars Thatcher, with a deep crown; Rescue, with a shallow crown; and Cypress and Chinook, with crowns of inter-

mediate depth. It was deduced that Thatcher and Rescue differ by two genes, Cypress and Chinook have the same gene complement, and Cypress and Chinook both differ from Thatcher by one gene and from Rescue by one gene.

Varieties with deep crowns are preferred because they reputedly have better resistance to root rot and spring frost injury, and have better crown root development in dry soil. Since inheritance is not complex, it should be fairly easy to incorporate the deep-crown character into the shallow-crowned sawfly-resistant cultivars.

Nugaines licensed in Canada. Nugaines, a high-yielding, semidwarf, strong-strawed cultivar of soft white winter wheat, *T. aestivum,* was licensed in 1969 based on tests in Alberta and British Columbia. Nugaines was developed by Dr. O. A. Vogel, USDA. It is expected to replace Gaines in the USA. In Canada, it will be used mainly as a feed wheat. Nugaines is resistant to most races of bunt and has some resistance to stripe rust. Its low level of winterhardiness limits its use to only the areas most favorable for growing winter wheat.

Forage Crops

Seedling growth of rough fescue and tall fescue. Seedling growth rates of a native grass, rough fescue, *Festuca scabrella* Torr., and of a tame grass, tall fescue, *Festuca arundinacea* Schreb., were compared in the greenhouse for 10 weeks. The plants were grown in a Perlite rooting medium, and watered with a complete nutrient solution. Net assimilation rate was similar in both species, but leaf area ratio and relative growth rate were higher in tall fescue. Tiller numbers were similar for both species, but tall fescue produced more leaves. After 10 weeks the dry weight of tops of the tall fescue was 17 times that of the rough fescue.

Viable seed populations in Alberta prairie topsoils. Naturally disseminated seeds in soil obtained from several native and cultivated grass stands were germinated and grown in pots at various soil temperatures, or in greenhouse flats at a constant temperature. There were differences in number of seeds of various species that germinated at various temperatures, but the greatest differences were among collection sites. Grazing affected the number of seeds of a species that germinated; grasses decreased and weeds increased as intensity of grazing increased. The number of viable seeds ranged from 204 to 12,342/m^2. Distribution of numbers of seeds was skewed, with the mode at 780/m^2. When the vegetation was disturbed, the presence of viable seeds of many species on or in the topsoil would assure secondary succession.

Fertilizers affect water use by range vegetation. N and P fertilizers were applied to range vegetation at five locations. N was applied at 475 to 705 kg/ha with or without P at 380 to 545 kg/ha. Mean dry matter yields, in kg/ha per cm of precipitation during the growing season, were: control, 33.3; P, 37.0; N, 52.3; N + P, 73.4. Yields of control and P-treated vegetation were influenced mainly by fall soil moisture, and N and N + P-treated vegetation by June precipitation.

Rates of seeding orchardgrass in a pasture mixture. Orchardgrass, *Dactylis glomerata* L., was seeded at eight rates from 0 to 7.7 kg/ha, along with 14.4–22.4 kg of a mixture of smooth bromegrass, *Bromus inermis* Leyss., creeping red fescue, *Festuca rubra* L., and white clover, *Trifolium repens* L. In the second year after sowing, orchardgrass comprised 50–75% of the herbage at all but the zero seeding rate. White clover comprised 30–40% of the herbage where orchardgrass was excluded, and as little as 7% where orchardgrass was included. After 5 years, fescue and bromegrass were practically eliminated from all orchardgrass plots.

Melrose sainfoin licensed. Melrose, a new cultivar of sainfoin, *Onobrychis viciaefolia* Scop., has been licensed in Canada. Melrose, which resulted from a cooperative program conducted by the research stations at Lethbridge, Melfort, and Saskatoon, was derived from an introduction from the USSR and was selected from among more than 200 sainfoin strains and species tested in various parts of Western Canada for 5 years.

Melrose is more winter-hardy and has produced higher forage and seed yields than other sainfoin strains. Hay and pasture yields of Melrose have compared favorably with those of alfalfa. Melrose does not induce bloat in livestock, and therefore it is expected to be particularly useful as a pasture legume. Also, Melrose is immune to the alfalfa weevil.

About 270 kg (600 lb) of Breeder seed was

produced in 1969 and will be distributed to Foundation seed producers in Alberta and Saskatchewan in 1970. Certified seed will not likely be available before 1972.

Weeds

Aquatic weed control. A herbicide sprayer, pressurized by CO_2, was used successfully to treat shoreline, emergent, and rooted aquatic weeds in two lakes. The herbicide used was a 1:1 mixture of diquat and paraquat, diluted 1:10 with water. A dilution of 1 ppm of active ingredient of this mixture in lake water controlled flat-stemmed pondweed, sago pondweed, Richardson pondweed, Canada waterweed, common coontail, and green and northern water-milfoil for one season.

Seed dormancy of wild oat affected by temperature and moisture during production. Dormancy of primary seed of two varieties of wild oats was affected more by temperature at which the seed was produced than by soil moisture level. Seed produced at lower temperatures (15.6 to 18.3 C) was 30% to 100% more dormant than seed produced at higher temperatures (25.3 to 28.4 C), the magnitude of difference varying with strains and varieties. Seed dormancy was decreased slightly by lower levels of soil moisture (25% vs. 75% available) during production.

Weed control in sweet corn. Good control of both broadleaf annuals and green foxtail in sweet corn, *Zea mays* L., was obtained with directed-shielded postemergence applications of linuron plus dalapon at 1.68 + 1.40 kg/ha (1.5 + 1.25 lb/acre); paraquat at 0.56 kg/ha (0.5 lb/acre); and SD-15418 (Shell Canada Ltd.) at 2.80 kg/ha (2.5 lb/acre) plus emulsifiable oil at 22.46 liters/ha (2 gal/acre). Special equipment and extra care in operation were needed to make these applications. Both SD-15418 at 2.24 kg/ha (2 lb/acre) plus oil, and S-6115 (Gulf Oil Corp.) at 1.12 kg/ha (1 lb/acre) show promise for use as overall or over-the-row herbicides that only slightly injure corn.

Preplanting treatment with either butylate or EPTC (Stauffer Chemical Co.) plus atrazine at 2.24 + 1.12 kg/ha (2 + 1 lb/acre) gave good to excellent control of mixed broadleaf annuals and green foxtail. EPTC plus atrazine resulted in slightly greater ear yield, but a few of the corn plants were injured by EPTC.

SOIL SCIENCE

Soil and Crop Management

Dryland grass fertilization. Forage production on semiarid grasslands was substantially increased by the establishment and maintenance of an N pool in the soil. Maintenance of this reserve of soluble mineral N in the soil ensured that grass growth was not restricted by lack of N when moisture and other climatic conditions were favorable for growth. Loss of soluble N by leaching through the soil was insignificant over a 7-year period, because of rather low precipitation and the mass of grass roots that was always present.

Restoring productivity to eroded soil. Spring wheat grown on uneroded dryland soils failed to respond to applied fertilizer, but when grown on soils from which topsoil had been removed it responded, especially to P. Unfertilized plots that had lost 20 and 45 cm of soil yielded 137 and 100 kg/ha, whereas fertilized plots yielded 222 and 171 kg/ha. Undisturbed soils without fertilizer yielded 308 kg/ha. Therefore, fertilizer may not be able to replace dryland topsoil lost by erosion.

Soil microbiology. Root extracts of six climax species of grasses and eight species of grasses or forbs that invade or increase on overgrazed land were bioassayed for substances that inhibit nitrifying bacteria. The presence of inhibitors in root extracts of invader or increaser species suggests an important role for these plants in the economy of N of grassland soils.

Substitution of a chromosome pair from Apex, a spring wheat cultivar relatively resistant to common root rot, for the corresponding chromosome of S-615, a highly susceptible variety, changed the rhizosphere microflora characteristics qualitatively and quantitatively. These changes induced by the disomic chromosome substitution indicate a possible mechanism by which the rhizosphere characteristics of crops may be beneficially altered.

Biomagnetism. Recent experiments indicated that treating seeds magnetically before they germinated resulted in major changes in physiology and biochemistry during germination. For example, treated seeds of Kharkov winter wheat respired more slowly, released less heat energy, absorbed more moisture, contained more reducing sugars, and grew faster than untreated seeds. During germination production or release, or both, of a volatile phytotoxin that inhibited cucumber and cress radicle growth was delayed. Similarly, after 56 hr of germination magnetically treated barley seeds contained more reducing sugars but less α-amylase than untreated seeds. There was some evidence that magnetic treatment altered the oil content of wheat, oat, and barley seeds, but probably not of flax, rape, sunflower, soybean, or safflower seeds.

Irrigation and Drainage

Bush beans. Bush beans grown on plots protected from rain were subjected to a soil-water stress of 8 bars at the preflowering, flowering, and postflowering stages of growth. Total weights of green pods from four harvests were 53%, 71%, and 35% lower, respectively, than those of plants that were not under stress.

Evapotranspiration. In a 3-year experiment on irrigated plots at Kimberley, B.C., and at Vauxhall and Youngstown, Alta., evapotranspiration (ET) at maximum crop yields was much less affected by soil variability than was crop yield. Therefore, the precision of ET measurements made by the plot method should be acceptable for practical purposes if the crop is well watered, growing vigorously, and providing full ground cover. Under these conditions ET does not vary proportionately with variations in crop yield, presumably because it depends primarily on the energy available for vaporization.

Irrigation scheduling. During an 8-year period, irrigation of sugar beets, canning corn, barley, and sweetclover was scheduled by evaporation–conversion techniques similar to those recommended for extension purposes in southern Alberta. The crop yields obtained by the use of recommended procedures were consistently better than average for the area and were as good as or better than those obtained from plots maintained at either higher or lower moisture levels. No increase in salt content of the soil resulted.

Sewage effluent for irrigation. Irrigation with a municipal effluent having a salt content of 1,900 mg/liter and a sodium adsorption ratio (SAR) of 9 produced no deleterious effects on soil. Industrial sewage with a similar salt content and an SAR of 16 markedly reduced permeability to water and increased the salt and sodium content. In laboratory studies with 3-m columns of soil, P and dieldrin were absorbed in the first 45 cm, detergents were absorbed in the first 30 cm, and the biological O demand increased with depth because of dispersion of organic matter.

Hydrologic budget. Analyses of hydrologic budget items for the Bow River Irrigation Project indicated that from 1958 to 1968 the average farm delivery was 41 cm and the gross diversion was 63 cm. If consumptive use requirements were 46 cm, diversion losses and losses on the farm were 26% and 20% of the total supply (gross diversion plus seasonal precipitation). The area of land irrigated in a year varied from 36% to 76% of the total irrigable area.

Hydraulic properties of soils. When soils were saturated with a core test fluid at atmospheric pressure, about 20% of the available pore space was filled with air. This reduced the permeability by about 50% of that obtained by saturating the soil under vacuum, but did not affect bubbling pressure and residual saturation.

When water was used instead of core test fluid, outflow barriers became blocked. By enlarging the openings in these barriers by a factor of 12, it was possible to obtain water permeability data for saturated and unsaturated soils.

Soil Chemistry

Organic matter. Use of a sodium amalgam reduction treatment showed differences in the nuclei of humic acids obtained from a number of morphologically similar Chernozemic soils. Although nuclei from the Ah and Bm horizons within soils did not differ, there does not seem to be a specifically definable compound that can be called humic acid.

Columns of Orthic Black Chernozemic Ah soil were leached for 14 months with distilled water and aqueous extracts of black and as-

pen poplar leaves collected in late August. Chemical changes in the soil organic matter indicate that the invasion of aspen poplar, *Populus tremuloides* Michx., into the prairies should have a greater transforming effect than black poplar, *P. balsamifera* L., when age of the poplar stand and climatic conditions are about equal.

Silica opaliths. Opaline silica bodies, originally formed in epidermal cells of grass and deposited in soils, serve as fossil records of the occurrence of grass on particular soil sites, regardless of present-day vegetation. The infrared spectra of the humic acids in soils containing grass opals were also characteristic of grassland soils. Through identification of grass opals in the soils on a hillslope, the source of the soil material that contributed to the formation of cumulic soils was traced to the moisture-discharge zone of the slope.

Endrin–soil reactions. Reactions of endrin with soil varied, depending on solvent used in equilibration. In H_2O, endrin reduced electrophoretic mobility (ν_M) of the clay and apparently reduced cation exchange capacity (CEC), and heat of reaction (ΔH_R) was large. In acetone and acetonitrile, endrin increased ν_M and seemingly increased CEC, and ΔH_R was small. At a limited number of selective sites, endrin appeared to be sorbed by forces other than Van der Waal's.

Sodic soils. The presence of ammonium or divalent cations (0.1 N) permitted solutions to penetrate sodic soils up to 50 times faster than pure water. A detailed study of the physical chemistry of ammonium-saturated soils may clarify the reasons for the higher rate of penetration.

PLANT PATHOLOGY AND PHYSIOLOGY

Cold Hardening of Wheat

Gibberellic acid induced a slight decrease in the coldhardiness of Kharkov 22 MC when it was supplied through the roots of plants grown in vermiculite at 5 C or 20 C. A similar result was obtained with gibberellin A_7 on plants grown at 5 C. These results indicate that cold-hardy winter wheat plants may contain a lower concentration of gibberellins than do unhardened wheat plants. This concept is supported by two other observations: cold-hardy varieties of wheat are dwarfed when grown under conditions inducing coldhardiness; and chlorocholine chloride, a gibberellin antagonist, slightly increases coldhardiness in Kharkov 22 MC winter wheat.

Alfalfa Diseases

Field tests showed that crown bud rot was more severe in stands of irrigated alfalfa infected by the stem nematode than in stands that were not infected. Yields of hay from these infected stands were significantly reduced. Bacterial wilt was found only in association with stem nematodes in the wilt-resistant varieties Beaver and Vernal.

Stem nematodes produced a reaction with wilt-resistant alfalfa that made the plants susceptible to infection by the wilt bacteria at sites other than those infected with the nematode.

Snow mold of forage crops and turf grass on the Canadian prairies was caused almost exclusively by a sterile psychrophilic basidiomycete. Virulent isolates of the pathogen that do not produce HCN in culture released toxic amounts of this gas in their parasitic interaction with alfalfa, winter wheat, and various species of grass. This interaction occurred at different temperatures, depending on the host. Resistance to snow mold appeared to be related to the coldhardiness of the host, because resistance broke down sooner in nonhardy than in hardy alfalfa plants as the soil temperature was lowered. These results showed that susceptibility to the disease may depend on the accessibility of cyanogenic substrates from the host to the fungus rather than the quantity of the cyanogens held in the host tissue, and that low temperature may cause the release of the cyanogens from the tissue more readily in the susceptible plants.

Soil-borne Pathogens

Four fungicides at two rates were applied to the soil of field plots for the control of pea root rot. Root rot, measured by lesioning of the cotyledonary node, was lower in peas grown in soil treated with benomyl than in

those grown in untreated soil. Plantvax (UniRoyal Ltd.), Bay 78175 (Chemagro Ltd.), and Chemagro 5506 (Chemagro Ltd.) did not control root rot. Yields of the fungicide-treated and untreated plots were not significantly different. Benomyl appeared to control root rot caused by *Fusarium* but did not prevent invasion of secondary roots by *Pythium* and *Rhizoctonia*.

A soil-borne *Pythium* sp. was found to be an important seedling pathogen of rye sown for fall forage. Several fall rye cultivars, Prolific spring rye, and four *Triticale* lines were susceptible. A number of barley cultivars and Thatcher wheat were resistant. Several of the seed-treatment fungicides tested gave partial control of the disease.

Crop Residue

Crop residue from rape was toxic to wheat seedlings in both sterile and field soil. This indicates that the residue contained a toxin. In contrast, cereal crop residues were dependent on microbial activity to be phytotoxic in soil. Only residue of mature rape was phytotoxic. Residue containing chlorophyll stimulated seedling growth. The toxin was confined to stems, branches, and roots of the rape plant. The toxin was readily leached by water from residue and was not readily inactivated by soil.

VETERINARY-MEDICAL ENTOMOLOGY

Warble Flies

Aggregation of males. An aggregation site for the male *Hypoderma bovis* (L.) was discovered in July 1969 in the range country of the foothills in southern Alberta. The characteristics of this site, the first to be reported in North America, were similar to those described for the male *Hypoderma lineatum* (de Villers) aggregations in California. Males were found to mate at stations along a cow path parallel to a stream in a coulee. They took up positions near the original points of capture when released in the vicinity of the site.

Grubs in horses. Warble infections that disable saddle horses and hamper ranching operations have been reported in increasing numbers. A survey of about 700 ranch horses in southern Alberta showed that the problem was widespread. Apparent infection rates ranged from 10% to 20% and were associated with severe infections in range cattle.

Biting Flies

Black flies. Field studies on infestations of *Simulium arcticum* Malloch along the Athabasca River in northern Alberta have shown that annual population densities are extremely variable. Infestations on cattle were observed to average less than 200 per animal in 1969, compared with several thousand in 1968. Adult activity measured in samples above the surface of the river was very light. Unusually high water throughout the spring may have interfered with normal development and emergence of flies in 1969. Several years of work will be needed to estimate the frequency of epidemic infestations.

Horn flies. The effect of horn flies on production was measured in beef cattle on irrigated pastures. The greatest economic effect was observed in yearlings that had access to high-quality grass. Losses reached a maximum of 21% of total gains in fly-free animals during the primary grazing period. Compensatory gains in fall during the fly-free period reduced the total losses to a maximum of 12%.

Pest Control

Immunology and serology. Indirect hemagglutination was an effective technique in determining antibodies to *H. lineatum* in cattle. Precipitin techniques using agar diffusion failed to detect animals infected with grubs. New sources of chemicals and cells are being screened to exploit the use of indirect hemagglutination for practical diagnosis of infections of *H. lineatum* in cattle.

Pesticide evaluation. Phosmet (Prolate; Stauffer Chemical Company) was effective for the systemic control of grubs in yearling cattle. A high-pressure spray treatment at 36 mg/kg and a pour-on at 26 mg/kg killed 98% and 100% of grubs, respectively, in infected heifers. During a subsequent 180-day feeding period weight gains were higher in treated than in untreated animals.

Caged adult mosquitoes were used to test seven new pesticides as replacement compounds in mosquito abatement. Dichlorvos and Dursban (Dow Chemical Company) were highly effective organophosphorus adulticides, and can be used as alternatives to DDT.

Toxicology. Acute esophagitis occurred in calves in the autumn following pour-on applications of crufomate (Ruelene; Dow Chemical Company), trichlorfon, and phosmet, when *H. lineatum* larvae were lodged in the esophagus. The disease, which was discovered only on necropsy, produced no chemical symptoms in affected animals. The pesticides have been shown to inhibit the cholinesterases in the brains of the grubs. Sialagogic effects of the systemic action of organophosphorus compounds in cattle may be produced also in the parasites within treated hosts. Further studies are in progress to determine the role of proteolytic materials in causing esophageal lesions when they are released in excessive quantities in response to the cholinergic effect of pesticides.

Warble eradication. Cooperation was continued with the Alberta Department of Agriculture in an areal program to exterminate warble flies. An evaluation of progress in the pilot organization for the County of Wetaskiwin showed that 80% of cattle were treated and the number of grubs was reduced by 95%. Demonstrated success in the Wetaskiwin project is encouraging rapid adoption of the program by neighboring counties.

CROP ENTOMOLOGY

New Insect Pests

In 1968, chinch bugs attacked several fields of barley and wheat after they had destroyed the bromegrass in which they overwintered. No damage was reported in 1969. In 1968 the rye jointworm, *Harmolita secale* (Fitch), damaged fields of fall rye east of Lethbridge and in 1969 was widespread northeast of Lethbridge. Infestations of over 40% were observed. In 1969 the alfalfa looper damaged a considerable number of fields of rape west of Lethbridge.

Aphids

Over 100 species of aphids, some of which are potentially serious pests of crops, have been recorded from Alberta. Barley yellow dwarf virus and four species of aphids, the English grain aphid, the corn leaf aphid, the greenbug, and the oat bird-cherry aphid, *Rhopalosiphum padi* (Linnaeus), were prevalent in oat pastures in southern Alberta. In the greenhouse *R. padi* reduced the weight of forage from oats by about 19% and barley yellow dwarf reduced it by about 21% more.

Sugar beets infected with beet yellow virus have been found in the Taber area. The bean aphid and the green peach aphid, vectors of the virus, were also found.

Cutworms

In 1969 the army cutworm caused moderate to severe damage in southern Alberta and southwestern Saskatchewan. Some fields required the use of insecticides; others had to be reseeded. Although no serious infestations of the red-backed or pale western cutworms occurred in 1969, the numbers of moths present in the fall indicated a considerable increase in 1970.

Sex pheromones have been detected in the army, red-backed, and pale western cutworms and in *Euxoa tristicula* Morrison. Bioassay techniques developed for each species showed much variability in the times at which the females released the pheromones and in the times at which the males responded to them.

Eighty insecticides have been tested in the laboratory against the pale western and the red-backed cutworms. Seven organophosphorus insecticides show promise as replacements for endrin for use against both species. The larvae of both species readily detoxified the 19 carbamate insecticides tested.

Grasshoppers

In 1969, grasshopper populations reached their lowest numbers in 20 years. The area of damage forecast for 1970 comprises only about 100 km^2 (40 sections), north and west

of Lethbridge. The two-striped grasshopper is the predominant species.

Virgin females of the migratory grasshopper, when crowded, lay an average of 8.3 pods of eggs each. This is less than the number laid by fertilized females. About half these eggs do not develop and only about 5% hatch.

Carbofuran and Dursban controlled grasshoppers in the laboratory. Carbofuran was more toxic than dieldrin to both species; Dursban was as toxic as dimethoate to the two-striped grasshopper and more toxic to the migratory grasshopper.

Wheat Stem Sawfly

The loss of yield in wheat caused by sawfly larvae varies with the weather. In 1969 losses averaged 7%. In tests in the previous 5 years, losses in Thatcher varied from 2% to 15% and in Red Bobs from 6% to 19%.

Malathion and dimethoate had no effect on sawfly larvae or their parasite, *Bracon cephi* Gahan.

For studies on the sex ratio of the wheat stem sawfly a technique was developed for sexing the larvae by their developing imaginal discs.

Pollinating Insects

Most alfalfa seed grown in the prairies is produced with the aid of alfalfa leaf-cutter bees; about 10 million bees are raised in the region each year. Yields of 1,009 kg/ha (900 lb/acre) of seed have been obtained.

Hives for leaf-cutter bees that were constructed with felt-paper backs were lighter and less likely to produce mold than hives with wooden backs. Three combinations of colors, blue on red, blue on black, and blue on green, painted across the face of the hives encouraged the bees to spread out and build nests evenly across the hives.

The bees efficiently used tunnels that were double the normal length.

Sugar-beet Insects

Trichlorfon at 0.56 kg/ha (8 oz/acre) gave 100% control of the beet leaf miner. The use of insecticides is unlikely to be recommended, however, because yields of beets from treated plants were no higher than those from untreated plants.

Numbers of the sugar-beet root maggot are approaching economic levels again. In 1969 severe damage was limited to a few fields of sugar beets, but infestations were found in more than half the fields examined.

Cabbage Maggot

Cabbage maggots on rutabaga were partially controlled with chlorfenvinphos, carbofuran, fensulfothion, and trichloronat. Control was most effective with a drench at the two-leaf stage and another in mid-July; a single drench did not persist through the growing season. Soil type and growth of the crop at the time of the second application affected the control obtained. Carbofuran also controlled flea beetles and stimulated plant growth.

The adult males were found to produce a substance during mating that induces oviposition. By marking the flies with spray paints it was found that the adults fly for at least 15 days and travel at least 400 m from their release points. This information will be used in field tests on male sterilants for controlling the maggot.

The Edmonton strain of the cabbage maggot has been shown to be resistant to dieldrin. The strain, however, was not homogeneous; 30% of the females and 36% of the males were 20 and 45 times more resistant to dieldrin than the rest of the strain, which were as susceptible to dieldrin as were the Lethbridge strain.

Insect Coldhardiness

It was shown that a frequency distribution curve of the freezing temperature of a hibernating insect species provides a diagnosis of its behavior in preparation for, and during, hibernation and indicates its chances of surviving winter. Conversely, freezing temperatures may be predicted from knowledge of the prehibernating and hibernating habits of the species.

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INTRODUCTION

This report summarizes the main research findings for 1969 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. A research program on ornamental turf was established this year. The work will be directed by Dr. D. K. Taylor.

M. F. Clarke
Director

Soils

Distribution of Inorganic Phosphorus

Phosphorus in 38 surface samples representing 6 soil orders in Western Canada was fractionated into calcium P, aluminum P, iron P, and reductant-soluble P. The distribution of these forms of P was found to be characteristic of the soil orders. Calcium P predominated in Chernozemic, Regosolic, and Gleysolic soils. Podzolic and Brunisolic soils were high in aluminum P and iron P. Percentage of base saturation, pH, organic C, and free Fe partly explained the variation in the distribution of inorganic P in the soils. The influence of these factors on the form of P was different for the various orders of soils. However, it was concluded that soil-forming process was a better index than soil reaction for determining the type of P compounds present.

VEGETABLES

Response of Pea Plants to Foliar Applications of Cycocel, Phosfon, B-Nine, and Dimethyl Sulfoxide

In two greenhouse experiments, 15-day-old pea seedlings were sprayed with 1 or 100 ppm of Cycocel (American Cyanamid Co.), Phosfon (Mobile Chemical Co.), or B-Nine (UniRoyal Ltd.). The plants were grown until the peas were of marketable maturity. Cycocel at 1 ppm increased plant height, internode length, pea yield, and total dry matter yield, but decreased chlorophyll concentration and the ratio of chlorophyll *a:b*. At 100 ppm Cycocel decreased plant height, internode length, and total dry matter, but had no significant effect on pea yield. Phosfon at 1 ppm had little effect on growth and yield. At 100 ppm Phosfon markedly reduced plant height and pea yield, but increased chlorophyll concentration. B-Nine at both concentrations did not alter the growth pattern of the pea plant.

Cycocel increased the concentrations of N, P, and Mg in the pea vine. Phosfon increased P and Ca. B-Nine at 1 ppm decreased N and P, but increased both at 100 ppm. All three compounds reduced K.

In field trials at two locations in British Columbia, dimethyl sulfoxide (DMSO; Crown Zellerbach Corp.) applied as a 5% foliar spray increased the yield of Dark Skin Perfection peas by 11.5% and 25.3%. The foliar application of Cycocel at 50 ppm increased yield by 14.6 and 17.4%. The effects of DMSO and Cycocel were additive, there being no interaction.

Effect of Soil Water Stress on *Rhizoctonia*

The effect of various soil-water regimes on *Rhizoctonia* infection of potatoes was studied for 2 years. Treatments that maintained soil water at an adequate level during the growing period reduced infection. Imposed water-stress conditions increased infection.

Compatibility of Herbicides and Insecticides on Direct-seeded Brassica Crops

The compatibility of five preemergence herbicides and three soil-applied insecticides was assessed by comparing germination, plant stand, and yield of four brassica crops. CDEC (Monsanto Chemical Co.) and DCPA (Diamond Shamrock Corp.) combined with the insecticide thionazin (Cyanamid of Canada Ltd.) reduced plant stand in cabbage

and cauliflower. The herbicide C-7019 (CIBA Company Ltd.) alone reduced germination in cabbage. C-7019 combined with the insecticide fensulfothion greatly reduced germination in cabbage and reduced crop yield in broccoli. A combination of nitrofen (Rohm & Haas Co.) and each of the three insecticides reduced plant stands of cauliflower and rutabaga. Nitrofen and thionazin reduced plant stand of cabbage, but broccoli was not harmed when nitrofen was combined with any of the insecticides. Propachlor (Monsanto Chemical Co.) showed promise as a preemergence herbicide for direct-seeded brassica crops. At 4.5 kg/ha (4 lb/acre), propachlor was compatible with any of the three insecticides used on the four crops. However, propachlor at 6.8 kg/ha (6 lb/acre) combined with thionazin reduced plant stand and yields of the four crops. The herbicides did not reduce the efficacy of the insecticides. Carbofuran (Niagara Chemicals) and fensulfothion were more effective than thionazin for control of root maggots.

SMALL FRUITS

Variations in Susceptibility to Fruit Rot Among Red Raspberry Cultivars

Twenty-seven red raspberry cultivars were screened for susceptibility to fruit rot, caused mainly by *Botrytis cinerea* Pers. Percentage of rotted fruit was determined 72 or 96 hr after harvest at temperatures between 21 and 26 C. Among the least susceptible cultivars were Carnival and Matsqui. Fairview, Sumner, Latham, and Malling Jewel were among the most susceptible. A simple screening procedure was designed for use in red raspberry breeding programs that need selections with lower levels of susceptibility or tolerance to fruit rot.

Evidence for a Single Race of *Amphorophora agathonica* on Red Raspberries

The aphid *Amphorophora agathonica* Hottes is the vector of red raspberry mosaic virus in North America. The cultivar Lloyd George is a recognized source of immunity to the aphid. Immunity seems to be controlled by a single dominant gene that is heterozygous in most Lloyd George derivations existing today. Conflicting reports from Massachusetts and British Columbia on the reaction of cv. Rideau, a Lloyd George derivative, to *A. agathonica* suggested that at least two races of the aphid might exist. Other cultivars tested in both areas showed no difference in reaction. Plants from common sources of seven cultivars, including Rideau and Lloyd George, were tested in British Columbia and Vermont. Readings on aphid populations during a 2-year period showed no differences between the test sites. Rideau and Lloyd George were immune at both sites. The Rideau that was previously recorded as susceptible in Massachusetts was probably misnamed, and the evidence therefore indicates that there is a single race of *A. agathonica* in North America.

Effect of Mosaic Virus on Raspberries

Raspberry mosaic and its heat-labile components reduced the yields of Fairview, Sumner, Newburgh, and Willamette raspberry during the first cropping year. In subsequent years, the yield losses of Fairview and Sumner stabilized at about 14% and 11%, respectively. Newburgh and Willamette resisted infection. After the plants were well established, the yield of plants infected with the single virus was the same as those infected with the virus complex. The cultivars Fairview and Sumner produced smaller fruit and shorter, thinner canes. Only 12 of the 240 virus-free plants were contaminated with mosaic at the end of the trials. Most contaminations occurred in Newburgh, a cultivar that supports high populations of the aphid vector.

Selecting for Winterhardiness in Strawberry Cultivars for Southwestern British Columbia

Winter injury greatly limits strawberry production in southwestern British Columbia. Because strawberry plantings in the region were severely injured during the winter of 1968–69, selections from the strawberry breeding program were screened for hardiness. BC 18 and BC 25 were much hardier than the standard cultivar Northwest. BC 18 has good fruit quality for processing as a frozen product and will be grown on a lim-

ited commercial basis in 1970. BC 25 was even hardier than BC 18, but its fruit is too soft to make an ideal frozen product. However, BC 25 merits wider testing. The recently named cultivar, Cheam, was winter-hardy, but it has poorer fruit quality than BC 18 or Northwest.

Use of Alar to Reduce Winter Injury in Strawberries

Alar (UniRoyal Ltd.) was assessed for 3 years as a protectant against winter injury in the susceptible cultivar Northwest. Trials in 1966 and 1967 showed that a solution of 5,000 ppm of Alar applied in the fall was optimum. In 1968, application dates were August 29, September 4, 18, October 3, 16, and 31. The 1968–69 winter was extremely severe. Plants sprayed with Alar on October 3 showed a significant increase in spring vigor and fruit yield. Plants treated on other dates had slight yield increases. However, yield increase was due to increased numbers of fruit, not berry size. Alar may reduce injury to cv. Northwest. Response to Alar seems to depend on several factors, such as time of application, concentration, season, and cultivar.

ANIMAL SCIENCE

Nitrogen Utilization by Dairy Cows fed Soybean or Rapeseed Meal

Soybean and rapeseed meals were compared as the main source of supplemental protein in grain rations for 10 pairs of high-producing Holstein-Friesian cows receiving corn silage as roughage. Cows fed soybean meal produced more milk containing a higher percentage of milk fat and protein. Comparative digestibility of total ration crude protein was 71.5% and 66.2% respectively for the soybean- and rapeseed-fed group. Cows fed soybean meal lost 29.8% of their ingested N as urinary N compared with 25.7% for the animals fed rapeseed meal. N loss in the feces was 28.5% and 33.3% respectively for the soybean- and rapeseed-fed group. Both groups retained 7% of the N consumed. Efficiency of N utilization of the two supplements was similar. Greater milk production from the soybean-fed group was probably due to greater efficiency in energy utilization rather than in N utilization.

Dehydrated and Pelleted Whole-plant Corn vs. Corn Silage

Corn silage was compared with dehydrated, ground, and pelleted whole-plant corn in feeding and digestion trials with Holstein-Friesian cows. In a preliminary 90-day lactation trial cows fed silage consumed more dry matter than those fed dehydrated pellets. However, in a 24-day digestion trial, cows fed dehydrated corn pellets consumed 0.91 kg more dry matter per day than cows fed corn silage. In the lactation trial, the silage-fed cows produced more milk of higher fat content, but lower in protein, lactose, and solids-not-fat. Digestibility of dry matter, N, and acid detergent fiber was higher for cows fed silage. More research is needed before dehydrated whole-plant corn can be recommended as a roughage source for lactating cows.

Effect of Growth Stage at Harvest on Nutritive Value of Corn Grown for Silage

The yield and nutritive value of whole plant, stalk, leaf, husk, and ear were studied for the hybrid Pioneer 383 at 8 weekly intervals following silking in 2 separate years. Percentage of dry matter (DM) increased with maturity. Stalk DM averaged 17.4% at the glazed stage and 28.9% for the whole plant. Kernel DM was 60% at the glazed stage for both years with a ± 2% within-plot variation. The whole-plant yield of DM increased with maturity. Stalk, leaf, husk, and ear contributed 35%, 14%, 7%, and 44% respectively to whole-plant yield of DM. Total N declined with maturity. Ear N averaged 65% of the whole-plant N. Water-soluble carbohydrate content of the whole plant was greatest for the second and third harvests, but was high for all harvests. The yield of in vitro digestible dry matter (IVD DM) was greatest for ear, which contributed 52.8% of the total IVD DM compared with 29.1%, 13.4%, and 7.6% for stalk, leaf, and husk. Digestible energy, based on sheep trials, was similar for most growth stages. Digestible crude protein (CP) and g/kg DM CP tended to decline with maturity.

Complete Rations for Early-weaned Calves

Six complete rations containing forage and grain for calves weaned from milk at 5 weeks of age were studied. These rations include a control ration of calf starter based on milk products and cereal grains; control plus dehydrated grass meal; wheat mixed feed; dehydrated grass; barley – soybean meal; and barley – soybean meal plus dehydrated grass and beet pulp. Preliminary results indicate similar growth rate on all but the wheat mixed feed and dehydrated grass rations. The absence of milk products in three of the starter rations did not reduce performance below that of the calves on the control ration. Calves fed starter rations without milk made body weight gains at lower cost. The work is continuing.

Taste-panel Evaluation of Beef from Holstein-Friesian Steers and Bulls

Holstein-Friesian steers and bulls were reared on an all-concentrate ration and slaughtered at 480 kg. Hormone treatment did not affect carcass quality according to taste-panel evaluation of a three-rib cut. Roasts from steers were significantly more tender and had higher drip losses during cooking than roasts from bulls. There was a significant difference in tenderness between sire groups.

Effect of Hormone Implantation and High-roughage Finishing

Implanting steers twice during the finishing phase, at 300 to 500 kg, did not significantly improve the performance obtained from a single implant when both groups received an all-concentrate ration. When steers were implanted twice and restricted to 40% total concentrate intake during the finishing phase, growth was slightly reduced. This energy restriction caused a significant decrease in fat deposition in the carcass. The lean deposition was the same for both high- and low-energy groups.

Fumarase Activity of Frozen Bull Spermatozoa

Fumarase activity in frozen semen was examined for nine bulls of each of the dairy breeds Holstein-Friesian, Ayrshire, Guernsey, and Jersey. Fumarase activity was the same in each breed. The correlation coefficients between fumarase activity and fertility were not significant when calculated for each of the four breeds or for all breeds grouped together. The mean value of fumarase activity in bull spermatozoa expressed as μ moles of fumaric acid produced per 10^7 cells per 60 sec was 7.68.

POULTRY

Limited Water for Laying Stock

For 2 years the effect of regulated water intake by caged laying birds was studied. Each trial included 320 pullets and 640 hens housed in single bird cages for a laying period of 322 days. In the first year, water was limited when pullets and hens were 41 and 93 weeks of age, respectively. Except for a slight improvement in feed efficiency, the effects on performance were negligible. In the second year, water was limited when pullets and hens were 21 and 73 weeks of age, respectively. Water limitation reduced egg production by pullets and increased mortality for birds. Feed efficiency improved slightly for pullets and hens. Egg production of hens was not affected. The treatment had no effect on internal egg quality, egg solids, or shell strength.

Egg Quality

A 4-year study on egg quality showed that weak albumen and weak shells are the main factors that lower the grade. Age of bird, length of lay, and frequency of marketing had the greatest effect on albumen and shell quality. A 2% drop in grade A occurred for every day that eggs were kept on the farm. If eggs are shipped twice a week, 8 to 12 additional weeks of grade A production can be achieved.

Cold-stressing Chicken Embryos

The effect of cold-stressing 17-day chick embryos was studied for 2 years. Embryos exposed to 21.2 C for up to 24 hr showed little reduction in hatchability. Exposure to 11.3 and 5.2 C decreased hatchability. All temperatures increased chick weight at

hatching. Exposure to 21.2 C had no effect on 2-, 4-, and 6-week body weight of males, but reduced 2-week body weight of females. Exposure to 11.3 C reduced 4- and 6-week body weight of males and females. Embryos exposed to 5.2 C for 4 and 8 hr showed an increase in body weight at 4 and 6 weeks; 12 hr of exposure reduced body weight at 2, 4, and 6 weeks of age. Exposure to 5.2 C for 12 and 16 hr increased posthatching mortality in the first year. In the second year prolonged exposure to all temperatures increased mortality. Cold stress had no effect on sex ratios for any temperature used in these experiments.

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Research Station
Kamloops, British Columbia

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Departure

L. C. CURTIS, B.A. Retired March 12, 1969	Biting flies

INTRODUCTION

The Research Station, Kamloops, B.C., deals mainly with problems of the ranching industry. During 1969 at the Station research was done 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 also concerned the ecology, physiology, and control of cattle grubs and several species of ticks. As in other years, many of the experiments were conducted on ranches in cooperation with the ranch owners.

R. H. Handford
Director

FOREST AND ALPINE SOILS

Within a small study area, forest and alpine soils at elevations of 2,073 to 2,621 m (6,800 to 8,600 ft), near 49° 03′ N lat and 120° 09′ W long in south central British Columbia, 17% were placed in a Podzol, 17% in Alpine Brown, Continuous Ash, 50% in Alpine Brown, Discontinuous Ash, and 16% in a miscellaneous group. Units of the three main groups were classified according to drainage, and where applicable these classes were divided into phases according to topography, stoniness, surface erosion, or disturbance by solifluction. Each phase was described in detail.

In the 1968 Canadian classification system, profiles of the Podzol group generally corresponded to Orthic Humo-Ferric Podzol; the Alpine Brown, Continuous Ash to Sombric Humo-Ferric Podzol; and the Alpine Brown, Discontinuous Ash to Alpine Dystric Brunisol.

Parent materials are considered residual, derived from local diorite and volcanic rocks, except for a volcanic ash layer, up to 25 cm thick, that is nearly continuous on the Podzol and the Alpine Brown, Continuous Ash units. On Discontinuous Ash units the volcanic ash layer has been removed by erosion on steeper slopes, and buried by frost heaving or solifluction processes on gentler slopes.

Podzol profiles have thin organic and A2 horizons overlying Birh horizons, which show their maximum expression in the fine sandy loam ash material that has low bulk density and few coarse fragments. At a depth of about 40 cm the B horizons grade into C horizons and they contain coarse fragments that have silt accumulations on their surfaces. The sola have low pH and low base saturation; organic carbon and extractable Fe and Al show maxima in the Birh. Clay, which is low throughout the profiles, is dominated by amorphous material in the ash, but A2 horizons contain a montmorillonite.

Alpine Brown, Continuous Ash profiles have hummocky microtopography and A1 horizons, which are turfy and high in organic matter and base saturation in the upper part. The Birh and C horizons in Alpine Brown, Continuous Ash profiles are similar to those of the Podzol profiles.

The Discontinuous Ash profiles differ from the Continuous Ash profiles by having lower organic matter and ash in their A1 horizons and never having Birh horizons. Buried horizons containing a large amount of ash occur often, and silt accumulation in the C horizon is pronounced.

Vegetation of the Podzol group is similar to that of the *Abies lasiocarpa* (Hook.) Nutt. – *Vaccinium scoparium* Leiberg association, but *Picea engelmanni* Parry and *Larix lyallii* Parl. are dominant tree species. Tundra-like communities, dominated by sedges and grasses, cover Alpine Brown units, but *Dryas* L., *Salix* L., and *Lupinus* L. species are dominant on disturbed sites. The miscellaneous group has little cover and consists mainly of rock, talus, and snowbank units.

Only about 5% of the study area appeared to be suitable for grazing by domestic livestock. This area includes most of the poorly drained units, which support taller, denser vegetation and produce probably four or five times as much forage as the well-drained units. The poorly drained units occur at all elevations and in all three major soil groups, but they are more common at the lower ele-

vations and extend well below the tree line. Deer visit the poorly drained units to browse the willow shrubs. The sedge grass cover of the main portion of the well-drained to imperfectly drained units provides less than 222 kg/ha (200 lb/acre) of forage per year. Domestic livestock rarely use this forage, but wild sheep and rodents sometimes do.

FORAGE CROPS

Experiments were started in 1966 to compare the yields of various forage species under different environmental conditions. In 1969, wherever water supplies and heat units were low, grasses produced more hay than alfalfa did. Reed canarygrass was the highest yielding species at a site 22.5 km (14 miles) from the Research Station, at an elevation of 853.4 m (2,800 ft), where the plots were irrigated only twice during the season. Meadow fescue was second at this site and Timothy third. Timothy placed first at a site about 72.4 km (45 miles) from the Station, at an elevation of about 944.9 m (3,100 ft), where the plots were irrigated only once. Bromegrass was second at this site and reed canarygrass third. Alfalfa, however, far outyielded the other species on the well-irrigated plots in the Thompson River valley at 335.3 m (1,100 ft), producing 14,600 kg/ha (6.57 tons/acre) of dry matter. The average yields for all species were 9,178 kg/ha (4.13 tons/acre) at the Station, 2,521 kg (2.78 tons) at an elevation of 853.4 m, and 1,960 kg (2.16 tons) at 944.9 m. The other species in the test were bromegrass, Alta fescue, orchardgrass, meadow foxtail, alsike clover, and ladino clover.

An experiment on frequency of harvesting showed that total dry matter yields of reed canarygrass in 1969, the third year of harvesting the stand, were reduced significantly when harvested more than three times, and the cost was, of course, higher. Two cuts per year resulted in higher yields than three cuts, especially when N was applied at 222 kg/ha (200 lb/acre), but not when N was applied at 181.4 kg. The quality of the hay has not yet been determined, but it is reasonable to expect that it has improved slightly with more frequent harvesting. Considering yield, quality, and cost, three cuts appear optimum for the Thompson River valley at Kamloops.

P increased yields of alfalfa when applied to soil that before treatment averaged 14.7 ppm of P. The increases in the fourth and fifth years after treatment were substantially greater than those in the first 3 years. The total value of the additional hay produced over 5 years was well above the cost of the single application of fertilizer, especially when P was applied at 97.6 kg/ha (88 lb/acre), in the highest rate of fertilizer used in the test. The increases after fertilizer was applied were approximately proportional to the rates applied. There was no marked difference in increases from P broadcast with the seed and raked into the top inch of soil, P drilled in with the seed, or P broadcast on the established stand in the early spring of the year after seeding.

Corn of the variety Pioneer 383, planted April 18, 1969, and irrigated the same day, produced only 203 plants out of a possible 296, whereas corn that was not irrigated until May 1 produced 239 plants. The final yields of dry matter, however, were somewhat closer: 27,556 kg/ha (12.4 tons/acre) for the earlier irrigation and 29,111 kg/ha (13.1 tons/acre) for the delayed irrigation.

UREA AND CORN SILAGE

Corn silage to which urea was added at 4.54 kg/907 kg of silage (10 lb/ton) at the time of ensiling produced higher daily gains and better feed efficiency when fed to Hereford steer calves than silage to which 4.54 kg of urea was added at the time of feeding, and also better than silage without urea. Silage to which urea was added at the time of feeding had no advantage over silage without urea.

Two applications of crufomate, 3–4 weeks apart, gave 100% control of cattle grubs, *Hypoderma lineatum* (de Vil.), in tests in 1967–68 and 97.4% in 1968–69; the corresponding best single treatments were 97.7% and 91.9%. The excellent results achieved with two applications show that experimental attempts to eliminate grub populations should again be made. A ready-to-use formulation of crufomate (Ruelene 12R; Dow Chemical of Canada) gave results somewhat better than those obtained with Ruelene 25E. Treatments of crufomate and fenthion, applied when animals were dripping slightly from light rain, reduced grubs by less than half of the results achieved from similar treatments applied when animals were dry.

In a testing program started in 1956, crufomate proved to be the most versatile of eight insecticides, showing high efficiency when applied as a spray, pour-on, intramuscular injection, or feed additive. Intramuscular injection was the most effective method, but pour-on was the most practical. Ronnel boluses and trichlorfon pour-ons were also effective.

In 1969, tests showed that lindane is a satisfactory substitute for technical BHC for protecting cattle against ticks: 0.25% lindane gave protection from infestations of the Rocky Mountain wood tick (RMWT), *Dermacentor andersoni* Stiles, for 5 to 6 weeks. Because of continued light infestations of ticks in 1969, yearling calves became significantly resistant to reinfestation with RMWT, but after 3 weeks of infestation not all calves were sufficiently resistant to be protected from infestations that would cause paralysis.

Two forms of skin reaction developed after 2 weeks of infestation. One form in most of the calves did not appear to inhibit tick feeding; the other form in 20% of the calves significantly inhibited tick feeding. The latter was a dry, sloughing scab-type reaction that tended to detach the tick from the vascular layer of the epidermis.

When males of the Saskatchewan strain of the RMWT were crossed with females of the British Columbia strain, the resulting first generation were interfertile, and produced live larvae. When applied to cattle, some of the adult progeny of this cross migrated to the head, thus behaving like British Columbia (montane) ticks rather than prairie ticks.

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Research Station
Saanichton, British Columbia

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K. W. CHONG, B.S.A. (Production and Marketing Branch)	Supervisor, Post Entry Quarantine Station

INTRODUCTION

This report presents the main research findings at the Research Station, Saanichton, 1969. The primary objective is the improvement, culture, and protection of ornamental and greenhouse crops. This station also operates the Post Entry Quarantine Station in cooperation with the Plant Protection Division of the Canada Department of Agriculture and is the center for the introduction and distribution of foreign grape and tree fruit stocks for Canada.

H. Andison
Director

PLANT SCIENCE

Grapes

Evaluation of early grape varieties. The most promising wine varieties planted in 1965, which produce 16% to 21% soluble solids, are: Seibel 9549, Seibel 13053, Foch, Aurora, Diamond, Himrod, N.Y. Muscat, Schuyler, Vineland 37034, Precoce de Malingre, Siegerrebe, and Seyval. None appeared to be damaged by the record low winter temperature of -14 C. Commercial wineries have obtained samples of some to make wine. After two recent cold winters, which caused severe damage to wine varieties in the Okanagan valley, these companies are interested in the possibility of growing grapes in the coastal areas of British Columbia.

Greenhouse Tomatoes

Blotchy ripening of greenhouse tomatoes. Blotchy ripening of greenhouse tomatoes results in heavy financial losses to commercial growers. In a sawdust medium with preincorporated increments of phosphate and dolomite, doubling the standard P level has given a total yield increase of 0.4 kg per plant to a total yield of 4.2 kg per plant in a 12-week picking period. A further increase of 0.2 kg per plant was obtained by doubling the standard amount of dolomite in the sawdust. The incidence of blotch remained about 6% at both levels of P, but the increased dolomite level doubled the incidence at both the high and low P levels.

Blotch in soil-grown tomatoes yielding 4.1 kg per plant was several times as high as in sawdust-grown plants. Incorporations of sawdust or chipped straw to suppress nitrate levels in steam-sterilized greenhouse soils did not reduce blotch.

Source of iron in soilless culture. Ferric citrate, the usual source of Fe, is occasionally unobtainable. In an experiment with equivalent rates of elemental Fe, the chelated form resulted in comparable growth.

Effect of black fiber pots on tomato transplants. November-sown tomato seedlings pricked out into 9-cm and 11.5-cm diameter black fiber pots filled with fertile potting soil were compared to plants in plastic pots. A toxic condition developed in the smaller black fiber pots, and 6 weeks after pricking out a growth depression was observed. After 8 weeks plants in these small containers were unsuitable for planting, whereas in the larger-sized pots normal plants were produced.

Growth Regulators on Rhododendrons

Effect of Phosfon, light regime, and pinching on flower bud production in hybrid rhododendrons. Phosfon soil drench (Mobile Chemical Co.), 337 ppm, applied once (April 15) to rooted cuttings of Anna Rose Whitney rhododendrons resulted in 100% of the standard-grown and single-pinch plants producing flower buds by November, under natural days only or with 4 hr night lighting added. Plants pinched again the first week of July failed to produce flower buds as did all the plants without Phosfon. The cultivar Sappho gave the same response, but generally fewer Phosfon-treated plants produced flower buds. The exception was the standard plants under natural-day conditions, all of which had flower buds.

Effect of Ethrel on flower bud development. Two foliar applications of Ethrel (Amchem Products Inc.) at 500, 1,500, and 2,500 ppm to pinched plants of rhododendron cultivars in their first year from cuttings did not promote flower bud formation under natural days in the greenhouse. Moderate leaf distortion resulted from concentrations of 1,500

ppm and higher to the cultivar Cosmopolitan, but 5,000 ppm was applied before leaves of Anna Rose Whitney were injured.

Effect of Phosfon and Alar on flower bud development of rhododendron leaf cuttings. One application of Phosfon soil drench, 337 ppm, applied June 30 to established rooted cuttings, each from a single leaf bud of Anna Rose Whitney rhododendron, resulted in 60% of the plants producing flower buds within 15 weeks of treatment. Similar plants without Phosfon produced no flower buds, and neither did plants receiving Alar (U.S. Rubber Co., Naugatuck Chem. Div.).

Potatoes

Effect of maturity of seed tubers on the yield of Netted Gem potatoes. In a 3-year test, the maturity of the seed tubers of Netted Gem potatoes affected yields significantly. Seed produced from late-planted tubers yielded 15% more than seed from tubers planted early and harvested late. A high or low specific gravity of seed tubers had no effect on the yield of the crop. A 5% yield increase was obtained by using 170-g tubers for seed, instead of 85-g tubers, in only 1 year out of 3. No increase was obtained in the other 2 years.

Weed Control

Weeds in seedling turf grass. Ioxynil and bromoxynil at 0.56 to 1.12 kg/ha proved promising for eliminating early competition of weeds emerging with lawn grass seedlings. Applications in spring or fall as soon as the new grass was fully emerged caused no significant injury to fescue, blue grass, or bent grass, but controlled weeds well and permitted vigorous grass growth. Treatments with 2,4-D were not only less effective in controlling weeds, but damaged the seedling grass, particularly in fall applications to blue and bent grass.

PLANT PATHOLOGY AND ENTOMOLOGY

Diseases

Phytophthora root rot of Lawson cypress. Nabam and mancozeb at 8,000 and 12,000 ppm (active ingredient) applied twice as a preplant and a postplant drench prevented phytophthora root rot in *Chamaecyparis lawsoniana* Parl. var. *ellwoodii*. More recently, similar drenches of zineb applied at the above rates were somewhat less effective. Studies on residual fungitoxicity indicated that, in soil drenched once with mancozeb at 12,000 ppm, all plants remained healthy in pots infested with inoculum of *P. lateralis* Tucker & Milbr. 7 days after soil treatment. In similarly drenched soil, only a few plants became infected when infestation with inoculum was delayed 2 or 3 weeks after soil treatment. The fact that these few plants became infected 2 months later than those in untreated infested soil indicated that the residual fungitoxicity of the pretreated soil had reduced the number of viable inoculum propagules.

Insects

Greenhouse whitefly. Naled vaporized from heating pipes has been satisfactory for control of adult greenhouse whiteflies if treatments were repeated at 5-day intervals. Repeated treatments of sulfotepp smoke were effective. Malathion and lindane smokes and endosulfan foliage sprays were not satisfactory. Applications of the systemic insecticide disulfoton (as Solvirex 10% granules; Sandoz Ltd., Basle, Switzerland) at rates of 20 to 630 mg of the formulation per 100 cm^2 of soil surface failed to kill whitefly scales on potted bush beans.

Holly leaf miner. Populations have reached high levels in a plantation in which no controls have been applied since 1966. In the same planting, populations of a parasite, *Chrysocharis gemma* (Walker), lagged far behind its leaf miner host. In 1968, when leaf miner infestations averaged 2% of leaves and peaked at 16% on some trees, 28% of the miners were parasitized. In 1969 when infestations averaged 28% and peaked at 78%, only 1% of the miners were parasitized.

The effect of D-D on tulips and iris. At the request of the Plant Protection Division possible injury to tulip and iris resulting from high rates of D-D soil fumigant (Shell Chemical Co.) was evaluated. In the field, D-D applied at 45 liters/ha in either July or September to control nematodes did not reduce tulip yields. The July applications of 112 and 225 liters/ha did not reduce yields, but the September applications did.

In the greenhouse, the grade as determined by fresh weight of flowers was affected significantly by high early and high late treatments in the Elmus tulip but not in Aristocrat. In Wedgewood iris fresh weight of flowers was affected significantly only by the high late treatment. Cutting dates were not appreciably altered by any treatment in either tulip variety. However, the high early and high late D-D soil treatments delayed blooming significantly in Wedgewood iris.

Benomyl systemic pesticide. Benomyl (Benlate; DuPont of Canada Ltd.) applied for the third year as a foliar spray at 113.3 g/454.6 liters gave outstanding control of powdery mildew *Podosphaera leucotricha* (Ell. & Ev.) Salm., and apple scab *Venturia inaequalis* (Cke.) Wint., on Spartan and McIntosh apples. It was also effective against mildew on greenhouse azaleas, begonias, roses, and cucumbers.

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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
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D. L. MCINTOSH, B.S.A., Ph.D.	Parasitic tree fruit diseases
R. M. ROSHER, B.A., M.A.	Parasitic tree fruit diseases

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S. W. PORRITT, B.S.A., M.S., Ph.D.	Fruit harvesting and storage

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Departures

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H. SUGISAWA, B.S., Ph.D. Term appointment ended June 30, 1969	Flavor biochemistry

VISITING SCIENTIST

J. M. ERSKINE, Ph.D. National Research Council postdoctorate fellow 1969–70	Microbial genetics

INTRODUCTION

This report summarizes the principal findings of our research programs in the production of deciduous tree fruits, grapes, and vegetable crops; in fruit and vegetable processing; and in the cause and prevention of bloat in cattle.

Detailed scientific and technical accounts will be found in journals and reports listed under Publications. Reprints are normally available from the authors.

The autocidal codling moth control program being developed for use in industry moved into a pilot operation on 120 acres of commercial apple orchard, where better control has been obtained than in most chemically sprayed orchards. This application–development program will be continued for another 3 or 4 years.

The new specially devised codling moth rearing laboratory required for the autocidal program was officially opened by the Minister of Agriculture on March 14, 1969.

C. C. Strachan
Director

AGRICULTURAL ENGINEERING

Mechanical Harvesting of Apples

Changes were made in the shake-and-catch equipment to eliminate manual effort and speed up moving from tree to tree. Of five varieties of apples harvested, McIntosh, Spartan, Red Delicious, Golden Delicious, and Winesap, records were made of the number and size of skin breaks, the number and size of bruises, and the number of pulled stems, attached spurs, and free spurs. The method proved unacceptable for harvesting these varieties for fresh market sale principally because of excessive fruit damage, but with further improvement of equipment the method should be acceptable for harvesting apples for processing.

Sprayer Development

An airblast sprayer was modified to improve its efficiency in spraying hedgerow plantings of dwarf and semidwarf trees. The spray-laden airstream, directed almost horizontally through the various levels of the trees, facilitates uniform distribution of the spray from top to bottom of the trees.

ANIMAL SCIENCE

Protein Denaturant in Nonbloating Legumes

In some nonbloating legumes the protein foaming agent (Fraction 1 protein) is inactivated when the plant is crushed. Attempts to isolate the protein denaturing agent were unsuccessful. The agent appears to be a phenolic compound. It was not found in alfalfa or in 45 strains of white clover, but it was present in *Trifolium arvense* L. This research was undertaken as a transfer of work project in association with an assembled team of specialists on bloat research at the Department of Scientific and Industrial Research, Applied Biochemistry Division, Palmerston North, New Zealand.

Copper Deficiency in Feeds

Approximately 95% of 1,000 feed samples, representing all classes of cattle feed produced in British Columbia, contained less than 10 ppm Cu, and 50% of the samples less than 5 ppm Cu. Average Cu concentration in alfalfa hays was 7.2 ppm and in grass hays 4.5 ppm. In Cu content, corn silage, oat hay, and grain were comparable to grass hays. There were no high Cu concentrations, and the values found were well below the average for feeds produced elsewhere in Canada and the United States.

ENTOMOLOGY

Codling Moth

Autocidal control. In 1969, sterilized codling moths, exposed as adults to 50 krad in a CO_2 atmosphere, were released three times per week from late April to mid-September in a 120-acre commercial orchard. A total of 2,021,000 male and female moths were liberated, 90% of which had been fed an artificial diet. The moths were distributed in the orchard from a helicopter flying about 45 mph in flight lines 100 ft apart. Cardboard boxes containing the moths were dropped every 100 ft; consequently, the distribution rate was about 5 boxes/acre. All moths were marked with a fluorescent dye so that the ratio of sterile (marked) to native (unmarked) male moths could be established from sex traps. The ratio of sterile to native males never fell below 35:1, except in early May, when the ratio was 5:1. At apple harvest, only about 0.05% of the fruit had been injured by the codling moth. Autocidal control, therefore, was better than that achieved in most chemically sprayed orchards in the district.

Integrated control. Phosalone and tetrachlorvinphos (Gardona) at 3 and 4 lb/acre applied May 28, June 17, July 15, and August 11 controlled the codling moth in an orchard where the check trees averaged 94% injured fruit. Lannate at 3 lb/acre failed to give acceptable control. Lannate and phosalone were not toxic to predaceous mites, and phytophagous mites did not increase to levels that needed treatment. Trees sprayed with tetrachlorvinphos had high populations of European red mites and McDaniel spider mites and by late July the foliage was brown. When used in a codling moth spray schedule, both tetrachlorvinphos and phosalone controlled the white apple leafhopper and suppressed the apple aphid.

Fruit-tree Leaf Roller

Integrated control. Pink bud sprays of diazinon at 4 lb/acre, azinphos-methyl at 2.5 lb/acre, or tetrachlorvinphos at 3 lb/acre gave seasonal control of the fruit-tree leaf roller on McIntosh, Spartan, and Red Delicious apple trees. Phosalone reduced fruit-tree leaf roller damage below the amount of damage in the check, but did not provide commercial control. When oil was combined with either diazinon or azinphos-methyl, control was not improved and there was injury to the primary leaves on all three apple varieties. Phytophagous and predaceous mites were not affected by the pink bud sprays, except in the plots treated with tetrachlorvinphos. Trees sprayed with this material had injurious levels of McDaniel mite by mid-July.

Orchard Mites

Ecology. In the extremely cold winter of 1968–69 low temperatures reached –30 C. Predaceous phytoseiid mites were greatly reduced by these temperatures, and only mites that wintered on tree trunks below the snow line survived. In spite of this high mortality, predator mites increased sufficiently in most orchards to control the McDaniel mite. In all but one of six orchards where demonstration-integrated control programs were followed, the predators controlled the European red mite and McDaniel mite.

Chemical control. Dormant oil at 6 gal/acre and Plictran at 2 lb/acre applied at the 1/2 in the green bud stage and in the pink bud stage gave good control of European red mite and the applications were not toxic to predaceous phytoseiids. Chinomethionat (Morestan) at 4 lb/acre and fenazaflor at 6 lb/acre gave poor control of the European red mite and both chemicals were highly toxic to phytoseiids. In an orchard with tetradifon resistance, Micasin at 4 lb/acre, Milbex at 4 lb/acre, and tetradifon at 4 lb/acre failed to control the European red mite. Excellent control of the European red mite was obtained with summer sprays of fenazaflor 20% at 1.5 lb/100 gal or 40% at 0.75 lb/100 gal, propargite (Omite) at 1 lb/100 gal, or bromopropylate (GS 19851) at 0.75 pint/100 gal, but the materials were highly toxic to predator mites. Chlorphenamidine at 1 pint/100 gal (or 10.5 oz/100 gal) was less effective for controlling the European red mite and very toxic to predators. Plictran at 4 oz/100 gal gave excellent control of the European red mite and showed no effect against the predators. This chemical would fit well into an integrated control program.

Pear Psylla

Ecology. Record low temperatures during the winter of 1968–69 markedly reduced populations of overwintering adults of the pear psylla. A mortality of 90–95% was recorded after temperatures fell to –27 C and –29 C. No adults were found in areas where the temperature dropped to –38 C and –41 C. The predators of the pear psylla, Miridae, Anthocoridae, and Chrysopidae, were also affected by the cold, but most species increased to normal population levels by midsummer. *Anthocoris nemoralis* (F.), a predator introduced from Europe, survived the winter without abnormal mortality.

Chemical control. Dikar at 8 lb/acre gave excellent control of pear psylla. In June, when there was significant foliage growth, two sprays applied 2 weeks apart were more effective than a single spray. After mid-July, when little new growth was present, a single spray gave as good control as two applications. Dikar had little toxicity to adults or eggs of the pear psylla, but residues exhibited a persistent toxicity to newly hatched nymphs. The material is not toxic to the predators of the pear psylla, and therefore it may be of value in an integrated control program for this pest. A study on the effective rates of petroleum oil as a summer spray for control of pear psylla showed that 4 gal/acre was sufficient, but lower rates were not adequate. Summer oil at 4 gal/acre is safe on Bartlett pears, but phytotoxic to the Anjou variety.

Tuber Flea Beetle

Chemical control. In the Salmon River district of British Columbia, a program of area control, which included net-sweeping to determine the need for spraying combined with destroying or treating all noncrop potato plants, resulted in better control of the tuber flea beetle and reduced the number of insecticide treatments by 50%. Formerly, a minimum of seven treatments was applied at 10-day intervals. Bioassay of treated potato leaves showed that carbaryl had the highest knockdown and toxicity rating against adult tuber flea beetles; the next best were DDT, phosmet (Imidan), endosulfan, and diazinon. Sprinkler irrigation significantly reduced the toxicity of all these insecticides except DDT.

FRUIT AND VEGETABLE PROCESSING

A Continuous Process for Dehydrofreezing Apples

A rapid continuous process for dehydrofreezing apple slices was developed on a pilot plant scale. The chief advantage of the improved process was shown to be the rapid and even penetration of SO_2 into the fruit tissue. Such penetration has made possible the elimination of the 4- to 5-hr holding period previously required for complete SO_2 penetration after the conventional SO_2 dip process. Further advantages were an increase of up to 5% in water uptake during rehydration and a distinct quality improvement in pies made from the rehydrated product.

High-strength Fruit Essences

A small-scale vacuum aroma-concentration column was built and operated to provide concentrated water-soluble fruit aromas for use in flavor-locking research. This unit can be programmed to produce 20,000-fold fruit essence with fruits that have relatively low boiling volatiles. However, with fruits such as raspberry many flavor notes are high-boiling and are lost in the column bottoms.

Locking Water-soluble Fruit Volatiles in Powdered Form

A new process was developed for fixing water-soluble fruit aromas in a low-moisture form with a minimum of volatility. In this process a highly concentrated fruit essence is mixed with sugar polymers and a small amount of glycerol, which serves as a binding agent. The mixture is whipped into a foam, vacuum-dried, and ground into powder. The powder is white, slightly sweet, and without aroma when dry. Aroma compounds remain locked in the powder until it is wetted, when they are released. After 6 months' storage at 20 C and low relative humidity, the powder still retains the aroma essentially unchanged in its complex stereostructure.

The process was first applied in adding back aroma to drum-dried applesauce flakes. A blend of one part flavor-locked sugar and three parts of dry, unsweetened applesauce

flakes had the full aroma of fresh applesauce when reconstituted after 3 months' storage in nitrogen pack at room temperature.

Applesauce Flakes

Drum-dried apple flakes made from Golden Delicious, Jonadel, Newtown, and Winesap apples reconstituted into an applesauce of good quality. Color was related to variety, and it ranged from an attractive bright yellow (Golden Delicious) to a pale yellow-white (Jonadel and Winesap). Applesauce made from flakes was darker and less glossy than canned sauce. In addition, flavor was significantly different (lacking freshness). However, taste panel evaluations rated it acceptable to highly acceptable.

Spartan and Red Delicious proved to be poor varieties for drum-drying. The color of the reconstituted sauce was too dark, and the flavor was borderline to unacceptable. Drum-dried flakes stored well at room temperature. Cold or cool storage was not necessary. For periods up to 12 months at 0 C and 21 C storage, color and flavor of reconstituted sauce showed no significant differences (1% level). At 38 C storage, color and flavor were unsatisfactory within 3 to 6 months, respectively.

PLANT NUTRITION, SOILS, AND IRRIGATION

Irrigation Management of Grapes on Sandy Soils

Yields of grapes were 3.9 lb/plant when irrigation intervals were 9 days, 2.3 lb/plant at 10–11 days, and 1.7 lb/plant at 13–14 days. Cover crop had no significant effect and irrigation treatments had no effect on acids or solids.

Effect of Soil Volume and Water Content on Water Uptake

Measurements of water flow through model root systems showed that water flow per unit of time was not restricted as long as spaces between roots were greater than about 2 mm in both sandy and silt loam soils.

Low Calcium Causes Breakdown in Spartan Apple

Spartan apple trees were grown in silica sand to which nutrient solutions were applied. One-eighth Ca supply in a solution produced 40% of apples with breakdown, one-quarter produced 30%, one-half 11%, and full supply 2.5%. This experiment fully confirmed earlier field plot research, which showed that Ca concentration of fruit pulp was related to breakdown incidence.

Fertilizers in Polythene Packets

An extensive test with apple trees on a good silt loam soil showed no uptake of nutrients from a variety of fertilizer packets. However, $ZnSO_4$ hoed into the surface of the 3-ft planting hole at 1 or 2 lb/tree increased leaf concentration of Zn from 20 ppm in the check to 35 ppm in the treated.

PLANT PATHOLOGY

Crown Rot of Apple Trees

Crown rot, caused by *Phytophthora cactorum* (Leb. & Cohn) Schroet., has threatened the maintenance and productivity of orchards planted with the susceptible rootstocks M II, M VII, MM 104, MM 106, MM 111. Losses of trees on M IV and M IX have been rare. Plantings of M 26 appeared to be free from the disease in 1969.

When recently germinated apple seeds were planted in wet and in comparatively dry soils infested with zoospores of *P. cactorum*, about the same number of seedlings became infected in dry soil as in wet soil. This finding showed that any measures designed to prevent infection by keeping soil around the root crown drier than that in the feeding root zone may not be effective.

Control of Apple Scab With Postharvest Sprays

A low-volume (70 gal/acre) spray of benomyl (Benlate) at 6 lb plus Surfactant F at 6 oz, the two together per acre, applied October 29, 1968, to heavily infected apple foliage prevented ascospore formation almost completely during the winter and spring months, indicating that low-volume sprays are just as effective for this purpose as drench-type sprays.

Postharvest Control of Bull's Eye Rot of Apples

Green apples are highly resistant to the bull's eye rot fungus, *Gloeosporium perennans* Zeller & Childs (stat. conid.), and rot develops in storage only as fruit approaches maturity. On the assumption that oxidative changes in the skin of the apple are related to loss of resistance, Newtown apples from a heavily infected orchard were given postharvest dip treatments in the reducing agent ascorbic acid. Highest rot reduction, 82%, resulted from ascorbic acid treatment without wetting agent. Only one fungicide, benomyl, a material not registered for use, gave comparable rot control. Ascorbic acid treatment, then, may retard oxidation of naturally occurring polyphenols in the skin of the apple, and fungitoxicity of the unoxidized polyphenols may be responsible for delaying infection.

Virus Diseases of Apple

In a screening trial, Heyer 12, a promising, hardy framework stock, proved sensitive to brown line decline virus and developed weak junctions with brown bark overlay. In a grower orchard, 300 trees of Red Delicious on Heyer 12 declined and similar symptoms were evident, whereas trees of Red Delicious on Haralson were normal. The symptoms were recorded previously only on crab cultivars.

Rubbery wood virus has induced serious symptoms on standard and spur Golden Delicious, more commonly on the latter. Hitherto, symptoms have been seen only on the indicator, Lord Lambourne, although the virus occurs commonly in commercial plantings of most varieties. Most spur Golden Delicious budwood is known to be infected, and attempts to obtain clean budwood by heat therapy have not been successful so far.

Detection of a Second Filamentous Virus From Sweet Cherry

A filamentous virus was isolated from a field tree of the sweet cherry cultivar Stella. This virus, tentatively called Type A, differs from the previously described virus from Lambert (Type B) in symptom expression on herbaceous hosts, host range, and serological characteristics. Infection in fruit trees and woody indicators is completely latent.

Occurrence of and Resistance to TMV in Tomatoes

Twelve isolates of tobacco mosaic virus from tomato fields and greenhouses were characterized on herbaceous hosts and by heat inactivation points. All isolates belonged to the tomato atypical mosaic type, which makes it unlikely that smoking workers had been the source of the original infection. Twenty tomato breeding lines that had been pretested with a TMV laboratory isolate were then inoculated twice with four of the field isolates. All plants remained virus-free, which indicates that the type of resistance present in the breeding lines is likely to hold up under field conditions.

POMOLOGY

Control of Scald on Waxed Apples

Within the last 3 years almost all packing plants have installed fruit waxing equipment. This was done before there was much information on effects of waxing on fruit physiology and physiological disorders. During the last 2 years some of the factors associated with the use of ethoxyquin (Stop Scald) in conjunction with waxing have been investigated.

Fruit from last season's experiments, which included 14 different replicated treatments, was examined after 8 months' storage. Results confirmed that ethoxyquin protection was not removed by the hot-water and detergent wash that accompanies wax-

ing, provided that fruit was allowed to dry after ethoxyquin application. Some interesting observations follow.

Paper wraps containing ethoxyquin should be applied over waxed fruit to give effective control of scald.

Immersion of fruit in hot water (52 C for 3 min) before storage effectively reduced scald (17% incidence compared with 61%). A 1-min immersion resulted in 33% incidence of scald. However, some injury to calyx lobes on Delicious apples resulted from this treatment.

Waxing reduced scald somewhat, probably because of heat used in the treatment accompanying the process.

Urea dips used in combination with ethoxyquin and waxing had no effect on scald or on fruit firmness. Other tests showed that calcium salts were incompatible with the ethoxyquin emulsion.

Waxed fruit was slightly, but significantly, softer than nonwaxed fruit. The 3-min hot-water treatment, however, did not result in accelerated softening.

Influence of Ethrel and Alar in Mechanical Shaking of Sour Cherries

Both Alar (succinic acid 2,2-dimethyl hydrazide) and Ethrel (2-chloroethylphosphonic acid) improved mechanical harvesting and improved the quality of harvested Montmorency cherries in a 2-year trial concluded in 1969. Alar applied 2 weeks after bloom at 2,000 ppm reduced fruit acid levels, reduced the force required for fruit removal, and advanced red color development, but when used alone did not reduce pull force enough to make shake-and-catch harvesting economical. Ethrel at 500 ppm applied 1 week before harvest, in addition to Alar applied earlier, proved to be the best treatment each season on trees tested in both years. This combination resulted in adequate fruit removal and in better fruit quality than was attainable with Ethrel alone. Ethrel at 250 or 500 ppm effectively aided fruit removal, but phytotoxicity of Ethrel at 1,000 ppm was evidenced by gumming and leaf removal.

Light Regimes Within Standard-size Apple Trees

Spectrophotometric measurements of light striking the periphery of apple trees showed similar quality to that penetrating into the deepest portions of the tree as sun patches or flecks. The main energy peaks occurred at approximately 525 and 625 mμ and lower peaks at 750 and 1,000 mμ. Because in full shade the predominant energy peaks were at 800 and 1,050 mμ shade light was shown to be rich in the near infrared and poor in photosynthetically active light.

By averaging numerous individual readings obtained with the spectrophotometer in the photosynthetically active bands, light zones very similar to those obtainable with the simpler uranyl oxalate actinometric technique were demonstrated. It was concluded that the uranyl oxalate procedure is valid in that it reflects real differences in photosynthetically active light within different parts of apple trees.

Mutation Frequencies in Different Zones of Primary Bud in Cherry

Dormant primary leaf buds of Bing cherry were irradiated with 4,000 r of gamma rays. The primary shoot produced from each irradiated primary bud was divided by propagating separately the secondary buds 6–15, counting from the shoot base. Mutations in leaves, such as chlorophyll deficiencies, distortion of leaf blade, and reduction in size of the blade, were recorded in the secondary shoots. The highest mutation frequencies were registered in secondary shoots originating from the 6th to the 10th secondary buds. These secondary buds originated in the zone of the primary bud where, at the time of irradiation, leaf initials were already developed but bud initials could not be distinguished. The observations in sweet cherry corresponded closely to those in apple and peach, that is, the highest mutation frequencies were recorded in secondary shoots that originated from the apical portion of the primary bud, with 2 to 4 leaf initials. Most secondary shoots with bifurcations originated from the secondary buds 6 and 7.

Selection of Mutants of Van Cherry that Have Reduced Fruit Set

The Van cherry frequently sets too heavy crops in British Columbia. In the search for useful mutants in gamma-ray treated material, pollen stainability was determined in flowers of 110 young orchard trees. The amount of stainable pollen ranged from 18 to 96%. The distribution of trees in stainability groups indicated that trees with pollen stainability of 80% and lower could be considered as affected by irradiation. Ratings of fruit set were given to individual trees. Trees with pollen stainability of over 80% had an average rating of 5.2 fruit set (about 50% of maximum possible set), trees with pollen stainability of 80% or lower had an average rating of 3.9 fruit set (about 40% of maximum possible set). It appears that it will be possible to select clones with desirable rate of fruit set for conditions in British Columbia.

Spur-type Strains of McIntosh Discovered in the Interior of British Columbia

A number of spur-type strains of McIntosh have been discovered in the interior of British Columbia in the past several years. Six of these strains, 8 to 9 years of age, from different nurseries and usually on different rootstocks, appear to have commercial possibilities. Most of them have been assigned to individual nurseries, and one is held jointly by the B.C. Fruit Growers' Association and an Eastern American nursery, which has had it covered by a U.S. Plant Patent under the name MacSpur. Four of the strains have been propagated for second trial at the Station and are undergoing virus indexing.

These strains would appear to mark a turning point in the history of the McIntosh variety. They, like spur strains of Delicious and Golden Delicious, combine compact tree size with early and heavy bearing. All are sports of Summerland Red McIntosh. None of these strains is afflicted with bare wood devoid of buds or shoots, so common in McIntosh. At least one and probably others in this group show mildew resistance and superior fruit-bud hardiness. All strains have sturdy, upward-growing branches with great structural strength and ability to carry heavy loads. Fruit color is good but there is a greater tendency than in regular McIntosh for fleshy stems. It will take 10 years to fully evaluate the relative merits of these strains.

VEGETABLES

Sumoka Tomato Ready for Grower Trial

Sumoka is a greenhouse tomato involving Ohio MR 6318-18, which has shown resistance to TMV. It is vigorous and indeterminate, has heavy foliage, and bears satisfactory yields 5–7 days later than Selandia. Under poor light conditions set has been good but some roughness is associated with reduced seed.

Pricking-out to Field Cuts Tomato Costs

In dense plantings costs of transplants become formidable. When seedlings were pricked out from the seedbed into the field, the cost of 16,500 plants/acre was reduced from $495 to $55.50. As the seedlings were small, a special transplanter was built. This performed well provided the beds were smooth and level but not deeply compacted. Of 20 varieties compared to determine adaptability, survival differed from 34% to 84%. Corrected yields to August 29 ranged from 2.94 to 12.25 tons/acre in two picks.

MANUFACTURERS OF PESTICIDES AND OTHER CHEMICALS IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Alar	UniRoyal Ltd.
Benlate	DuPont of Can. Ltd.
Dikar	Rohm & Haas Co. of Can. Ltd.
Ethrel	Amchem Products Inc.
Gardona	Shell Can. Ltd.
GS 19851	Geigy Can. Ltd.
Imidan	Stauffer Chemical Co. of Can. Ltd.
Lannate	DuPont of Can. Ltd.
Micasin, Milbex	Ihara Chemical Co. Ltd. (Green Cross Products)
Morestan	Chemagro Corporation
Omite	UniRoyal Ltd.
Plictran	Dow Chemical of Can., Ltd.
Stop Scald	Monsanto Canada Ltd.
Surfactant F	DuPont of Canada Ltd.

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Vancouver, British Columbia

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[1] On transfer of work, at Auckland, N.Z.

INTRODUCTION

This is the seventh report of the Research Station, Vancouver. It covers the work completed and in progress in 1969.

Both the report and reprints of the publications are available on request. Correspondence should be addressed: Research Station, 6660 N.W. Marine Drive, Vancouver 8, B.C., Canada.

R. E. Fitzpatrick
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Isolation of DNA from aster-yellows-infected plant tissues. In the process of characterizing the general mechanism of intracellular nucleic acid and protein synthesis in tissues of aster infected by aster yellows disease, a new method for purifying DNA from plants and leaf tissues has been investigated. The method employs toluene as a denaturing agent and avoids conditions known to degrade DNA. It gives yields of high-molecular-weight DNA from aster leaves as well as from several other types of plant tissues.

Cellular ultrastructure and virus synthesis. Susceptible cells are known to support virus establishment and virus synthesis to varying degrees, depending on their age and environmental conditions. These factors affect virus–host relationships because they bring about cytological changes, including ultrastructural ones. Therefore, an attempt was made to establish the minimum of cellular structural integrity able to support synthesis of virus, but still vulnerable to cytopathic effects of virus. Vigorous, mature leaves of *Nicotiana glutinosa* L. were excised and starved in normal daylight and atmospheric conditions, and then tissue sections were examined in the electron microscope. In the mesophyll cells, the main ultrastructural changes caused by excision were vacuolation of the cytoplast, rearrangement of chloroplast material, accumulation of cytoplasmic crystals and of starch, and lysis of the tonoplast. Rearrangement of chloroplast material resulted in extended, three-dimensional arrays of electron-dense globules 85–100 A in diameter. These changes differed from those that occur in comparable attached leaves during aging. Ultrastructurally, therefore, excision does more than merely accelerate the aging process. Although the ultrastructural degeneration of mesophyll cells in excised *N. glutinosa* leaves is not synchronized, leaves excised for only 4 days before inoculation with tobacco mosaic virus (TMV) already developed fewer than half the number of local lesions that developed on comparable attached leaves. The amount of TMV antigen produced in excised leaves per lesion was only 60% of the amount in comparable attached leaves. This is a drastic reduction from the earlier-reported 16-fold increase of TMV in newly excised leaves.

Amino acid composition and serological properties of virus strains. Strains of alfalfa mosaic virus isolated from potato and alfalfa had distinct host ranges, but were serologically indistinguishable. Differences in the amino acid composition of these strains were not detectable by analysis.

The serological properties and amino acid composition of two strains of tomato bushy stunt virus (TBSV) were determined and compared with those of two strains of southern bean mosaic virus (SBMV). There were great differences in the serological properties of the TBSV strains and smaller differences in the serological properties of the SBMV strains. However, differences in the amino acid composition between the two SBMV strains were much greater than the differences in amino acid composition between the two TBSV strains.

Physiology and cytology of virus-infected plants. The effects on respiration of four strains of potato virus X (PVX) were studied. The strains varied in the severity of symptoms they produced on tobacco leaves. Respiration rates did not change in either inoculated or systemically infected but symptomless leaves, even though there was a significant increase in virus concentration during the experimental period. Respiration increased in any leaves on which symptoms developed, and this increase was directly cor-

related with the severity of symptoms. At the same time, there was a great increase in virus concentration.

Measurement of the respiration patterns of single local lesions showed that respiration increased each time a chlorotic and necrotic ring formed in the tissues. The use of metabolic inhibitors indicated that metabolic controls in leaves infected with latent or mild strains are different from those in leaves infected with severe, necrotic strains. To define the causes for the increased respiration, the oxidative and phosphorylative activities of leaf mitochondrial preparations, as well as the hexose and pentose metabolism of cell-free extracts, were studied. No differences were found in mitochondrial activities between preparations from healthy leaves and those from leaves infected with the severe ringspot strain at the stage of maximum respiratory increase. However, in the cell-free extracts from leaves infected with each of the four PVX strains, glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase showed much greater activity than extracts from healthy leaves. Phosphoriboisomerase activity was less than it was in the controls. Comparison of C_6/C_1 ratios showed a decrease in both inoculated and systemically infected leaves with all four strains. It is concluded that the increase in respiration of PVX-infected tobacco leaves is connected with an increase in the activities of the enzymes in the pentose phosphate pathway.

The ultrastructural cytochemistry of virus-infected leaf cells embedded in glycol methacrylate was compared with that of published studies on animal cells. There were substantial differences in the quality of structural preservation and accessibility to enzyme digestion. When a number of fixatives were evaluated, it was considered that although a mixture of acrolein and formalin results in crude preservation of cellular structures, it is the most practical fixative for subsequent enzyme digestion. Pepsin and trypsin may be used with confidence to characterize proteins in leaf tissues embedded in glycol methacrylate. Deoxyribonuclease appears to be active in the chromatin regions only after formalin fixation, but there is still doubt about the effectiveness or reliability of ribonuclease digestion.

PLANT PATHOLOGY

Potatoes

Potato virus X and potato virus S. Eradication of potato viruses X (PVX) and S (PVS) by nutrient culture of axillary buds excised from heat-treated plants was continued in 1969. In addition to the 24 varieties reported in 1967 and 1968, the following varieties and seedlings were freed from PVX and PVS: Arran Victory, Cherokee, Chieftain, Chinook, La Rouge, Lenape, Norchief, Ontario, Superior, Viking, Waseka, F 5773, F 5961, F 6087, F 6238, G 597-20, and USDA 41956. The varieties Raritan, Wauseon, and York were already free from PVX and PVS.

From most of the plants PVX was eradicated more easily than PVS, but the heat tolerance of the viruses varied with the source plant. In two selections PVS was the more difficult virus to eradicate. The proportion of plantlets that were virus-free was sometimes lower after prolonged heat treatment than after a short treatment of 6–8 weeks.

Samples of all virus-free clones were maintained in isolated field plots. Some clones were increased by Elite seed growers in British Columbia. Fields of the varieties Kennebec, Norland, and Red Pontiac were certified Elite III in 1969. In addition, plots of these varieties plus Cariboo, Early Epicure, Early Rose, Netted Gem, Norgold Russet, Red La Soda, Warba, and White Rose were certified Elite I and enough seed became available for field plantings in 1970. All clones in the Elite seed program are tested during the winter for PVX, PVS, PVM, and for mild strains of leaf roll virus and spindle tuber virus. Field tests are also made for PVX and PVS.

Meristem culture. During the program on eradication of latent viruses from commercial potato varieties, factors affecting the development of excised potato buds into rooted plants were investigated. Factors that influenced survival and rooting were the composition and pH of the culture medium, the season of the year, the variety of potato, and the need to transfer buds to fresh media during

culture. Liquid medium was superior to solid, judged by rate of growth and proportion of rooted buds. Common growth-promoting substances incorporated into the medium were more detrimental than beneficial. Development was optimal at pH 5.7, but rooting was inhibited at pH 4.8 or pH 6.2. Buds excised in the spring and early summer rooted more readily than those taken later in the year. Even in the best medium tested, usually less than half the excised buds developed into established plantlets unless they were transferred to fresh medium. Plantlets that developed shoots without roots were sometimes established normally when they were transferred directly to soil.

Small Fruits

Mummy berry of highbush blueberry. Ascospores of *Monilinia vaccinii-corymbosi* (Reade) Honey, causal agent of mummy berry of highbush blueberry, are optimally discharged during periods of lowest humidity and highest temperatures of the day. The results of spore-trapping experiments correlated with microclimatic data on temperature, humidity, and leaf wetness indicate that apothecia do not discharge during active rainfall. The spore discharge period during 1969 was unusually long, lasting 33 days, and the heaviest discharge occurred between the 10th and 23rd days.

Ferbam at 2.2 kg toxicant/ha (2 lb/acre); benomyl (Benlate) at 2.2, 1.1, and 0.6 kg (2, 1, and 0.5 lb); and NF-35 at 2.2 kg were applied four times as sprays to mature highbush blueberry, variety Rancocas. Benomyl at 2.2 kg/ha was applied once only. Each treatment was examined for three types of infection, leaf shoot, flower cluster, and mummy berry. Benomyl at the low rates decreased conidial infections, but was not better than ferbam and NF-35 for controlling ascospore infections. It had no effect on yield. The total loss to the blueberry industry in the province from mummy berry disease was calculated to be $66,462.

Effect of mosaic on raspberry yield. In a cooperative test with the Research Station, Agassiz, B.C., plots were established to measure the effects of raspberry mosaic and the heat-labile component of mosaic on four raspberry cultivars. Raspberry mosaic and the heat-labile component reduced the yields of Fairview, Sumner, Newburgh, and Willamette raspberry in the first cropping year. In subsequent cropping years, yields of Fairview and Sumner were reduced, but Newburgh and Willamette resisted virus infection. The yield loss was about 14% in infected Fairview and 11% in infected Sumner, and no difference was found between plants infected with the single virus and those infected with the virus complex. Susceptible cultivars produced smaller fruit and shorter and thinner canes than resistant ones. Only 12 of 240 virus-free plants were contaminated with mosaic by the end of the trials. Most contaminations occurred in Newburgh, a cultivar that supports high populations of the aphid vector.

Vegetables

Lateral root die-back of carrot. Pythium debaryanum Hesse was consistently associated with a disease of carrots that reduced yields and increased the numbers of unmarketable carrots. First symptoms after the two-leaf stage are a rusty necrosis of the root tip followed by excessive root proliferation and branching, then wilting or stunting of the top growth. In the greenhouse it was controlled by applying Dexon as a preemergence drench.

The following varieties are listed in order of decreasing susceptibility: Carousel, Gold Pak, Pioneer, Special Long Type Nantes, Hipak, and EN 47.

Nematodes

Baker dagger nematode. Xiphinema bakeri Williams is widespread in sandy soils throughout the Fraser Valley. It causes stunting, swelling, and a characteristic curling of the root tips on which it feeds. Populations in commercial berry fields may reach 2,000–4,000/liter of soil, and cause severe stunting and chlorosis in plants. Formation of shoots and runners are reduced in raspberries and strawberries. Because *X. bakeri* has a wide host range and is indigenous to the Fraser Valley, it is a potential threat to new plantings and replantings. In 12 weeks under laboratory conditions, *X. bakeri* increased fourfold on strawberry and destroyed the roots of 50% of the test plants.

Needle nematode. Longidorus elongatus Thorne & Swanger caused stunting and deformation in field-grown strawberry plants. This first report of the species in British Co-

lumbia is important because the nematode is highly pathogenic to strawberry and is a known vector of strawberry and raspberry viruses.

ENTOMOLOGY

Vectors

Colonies. The following vectors were maintained throughout the year under controlled conditions: green peach aphid, *Myzus persicae* (Sulz.); potato aphid, *Macrosiphum euphorbiae* (Thom.); bean aphid, *Aphis fabae* Scop.; pea aphid, *Acyrthosiphon pisum* (Harr.); cabbage aphid, *Brevicoryne brassicae* (L.); and six-spotted leafhopper, *Macrosteles fascifrons* (Stal).

Morphology and fine structure. The stylets of *M. persicae* and *M. fascifrons* were examined with a scanning electron microscope. This showed the structure of the barbs and ridges at the tips of the mandibular stylets and how the food and salivary canals terminate. The labium of the pea aphid was also examined.

A method of feeding leafhoppers on agar in order to detect microorganisms was developed and used with groups of *M. fascifrons* that transmitted aster yellows and groups that did not transmit the disease. Mycoplasma-like bodies ranging from 30 to 400 mμ were found in the saliva and salivary sheaths of both groups.

In cooperation with the Faculty of Forestry, University of British Columbia, the balsam woolly aphid, *Adelges piceae* (Ratz.), was studied for comparison with vector aphids. The morphology and fine structure of the stylets, labial clamp, and crumena were described from electron micrographs. Each mandible has a central duct running from the base nearly to the tip, and it contains three dendrites. Near the tip of the labium the stylet bundle is held by the labial clamp, a heart-shaped chitinous structure that surrounds the labial groove; it has five muscles that produce a vice-like clamping action. Six pairs of dendrites innervate sensory pegs at the tip of the labium. In the mobile crawler stage, the stylets are contained in an unusually long, folded crumena, an invagination of the body wall lined by epidermal cells.

A new virus disease. A mild virus disease transmitted by the green peach aphid was discovered in 60% of steckling sugar-beet plants grown for seed on the Fraser River delta. It was identified by its host range and vector relations as being caused by beet western yellows virus.

Root Weevils

In blueberry. Observations were made on adults of the black vine weevil, *Brachyrhinus sulcatus* (F.), after they fed for 2, 3, 4, or 5 weeks on leaves of the acceptable blueberry cultivar Stanley, or of the unacceptable cultivar Cabot. On Cabot the weevils had reduced feeding rates and fat contents, weight losses, and proportionately increased moisture contents. The low feeding rates indicate the presence of a feeding deterrent. The weight losses and the low fat contents indicate that the Cabot foliage that was ingested did not contain the nutrients essential for the normal growth of reproductive organs or the fat body. The factors responsible remain obscure.

In strawberry. Adults of the black vine weevil and the woods weevil, *Nemocestes incomptus* (Horn), were controlled by carbofuran (Furadan 4 flowable) in water at 1:1,600 or 1:400, applied to strawberry foliage. At 1:400 the material remained effective against both species for up to 35 days.

Wireworms

Chemical control. In peat soil planted to potatoes, single applications of Bux (Ortho 5353) as a 15% granular formulation, and carbofuran, fonofos, and N 2596, each as 10% granules, were incorporated to a depth of 13 cm (5 inches) to control *Agriotes lineatus* (L.) and *Ctenicera lobata* (Esch.). When the soil was treated with Bux at 4.5 or 9.0 kg toxicant/ha (4 or 8 lb/acre), 91% of the tubers were marketable; with carbofuran at 4.5 kg (4 lb), 88%; with fonofos at 5.6 kg (5 lb), 87%; with N 2596 at 4.5 kg (4 lb), 75%; and without treatment, 62%.

Leatherjackets

Chemical control. In pastures, single applications of insecticides were tested for control of larvae of the European marsh crane fly, *Tipula paludosa* Meig. In the spring, fensulfothion and N 2596 at 2.2 kg (2 lb) and carbofuran at 1.1 or 2.2 kg toxicant/ha (1 or 2 lb/acre) reduced the population by more than 93%; parathion at 0.6 kg (0.5 lb), R 15792 at 2.2 kg (2 lb), and fensulfothion at 1.1 kg (1 lb) by 81% to 84%; Bay 77488 and bromophos each at 2.2 kg (2 lb) by 77% and 74% respectively. Methomyl (Lannate) at 0.6 kg (0.5 lb) and methoxychlor at 2.2 kg (2 lb) were inadequate. In untreated pastures, the population was 301 leatherjackets/sq m (28/sq ft). In the fall, chlordane at 2.2 kg toxicant/ha (2 lb/acre), parathion at 0.6 kg (0.5 lb), diazinon and bromophos each at 3.3 kg (3 lb), and Perthane at 2.8 kg (2.5 lb) reduced the population by more than 92%. Methoxychlor at 3.2 kg (3 lb) reduced the population by 86%; diazinon at 1.7 kg (1.5 lb) and phosmet (Imidan) at 2.2 kg (2 lb) by 70%, but the population was still about 430 leatherjackets/sq m (40/sq ft). The untreated population averaged 1,431/sq m (133/sq ft).

Biological control. Siphona geniculata De Geer, a tachinid parasite of *T. paludosa* imported from Germany in 1968 and released in two areas in the lower Fraser Valley, was not recovered.

Tansy Ragwort

Biological control. The cinnabar moth, *Tyria jacobaeae* L., released in the Nanaimo area 1964–67 to control tansy ragwort, *Senecio jacobaea* L., was well established. In 1968 the population on 6.9 ha (17 acres) was more than 400,000 larvae. The average numbers and the area affected increased in 1969. Larvae from Nanaimo released at Abbotsford in 1967 were well established by 1969.

Root Maggots

Compatibility. In peat and sandy loam soils, the insecticides chlorfenvinphos, fensulfothion, and carbofuran (Furadan) were applied as granules over seeded rows of cauliflower previously treated with NH_3, NH_4OH, Hg_2Cl_2, and quintozene. A drench of the insecticides was applied 28 days after seeding. In peat soil, germination was reduced by all rates of NH_3 and NH_4OH, but clubroot also was reduced. The insecticides reduced maggot damage, and yields were 40–70% greater than those in untreated blocks. In sandy loam the number of emergent seedlings was reduced by all fungicides except Hg_2Cl_2 and the lowest rate of NH_4OH. The fungicides, except the low rates of NH_3 and NH_4OH, reduced the clubroot. Carbofuran, chlorfenvinphos, and fensulfothion were effective, and all the plots treated with these insecticides produced more cauliflower than untreated blocks did.

Fensulfothion, carbofuran, and thionazin were applied as granules over seeded rows of broccoli, cabbage, cauliflower, and rutabaga in silt loam soil treated before seeding with the herbicides Dacthal, Eptam, RO-Neet, Sutan, SD 11831, trifluralin, and Vegadex. All the plants were drenched with insecticide 28 days after seeding and the rutabagas again at 49 and 70 days. There were no apparent incompatibilities between the herbicides and insecticides, but emergence of seedlings and yields were occasionally reduced.

Toxicology. Cyclodiene-resistant strains of the seed-corn maggot, *Hylemya platura* (Meig.), were compared with susceptible strains by topical applications and exposure to papers impregnated with insecticides. Values of LD_{50} and LC_{50} were calculated for both strains for insecticides representative of the organocarbamate, organochlorine, and organophosphorus groups. Strains resistant to the cyclodiene organochlorine group showed no cross-resistance to the other groups.

Residue Chemistry

Organophosphorus residues in carrots. Granules and drenches of fensulfothion and thionazin were applied at various rates to protect carrots from cyclodiene-resistant strains of the carrot rust fly, *Psila rosae* (F.). Samples were taken 1, 3, 5, 7, 14, 28, 42, and 56 days after the final treatment and held in frozen storage. The residues were determined by gas chromatography with flame photometric detection. The maximum residues, which occurred within 7 days after the last treatment at the highest rate, were fensulfothion 1.03 and thionazin 1.46 ppm. At 56 days after the final treatment the residues were 0.32 and 0.33 ppm, respectively.

Carbofuran residues. A modification of the original microcoulometric method enabled carbofuran (Furadan) and its 3-hydroxy metabolite to be determined in rutabagas, but

attempts to develop a suitable method for their determination in rapeseed have been unsuccessful. Residues in rutabagas were below the tolerance level of 0.5 ppm.

D-D residues in soil. Curves obtained by plotting the rate of loss of D-D from a mineral soil showed that during the first 3 months the concentration decreased from about 10 ppm to 2 ppm, but that little loss occurred during the next 4 months.

Loss of persistent organochlorine insecticides from soil. Laboratory tests showed that when black polyethylene was laid over soil containing aldrin, dieldrin, and DDT, and then exposed to simulated sunshine, the concentration of all three insecticides in the top 6 cm of soil was significantly reduced by the end of 4 weeks.

Inquiries

Inquiries about insects increased in the past year. Other than inquiries concerning purely agricultural pests, information was most often sought on the following:

Merchant grain beetle. Oryzaephilus mercator (Fauv.) is the most persistent and troublesome cupboard pest in households and apartments.

Ants. Carpenter ants, *Camponotus* sp., were often found in houses of post and beam construction. Another ant, *Lasius sitkaensis* Pergande, which may form colonies in damp, rotting wood, often revealed its presence in houses during the swarming of alate adults in late summer.

Marsh crane fly. Information on leatherjackets, the larvae of *Tipula paludosa* Meig., was in keen demand.

Tent caterpillar. Malacosoma pluviale (Dyar) caused heavy damage to deciduous trees.

Lecanium scale. Infestations were common on shrubs, blueberries, and fruit and ornamental trees. Branches were often killed.

Mediterranean flour moth. This insect was a common and sometimes serious pest in feed-processing plants.

Cat flea. Ctenocephalides felis (Bouché) was the most common pest on pets in homes. A parasite of dogs, the pacific tick, *Ixodes pacificus* Cooley & Kohls, was often examined.

Wasps and hornets. Vespula spp. were unusually abundant, and were a major nuisance during the late summer.

PEDOLOGY

Basic Soil Surveys

The field work for the Peace River area, Rose Prairie-Blueberry, 94A N half, and Upper Milligan Creek - Nig Creek, 94H S half, was completed and the map is in preparation. Field work was started on the Halfway River area, 94B E half. The map for the Princeton sheet, 92H SE, was prepared and the final draft of the report is nearing completion. The final maps and reports for the Lac la Hache - Clinton area, 92P W half, and the Williams Lake - Alexis Creek area, 93B S half, are being prepared. The map and report for the Fort Nelson area, 94J NE, were completed and submitted for publication. Field work for about one million acres of the Merritt area, 92I SE, was completed. The map and report are in preparation.

Soil capability for agriculture surveys were completed for Chilcotin, 92O NE, and Moffat Creek, 93A SW.

Soil genesis and land classification. A study of the genesis of alpine soils and their chemical, physical, and mineralogical properties, was made, and methods for their classification were recommended.

A method of classifying terrain was devised to serve as a basis for soil mapping. The method was used in the Fort Nelson report and map.

The suitability of infrared and color aerial photography for soil survey is being tested.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Bay 77488	Chemagro Corp.
benomyl (Benlate)	DuPont of Canada Ltd.
Bux (Ortho 5353)	Chevron Chemical Co.
carbofuran (Furadan)	Niagara Chemicals
D-D	Shell Chemical Co.
Dacthal	Stauffer Chemical Co.
Dexon	Chemagro Corp.
Eptam	Stauffer Chemical Co.
methomyl (Lannate)	DuPont of Canada Ltd.
N 2596	Stauffer Chemical Co.
NF-35	Nippon Soda Co.
Perthane	Rohm & Haas Co. of Canada Ltd.
phosmet (Imidan)	Stauffer Chemical Co.
R 15792	Plant Protection Ltd.
RO-Neet	Stauffer Chemical Co.
SD 11831	Shell Canada Ltd.
Sutan	Stauffer Chemical Co.
thionazin (Zinophos)	American Cyanamid Co.
Vegadex	Monsanto Canada Ltd.

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INDEX OF PROFESSIONAL STAFF AND VISITING SCIENTISTS

SUBJECT INDEX

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