RESEARCH BRANCH REPORT

1971

Agriculture
Canada

Research Branch Report

1971

CANADA DEPARTMENT OF AGRICULTURE

Cat. No.: A51-1/1971

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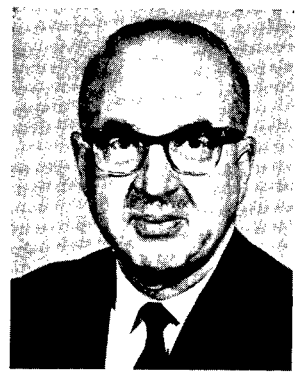

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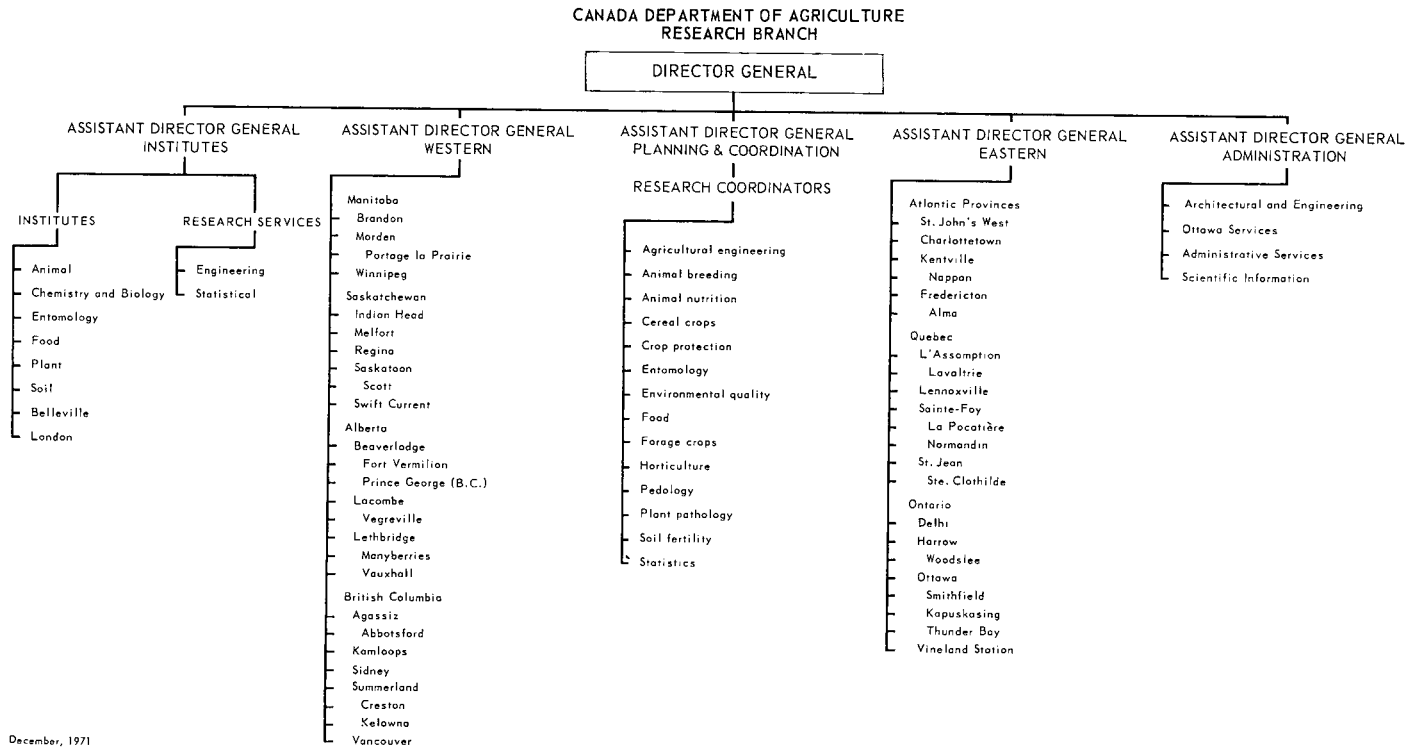

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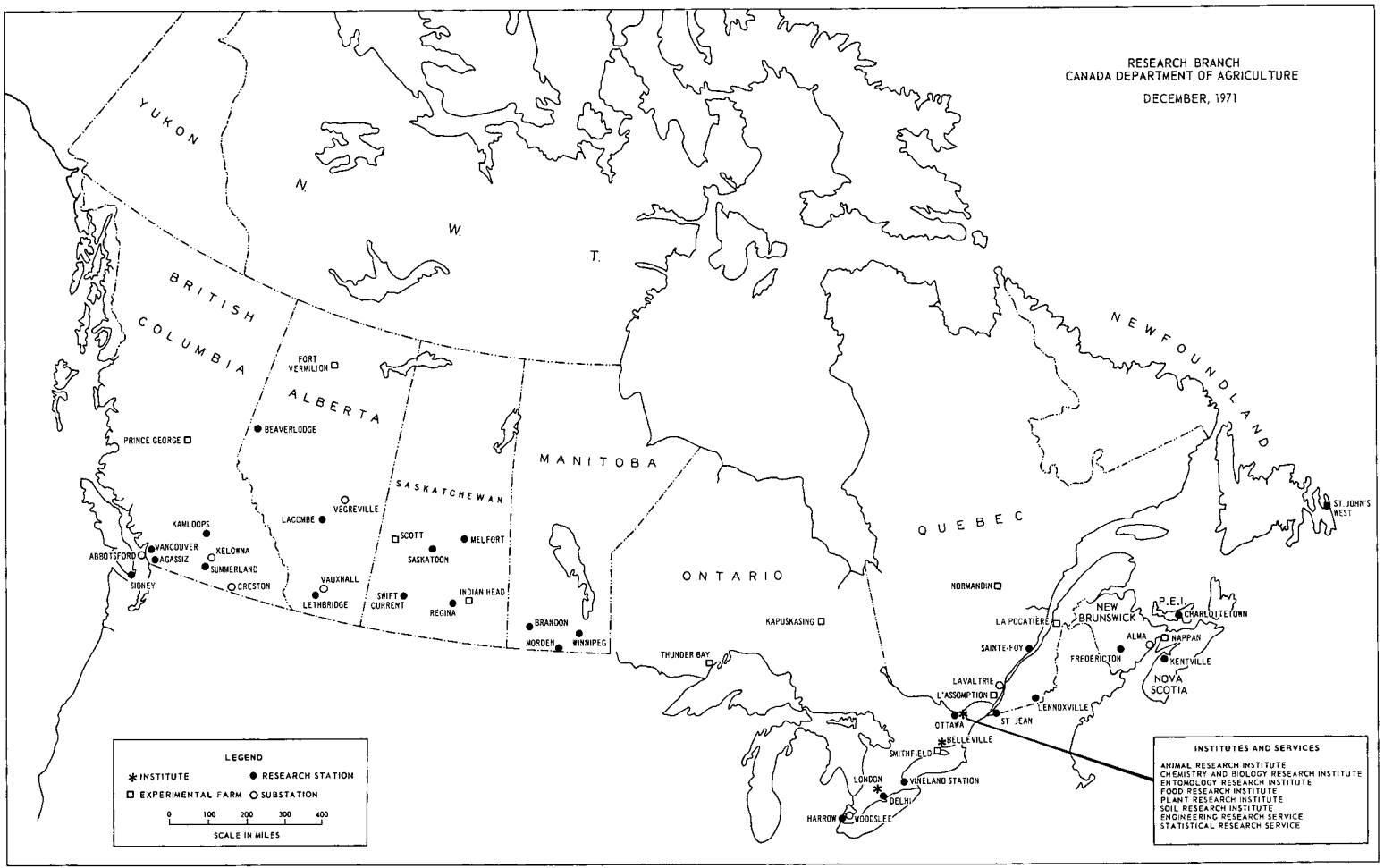
RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE
DECEMBER, 1971
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FOREWORD

One of the reasons for compiling and publishing this report is to meet the need for accountability. Thus these reports, prepared by the directors and scientists throughout the Research Branch, enable each establishment to account for its efforts during the year. Since the Research Branch is simply the sum of its parts, this report describes the Branch operation.

Our overall program report could be presented in terms of objectives and goals, but such a presentation would not allow each director to account for his individual responsibility center where, we all are aware, the research is done. To enable the readers to see how the Research Branch program is planned and coordinated, the fly leaf at the back presents the outline of the program structure in terms of our current objectives and goals.

The changes in research activities of establishments, and thus of the Branch, are apparent when a series of annual reports is compared. These changes have been instituted in accord with new priorities brought about by scientific advances and changes in Canadian agricultural operations. Although we may not have introduced as many changes as some deem advisable, we believe we have been able to change our programs where the need was most urgent—and this in the face of difficult circumstances.

Progressive change can be brought about quite easily in an expanding organization. In the absence of increasing personnel and dollars, flexibility is reduced. Change is thus restricted to the rate of attrition. Such has been our situation for the past three years. Despite this imposed inflexibility, we have managed to move resources from low to high priority areas and have consolidated many resources, enabling us to progress and carry our responsibilities more effectively.

A number of changes have occurred in management personnel. Dr. A. E. Hannah and Dr. A. S. Johnson have been seconded to the Department to organize a group that will introduce a food systems approach into the operations of the Department. Dr. J. L. Bolton has retired as Coordinator for Forage Crops and Dr. N. Tape was promoted to the position of Coordinator for Food Research and Product Development.

Dr. F. Kristjansson was promoted to the directorship of the Ottawa Research Station upon the retirement of Dr. A. W. S. Hunter. Dr. G. M. Weaver, Director of the Research Station at Vineland Station, was appointed Director of the Research Station at Fredericton, a vacancy created by the untimely death of Dr. F. Whiting. Dr. A. J. McGinnis was promoted to the directorship of the Research Station at Vineland Station.

Mr. J. Richard retired as Director of the Experimental Farm at L'Assomption and was replaced through the promotion of Dr. P. P. Lukosevicius. Dr. R. E. Fitzpatrick retired as Director of the Research Station at Vancouver, and Dr. M. Weintraub was promoted to this post. The unfortunate passing of Dr. R. M. Hochster left the Chemistry and Biology Research Institute without a permanent director. Dr. G. Fleischmann has been promoted to this position.

One of the highlight happenings during the year was the Ottawa Directors' Conference in October. The active participation of all directors at this conference and their real and meaningful contribution to the annual program review reflect the health of the Branch. We are fortunate to have such a capable director cadre responsible for the research activities of the CDA Research Branch.

B. B. Migicovsky
Director General

AVANT-PROPOS

L'une des raisons qui motivent la compilation et la publication de ce rapport, c'est de vouloir rendre compte de nos activités. De même que les rapports des directeurs et des scientifiques de la Direction de la Recherche permettent à chaque établissement de rendre compte de leurs travaux, ainsi la Direction de la Recherche, constituée de la somme des parties, fait part de ses activités.

Notre programme pourrait se présenter en termes d'objectifs et de buts, mais une telle présentation ne permettrait pas à chaque directeur de soumettre le rapport des équipes de recherches qui tombent sous sa responsabilité et qui, nous le savons tous, poursuivent les recherches. Pour permettre au lecteur de se familiariser avec les divers aspects de la planification et de la coordination de la Direction de la Recherche, vous trouverez sur le feuillet de garde un schéma de la structure de nos programmes en fonction de nos objectifs et buts.

C'est en comparant une série de rapports annuels qu'on constate les changements qui ont eu lieu au niveau des divers établissements et, cela va de soi, de la Direction. Ces changements ont eu lieu à la suite des nouvelles priorités qui découlent à la fois des progrès techniques et de l'évolution de l'agriculture canadienne. Bien que nous n'ayons pas évolué autant que certains l'auraient voulu, nous croyons avoir apporté des changements à nos programmes là où les besoins étaient les plus urgents—et ceci dans des circonstances particulièrement difficiles.

Il est assez facile d'opérer des changements progressifs au sein d'une organisation en expansion. On perd beaucoup de souplesse si on ne peut compter sur un accroissement des budgets ou des effectifs scientifiques. Les changements ne se font plus qu'en fonction de l'attrition. Cela a été notre cas au cours des trois dernières années. Malgré ce facteur d'inertie, nous avons réussi à déplacer certains de nos effectifs vers des domaines de haute priorité et à regrouper des ressources qui nous ont permis de progresser et d'assumer nos responsabilités avec plus d'efficacité.

Des changements ont eu lieu au niveau du personnel de gestion. Le Dr. A. E. Hannah et le Dr. A. S. Johnson ont été mis à la disponibilité du Ministère pour former un groupe de travail sur l'étude des composantes de la chaine alimentaire. Le Dr. J. L. Bolton, Coordonnateur de Recherches (Plantes fourragères) a pris sa retraite. Le Dr. N. Tape a été promu au poste de Coordonnateur de Recherches (Alimentation et Développement de produits).

Le Dr. F. Kristjansson a été promu au poste de Directeur de la Station de Recherches d'Ottawa à la suite de la retraite du Dr. A. W. S. Hunter. Le Dr. G. M. Weaver, Directeur de la Station de Recherches de Vineland Station, a été transféré à la Station de Fredericton à la suite de la mort prématurée du Dr. F. Whiting. Le Dr. A. J. McGinnis a été promu Directeur de la Station de Recherches de Vineland Station.

M. J. Richard, Directeur de la Ferme Expérimentale de l'Assomption, s'est retiré et fut remplacé par le Dr. P. P. Lukosevicius. Le Dr. R. E. Fitzpatrick, Directeur de la Station de Recherches de Vancouver, a pris sa retraite et fut remplacé par le Dr. M. Weintraub. A la suite du décès du Directeur de l'Institut de Recherches Chimiques et Biologiques, le Dr. R. M. Hochster, le Dr. G. Fleischmann a été appelé à lui succéder.

L'événement important cette année à Ottawa fut la Conférence des Directeurs, en octobre. A en juger par la participation de tous les Directeurs et à leurs efforts apportés à la révision annuelle des programmes de recherches, notre Direction se porte bien. Nous sommes réellement favorisés d'avoir un tel groupe de cadres responsables des recherches à la Direction de la Recherche du MAC.

B. B. Migicovsky
Directeur général

Research Station
St. John's West, Newfoundland

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Horticulture Section

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Plant Breeding and Pathology Section

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P. K. HERINGA, B.Sc., M.Sc.	Pedology
A. SCHORI, B.Sc., M.S.A.	Pedology

INTRODUCTION

Research at St. John's West emphasizes continuing work on regional agricultural problems including reclamation and use of peat soils, resistance to potato wart disease, and golden nematode control. Studies on insect control, plant diseases, and those concerning plant nutrition, storage, and suitable vegetable varieties are included in the program. Soil survey work is in progress in both the eastern and western sections of the province.

This seventh report covers work completed and in progress in 1971. Previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Canada Department of Agriculture, P.O. Box 7098, St. John's West, Nfld.

H. W. R. Chancey
Director

SOIL SCIENCE

Soil Survey

Observations and chemical analyses of soils on the Avalon Peninsula revealed characteristics not common in other parts of the country. Among these is the high clay content of the Ae horizon, which may be as much as 40% higher than that of the underlying B horizon. Parent materials are moderately coarse.

In coastal areas, nearly white Ae horizons occur that contain as high as 20% organic matter as well as free Fe. Organic matter movement and free Fe movement into the B horizon is common but often without the accompanying occurrence of dark or red colors. Clay accumulation in the B horizon does occur in areas with finer-textured soils, but an increase in silt content in the BC horizon is common, possibly due to frost action.

Analyses of two profiles developed on the same parent material and located within a short distance of each other showed only slight chemical differences, although one had a thin Fe pan and the other a Mn pan. The former, classified as a Placic Orthic Podzol, supported heath-type vegetation, whereas the latter underlaid a shallow organic soil with mainly sphagnum cover. Biological influences are being considered.

In the Codroy Valley area field investigations for detailed reconnaissance soil survey were completed for 32,400 ha (80,000 acres). Approximately 6,075 ha (15,000 acres) remain to be surveyed. Ten tentative soil series were established, representing the Podzolic, Gleysolic, and Regosolic orders. A sufficient number of these have now been described to typify all soils observed in the area and the soil map legend has been completed.

Peat Soils

Fertility. The effects of different initial fertilizer treatments on responses of forage yields and botanical composition to different maintenance treatments in the year after seeding have previously been reported (1968). When the same maintenance treatments were carried into the second year after seeding some rather surprising changes occurred that could affect fertilizer practices. Thus the stimulation of clover through high levels of initial P followed by high levels of maintenance P, if carried into the next year, resulted in lower clover percentage and yield than did a lower level of maintence P. However, these tests contained predominantly red clover, which is erratic in second-year production, so further study is needed to determine the best long-term compromise for red clover and how generally this principle applies to other legumes and other management practices.

The effect of split applications of N, P, and K side-dressings on transplanted late cabbage showed that preplant N at 224 kg/ha plus N side-dressing at 224 kg/ha produced yields equivalent to those obtained with preplant N at 336 kg/ha plus N side-dressing at 224 kg/ha. Side-dressing with K at 224 kg/ha significantly increased yields. There was, however, no significant difference between a single side-dressing and split side-dressing applications.

Drainage. The permeabilities of peat in the cultivated layer were studied in plots comparing different drainage intensities and cultivation periods. The water conductivity

was determined on duplicate soil cores 7.5 cm (2.95 inches) in diameter and 8 cm (3.15 inches) deep starting at about 2.5 cm (1 inch) below the soil surface. There was generally good agreement between duplicates, but there was great variability thoughout the experimental area with conductivity measurements ranging from 0.63 to 114.5 cm/hr (0.25 to 43 inches/hr). However, despite this variability, land that was under cultivation for 4 years was significantly less permeable than virgin peat or peat that had been cultivated for only 1 year. There also appeared to be reduced permeability with the increase in drainage intensity provided by ditches spaced at 30.3, 22.8, 15.2, and 7.6 m (100, 75, 50, and 25 ft), but this result approached significance only after 4 years in cultivation. Results from determinations taken on cores obtained at 25 cm (10 inches) in the soil profile showed a greatly reduced permeability with respective lateral and vertical conductivities of 0.23 and 0.04 cm/hr (0.09 and 0.016 inches/hr). These values may be compared to determinations by the pieziometer method of 0.31 cm/hr (0.12 inches/hr) at 30–45 cm (12–18 inches) depth.

Mineral Soils

Fertility. The response of Kennebec potatoes to sources of N and to split applications of N and K were studied for 5 years. Results were examined in the light of monthly heat units and rainfall, of which July rainfall appeared to be the most important. In 2 years distinguished by a July drought, yields were improved by the ureaformaldehyde, split K treatments. In years of normal July rainfall (8–10 cm), total application of ammonium nitrate and muriate of potash at seeding time was as good as other treatments, but after an excessively wet July (12.5 cm) the split application of ammonium nitrate and muriate of potash was more effective. Specific gravity was not greatly affected by any of the treatments.

Several treatments consisting of preplant applications of N, P, and K with and without N side-dressing were compared using direct-seeded and transplanted late cabbage. With transplanted late cabbage preplant N at 336 kg/ha without N side-dressing produced yields equivalent to preplant N at 224 kg/ha plus N side-dressing at 112 kg/ha. However, with direct-seeded late cabbage preplant N at 224 kg/ha plus N side-dressing at 112 kg/ha gave higher marketable yields than preplant N at 336 kg/ha without side-dressing.

PLANT SCIENCE

Weed Control on Peat Soil

Carrot (var. Special Nantes 616). Treatments included postemergence applications of linuron, prometryne, C-6313 (Ciba-Geigy Canada Ltd.), and C-7019 (Ciba-Geigy Canada Ltd.). C-7019 did not control grass. Both linuron and prometryne at 2.2 kg of active ingredient (ai) per hectare gave good weed control, but C-6313 at 2.5 kg ai/ha was the best treatment.

Cabbage transplants (var. Houston Evergreen). Treatments were preemergence applications of BAS 2903-H (BASF Canada Ltd.) at 3.4, 4.5, 5.6, and 6.7 kg ai/ha. None of the treatments caused any visible plant injury. At 5.6 and 6.7 kg ai/ha the herbicide gave good control of broad-leaved weeds, but grass control was poor.

Weed Control on Mineral Soil

Rutabaga (var. York). Treatments included preemergence applications of chlorthal and R-7465 (Stauffer Chemical Co.) and preplanting incorporated applications of trifluralin, vernolate, chlorthal + vernolate, trifluralin + vernolate, EPTC, EPTC + R-7465, and EPTC + R-25788 (Stauffer Chemical Co.). EPTC in combination with R-7465 caused slight leaf injury (burning) at all rates. A combination of trifluralin and vernolate (1.1 + 1.7 kg ai/ha) gave better weed control and higher yields than trifluralin applied alone.

Cabbage transplants (var. Houston Evergreen). Treatments were preemergence applications of chlorthal, R-7465, and prometryne; and preplanting incorporated applications of trifluralin, EPTC, and EPTC + R-7465. R-7465 gave good control of lamb's-quarters and shepherd's-purse, but poor control of lady's-thumb. Trifluralin at 1.1 kg ai/ha, R-7465 at 2.2 kg ai/ha, and prometryne at 2.2 kg ai/ha gave equally good weed control, but yields were slightly higher with trifluralin.

Table beet (var. Detroit Dark Red). Treatments included preemergence applications of

chlorthal and pyrazon, postemergence applications of pyrazon, and preplanting incorporated applications of pebulate and trifluralin. Pebulate at 6.7 kg ai/ha was the best treatment because it gave excellent control of lamb's-quarters and shepherd's-purse without any apparent injury to the crop.

Forage Crops

Forage harvesting and preservation. High-yielding forage crops can be grown on peat soils under proper drainage and fertilizer management. However, due to high-density stands, poor drying conditions, and low soil bearing capacity, harvesting and preservation present particular problems. Although total preservation as silage is possible, storage of part of the crop as hay is desirable in that it greatly reduces the load transported over a bog, and after storage, it can readily be transported for use elsewhere.

Experiments have been conducted with the provincial Division of Agriculture to develop a "versatile system" of harvesting and storing hay and silage under variable weather conditions. The system is based on a rapid cutting and conditioning operation, followed by pickup in a chopped condition from the windrow either as silage or high-moisture hay, depending on the weather. The silage is blown into a horizontal silo using the wedge system and the hay into a flued drying barn. Most field operations were performed with 35 hp tractors fitted with half tracks, but a light tracked carrier was superior for towing forage trailers. A good sod supported machines and trailers well for a number of passes, but repeated passes with heavy loads over the same track caused sod breakdown.

A rotary mower allowed the fast, trouble-free cutting essential for a system geared to changeable weather conditions and a standard hay conditioner was operable when fitted with oversize flotation tires. Two types of forage harvesters were used both for picking up material from the windrow and for direct-cut silage. The offset type required a flotation tire on the harvester end and a special track for the heavier blower section; two light tracks supported the in-line harvester. The latter type was most suitable for picking up material from the windrow, whereas the former was more suitable for direct-cut harvesting. Although a workable system was achieved by adapting normal farm machinery, forage was macerated rather than chopped and it was obvious that a special pickup chopper combination is needed for satisfactory harvesting. Feeding trials are being conducted to assess straight silage versus hay–silage feeding for pregnant ewes.

ENTOMOLOGY

Cabbage Maggot

Carbofuran (Furadan 10G.; Niagara Chemicals) at 5.6 kg ai/ha applied to the seed furrow at seeding gave almost complete root maggot control (95%) in swede turnips. A similar application applied along the row at seed-leaf stage gave 90% control. A split drench application of carbofuran (Furadan 4.8F.; Niagara Chemicals), half at seed leaf and half at thinning, gave 82% control. A single drench at seed leaf was ineffective because it gave only 51% control.

Swede turnip seed pelleted with carbofuran (Furadan 75 W.P. and S.P.; Niagara Chemicals) and sown at 0.3- and 0.6-cm spacings gave 78% to 85% root maggot control, but was less effective when seed was spaced 1.2, 2.5, and 5 cm apart. Carbofuran was not phytotoxic as a pelleted wettable powder. N2596 25 W.P. (Stauffer Chemicals), TF5021 (pirimiphos-methyl (PP511) 50 W.P.; Chipman Chemicals), and TF5022 (pirimiphos-methyl (PP211) 50 W.P.; Chipman Chemicals) were ineffective and caused 9% to 50% seedling reduction. All treatments were at 12 g W.P./28 g seed.

Thirteen insecticide treatments were tested for root maggot control in cabbage. Fonofos (Dyfonate 1.8 kg E.C., Stauffer Chemicals) and thionazin (Zinophos 1.8 kg E.C., Cyanamid of Canada Ltd.) gave 100% control, but 25% to 50% of the roots were slightly injured. Carbonfuran (Furadan., 10G. and 4.8F.; Niagara Chemicals) and N2596 25 W.P. (Stauffer Chemicals) gave effective control. Only 6% of plants in the control plots died of cabbage maggot attack.

Blow Flies

At Blaketown, Trinity Bay, pyrethrum dip concentrations of 0.062% and 0.031% gave 67% control of the blow fly *Calliphora terraenovae* Macq. on light-salted sun-dried codfish. Fish in the untreated control were 31% infested. Under similar conditions at

Blaketown, 0.031% pyrethrum dips could be used without any reduction in effectiveness.

Diazinon (Basudin 50 W.P.; Ciba-Geigy Canada Ltd.) used as a 0.04% dip solution gave sheep complete protection from attacks by the blow fly *Phaenicia sericata* (Mg.). In the control group, 23.5% of the animals were struck. Strikes were generally severe and one animal died before treatment could be applied.

Golden Nematode Control

Seven nematocide treatments were field tested for golden nematode control at Cupids. Cyst counts averaged 10.7 per gram of air-dried sieved soil before planting. DPX 1410 (10G. and 0.9 kg E.C.; DuPont of Canada Ltd.) at 0.5, 1.4, and 2.7 kg ai/ha had the lowest percent cyst increases at 15, 27, and 20 respectively. The untreated control plots had an average 51% increase.

Results from crop rotation studies established at Cupids in 1964 are now beginning to show nematode population trends. After 7 years, cyst counts per gram of soil from the various rotations were as follows: grass monoculture, 5.0; potato monoculture, 13.8; potatoes every second year, 10.6; potatoes every third year, 8.3; potatoes every fourth year, 9.6.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and Golden Nematode

Selection N48-237 derived from a cross of the wart-resistant variety Urgenta and the USDA seedling X96-56 has completed 2 years' trials at five centers in Newfoundland. It appears to be a promising replacement for Urgenta, because it is much less susceptible to both blackleg and common scab and produces attractively shaped tubers of uniform size. Yields and dry matter content are similar to those of Urgenta.

In tests of seedlings for resistance to race 8 of the wart fungus, selections bred from Mira and the Fredericton selection 5218 remained free from infection. Two selections equaled or outyielded Kennebec in performance trials.

Crossing of wart-resistant and eelworm-resistant varieties or selections was continued with 34,000 seeds produced from 70 crosses. Genes conferring immunity to viruses X and Y were present in some of the parents used.

No further reports have been received of wart infections occurring on Urgenta or Pink Pearl.

Germination and Infectivity of Potato Wart Sporangia

Further work was carried out on the potential for fluorochroming agents to indicate sporangial viability. As a first step, and as an extension of the initial findings, 27 fluorochroming agents were investigated to determine the concentration and pH level for optimum secondary fluorescence. Secondary fluorescence was induced by cationic fluorochromes of arylmethane, acridine, and quinone-imine dye classes at about pH 7.6 and molarity of 1×10^{-4}. Fluorescence was enhanced in the presence of physiological saline. Certain cationic dyes, however, failed to induce fluorescence. The quenching mechanism for these and the anionic dyes is not known. Acridine dyes fluoresced bright apple green when internalized in apparently nonviable sporangia; apparently viable sporangia fluoresced red, orange, or yellow.

The influence of water stress on wart development was examined at 50 C under controlled-environment conditions in the growth room. The greatest amount of wart developed at field capacity (100%) and some (25%) developed at half-available water level. Infection carried out at very low water availability failed to induce wart formation. Development was greatest at the lower of two concentrations of wart per gram of potting mix. This fact was demonstrated previously and remains an anomaly. To compare the influence of different treatments and environmental conditions a wart index (WI) was developed that equals the product of percent infection and the ratios of dry to fresh weight of plant and wart gall, and dry weight of wart to dry weight of plant. Wart indices are usually less than unity, but some were noted at 5 × unity when pregerminated tubers with sprouts 3-, 16-, and 17-mm long were grown in infested potting mix. WI were 2.7, 4.0, and 5.3 respectively.

PUBLICATIONS

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Research Station
Charlottetown, Prince Edward Island

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INTRODUCTION

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

During 1971, three research scientists joined the staff: Dr. K. C. Sanwal, Nematology, by transfer from the Entomology Research Institute, Ottawa; Dr. J. A. MacLeod, to fill a vacancy in Nutrition (forages and cereals); and Dr. J. A. Ivany, in Weed Control (vegetable, forage, and cereal), who was provided under the Prince Edward Island Development Plan to increase the research capability of the Station.

The new Dairy Research Center was completed at the Upton Farm in August 1971, and all cattle under the dairy breeding and nutrition programs were moved from the Charlottetown site to the Center. In July 1971 construction began on a new office-laboratory complex, which will house the Research Station staff and the Production, Extension, and Veterinary Services of the P.E.I. Department of Agriculture and Forestry. Completion of this extension is scheduled for September 1972.

This report and reprints of the publications listed are available on request. Correspondence should be addressed: Research Station, Research Branch, Canada Agriculture, P.O. Box 1210, Charlottetown, P.E.I.

L. B. MacLeod
Director

CEREALS

Breeding and Testing

Barley. A six-rowed barley strain, AB 9-1, resulting from a complex cross involving six varieties, has yielded well in Maritime trials during 1970–71. Because of its resistance to the barley jointworm, *Tetramesa hordei* (Harris), it should be particularly valuable in Prince Edward Island where this insect is a serious menace to barley production. The strain is also resistant to loose smut, *Ustilago nuda* (Jens.) Rostr.

Wheat. In regional yield tests, the spring wheat variety Ankra yielded an average of 3.4 q/ha more than Opal. The winter wheat selection WW 1001-1 was equal to Yorkstar in yield and hardiness.

Nutrition and Management

Timing of N fertilization for barley. A soil culture experiment with Herta barley in the greenhouse showed that a high rate of N fertilizer, applied at the second week after emergence and earlier, and at the sixth week and later, was not efficiently utilized. The highest grain yield was obtained when N as NH_4NO_3 was applied to the soil at 175 ppm at the third week after emergence.

Boron increases the yield of cereal crops. Greenhouse experiments showed that application of B at 0.25 ppm resulted in 30%, 25%, and 15% increases in kernel yields of wheat, barley, and oats, respectively. However, only 0.5 ppm added B resulted in B toxicity in wheat and barley associated with a reduction in kernel yield. Barley was the most sensitive to B toxicity, oats the least, and wheat intermediate. Field surveys indicated that, for cereal production, many Prince Edward Island soils are deficient in B, and could benefit from applications of 0.25 ppm.

Spring N increases yield and protein content of winter wheat. Grain yields were 2,500, 3,490, 4,030, and 4,100 kg/ha and protein contents were 9.9%, 10.4%, 11.6%, and 13.0% from winter wheat fertilized in the spring with N at 0, 34, 68, and 100 kg/ha, respectively. Yorkstar was the highest-yielding cultivar, followed by Genesee, Talbot, and Richmond. Although percent protein was lower in Yorkstar than in the other cultivars, total protein yield per acre was equal to that obtained with the lower-yielding cultivars

Genesee and Talbot and higher than that obtained with Richmond.

Cultural practices. One year's data of a study on seeding rate showed that for the spring wheat varieties Opal, Kolibri, and Janus, seeded at 1.3 to 3.4 q/ha, more plants were present at the higher rates, but the number of heads per plot and the yield were similar at all seeding rates. A cool, wet spring reduced germination to 60–75%.

Diseases and Insects

Because of late spring seeding, and the early appearance of grain aphids, largely the bird-cherry oat aphid, *Rhopalosiphum padi* (L.), barley yellow dwarf infections were very common on all spring cereals. Field experiments indicated that early seeding is a better means of reducing yield losses than is the use of chemical sprays for aphid control. General aphid populations declined rapidly in late summer, but low population levels of the corn leaf aphid, *Rhopalosiphum maidis* (Fitch.), were found on fall-seeded wheats late into the autumn.

Treatment of cereal seed with Vitaflo (UniRoyal Chemical) benefited the emergence and early growth of barley and wheat under the cold, damp conditions of early seeding. Both percent emergence and height of barley and wheat seedlings were improved by the treatment. Oats failed to respond to the treatment. Field trials showed that the most useful materials for treating seed were Vitaflo, which significantly increased yields of barley and wheat, and Milstem (Chipman Chemicals Ltd.), which induced significant yield responses in wheat alone.

The localized outbreak of the barley jointworm was as severe in 1971 as in 1970. Snow cover greatly reduced overwintering mortality (18% compared with more than 90% in 1969–70). However, infestations spread only about a mile southeast.

FORAGES

Nematology

Nematocides increase legume yields. Nemacur (Chemagro Corp.) and fensulfothion, applied before seeding, suppressed *Pratylenchus* spp. numbers in the years after seeding and increased forage yields. Yields from nematocide-treated plots in an area of high initial infestation were increased by 25%, 9%, and 29% from alfalfa, red clover, and birdsfoot trefoil, respectively; increases in an area of low initial infestation were 4%, 17%, and 4%.

Nematode population densities and forage yield loss. Field microplot studies showed that, when infestations of root lesion nematodes, *Pratylenchus* spp., in soil and roots were low, red clover forage yields were 24% and 12% higher in the seeding year and in the year after seeding, respectively, than yields from microplots with high nematode infestations.

Soil pH determines nematode effect on alfalfa. Greenhouse studies showed that reproduction of an introduced population of Pratylenchus penetrans (Cobb) Filip. & Stek. was significantly greater at pH values of 5.2 and 6.4 than at 4.4 or 7.3, and was not related to root production. A significant nematode infestation × soil pH interaction on forage yield was recorded. Nematode infestations significantly decreased forage yields at pH values of 5.2 and 6.4, but not at pH 4.4 or 7.3.

Nutrition

High rates of N fertilization increase grass yields. Yields of bromegrass increased linearly from 3,500 to 10,800 kg/ha per year when rates of N fertilization were increased from 0 to 448 kg/ha per year applied as a split application, half in the early spring and half after the first cut. Timothy yields increased linearly from 3,000 to 8,800 kg/ha per year when N was increased from 0 to 224 kg/ha per year. Yields of bromegrass and timothy were similar when N was applied at 112 and 168 kg/ha, but bromegrass gave higher yields than timothy at higher and lower N rates. When N was applied at 224 kg/ha per year, highest yields of both bromegrass and timothy were obtained when 84 kg were applied in early spring and 140 kg after the first cut.

Boron nutrition of forage legumes. The optimum levels of B in alfalfa and red clover tissues, associated with maximum yield, were in the range of 45 to 55 ppm and 25 to 35 ppm, respectively. In the absence of added B, liming the soil to pH above 6.3 significantly decreased the yields of these crops.

Corn nutrition. When fertilizer K was

withheld for the third year, the yield of corn silage or of the grain component was reduced only slightly. Fifty-six kg N/ha was apparently sufficient for the yield of 8,000 to 9,000 kg/ha produced, and this rate also increased the dry matter of the grain component. Phosphorus increased both yields and percent dry matter of silage and grain.

Physiology and Management

Cutting management of alfalfa. Field experiments have shown that, by removing the first crop of Saranac and Narragansett alfalfa at the bud stage, and the second and third crops at early bloom, three cuts could be harvested before the fall rest period. This resulted in average dry matter yields of 7,300 kg/ha, with a protein content of 17% and an in vitro digestibility of 62% in the first- and second-year stands. However, by the third year, stands under this cutting system were thinned and dry matter yields lowered. Harvesting alfalfa at the vegetative stage, followed by two cuts at early bloom and one in late October, resulted in high first-year yields, a considerable reduction in the second-year stand, and an almost complete disappearance of alfalfa by the third year. Initial harvest at bud to 50% bloom, a second cut at early bloom, and a late-fall harvest resulted in good survival and equal or higher dry matter yields than from stands cut three times before early September. In the first cut, the decreases in protein content and in vitro digestibility were due to advanced maturity.

Carbohydrates in grasses. Gel-filtration fractionation of water-soluble carbohydrates in base stems of forage grasses showed that timothy and orchardgrass contained two main groups: long-chain fructosan and sugars; whereas the carbohydrates of bromegrass consisted of three main groups: long-chain fructosan, short-chain fructosan, and sugars.

Diagnosis of plant damage. An accurate and rapid method for determining cold damage of forage legumes, based on measurement of exudates released from the root tissue, was developed. Alfalfa roots injured by cold temperatures released up to three times as much K and 40 times as much sugars as undamaged roots. Although the exudation rate was less affected by nematode infestation, marked changes in color and intensity of fluorescence occurred in infested roots.

Seeded forage species vs. volunteer forage species for grazing. The productivity (forage production and animal gains) of seeded forages and a native volunteer stand, predominantly bluegrass, was measured for two consecutive years. Seasonal dry matter production (metric tons) and animal gains (kg/ha) were: Champ timothy—12.43, 360; Champ timothy - Empire birdsfoot trefoil—11.51, 337; Redpatch bromegrass—11.47, 306; and natural sward—11.24, 345. Under high fertilizer treatments and careful grazing management, the stand of bromegrass was reduced by an estimated 50% and birdsfoot trefoil by 98%. Volunteer wild white clover constituted 15% of the pasture forage and Kentucky and Canada bluegrasses infiltrated all seeded swards.

Parasite on clover root curculio. The Palaearctic braconid parasite, *Pygostolus falcatus* (Nees), was recorded from Prince Edward Island in 1971 for the first time in North America as parasitic on the clover root curculio, *Sitona hispidula* (F.). Up to 37% of the curculio adults examined were parasitized.

HORTICULTURAL CROPS

Potato Nutrition and Management

Plots on which potatoes had been grown continuously without fertilizer for 20 years were fertilized with 10-20-20 at 3,600 kg/ha plus ground dolomitic limestone at 2,240 kg/ha. Potato yields were increased from the former 5 metric tons/ha to 21.4 metric tons/ha in 1 year.

In a greenhouse study, the N component, especially in the form of NH_4NO_3 and $NH_4H_2PO_4$, of a mixed fertilizer was responsible for the release of large amounts of soil Mn. Lime applied with the fertilizer partly offset this Mn release.

Plant spacing of 28, 38, and 46 cm had no effect on total yield of Netted Gem potatoes in a N × K × spacing factorial experiment. However, increased spacing significantly increased the percentage of larger tubers. Total yields increased with N and K applications up to 55 and 56 kg/ha, respectively, and there were no interactions. Tuber specific gravities were reduced by K applied in either the current or previous year and, to a lesser extent, by currently applied N.

Simulation analysis of important variables

in potato harvesting in New Brunswick and Prince Edward Island indicated that, for conventional harvesters operating at 0.28 ha/hr, in enterprises of 49 ha, management returns per hectare were $22 higher in Prince Edward Island. The conventional harvester in Prince Edward Island showed management returns per hectare $4 higher than the air vacuum harvester in New Brunswick for this same enterprise size. The conventional harvester in New Brunswick showed management returns per hectare $35 higher than the hand-barrel procedure in New Brunswick. The optimum crew size for the hand-barrel procedure is 30 persons in an enterprise of 49 ha when the picking rate is 450 kg/hr. An examination of the relationship between management returns per hectare and enterprise size indicated that, for a range of 32 to 162 ha, 65% of the cost reduction was achieved at 57 ha.

Potato Insect and Disease Control

Important qualities of resistance and susceptibility to fusarium storage rots and verticillium wilt were noted as a guide to breeding and possible varietal introduction. The variety Dorita proved to be immune to decay caused by *Fusarium coeruleum* (Lib.) Sacc. The variety Wauseon and three Fredericton seedlings showed high resistance to wilt caused by *Verticillium albo-atrum* Reinke & Berth. Virus-free tuber stocks of the varieties Sebago and Kennebec were much less susceptible to decay caused by *Fusarium sambucinum* Fckl. f. 6 Wr. than those infected with viruses X and S. The systemic compounds Benlate 10% dust (DuPont of Canada) and NF44 5% dust (Ciba-Geigy Canada Limited), when applied to cut seed at 10 g dust/kg seed, were effective in the control of seed-borne verticillium wilt and fusarium seed-piece decay.

The most efficient control of potato late blight disease, caused by *Phytophthora infestans* (Mont.) de Bary, was provided by Bravo W75 and Bravo 6F (Diamond Shamrock Corporation), a captafol (Difolatan 4.8 Flowable; Chevron Chemical Co.), mancozeb, and Polyram (Niagara Chemicals). After several years of testing, it has been concluded that fungicides formulated from either fentin acetate or fentin hydroxide should not be recommended for potatoes in Canada because of their phytotoxic reactions.

Corn oil concentrate effectively replaced the diesel or fuel oil currently being added to dinoseb or dinitro-type potato top-killing spray mixtures and eliminated the possibility of the tubers acquiring an oily flavor.

A multiple regression equation for estimating losses in tuber yield caused by late blight on the foliage has been derived. Data from earlier field experiments showed that the difference between estimated loss, computed from the equation, and actual loss, derived by weighing, has been less than 5% in 90% of the comparisons made.

Crucifer Nutrition and Management

New clubroot-resistant rutabaga. A purple top rutabaga that has greater clubroot resistance than the variety York has been developed from crosses made in 1967 between green top Wilhelmsburger and purple top York. After 4 years of rutabaga production in a field infested with race 2 inoculum, Wilhelmsburger and the new line showed no evidence of disease in 1971, but York roots developed 41% infection. Clubbing, which occurred in York, is believed to be due to an aberrant of race 2 overcoming the single-gene resistance of this variety.

Effect of N, P, and K on rutabaga yields. In experiments conducted at nine locations over a 3-year period, banded applications of N and P have generally increased the yields of rutabagas, whereas applications of K have had little effect. Optimum yields were obtained where N was applied at 90 to 112 kg/ha and P at 49 to 74 kg/ha. At one location, where the initial soil K level was low, yields of marketable rutabagas were increased from 28.2 to 34.9 metric tons/ha by the application of K at 124 kg/ha.

Boron levels to prevent brown heart of rutabagas. A B content of less than 6.0 ppm in the tissue at the five-leaf stage of plant development was related to very severe brown heart. Optimum levels of B in the leaf tissue were in the range of 24 to 45 ppm. Under severe B deficiency conditions, brown heart was associated with rough or netted and elongated roots. Soil levels of 1.1 to 1.8 ppm available B were found to be optimum for producing rutabagas free from brown heart.

Once-over harvest for broccoli. Single-harvest marketable yields of broccoli of 6.7 metric tons/ha can be achieved with currently available varieties such as Gem Hybrid. To

achieve such a yield at a single harvest, it is necessary to increase plant population to 60,000 plants/ha in equidistant planting patterns. It is necessary to increase the N application by 112 to 140 kg/ha over conventional rates for maximum single-harvest yields of high population plantings. The optimum harvest period extends over a 3- or 4-day period beginning and ending when about 11% and 23%, respectively, of the spears are overmature.

Control of weeds in cole crops. Nine herbicide treatments were evaluated for weed control and crop tolerance on cabbage, Brussels sprouts, broccoli, cauliflower, and rutabaga. All herbicides gave 60–80% weed control with DCPA, propachlor, and niclofen (TOK-25; Rohm & Haas Company), all preemergence, at recommended rates being safe on all crops. Trifluralin (incorporated) caused slight reductions in germination and plant weight, but gave better weed control than in past years. A troublesome weed in cole crops is shepherd's-purse, *Capsella bursa-pastoris* (L.) Medic., because it is not controlled by common cole crop herbicides.

Control of Insects on Crucifers

Bioactivity of soil insecticides. The method of application of an insecticide in the soil determines its longevity. Persistence of a short-term residual material, such as Dursban (Dow Chemical of Canada Ltd.), when applied to the soil surface, could be prolonged to control insects by banding the compound at a depth of 3 cm. Trichloronat, which is highly persistent and relatively inactive when banded below the surface, can be more quickly activated and degraded by application to the soil surface.

Two carbamate compounds, carbofuran and C10015 (Giegy Agricultural Chemicals) were the only compounds tested that permeated upward from the subsurface band and killed adult insects on the soil surface. Toxicants of a new material, AC92100 (Cyanamid of Canada Ltd.), were much more persistent than the closely related compound phorate. No evidence of carbamate or organophosphorus resistance occurred after 6 successive years of testing in the same field.

Other Crops

Aster yellows control in carrots. Carbofuran at 2.24 kg/ha, when placed at 1.2 or 5 cm below the seed at planting, significantly reduced carrot yellows at harvest when compared with the untreated checks and a bromophos spray treatment. Supplementing the in-furrow treatment with a carbofuran foliar spray in mid-July was of no benefit.

Strawberry green petal. Sprays with DuPont 1410 (DuPont of Canada Ltd.), endosulfan, or Meta-Systox (Chemagro Corp.) were slightly more effective than a single application of granular carbofuran or phorate in reducing the incidence of the strawberry green petal disease. The strawberry cultivars or selections Gorella, Veestar, Vibrant, Kentville 60-98, Kentville 64-462, and Ottawa 55-01-01 exhibited some resistance to the disease-causing organism, or the leafhopper vector showed less preference for these varieties. A 1971 survey of first crop plantings indicated averages of 1.8%, 2.7%, and 7.5% infected plants in the cultivars Cavalier, Redcoat, and Sparkle, respectively.

TOBACCO

Nematode control. Vorlex drilled in at 23.4 liters/ha, fensulfothion broadcast at 11.2 kg/ha, and DPX 1410 (DuPont of Canada Ltd.) in transplant water at 2.24 and 4.48 kg/ha, applied to flue-cured tobacco to control root lesion nematodes, reduced nematode populations and did not affect root development.

Cutworm control. The red-backed cutworm and the black cutworm are the dominant species in tobacco in Prince Edward Island, less than 1% being the dark-sided species. Severe infestations of the red-backed cutworm were found only in areas with a high content of organic material (as in recently plowed headlands), and the black cutworm was abundant in well-sheltered areas. In a test plot, treatments of trichloronat, thionazin, N2596 (Chipman Chemicals Ltd.), leptophor, and Dursban destroyed cutworm larvae, but the insecticides also destroyed large numbers of carabid beetles and other insects. Because infestations depend on cultural practices, detailed investigation on attraction of moths to oviposition sites is required.

ANIMAL NUTRITION

Cull potatoes for steers. Holstein steers gained 1.3 kg/day over a 6-month period when fed potatoes, free choice, plus 1 kg hay and 1 kg protein supplement with one-half the supplemental protein provided as urea. This demonstrated the ability of such a diet to support rapid weight gains in steers over a prolonged feeding period when adequately supplemented with minerals and vitamins.

Urea for young calves. The addition of 0.1% elemental S to calf starter containing 2.6% urea did not improve animal performance when fed to Holstein bull calves weaned at 5 weeks of age. In another trial, a low protein starter was supplemented with 1.5% or 2.7% urea to give crude protein levels of 12.1%, 16.5%, and 20.5%. Daily feed intakes were 3.6, 4.7, and 4.8 kg; daily gains were 0.9, 1.4, and 1.5 kg; and feed-to-gain ratios were 3.95, 3,36, and 3.30 for the low, medium, and high protein starters, respectively.

Costing beef enterprises. Budgeted break-even prices for the cow-calf, short-keep, and long-keep feeders (on a corn silage and barley ration) were estimated to be 64, 60, and 65 cents/kg, respectively, under closely prescribed circumstances.

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Research Station
Kentville, Nova Scotia

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Departures

H. B. CANNON, B.S.A., Ph.D. Retired April 1, 1971	Statistician
F. T. LORD, B.S.A., M.Sc. Retired June 1, 1971	Ecology of insect predators

INTRODUCTION

This publication is a summary of the main research results of the Research Station at Kentville and the associated Experimental Farm at Nappan for 1971. During the year a toxicologist was added to the staff to study the effect of pest control methods on the environment. A fluidized bed freezer and drier was installed in the Food Technology Laboratory.

Copies of this chapter and reprints of the listed publications are available on request from Research Station, Research Branch, Canada Department of Agriculture, Kentville, Nova Scotia.

J. R. Wright
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush Blueberries and Cranberries

Soils with a high percentage of gravel or stony material provided the most favorable conditions for the germination of seeds and the growth and development of lowbush blueberry seedlings. In this experiment four soil series varying from a gravelly loam to a clay loam were tested. Roots of plants grown in sandy soil with few stones were spindly and had minimum development of branching or small roots. Roots of plants grown in fine-textured soils were only a quarter of the weight of roots of plants grown in the gravelly loam.

Lowbush blueberry plants fertilized with P and S at 56 kg/ha produced significant increases in stem numbers, length of stems, and numbers of fruit buds per stem compared with plants receiving no fertilization. In this experiment the application of N at 56 kg/ha was not beneficial.

Seeds of the lowbush blueberry germinated readily when extracted from fresh fruit and sown immediately. In this experiment 2,852 seeds from 18 crosses had an overall germination of 80% in a greenhouse at a temperature of 21 C.

Significant differences were found between clones in the number of cuttings rooted and the size of the root balls after transplanting. Success in rooting varied from 73% to 100% in the 16 clones examined.

Lowbush blueberry plants tolerated 0.0 C and -1.1 C for as long as 6 hr without impairment of fruit set. The set was reduced when temperatures of -2.2 C and -3.3 C were maintained for 4 and 6 hr but not for 2 hr. The experiment was carried out in a growth chamber with half the plants treated before and half after pollination. Plants exposed to -1.1 C for more than 4 hr and -2.2 C for shorter periods produced smaller and later-ripening berries than those exposed to higher temperatures.

Acetaldehyde and ethyl alcohol were identified as the two volatiles in nectar from lowbush blueberry flowers. Nectar samples were separated from 50 blossoms by using a centrifuge, and determinations of volatiles were made by means of gas-liquid chromatography.

The water level in the growth medium produced significant differences in growth in cranberry plants grown in a garden soil–peat–sand mix in containers. Plants grown in the high (5.5 cm from the surface) water level made the fastest initial growth but slowed down significantly toward the end of the 5-week experiment. Plants at the medium (19.5 cm from the surface) water level made the most total growth, whereas those at the low (34.5 cm from the surface) water level made little growth until the final week of the experiment. Root development was affected by water level; the most extensive system was produced by the medium water level.

Highbush Blueberries

Within the pH range of 3.5 to 6.0, growth of the cultivar Blueray did not appear to be limited because of the direct effect of pH. At pH 2.5, however, growth was nonexistent and at pH 3.0 it was restricted. The growth of seedling 50-6-9 was significantly greater at pH 4.0 and 5.0 than at pH 3.0 or 6.0. Plant roots became progressively darker as the pH increased from 4.0 to 4.5. In general root

nutrient levels, Ca excepted, were higher than foliar nutrient levels, although root and foliar Mg levels were not very different except at pH 3.0. Root Mn at pH 5.0 and 6.0 was 10 to 20 times greater than at pH 3.0 or 4.0.

Strawberries

Strawberry plants that were outdoors from August 28 to November 6 and then chilled at 0 to 2 C in the dark for 6 weeks produced the best plants for breeding. Runner tips were rooted in late August and placed in four different environments for varying lengths of time in an attempt to hasten the development cycle for breeding purposes. Plants that remained outdoors and were then chilled for 9 weeks and those that received their flower induction period in a growth chamber followed by 6 weeks of chilling were also satisfactory for early-winter plant-breeding experiments in a glasshouse.

Limestone applications that increased the soil pH value to 5.25 to 5.60 resulted in increased strawberry yields at early harvest dates in 2 of the 3 years of an experiment to test the effect of six rates of dolomite limestone on fruit yield and nutrient status. The soil before treatment had a pH of 4.4 and exchangeable Ca and Mg of 1.32 and 0.15 meq/100 g respectively, which is characteristic of many strawberry soils in the area. Seasonal total yields from plots having a pH of 5.25 to 5.60 were higher than those from unlimed plots, and the advanced maturity resulting from them may be as important an economic factor as total yield.

Over a 3-year period yields of the cultivar Acadia were not influenced by applications of up to 200 kg/ha of 20% superphosphate. The soil, after liming to adjust the pH from 4.6 to 6.8, contained 40–60 ppm P. Foliar levels at flowering were 0.23–0.31% and these levels were associated with optimum fruit yields.

Apples

Foliar absorption of Mg from sprays of 0.05 M $MgSO_4$ (Epsom salts) plus 0.0375 M $Ca(NO_3)_2$ was greater than from 0.10 M $MgSO_4$ alone and equal to absorption from 0.05 M $Mg(NO_3)_2$. The last costs about 2.5 times as much as the $MgSO_4$–$Ca(NO_3)_2$ mixture.

Sprays of succinic acid 2,2-dimethyl hydrazide (Alar, Uniroyal Chemicals) at concentrations as low as 62.5 ppm in three sprays delayed the drop of McIntosh cultivar apples. In these experiments the response to Alar was proportional to the amount applied and independent of the number of sprays. With one spray of 500 ppm at 12 weeks before harvest the response was the same as from four sprays of 125 ppm each, applied at 12, 9, 6, and 3 weeks before. Sprays of 250 ppm delayed a 10% drop 4 days and sprays of 1,000 ppm delayed it 8 days.

Vegetable Crops

Equivalent rates of N, P, and K fertilizers resulted in lower N, P, and K plant tissue levels in onions grown on previously uncropped sphagnum peat than on peat cropped for the previous 5 years. Yield data indicated that initially, previously unfertilized sphagnum peat should receive N, P, and K at 275–300, 40–50, and 70–80 kg/ha respectively.

The epidermal layers of roots of carrots grown on peat contained more ascorbic acid and less phenol, carotene, reducing sugars, and dry matter than those from mineral soils. The increased level of phenol and the decreased level of the antioxidant ascorbic acid are the likely contributing causes of the increased browning of carrots in mineral soils compared with peat soils.

Significant increases in linear growth (5% to 30%) of Scotia cultivar tomato plants were obtained and also significant increases in uptake by the plants of K, Ca, and P when direct currents applied to reinforce the endogenous current were between 15 and 3 μ amp per plant with the plant negative to ground. A reduction in growth occurred when the plants were treated with 15 μ amp positive to the ground or with any currents of magnitude greater than 30 μ amp per plant. The increased ion accumulation seems to be merely a passive movement under the applied potential, and it is thought that small currents may stimulate active ion pumps or alter the internal distribution of growth-regulating compounds in a somewhat erratic manner.

Field Crops

The effect of N on both leaf composition and yield of hybrid corn (*Zea mays* L.) was mainly linear and much greater than the effect of either P or K. In fertilizer trials conducted on 6 soil series at 14 locations during a 6-year period, applied N had an effect on leaf N at 10 locations, applied P on leaf P at 5, and applied K on leaf K at 6. There was a yield effect from N at 10 locations, P at 4, and K at 1. The results indicated that factors other than nutrient supply affected yield and that N, P, and K at 100–150, 30–45, and 30–40 kg/ha was generally adequate.

Leveling the ground with a spike-tooth harrow rather than a chain harrow did not significantly alter the appearance or subsequent yields of barley sown on frozen ground in April. In this experiment the cultivar Herta was sown at 4 weekly intervals beginning April 8. Incorporation of 381 kg/ha of 17-17-17 fertilizer on May 11 did not increase yield over the same amount broadcast on the surface. The main advantages of this "on the frost" system of seeding, compared with the conventional method of delay until the ground is thawed, are early grain maturity and greater freedom from disease. The average yield from the "on the frost" seeding was 3,226 kg/ha.

PROTECTION OF CROPS AGAINST PESTS

Insect Pests

Maximum rates of increase of the apple aphid, *Aphis pomi* De Geer, occurred during the first 5 weeks in an experiment in which aphids were reared on 1-year-old apple trees in a controlled environment cabinet. The simulated daylength–temperature conditions were those of mid-June to October. Maximum populations were obtained in 7 weeks or at the time the trees stopped growth. This occurred when the diel photoperiod was 14.8 hr, and light/dark temperature was 20.5/15.5 C. The ratio of nymphs to adults increased from 5:1 to 10:1 from week 2 to week 8, and then rapidly decreased. At week 12 there were more adults than nymphs and the nymph-to-adult ratio remained 1:3 through the remainder of the experiment. Alate aphids appeared 2 weeks after infestation and increased sixfold per week to a maximum at the end of 6 weeks. The aphids declined rapidly in number and were not seen after week 11. As the numbers of alate aphids decreased, apterous adults increased to week 12, remained constant to week 15, and slowly decreased with the shorter daylengths and lower temperatures. The rate of increase of apterous adult aphids was similar to the rate of accumulated degree-days during the first 8 weeks and again in the 10- to 15-week period. Aphids were concentrated on the tree tops during the first 6 weeks of the experiment. A gradual migration followed and the aphids became dispersed over the trees with minor concentrations near the centers.

The number of winter eggs of the European red mite, *Panonychus ulmi* (Koch), consumed per day by six species of miridae in a laboratory experiment compared favorably with the known predatory habits of these mirids under apple orchard conditions. The six species, common to apple trees in Nova Scotia, were used to develop laboratory rearing and feeding techniques for comparing the abilities of predators to consume prey. Both laboratory and orchard sources of information were used to give the predators a tentative rating. The mirids *Hyaliodes harti* Knight, *Diaphnocoris pellucida* (Uhler), *Pilophorus perplexus* Douglas & Scott, and *Blepharidopterus angulatus* (Fallen) are effective predators, approximately equal to each other in ability to consume the winter eggs of the red mite. The two species *Campylomma verbasci* (Meyer) and *Atractotomus mali* (Meyer), which are phytophagous as well as predacious, were less voracious. The results indicated that it may be feasible to develop a series of weighting factors, one for each stage of each predacious species, based on ability to consume prey.

Both the hairy woodpecker, *Dendrocopus villosus villosus* (Linnaeus), and the downy woodpecker, *D. pubescens medianus* (Swainson), were shown to be efficient predators of the larvae of the codling moth, *Carpocapsa pomonella* (Linnaeus). This information was obtained in a census of woodpeckers in 33 orchards in which predation of larvae was related to the number of woodpeckers observed.

Calcium arsenate dust applied when the relative humidity was 70% did not cause appreciable injury to the foliage of the lowbush blueberry. At 90% relative humidity there

was marked burning and considerable defoliation. The amount of injury was the same whether the dust was applied at 8.9, 17.8, or 26.7 kg/ha. The dust is used to control the blueberry maggot, *Rhagoletis mendax* Curran.

Plant Pathology

The Kentville strawberry selection K63-280 and the cultivars Redcoat and Elista were the least affected (5% or less) by green petal in a test of 13 cultivars and selections exposed to natural infection in a field test. The most affected was the cultivar Tioga; 56% of the plants showed the disease followed by Sparkle 24% and Vesper 20% with the others intermediate.

More isolates of *Gnomonia fructicola* (Arn.), the organism that causes stem and fruit rot of strawberry, formed perithecia on Leonian's agar than on potato-dextrose or cornmeal agar. Fortifying these media with a strawberry petiole extract stimulated perithecium formation on potato-dextrose agar but not on Leonian's or cornmeal agar. All eight isolates studied produced perithecia on strawberry petioles and one produced them only on petioles. The eight isolates were segregated into four cultural races according to their ability to form perithecia on the agar media and petioles.

Chloroneb was the only one of nine fungicides that gave satisfactory control of *Typhula* sp. mold on cold-stored strawberry plants with no phytotoxic effects. The fungicide-treated plants were inoculated with *Typhula* and stored at −1.1 C for 6 months.

A severe foliage infection caused by *Stemphylium botryosum* Wallr. was found on tomato plants in a greenhouse in Nova Scotia. The symptoms of the disease were similar to those described on field tomatoes in Israel. The tomato isolate produced only sterile perithecia, but its morphological similarity to an ascospore producing isolate from strawberry and the perithecial primordia, which formed in cultures, identified it as the asexual form of *Pleospora herbarum* (Fr.) Rabh.

Pesticide Residues

No amitrole was detected in samples of fruit from lowbush blueberry plants growing in plots treated with a spray containing 50% wettable powder at a rate of 5.6 kg/ha active ingredient. The result was the same whether the spray was applied to the blueberry plants in the late fall, before burning the next spring, or to new sprouts in the fall after burning in the spring.

No simazine residues were found in strawberry fruit from plants to which simazine had been applied for weed control 1 year previously. About 14% of the simazine remained in the soil to which up to 4.48 kg/ha had been applied 15 months previously.

The long-term persistence and effects of DDT, As, BHC, chlordane, S, ferbam, and parathion applied to a sandy loam in 1949–1953 were investigated in a field experiment during the period 1959–1969. Applications of DDT significantly decreased the yield of beans 16 years after application. More than 50% of applied DDT and As remained in the soil for 15 and 16 years respectively. Traces of parathion were detected in 1969. Plant N content was affected by both As and DDT treatments and the DDT residues changed the soil fauna.

Residues of technical BHC, DDT, and chlordane present in a sandy loam soil 15 years after the last application were 7.5%, 55%, and 16% respectively of the amounts applied. BHC residues consisted of the α, β, γ, and δ isomers at relative percentages of 36, 36, 16, and 12. The β isomer was the most persistent. DDT residues consisted chiefly of *p,p'*-DDT, *o,p'*-DDT, and *p,p'*-DDE. Residues in chlordane-treated plots were principally α- and γ-chlordane. There was little downward or lateral movement of these insecticides in the soil in 15 years.

STORAGE

The rate of output of total aroma factors from McIntosh apples collected at various stages of maturity increased with time. The aroma factors were identified as acetaldehyde, ethyl acetate, ethyl alcohol, ethyl propionate, ethyl butyrate, and caproaldehyde. Although the total output of all factors increased over the test period, the output of ethyl propionate and caproaldehyde decreased. The apples were stored at 0 C in air and tested once a month for rate of volatile production.

There was no consistent relationship between core browning of McIntosh apples and either position in the blossom cluster or stem-cavity depth. The incidence of stem-cavity browning and core browning increased

with an increase in fruit size. Stem-cavity browning was more severe in terminal apples than in lateral apples and decreased with increase in stem-cavity depth.

A temperature differential of 14.0 C was maintained for 8 days between cased apples in pallets with wrap-around insulation containing blocks of dry ice in ordinary ship stowage and apples stowed in the conventional way. The results were obtained in experiments designed to simulate conditions on cargo vessels lacking cooled space traveling from Halifax to Caribbean ports. The results were subsequently confirmed in a trial shipment of apples to Jamaica.

FOOD TECHNOLOGY

A new test was developed to provide a rapid means of grading instant potato flakes. The test consisted of making measurements of the consistency of reconstituted potato flakes with a mixer equipped with an electronic dynamometer. The records show how consistency is developed during mixing, the maximum consistency, and the time taken to reach it. The effect of excessive mixing on texture can also be observed. The test provides a rapid means of grading potato flakes.

Cranberries that were frozen and thawed twice before extraction produced juice with higher titratable acidity and total anthocyanin content than berries frozen either once or four times before extraction. The twice-frozen berries also gave a slightly increased juice yield with slightly decreased soluble solids. The freezing treatments produced juice superior to that from fresh berries.

Extraction by a pectin enzyme prior to pressing of the ground cranberries was superior to pectin enzyme treatment after pressing or extraction without any pectin enzyme. Yield, titratable acidity, and soluble solids were increased; the total anthocyanin content varied slightly depending on the pre-extraction treatment.

ANIMAL SCIENCE

Poultry

The motility and fertilizing capacity of avian spermatozoa was enhanced when semen was stored in an air or nitrogen environment at 21 atmospheres for 7 hr at 11 C. Fertilizing capacity was totally destroyed when semen was stored in an oxygen or carbon dioxide environment.

An improved storage method for eggs resulted in the higher hatchability of broiler chicks, lower mortality, higher growth rate, and higher monetary returns to 8 weeks of age compared with chicks hatched from eggs stored under standard conditions. The improved storage method consisted of eggs packed on fiber trays with the small end up, enclosed in gas-impermeable plastic and flushed with N. The conventional manner consisted of eggs packed on fiber trays with the small end down. There were no significant differences in the performance of chicks hatched from eggs stored for 3 and 4 weeks under the improved storage method and chickens hatched from eggs held only 48 hr prior to incubation. The deleterious effects on chick performance associated with prolonged storage under conventional methods can be reduced or eliminated by using this improved egg-storage method.

In two experiments with 8,800 chicks of four commercial genotypes, increasing the level of fish meal from 4% to 10% at the expense of soybean meal resulted in a significant positive growth response, which was not affected by a further increase in fish meal to 15%. Fish meal at 20% resulted in lower weights at 63 days of age in both experiments and significantly higher mortality in one experiment. A higher fat, lower protein type of fish meal fed at 15% of the diet resulted in the highest growth response in the first experiment but was not repeated in the second experiment.

Supplementing six finisher diets with activated charcoal for 21 days before slaughter resulted in increased growth, an increased proportion of Grade A carcass weight, and increased monetary gain when charcoal cost was considered equivalent to regular feed cost.

Cattle and Sheep

For the 4th year tests of wintering pregnant cows in the woods indicated that they suffer more from muddy, wet conditions than

from rain or snow. Experience this year indicated that dry footing and some overhead protection must be provided for calves born outside during this period of the year. Heavy snow, 160 cm, in December discouraged the cows from traveling in the woods, and they never did move very far from the feeders all winter. Wet snow in April when the cows were calving produced wet, sloppy conditions around the feeder. The cows appeared uncomfortable and the cold wet conditions under foot had a severe effect on the calves. Calf losses were 35% compared with 5% during the preceding three winters.

Silage made from oats proved to be equal to or better than grass silage with a higher digestibility as measured by gains made by Brown Swiss and Jersey crossbred heifers. The dry matter and digestibility as fed was 25.7% and 60.1% respectively for the grass and 24.3% and 53.5% for the oat silage. The silages were fed for a period of 83 days beginning November 25. Silage consumption was high. The Brown Swiss heifers consumed more grass than oat silage, but the reverse was true for the Jersey heifers.

Early breeding of Shropshire ewes was induced by the use of hormones. Results indicated that not only is out-of-season breeding possible, but more multiple births may result from hormone-induced estrus. In this experiment a Shropshire ewe, bred to a Dorset ram, gave birth to four lambs on November 3.

The growth of ewe lambs of the Shropshire breed declined and in some cases ceased at the end of July, when they grazed permanent pastures. This decline in growth coincided with a decrease of about three orders of magnitude in the numbers of viable rumen bacteria. At the end of July, an increase of one to two orders of magnitude was observed in the numbers of viable fungi collected from the pastures. Lambs grazing pastures developed from tidal marsh of the Bay of Fundy had a better growth performance than lambs grazing adjacent pastures developed from mixed conifer–deciduous forests. The forest soils supported a greater fungal population than the marshland soils, and several species were found predominantly on the forest soils.

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Research Station
Fredericton, New Brunswick

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C. VEER	Soil survey in Prince Edward Island
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Departures

L. M. BROWNLEE (Mrs.), B.Sc., B.A., B.L.S. Transferred to Department of the Environment, October 1971	Librarian
F. WHITING, B.Sc., M.Sc., Ph.D., F.A.I.C. Died May 12, 1971	Director

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[1] On transfer of work at Foundation for Agricultural Plant Breeding, Wageningen, The Netherlands; July 1971 to July 1972.

[2] On educational leave, University of Illinois, Urbana, Ill., USA.

VISITING SCIENTISTS

National Research Council postdoctorate fellows

R. E. HANNEMAN, B.S., M.S., Ph.D.	Haploid breeding and genetics
K. F. HARRIS, B.S., M.S., Ph.D.	Aphid-borne viruses

INTRODUCTION

The Research Station at Fredericton is the principal site in Canada for research on the potato crop with emphasis on breeding and genetics, pest and disease management, agricultural engineering, and soil and crop management. It is also the Atlantic center for research on animal nutrition and soil survey.

We record with regret the death of the Director, Dr. Frank Whiting, on May 12. His contribution to agriculture was significant, as a scientist researching animal nutrition at Lethbridge, subsequently as a Research Coordinator, and then as Director of this establishment.

This report summarizes the research accomplishments in 1971. Additional information can be obtained from reprints of publications or through communication with the Station. Correspondence should be addressed: Research Station, Research Branch, Canada Department of Agriculture, Box 280, Fredericton, N.B.

G. M. Weaver
Director

ANIMAL NUTRITION

Full-fat Soybean Flour in Milk Replacers

Milk replacers containing only milk protein or 25% of the total protein from full-fat soybean flour were fed to lambs and analyzed for digestibility, N balance, and growth responses. Edible lard was the primary fat source. Digestion of dry matter, N, and energy in the milk replacers averaged 93%, and N retention 53%, and were not affected by the protein source. Growth rates of lambs to slaughter at 18 kg liveweight averaged 218 and 223 g/day on the all-milk and full-fat soybean diets. Carcass dressing averaged 49% for all lambs. Energy digestion by lambs fed milk replacers containing 30% or 60% of the total protein from full-fat soybean flour, with bleachable fancy tallow as the primary fat source, averaged 92%, compared with 88% on the all-milk protein diet. Nitrogen retention was somewhat lower on the higher level of soybean flour than on the other two formulas (55% vs. 62%).

Commercial and Experimental Milk Replacers for Lambs

A commercial milk replacer (Ewelac) was superior to experimental formulas containing 25–35% fat, for lambs to 4 weeks of age. However, growth rates to 20 kg liveweight were similar for the commercial and experimental products (232 vs. 218 g/day). The commercial milk replacer produced better carcass quality (dressing, finish, and color) than the experimental replacers at slaughter weight (18 kg), but was not superior to concentrates and hay after weaning.

Fish and Soybean Proteins in Milk Replacers

A milk replacer in which the protein was supplied by equal parts of isopropanol-extracted fish and soybean protein concentrates was compared with an all-milk protein milk replacer in daily feedings. Calves were weaned abruptly when consumption reached 0.5 kg/day of starter concentrate or at 5 weeks of age. The growth rate to weaning was lower on the fish–soybean formula (283 vs. 364 g/day). However, daily gain to 15 weeks (630 g) and digestion of dry matter, N, and energy were not affected by protein sources. Retention of absorbed N was greater on the all-milk protein formula (54% vs. 45%).

Milk Replacer pH and Gastrointestinal Effects

The growth rate of calves increased by 15% when the pH of a milk replacer containing 23% partially delactosed acid whey powder was raised from 5.8 to 6.8. The higher pH promoted curd formation of digesta in the abomasum and delayed abomasal emptying. Total N, ratio of protein to nonprotein N, and total change in pH of abomasal digesta, collected 1 to 8 hr after feeding, were greater at the higher pH level. In addition, flow rate of intestinal digesta, total flow of N, and trypsin and chymotrypsin activities were reduced.

Homogenization of Milk Replacers with the Polytron®

The Polytron is a mechanical, high frequency, wet milling apparatus. High-fat milk replacers (20 kg with 40% solids) were added to hot water (55–65 C) and homogenized for 5 min. Homogenization of a product containing 73% skim milk powder and 27% bleachable fancy tallow resulted in a marked improvement in growth rate of calves (425 vs. 190 g/day) and nutrient digestion (92% vs. 73% for energy). Polytron treatment of liquid diets containing 25% partially delactosed whey powder increased the viscosity of the mixtures and held insoluble ingredients (20% solids) in suspension for several hours.

Rye Grain for Dairy Cattle

Increasing production of rye in the region offers a new grain source for dairy cattle. Three grain mixtures containing 0%, 30%, or 60% rye were compared over a 12-week period. Grass hay was provided ad lib. and the grain mixtures were fed according to milk production. Fat-corrected milk production for the three groups was similar, averaging 19.4, 19.2, and 19.6 kg/cow per day respectively. No differences were observed in feed consumption or in milk components with the exception of milk fat, which was slightly higher for the 60% rye grain mixture. Rye grain has a feeding value equal to barley and can constitute at least 60% of the grain mixture for dairy cattle.

Coated Urea for Feeding Ruminants

Urea is used extensively as a nonprotein N source for ruminant animals. Since rapid breakdown to ammonium in the rumen restricts its efficiency, attention has been given to the use of coatings to restrict N release. Several products (supplied by Mr. Nelson Adams, Fredericton) have shown promise in in vitro tests in our laboratory.

Steers fed coated urea showed a higher N balance (21.4 vs. 15.3 g/day). Cows fed the regular urea produced slightly more milk than those fed the coated product (24.5 vs. 23.1 kg/day). The size (1–2 mm) and density of the coated urea prills appeared to facilitate rapid passage through the digestive tract. Rapidity of grain consumption was improved with coated urea.

Formaldehyde-treated Rapeseed Meal

Most of the dietary protein consumed by ruminant animals is degraded to ammonium by rumen bacteria. The protein available to the animal would be increased if more of the dietary protein reached the lower digestive tract intact. Formaldehyde treatment has been used to protect protein concentrates from bacterial degradation. We have developed laboratory procedures for screening formaldehyde-treated protein concentrates. Treatments that appear promising are tested by feeding them to sheep fitted with reentrant duodenal cannulas. The amounts of crude protein reaching the duodenum and excreted in the feces are determined.

Results can be illustrated by comparison of commercial rapeseed with the same material treated with formaldehyde: protein N reaching the duodenum 14.2 vs. 18.6 g/day, total N reaching the duodenum 19.8 vs. 21.2 g/day, digestibility of crude protein 88.0% vs. 60.6%, urinary N 22.4 vs. 13.6 g/day, and N retention 7.3 vs. 13.7 g/day.

Protein Supplement for Rations High in Potatoes

Potatoes are low in digestible protein and require considerable supplementary crude protein to provide a balanced ration. A digestibility – N balance study was carried out to compare four supplements based on urea, soybean meal, and a mixture of soybean meal and urea or rapeseed meal. Digestibility was similar for each diet and N retentions were 18.7, 13.6, 15.9, and 14.9 g/day respectively.

A feeding trial was set up to test performance on three rations containing high levels of potatoes and supplemented with urea, rapeseed meal, or a mixture of urea and rapeseed meal. The trial lasted 91 days and the average daily gains for the three rations were 0.94, 1.09, and 1.03 kg/day respectively. These results failed to confirm the results of the N balance trial.

Potato By-products

Three dehydrated potato by-products were each mixed with an equal weight of a commercial calf-starter-grower and fed to sheep to determine digestibility of the crude protein and organic matter. The apparent digestibility coefficients for the starter-grower, potato meal, scalper waste, and classifier waste were

as follows: organic matter 81.6%, 86.4%, 94.9%, and 92.0% respectively; crude protein 82.4%, 0.0%, 58.9%, and 65.4%. All three potato products are suitable energy sources for ruminant animals but require protein supplementation. The indigestibility of crude protein in the potato meal confirmed previous work and is a reflection of the high temperature to which this product has been subjected.

POTATO BREEDING

Two Potential Potato Introductions

Two promising potato seedlings are in advanced stages of evaluation and may be named and released in 1973. F5748 is early maturing with good yield at 85 days after planting. It has a high specific gravity and is acceptable for chips at harvest, from 13 C storage, or from 7 C storage after 7 days reconditioning. It is a blocky type with good skin and possesses some resistance to common scab, *Fusarium sambucinum* (Fckl.), *Fusarium coeruleum* (Lib.) Sacc., and leaf roll virus. F5810 is a main crop seedling of uniform type and good appearance, yield, and specific gravity. It is an excellent boiler and baker but unsuitable for processing. It possesses some resistance to common scab, late blight, and *F. sambucinum.*

Genotypic Stability Analysis of Potato Varieties

Recent developments in statistical methods have provided breeders and geneticists with a means of evaluating genotypic stability in a range of environments. Analyses were performed on five characteristics (total, marketable, and small tuber yield; specific gravity; and total solids) for eight potato cultivars from New Brunswick trial data for 1961-70. Cultivars varied in their response to the range of environments for the five traits. By defining the general adaptability of a genotype as average in stability and above average in mean performance, it was shown that Kennebec has general adaptability for marketable yield, Hunter for specific gravity, and Netted Gem for total solids. No variety showed good stability for both marketable yield and specific gravity. There is a need for further research to determine the morphological and physiological basis of differential stability of economic traits in potato cultivars.

Visual Selection of Early Clonal Generation Potato Seedlings

Tubers of 500 random-sampled F_1 seedlings of 25 crosses were collected in 1968 and planted as single-hill lots in 1969. The harvested tubers of all seedlings were planted again as single- and 10-hill lots in 1970. Seven individuals were selected visually in the field during the 1969 and 1970 harvests. Top vigor, tuber appearance, and size and number of marketable and undersized tubers were recorded. Preliminary results revealed more agreement among selectors when assessing crosses than when assessing individual seedlings, and individual selectors were less efficient than the group. The relative importance of different characteristics involved in the visual decision was investigated by a path coefficient analysis. Tuber appearance showed a considerable influence on visual assessment of individual single-hill clones, whereas tuber size and appearance and top vigor were the major factors in the visual discrimination of average cross performance of single-hill seedlings.

Resistance to Late Blight

Continuing work with the Mexican diploid species *Solanum verrucosum* Schlechtd. as a source of resistance to late blight resulted in an improved scoring system for the detached-leaf screening technique. The 10-point scoring system ranges from zero infection to 100% lesion infection with sporulation.

Resistance to Common Scab

Advanced diploid selections derived from *S. chacoense* have completed four scab tests. Of the original 647 seedlings, 85 were free from scab in each test and on the basis of a field assessment of horticultural traits, the best clones were selected for further crossing.

Multiple Resistance to Diseases and Pests in Andigena Potatoes

A sample of the 1970 parental Andigena population was tested for resistance to a number of diseases and pests. Resistance to common scab was found in 34 of 105 seedlings. A moderate level of resistance to verticillium wilt was found in 11 of 75 seedlings.

Six of 31 seedlings were resistant to early blight. Screening for resistance to wart, carried out in Newfoundland, showed resistance in 67 of 84 seedlings. There was little or no resistance to late blight and the golden nematode (pathotype A).

Selections and crosses were made within the parental population to provide seed for the next generation of the mass selection program. A series of crosses was made between Andigena and Tuberosum clones to investigate methods of utilizing Andigena material in the breeding program.

POTATO PATHOLOGY

Potato Disease Detection by Aerial Photography

Evaluation of aerial photography in potato disease detection was continued. A significant correlation was found between optical density of color infrared photographs and late blight incidence and tuber yield of experimental plots. Color infrared photography was also of value in the early detection of small primary foci of late blight in commercial fields, and severe infections of verticillium wilt in experimental plots.

Late Blight and Potato Yield

A multiple regression equation was developed for estimating yield losses due to late blight. The increase in disease incidence during 9 weekly periods served as the independent variable and yield loss as the dependent variable. The difference between estimated loss and actual loss was less than 5% in 9 of 10 cases.

Black Scurf on Potato Tubers

Three levels of naturally occurring black scurf (sclerotia of *Rhizoctonia solani* (Kühn)) on tuber seed pieces did not reduce plant emergence, produce stem cankers, or affect yield in field experiments at two locations. Sclerotial viability decreased with time and treatment. Approximately 50% of the sclerotia were viable at the time of planting.

Samples of Red Pontiac tubers from two commercial fields were placed in storage for nearly 3 months and similar samples were shipped to Cuba and back by boat. Viability of sclerotia was 95% for stored samples, 55% for a sample shipped immediately after harvesting, and less than 15% for a sample held in storage for 3 weeks prior to shipping. These results provide additional evidence that sclerotia on tubers are not an important source of inoculum for the stem canker stage of *Rhizoctonia* in potatoes.

Virus-tested Potato Stocks

Virus-tested stocks (Netted Gem, Sebago, Kennebec, Katahdin, and Irish Cobbler) were grown on 4.9 ha at the elite seed farm in Prince Edward Island, and on 1.2 ha (Green Mountain) by a private grower. Smaller quantities of these varieties were grown on the elite seed farm in New Brunswick. Serological and plant indicator tests detected some reinfection with potato virus S (PVS) but little or none with potato virus X (PVX). Over 2,000 tubers were tested during the winter and spring on *Nicotiana debneyi* Domin. to detect PVS, PVX, and potato virus Y (PVY). Those found free were planted at the elite farms to provide preelite nuclear stocks.

Susceptibility to Potato Virus S

The older American cultivars Green Mountain, Irish Cobbler, and Netted Gem were more susceptible to PVS than the newer USDA varieties Katahdin, Sebago, and Kennebec in greenhouse experiments involving sap inoculation.

In a field trial with virus-free tubers, 57% spread occurred in Green Mountain, 19% in Kennebec, and 9% in Sebago. Less than half this spread was detected in foliage tests during the summer and the remainder was found in postharvest tuber tests. PVS was first detected on August 9.

Virus Resistance in *Solanum* Species

One hundred and forty-nine clones from 41 different *Solanum* species were tested for resistance to four viruses. Six clones from 2 species were resistant to virus M; 13 clones from 7 species to virus S; 17 clones from 5 species to virus X; and 8 clones from 7 species to potato spindle tuber virus (PSTV). There were several instances of multiple resistance in individual clones. One clone of *S. microdontum* Bitter was resistant to PVM, PVS, and PSTV; and one of *S. tarijense* Hawkes to PVS, PVX, and PSTV. One clone

of *S. megistacrolobum* Bitter was hypersensitive to PVS. A number of interspecific crosses were made and will be used for studies of inheritance, to lead to a combination of multiple resistance and commercial qualities.

Potato Variety and Seedling Resistance to Potato Virus Y

In field trials, two Fredericton-bred cultivars, Sable and York, showed resistance to potato virus Y (PVY) comparable to the leading USDA varieties, Katahdin, Kennebec, and Sebago. Three other Fredericton cultivars, Chinook, Hunter, and Huron, were moderately resistant. Increasing susceptibility occurred in Fundy, Pink Pearl, Raritan, Avon, Canso, Keswick, Grand Falls, and Cariboo. The last four varieties were as susceptible as Green Mountain and Netted Gem. Of 80 advanced Fredericton seedlings tested, 24 appeared to have worthwhile resistance to PVY.

Local Lesion Host for Potato Spindle Tuber Virus

Scopolia sinensis Hemsley, a member of the Solanaceae, produced local lesions when inoculated with crude sap from tomato, potato, or other plants infected with PSTV. The lesions were dark brown, necrotic, and roughly circular. They appeared in 7–10 days in response to the severe strain of PSTV and in 10–15 days in response to the mild strain. The *S. sinensis* leaves were suitable for the half-leaf test in estimating virus concentration. Reproducible results were obtained when plants were grown in a greenhouse at 21–23 C with 400–600 ft-c light intensity and a day length of 15–18 hr. The use of bentonite powder while grinding tubers or foliage increased the number of local lesions. The presence of viruses M, S, X, and Y in the inoculum mixture did not interfere visibly with PSTV lesion formation. Other species of *Scopolia,* e.g., *S. lurida* (Link) Dun., and *S. corniolica* Jacq. produced lesions under similar conditions.

Isolation of Potato Spindle Tuber Virus

Potato spindle tuber virus (PSTV) was extracted from tomato, potato, and *Scopolia* leaves and purified by precipitation with cetyltrimethylammonium bromide and by chromatography on DEAE-cellulose. Analysis of viral activity using the local lesion host, *S. sinensis,* revealed a 30- to 40-fold increase in infectivity. Further analysis of the purified virus by centrifugation in sucrose gradients and by electrophoresis in 2.4%, 5.0%, or 7.5% polyacrylamide gels showed that peak infectivity corresponded to a particle size of 4–5 Svedberg units. Susceptibility of the virus to exonuclease activity was examined, and in some cases infectivity decreased by 99% upon incubation with venom phosphodiesterase enzyme.

Effect of Low Temperature on Potato Spindle Tuber Virus

Saco potato plants inoculated with PSTV failed to develop symptoms at 3–7 C. Likewise, aerial and tuber symptoms were masked when field-grown infected plants were transferred to the low temperature prior to tuber initiation. Tubers were normal in shape and attempts to recover the virus were unsuccessful. When plants were grown from these tubers at 21–24 C, infective virus was recovered. In a related experiment at temperatures of 3–7 C and 21–24 C, the virus concentration in the plant declined sharply at the lower temperature and remained at a low level until maturity.

POTATO ENTOMOLOGY

Reproduction of Potato-infesting Aphids

Aphid reproduction over a range of temperatures and short-day conditions confirmed that *Macrosiphum euphorbiae* (Thomas) has no interval timer and that production of sexuals in young clones is possible. Males and oviparous females were produced by second and third generation parents 24 to 41 days after the fundatrix (female hatching from overwintering egg) began to reproduce. Males were produced earlier than oviparous females. The parthenogenetic cycle can be terminated within 4 weeks under a short-day regime (11–14.5 hr light), whereas 15 to 20 weeks are required under natural field conditions.

Males were produced after 30 days from a young clone of *Myzus persicae* (Sulzer) (temperature, 21 C; day length, 11L:13D). In both species there is a possibility that natural populations can be reduced by interrupting the parthenogenetic cycle.

Feeding Response of Aphids as an Indicator of Host Resistance

The acceptance or rejection of different host plants by two species of aphids, *M. persicae* and *M. euphorbiae,* was determined with a biophysical technique based on the different conductive qualities of aphid saliva and plant sap. The response from acceptable plant tissue showed that aphids salivated on initial penetration and ingested continously after approximately 25 sec. In the case of unacceptable substrates, the aphids did not ingest following salivation and initial penetration; often they withdrew their stylets, moved to another site, salivated, penetrated, and again withdrew their stylets. This behavior continued until eventually no penetration was attempted.

Forty-two *Solanum tuberosum* L. cultivars and 134 clones of *Solanum* species were examined for aphid acceptability. Six cultivars and seven species were classed as resistant. These results were confirmed by further exposure of the plants to natural colonies of aphids.

Aphid response to artificial substrates of different composition and pH was assessed by the electronic readout technique. A surprisingly wide range of pH was tolerated, but values below 5 were more generally acceptable.

SOILS AND POTATO MANAGEMENT

Growth Regulators

A soil drench treatment with 0.3% chlormequat applied to Netted Gem potatoes 2 weeks after emergence increased total and marketable yield and average weight of marketable tubers. Foliar spray and combination drench and spray treatments were not so effective but were superior to no treatment. The leaf-area index of treated plants was reduced because treated plants produced fewer leaves. Leaf size was not affected.

Close plant spacing (25 cm vs. 38 cm) increased total yield and proportion of small tubers but did not alter chlormequat treatment effects.

Interrelationships of Al and Mn on the Potato Plant

Netted Gem potatoes were grown in nutrient solution and sand cultures to study the interrelationships of Al and Mn on plant growth, mineral nutrition, and tuber yield. Counteracting effects of Al and Mn levels in the growth medium were observed in the color and size of plant tops. Visual symptoms of Mn-induced Fe deficiency were associated with Mn/Fe concentration ratios of 18 or more in solution culture. Aluminum counteracted these symptoms by increasing plant Fe content and decreasing Mn/Fe ratios to below 18. Aluminum stunted plant tops, but Mn lengthened plant tops in sand culture studies. Potato tuber yields were reduced by Mn with 0 ppm Al; were not affected by Mn at intermediate Al levels (5 to 10 ppm); and were increased by Mn at a higher Al level (20 ppm). Aluminum decreased the number and increased the size and specific gravity of tubers, whereas Mn had no effect. An accurate evaluation of the influence of soil acidity on potato production requires consideration of the effects of both soluble Al and Mn concentrations in soils.

Effect of Mechanically Induced Compaction on Potato Yields

Marketable yields of Netted Gem and Kennebec potatoes decreased 20–25% as the number of tractor passes immediately after hilling was increased from 0 to 12. These treatments resulted in bulk densities of 0.99 and 1.17 g/cm^3 respectively. Soil temperatures at the 10-cm and 15-cm depths increased with increasing bulk density, and soil water potential measurements indicated restricted moisture movement to the rooting zone with increasing traffic and compaction.

FRUIT

Mechanical Apple Harvester

A catch frame with attached shaker and bin filler was developed for harvesting of processing apples. A new concept involving a vertical head on a horizontal boom limb shaker was effective for fruit removal. A suspended boom on a two-piece hydraulically controlled arm overcame previous problems in maneuvering and attaching the shaker to the limbs. Harvesting was adversely affected

by large as well as inadequately pruned trees and by low-hanging branches.

Red-striped Fireworm on Blueberries

The red-striped fireworm has become of economic importance in the past 2 years although its presence in blueberry fields has long been recognized. It does not normally feed on the fruit buds but builds castings around the foliage and buds in the nonfruiting year, which appear to affect plant development and may reduce yields by 50% in the succeeding year. Preliminary results indicate control with azinphos-methyl applied about August 1.

Nature of Growth Substance in Blueberry Buds

Avena bioassay tests and thin-layer chromatography confirmed the presence of a gibberellin-like growth substance in flower buds of lowbush blueberry, *Vaccinium angustifolium* Ait., under short-day conditions. The development of these buds into naturally parthenocarpic fruit indicated that this compound was under short-day control and that its production continued under a short-day regime.

CEREALS AND FORAGES

Horizontal Silos

Wire mesh fencing lined with polyethylene was unsatisfactory for walls of horizontal silos. The polyethylene was vulnerable to puncturing by the wire mesh and there were high spoilage losses. Because the wire fence gave no protection from the wind, the handling of the plastic was very difficult at times.

A commercial silo unloader for horizontal silos was evaluated on two farms. The unloader made a clean cut in the face of the silo to a height of approximately 3.5 m and delivered well-chopped and mixed material into the wagons. The loading rate was higher than a front-end tractor loader and could be effective in a large operation.

Barley Harvesting Losses

Two years' data have demonstrated the importance of harvesting grain when it reaches maturity. Average losses due to delayed harvesting were as high as 25 kg/ha per day over a 4-week period.

Barley Yellow Dwarf Virus in Cereals

Barley yellow dwarf virus was prevalent on a large acreage of late-seeded cereals in the Florenceville and Fredericton areas in 1970. Areas of diseased plants within fields were successfully located by aerial surveying. The virus, isolated from samples, was transmitted most efficiently by *Rhopalosiphum padi* (L.) and less efficiently by *Macrosiphum avenae* (Fabricius), *Schizaphis graminum* (Rondani), and *Acyrthosiphon dirhodum* (Wlk.), but rarely by *R. maidis* (Fitch), and on this basis is a nonspecific strain of barley yellow dwarf virus. The yield of dry matter from diseased forage oats (O.A. 123-1) was 63% less than that from healthy oats.

Coating Barley Seed with Phosphorus

Early seeding of cereals is of prime importance in the Atlantic region. Broadcast methods offer considerable promise over the conventional seed drill because of the rapidity with which the operations can be performed. The main complicating factor is the placement of fertilizer phosphorus. Many experiments have demonstrated the desirability of applying this element close to the germinating seedling.

As a potential solution to this problem, consideration has been given to coating barley seed with a phosphate carrier. A marked reduction in germination was encountered initially, but in recent trials a coating of peat moss, limestone, and triple superphosphate (supplied by Mr. Nelson Adams, Fredericton) has performed well in preliminary greenhouse and field investigations.

Maintenance of Timothy Stands

Poor haplocorm formation and weak vegetative reproduction, due to improper N/K balance and harvesting at an immature stage (boot or preboot), have accounted for poor maintenance of timothy stands. Nutrient imbalance can be rectified by applying N and K at rates to provide a 1:1 ratio of these elements in the plant at harvest time. Immature harvesting of timothy in timothy–legume

stands has been accentuated by introduction of earlier-maturing legumes and improved harvesting and storing facilities.

The need for an earlier-maturing timothy cultivar was apparent and to meet this requirement, the American cultivar Clair was licensed in 1971 after extensive regional evaluation. It is expected to permit earlier harvesting without sacrificing yield or longevity of stand and to provide a product of higher digestibility.

SOIL SURVEY

Maritime Soils

During 1971 approximately 14,000 ha were mapped in Colchester County, Nova Scotia, 79,000 ha in the O'Leary area, Prince Edward Island, and 19,000 ha in the Mount Carleton area of New Brunswick.

Soil survey reports for Cumberland County in Nova Scotia and Northern Victoria County in New Brunswick were prepared for publication. A map of Nova Scotia was prepared showing the distribution of different soils based on parent material, texture, and drainage. Seventeen new sites were established in Nova Scotia for continuing moisture studies. In New Brunswick the land capability inventory for agriculture was completed.

An investigation of interrelationships of pH-dependent cation exchange capacity and organic matter, clay, and sesquioxide contents was initiated on 38 soil profiles in a search for improved criteria for Podzol classification. Studies were begun also on the nature of fragipans in Maritime soils.

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Ferme expérimentale
L'Assomption, Québec

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Tabac

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Retraité en septembre 1971

INTRODUCTION

Le rôle principal de la Ferme expérimentale de l'Assomption est d'améliorer la qualité et le rendement des tabacs au Québec. Ce rapport présente un bref résumé des recherches poursuivies durant l'année 1971. Les chercheurs de la Ferme ont collaboré étroitement avec d'autres institutions en ce qui a trait à l'amélioration de la culture du tabac. En septembre 1971, M. Julien Richard, directeur de la Ferme depuis 1962, a pris sa retraite.

P. P. Lukosevicius
Le directeur

TABAC

Tabac à cigare

Sélection. En 1971, le groupe de sélection se composait de 826 lignées hybrides de sept générations différentes et de trois cultivars commerciaux (Ottawa 705, R.H. 211 et Penbell 69). A la suite d'observations visuelles faites dans le champ, 46 lignées, soit 5.6%, ont été éliminées du groupe et de ce nombre, 38 lignées, soit 82.6%, avaient Ottawa 705 comme parents. D'autres lignées seront probablement supprimées lorsque nous posséderons les données de classification du tabac séché.

Test préliminaire. Cet essai en 1971, groupait 10 cultivars connus, cinq cultivars provenant de France et 25 lignées hybrides. Cinq cultivars connus, quatre cultivars français et 12 lignées hybrides ont dépassé la moyenne de l'essai (116.6 cm) (45.9 pouces) pour la hauteur des plants après l'écimage. Quatre cultivars connus, deux cultivars français et 15 lignées hybrides ont donné plus de feuilles que la moyenne de l'essai (20) et cinq cultivars connus, deux cultivars français et 17 lignées hybrides ont surpassé la moyenne (50.1%) pour l'indice de la feuille, c'est-à-dire (largeur/longueur) × 100. Des cultivars connus, Wisconsin Havana 503 a produit les plants les plus longs après l'écimage (126.8 cm) (49.9 pouces) mais fut le plus tardif avec 74 jours. Il se classa dans la moyenne pour le nombre de feuilles (20) et l'indice de la feuille (50%). Les plus petits plants après l'écimage (99.2 cm) (39.1 pouces) appartiennent au cultivar Belge amélioré 807 avec les entre-noeuds les plus courts (4.9 cm) (1.9 pouces), les feuilles les plus étroites (22.3 cm) (8.8 pouces) et l'indice de la feuille le plus bas (39.4%). Parmi les hybrides, la lignée L 64-210 F_7 fut la meilleure pour la hauteur des plants après l'écimage (127.9 cm) (50.4 pouces) mais se classa deuxième pour le nombre de feuilles, soit 21.2, et moyenne pour l'indice de la feuille. La qualité de la feuille (64.7 ¢/kg) (29.4 ¢/lb) en fut inférieure à la moyenne de l'essai, tandis que la productivité en filasse en fut légèrement supérieure (1.2%). Le cultivar R.H. 211 a produit une feuille de qualité, de 70.3 ¢/kg (31.9 ¢/lb), et un pourcentage de filasse, soit 91.1%, supérieurs au cultivar Ottawa 705 avec 63.5 ¢/kg (28.8 ¢/lb) et 71.1%.

Test avancé. Cette année, nous avons comparé quatre cultivars connus, Ottawa 705 et R.H. 211 inclus, et huit lignées hybrides. Une lignée hybride, L 64-212 F_7, fut supérieure pour la hauteur des plants avant et après l'écimage (165.4 et 126.8 cm) (65.1 et 49.9 pouces), le nombre de feuilles (19.6) et la longueur de la feuille (63.5 cm) (25.0 pouces). Elle fut cependant la plus tardive, avec 66 jours. Le cultivar Strain 607 a eu les entre-noeuds les plus espacés, de 7.7 cm (3.0 pouces), le moins de feuilles, soit 16, mais il a produit la feuille la plus large, de 32.5 cm (12.8 pouces). Pour l'essai, ce cultivar se situa au deuxième rang pour la hauteur des plants après l'écimage, soit 122.8 cm (48.4 pouces) et la longueur de la feuille, soit 61.7 cm (24.3 pouces). Des différences appréciables dans la qualité de la feuille séchée et le pourcentage de filasse favorisent le cultivar R.H. 211 sur le cultivar Ottawa 705, mais celui-là n'a eu que des différences légèrement supérieures à l'hybride L 64-169 F_7.

Dates de plantation. Introduit en 1970, cet essai fut reproduit en 1971 avec les mêmes éléments, à savoir: trois dates de plantation, trois taux d'espacement sur le rang et deux cultivars. Comme en 1970, la précocité des dates de plantation a influencé positivement la longueur d'entre-noeuds et la hauteur des plants avant et après l'écimage. Toutefois,

une plantation tardive a réduit la période de croissance. Surclassant la première date de plantation (26 mai), la seconde (9 juin) a contribué le plus cette année à augmenter la largeur et la longueur de la feuille. La précocité des dates de plantation a également augmenté le pourcentage de la filasse mince et les indices de qualité et de revenu. Les taux croissants d'espacement ont donné des plants plus hauts avant l'écimage mais plus bas après. Ces taux croissants ont aussi majoré le poids des plants, la largeur, la longueur et l'indice de la feuille. De plus, le pourcentage des filasses minces, épaisses et totales, ainsi que l'indice de qualité, le rendement et l'indice de revenu ont bénéficié de l'augmentation des taux d'espacement. Le cultivar Ottawa 705 a produit des plants plus hauts et plus lourds, une feuille plus large et plus longue que le cultivar L 64-169 F_8; par contre, celui-ci a donné une feuille de meilleure qualité.

Résistance aux maladies. Dans le but d'évaluer principalement leur résistance à la pourriture noire de la racine causée par le champignon *Thielaviopsis basicola* (Berk. & Br.) Ferr., cinq cultivars connus, neuf lignées provenant de France et de Puerto-Rico et 214 lignées hybrides de différentes générations ont été cultivés au champ. En général, les lignées hybrides provenant du cultivar R.H. 211 ont montré plus de résistance que celles des cultivars Ottawa 705 et Penbell 69.

Séchage. Un essai fait en 1971 avait le but d'étudier l'influence de la température sur le séchage du tabac à cigare. Quatre chambres de séchage furent soumises à quatre températures différentes, de 35, 32.2, 23.8 et 18.3°C (95, 90, 75 et 65°F), et à une même humidité relative uniforme de 80%. Une seconde épreuve de séchage fut reproduite dans les chambres soumises aux températures de 35 et 32.2°C (95 et 90°F), après la fin du séchage de la première épreuve. Le tabac soumis à la température de 23.8°C (75°F) a servi à un test préliminaire d'inoculation des champignons *Botrytis cinerea* Pers. et *Rhizopus reflexus* Bain. causant le chauffage à la pente, ce qui a eu une influence relative sur la qualité de la feuille séchée. Des trois autres traitements de la première épreuve, l'augmentation de la température a contribué à améliorer la qualité de la feuille séchée et le pourcentage des filasses, tout en diminuant la durée de la période de séchage. Dans la seconde épreuve, une température de 32.2°C (90°F) fut plus bénéfique pour ces deux facteurs de qualité qu'une température de 35°C (95°F), tout en ayant une période de séchage identique.

Répression des drageons du tabac. En 1971, l'expérience sur la répression des drageons du tabac à cigare s'est poursuivie avec l'essai de six produits différents combinés à deux époques d'application: Delspray T-148, de Procter & Gamble Co. of Canada; Emtrol 1630B, des Emery Industries (Canada) Ltd; Sucker-Plucker T-148, de Fisons (Canada) Ltd; Antak, de l'Ansul Company; TSC-350, de Pfizer Co. Ltd et Penar, de Pennsalt Chemicals of Canada Ltd. La majorité des produits ont assuré un excellent contrôle des drageons. Leur influence sur la qualité de la feuille n'est pas connue, les résultats n'étant pas encore disponibles.

Tabac à cigarette

Évaluation des cultivars et des hybrides. En 1971, nous avons comparé la valeur agronomique de 15 cultivars et 40 lignées. Le cultivar Strain 205 s'est révélé le meilleur pour le rendement et le revenu brut à l'hectare et de plus, il a produit un tabac d'excellente qualité. Le cultivar Yellow Gold fut le meilleur pour la qualité de la feuille. Coker 411 a produit le plus grand nombre de feuilles par plant. Quant aux hybrides, la lignée 352 $P_1 \times$ a donné le meilleur rendement à l'hectare, la lignée 138 $P_1 \times$ le meilleur revenu tandis que Coker 298 a produit un tabac de meilleure qualité.

L'effet du pH et de la fertilisation sur la croissance du tabac. En 1971, six niveaux de pH différents ont été comparés entre eux. A chaque niveau, on a combiné trois taux d'engrais 2-12-12 T. Les résultats obtenus indiquent que l'on a atteint l'objectif désiré pour seulement les quatre premiers traitements. Seul l'indice de maturité n'a pas répondu aux traitements d'une manière significative. Le meilleur rendement a été obtenu avec un pH de l'ordre de 6.5 et une application de 2 017 kg/ha (1 800 lb/acre), la plus haute qualité avec un pH de l'ordre de 5.0 et une dose d'engrais de 672 kg/ha (600 lb/acre) et le revenu maximum a été obtenu en combinant un pH de 6.0 à une application de 2 017 kg/ha (1 800 lb/acre).

Méthodes culturales. Dans cette expérience, nous avons étudié le comportement de trois cultivars de tabac jaune soumis à trois

degrés de compacité et trois taux de fertilisation. Le cultivar Virginia 115 fut supérieur à Delhi 34 et Yellow Gold pour le rendement. Un espacement de 56 cm (22 pouces) sur le rang a augmenté le rendement. Une fertilisation de 1 680 kg/ha (1 500 lb/acre) a augmenté le rendement et le revenu mais a diminué la qualité. On a obtenu la meilleure qualité avec une fertilisation moindre, soit 1 120 kg/ha (1 000 lb/acre).

Répression des drageons du tabac. En 1971, six produits différents ont été comparés pour la répression des drageons. L'essai comprenait aussi deux stades et deux méthodes d'application. Tous les produits ont assuré un bon contrôle des drageons. L'application avant l'écimage est censé préférable. La meilleure qualité de tabac a été obtenue avec une application après l'écimage et le meilleur revenu avec une application avant l'écimage. Les produits employés étaient les suivants: Delspray T-148, de Procter & Gamble Co. of Canada; Emtrol 1630B, des Emery Industries (Canada) Ltd; Sucker-Plucker T-148, de Fisons (Canada) Ltd; Antak, de l'Ansul Company et TSC-350, de Pfizer Co. Ltd.

Répression des mauvaises herbes. Des différents herbicides mis à l'essai, R-7465 de Stauffer Chemical Company est le seul qui a amélioré le rendement, la qualité et le revenu brut; seuls les herbicides R-7465, GS 38946 de Green Cross, non incorporé, et Balan de l'Eli Lilly Company ont augmenté le revenu brut. Des 16 herbicides, cinq seulement ont légèrement augmenté le rendement. Onze herbicides ont diminué la qualité, dont quelques-uns très sévèrement.

Répression des nématodes. Seize des 18 traitements utilisant le produit DuPont 1410-L ont amené des augmentations de rendement, alors que neuf traitements seulement ont amené des indices de qualité supérieurs à ceux des parcelles non traitées. Les pulvérisations du feuillage en serre, 24 heures avant l'arrachage des plants, aux taux de 1.121 et 2.242 kg/ha (1 et 2 lb/acre) se sont avérées les plus efficaces des traitements. Les écarts maximums entre les traitements ont été de 232 kg/ha (207 lb/acre) pour le rendment, de 18 ¢/kg (8.2 ¢/lb) pour la qualité et de $568/ha ($230/acre) pour le revenu brut.

Huit des 18 traitements avec methomyl, de DuPont of Canada, ont amené des augmentations de rendement tandis que deux traitements seulement ont amené des indices de qualité supérieurs à ceux des parcelles non traitées. L'application en bande de 41 cm (16 pouces) de 4.483 kg/ha (4 lb/acre) s'est avérée supérieure aux autres traitements. Les écarts maximums entre les traitements ont été de 389 kg/ha (347 lb/acre) pour le rendement, de 10.5 ¢/kg (4.8 ¢/lb) pour la qualité et de $528/ha ($214/acre) pour le revenu brut.

Les autres nématicides n'ont apporté d'amélioration appréciable pour aucun des caractères de rentabilité. CHE 7375 (Chemagro Corporation) a été très phytotoxique, et les jeunes plants dont les racines ont été trempées dans une solution de 500 ppm sont morts durant les premières semaines suivant la transplantation. A la concentration de 300 ppm le produit a été moins phytotoxique, mais les jeunes plants ont mis du temps à s'établir.

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Lennoxville, Québec

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INTRODUCTION

Les résultats d'expériences consignés dans ce rapport décrivent sommairement la recherche en cours. Ils démontrent une orientation de l'expérimentation qui se veut de plus en plus une recherche multi-disciplinaire où l'on mesure à la fois le jeu des éléments sols–plantes–animaux. C'est ainsi qu'on y trouve, par exemple, l'étude de la fertilisation des sols en rapport avec le rendement de diverses plantes fourragères et la performance de bouvillons de provenance génétique variée.

Le rôle et les activités de la Station dépassent les cadres rigides d'une recherche programmée, dont ce rapport n'est qu'un résumé. Les chercheurs, entre autres, participent activement à la formulation des recommendations qui émanent des agronomes du Québec chargés de la vulgarisation des techniques agricoles auprès des cultivateurs. Quelques milliers d'agriculteurs visitent annuellement la Station pour y puiser les méthodes d'exploitation les plus nouvelles. Enfin, les scientistes prêtent leur concours à de nombreuses activités qui touchent, de près ou de loin, la classe agricole et les industries connexes.

Une description plus élaborée des programmes de recherche est disponible; adresser les demandes à la Station de Recherches, Ministère de l'Agriculture du Canada, Lennoxville, Qué.

C. S. Bernard
Le directeur

PRODUCTIONS VÉGÉTALES

Influence du pH des sols sur les légumineuses

Depuis 1960, nous avons étudié l'action du pH des sols sur la luzerne, le trèfle ladino et le lotier croissant en association avec le mil. L'expérience s'est poursuivie en plein champ sur les quatre types de sol suivants: loam limoneux de Coaticook, loam de Greensboro, argile Ste-Rosalie et sable St-Jude. Nous avons fait varier à la fois le pH des sols aux niveaux de 5.2, 6.0 et 6.5, et l'application de P_2O_5 et K_2O aux doses de 0, 112 et 224 kg/ha.

Les rendements du mélange luzerne–mil ont augmenté linéairement avec l'addition de pierre à chaux au sol. L'augmentation s'est maintenue jusqu'au pH de 6.5. Les changements de pH du sol ont beaucoup moins influencé les rendements des mélanges ladino–mil et lotier–mil; le pH optimum de ces deux mélanges a été de 6.0.

On a noté une interaction significative entre le pH du sol et le phosphore appliqué à la luzerne sur le loam de Coaticook et le loam de Greensboro. La réponse des plantes aux applications de phosphore a été beaucoup plus marquée en sol acide qu'en sol chaulé. On a également observé la présence d'une interaction entre le pH du sol et le potassium. Contrairement aux effets du phosphore, l'application de potassium a augmenté les rendements en sol chaulé de beaucoup plus qu'en sol acide.

Le pourcentage de luzerne dans le gazon était fonction à la fois du pH du sol et de la dose de potassium appliquée. En sol acide ne recevant pas de potassium, on n'a retrouvé que 1% de luzerne tandis que dans les parcelles chaulées à pH 6.5 et recevant 224 kg/ha de potassium, on a enrégistré jusqu'à 70% de luzerne.

La proportion de trèfle ladino et de lotier dans les gazons végétaux a été fonction surtout de l'apport de potassium au sol; l'élévation du pH des sols n'a entraîné qu'un faible accroissement du pourcentage de trèfle ladino dans le gazon.

Croissance de la luzerne et du lotier en fonction du régime hydrique et du pH du sol

Le régime hydrique d'un sol peut grandement modifier la réponse des plantes à l'accroissement du pH des sols. C'est ce qui ressort d'une étude de l'interaction entre le pH du sol et son régime hydrique. On a cultivé, en serre, de la luzerne et du lotier sur l'argile Ste-Rosalie et le sable St-Jude ajustés aux pH de 5.0, 6.5 et 7.5. Les régimes hydriques comparés étaient: très humide, optimum et très sec.

En régime très humide, les rendements de luzerne ont augmenté linéairement avec l'élévation du pH du sol. Ceux du lotier ont augmenté jusqu'à pH 6.5, pour demeurer constants par la suite. En régime d'humidité optimum, on a obtenu les plus hauts rendements à pH 6.5; ils ont diminué au pH plus élevé de 7.5. En régime de sol très sec, la luzerne a profité du chaulage au pH de 6.5, où l'on a enrégistré des augmentations de rendement de l'ordre de 70%. A pH 7.5, toutefois, les rendements ont été de 10% plus bas qu'en sol acide.

La production du lotier s'est accrue seulement de 5% sur le sol chaulé à pH 6.5. L'effet du surchaulage a été très prononcé à pH 7.5, les rendements étant réduits de plus de 40%. Cette réduction de rendement est probablement due à une diminution de l'assimilabilité du bore à la suite d'une forte application de chaux en sol soumis à un régime de sécheresse.

Le mauvais égouttement a réduit les rendements de luzerne de 29%. Cette réduction s'est accentuée avec le degré d'acidité du sol, pour atteindre 55% à pH 5.0. L'excès d'eau dans le sol n'a cependant pas eu d'effet défavorable chez le lotier. Au contraire, les rendements en ont été légèrement supérieurs en sol très humide, ce qui indique que le lotier est réellement une légumineuse adaptée aux sols mal égouttés.

La sécheresse du sol a réduit de 43% en moyenne les rendements des deux légumineuses. L'effet de la sécheresse a été beaucoup plus marqué à pH 7.5, où la diminution de rendements s'est chiffrée à 57% comparé à 30% au pH de 5.0. Les deux légumineuses ont réagi à la sécheresse d'un façon similaire.

Lessivage des éléments N, P, K à travers une colonne de sol

Ce travail expérimental porte sur les pertes en NO_3, P et K par lessivage à la suite de l'apport de quatre doses consécutives de 75 kg/ha d'azote, de phosphore et de potassium appliquées à des colonnes de sols non remaniés et de deux textures différentes, maintenus en état saturé ou non saturé d'eau.

Au cours des 120 jours de lessivage intense à l'eau distillée (2.50 cm/semaine), les pertes cumulées chez les deux sols fertilisés, au début et à la fin de l'expérience, étaient de 0.007 et 0.943 mg pour les nitrates, de 0.015 et 5.18 mg pour le potassium et de 0.0001 et 0.3024 mg pour le phosphore. Dans les conditions comparables on a retrouvé chez les témoins 0.003 à 0.336 mg, 0.061 à 3.75 mg et 0.0009 à 0.0892 mg, respectivement. On a constaté que les ions NO_3^- et K^+ ont été entraînés en fonction du volume de percolat écoulé. En milieu saturé d'eau, le lessivage des nitrates a été plus considérable à travers le sol de texture grossière, tandis que les pertes de phosphore l'ont été avec le sol de texture fine.

A haute fertilisation, il y a eu accumulation marquée du phosphore dans les 10 cm supérieurs de la colonne de sol. Cet élément a été entraîné en profondeur surtout dans le sol de texture grossière. Ainsi, le phosphore qui est l'élément le plus discuté en pollution des eaux, n'a pas tellement affecté la teneur des percolats puisque la majeure partie du P appliqué a été fixée soit en surface ou en profondeur du profil du sol.

Avec des valeurs cumulatives aussi peu élevées dans les percolats, on s'aperçoit que les trois éléments lessivés n'ont pas d'effet significatif comme agent polluant.

ZOOTECHNIE

Croissance de veaux mâles croisés, laitier × boucherie

Des veaux mâles, issus de vaches Holstein et de taureaux soit Charolais, soit Hereford, pesaient 53.7 et 44.1 kg à la maissance et 256 et 227 kg à 300 jours, respectivement. D'autre part, des veaux, issus des mêmes taureaux mais de vaches Ayrshire, accusaient un poids de 49.1 et 43.1 kg à la naissance et de 228 et 210 kg à 300 jours.

Le poids des veaux a varié en fonction de la race des taureaux Charolais ou Hereford, et non de la race des mères, Holstein ou Ayrshire.

Ces bouvillons croisés seront soumis à des rations, soit à haute teneur en concentrés, soit à forte proportion de foin, jusqu'à leur mise en marché.

Engraissement des bouvillons aux pâturages

On peut produire des bouvillons de marché sur pâturage, pourvu qu'on ne dépasse pas un chargement de 2.47 têtes à l'hectare (une tête à l'acre). Même une fumure massive ne saurait compenser l'augmentation du

chargement. Toutefois, la moulée servie en fin de saison, comme supplément à l'herbe, permet une production satisfaisante de viande bovine de bonne qualité même à un chargement de 4.94 têtes/ha. Telles sont les conclusions tirées d'une expérience effectuée de 1969 à 1971, au sujet de l'engraissement des bouvillons.

On a fait paître, chaque année, 2.47 et 4.94 bouvillons/ha (1 et 2 têtes/acre). De plus, on a servi, en fin de saison, de la moulée à raison de 9 kg/tête par jour à un groupe du chargement de 4.94 têtes/ha. A chaque chargement, on a comparé trois niveaux d'engrais, soit: 1 121, 2 242 et 3 363 kg/ha d'engrais 10-10-10. Les bouvillons sont entrés en pâturage à la mi-mai pour en ressortir en fin d'octobre, date à laquelle ils ont été abattus.

La fumure a fait légèrement augmenter le rendement, l'épaisseur de gras et la classification de la carcasse, mais elle n'a pas changé significativement le poids de la carcasse, les gains saisonniers et quotidiens, ni la surface de l'oeil de maigre.

Le chargement de 4.94 têtes/ha a amené une réduction du poids de la carcasse de 10%, du gain saisonnier de 27% et du gain quotidien de 30%. C'est surtout en fin de saison, de la mi-août à la fin d'octobre, que le fort chargement a été le plus nuisible, car on n'a enregistré qu'un gain quotidien de 332 g/tête, là où l'on gardait 4.94 têtes/ha. Ces effets de chargement ont été uniformes à chacune des doses d'engrais chimique utilisées.

L'apport de moulée aux bouvillons, en fin de saison, a amélioré leur performance. Les bouvillons ainsi alimentés ont fourni une carcasse de 244 kg. Leur gain quotidien a été de 937 g/tête, alors qu'il n'a été que de 560 g chez les animaux qui ne recevaient pas de moulée.

Il en ressort que l'apport d'engrais à doses massives n'a augmenté ni le gain de poids vif des bouvillons ni la quantité de viande produite à l'hectare. En doublant le chargement des pâturages, on n'a pas doublé la production de boeuf à l'hectare. Le gain saisonnier n'a augmenté que de 47% et la production de viande de 80%. Cependant, en doublant le chargement et en servant de la moulée, on a plus que doublé les gains de poids vif et la production de viande à l'hectare.

Si la fumure intensive n'a pas augmenté la production de boeuf, elle a accru la production herbagère. Les pâturages soumis au plus faible chargement ont produit assez d'herbe pour les bouvillons, même à la plus faible dose d'engrais. En augmentant les quantités d'engrais, on a simplement créé un surplus d'herbe qui a été récoltée comme foin, à raison d'un peu plus de 4 000 kg/ha. Sur les pâturages où le chargement était de 4.94 têtes/ha, la quantité d'herbe disponible a augmenté avec les doses d'engrais. Elle est passée de 5 921 kg/ha sur les pâturages recevant 1 121 kg de 10-10-10, à 8 200 kg pour les doses de 3 363 kg. Cette dernière quantité rencontrait à peine les besoins des bouvillons, si bien qu'en fin de saison, les animaux n'ont pu faire de gain appréciable sans un complément de concentrés.

Ensilage de maïs et foin de luzerne en comprimés pour les bouvillons

On a mesuré l'influence du foin de luzerne en comprimés, comme complément à un régime alimentaire d'ensilage de maïs, servie à des bouvillons Holstein. L'ensilage était servi ad libitum, tandis que les comprimés de luzerne formaient le tiers de la matière sèche ingérée.

Les bouvillons recevant de l'ensilage complété de comprimés de foin ont consommé 5.8 kg de matière sèche par tête et par jour, tandis que ceux qui recevaient l'ensilage seul n'en ont consommé que 4.9 kg. L'ingestation de foin en comprimés a réduit la consommation d'ensilage, mais la diminution était moins prononcée que celle occasionnée par un complément de concentré, tel qu'on l'avait constaté dans une étude précédente. Le gain de poids vif des bouvillons recevant de l'ensilage et du foin a été de 0.79 kg/tête par jour, soit de 112% supérieur à celui des animaux nourris d'ensilage seul.

Effet de la maturité de l'ensilage de maïs sur sa valeur nutritive pour le bouvillon

Dans le but d'évaluer des ensilages de maïs coupés à différents stades de maturité, on a servi quatre sortes d'ensilage à des bouvillons croisés, pendant une période de 8 semaines.

On a coupé l'ensilage aux quatre stades de maturité suivants: pâteux-mou, pâteux-dur, denté, et après gelée. La consommation quotidienne moyenne, en matière sèche, a été de 4.1, 4.6, 5.1 et 5.2 kg/tête et les taux de gain quotidien de 0.32, 0.49, 0.49 et 0.51 kg/bouvillon, respectivement. La valeur nutritive

de l'ensilage augmentait donc au fur et à mesure que le stade de maturité avançait.

A titre de complément à cette évaluation des ensilages de maïs, des brebis ont reçu les ensilages pâteux-dur et après gelée, comme seul aliment, à partir du deuxième mois de gestation. Les résultats, à date, laissent prévoir peu d'effet de ces traitements alimentaires.

Succédanés du lait pour agneaux

Succédané du lait à base de farine de fèvesoya non dégraissée. On a comparé un succédané du lait, dont la protéine provenait entièrement du lait, à un autre dont 25% de protéine totale provenait de farine de fèvesoya non dégraissée (20% matière grasse et 45% protéine). On utilisait, comme critère d'évaluation, le développement de 48 agneaux sevrés à l'âge d'un jour. Le saindoux comestible et l'huile de coco étaient les principales sources de matière grasse.

La croissance moyenne jusqu'au poids d'abattage de 18 kg a été de 223 g/tête par jour, et n'a pas varié d'un succédané à l'autre. Le rendement et la finition des carcasses, ainsi que la couleur de la chair des agneaux alimentés aux deux régimes étaient satisfaisants.

Succédané du lait commercial et expérimental. Les agneaux nourris au succédané du lait commercial (Ewelac), du sevrage jusqu'à l'âge de 4 semaines, on crû plus rapidement que ceux nourris au succédané expérimental, contenant de 25% à 35% de matière grasse. Cependant, les taux de croissance quotidienne respectifs de 232 et 218 g/tête, jusqu'au poids d'environ 20 kg, étaient sensiblement les mêmes aux deux succédanés. La qualité de la carcasse (rendement, finition et couleur de la chair) a été supérieure chez les agneaux alimentés à la formule commerciale, lorsque l'abattage se faisait au poids de 18 kg. Cet effet du succédané du lait a été éliminé, cependant, lorsqu'on servait des concentrés et du foin après le sevrage.

Performance des truies croisées

On a mesuré la capacité reproductrice des truies en comparant les 28 croisements possibles entre les races Yorkshire, Landrace, Lacombe, Hampshire, Duroc, Berkshire, Large Black et Tamworth. Les truies issues de ces croisements ont été accouplées à un mâle de race Poland China. La performance relative des truies croisées était mesurée d'après le nombre de porcelets et le poids des portées.

Au premier rang, les truies croisées Landrace × Yorkshire et Hampshire × Landrace ont sevré respectivement 20% et 13% plus de porcelets que la moyenne. Ces truies ont démontré une supériorité similaire quant au poids de leurs portées. Ensuite se sont rangées les truies Duroc × Lacombe, avec 10.6% plus de porcelets par portée que la moyenne, tandis que les truies Large Black × Lacombe ont produit un poids des portées de 13% supérieur à la moyenne.

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Scientifique en séjour d'étude

J. A. McKeague, B.A., B.S.A., M.Sc., Ph.D. Institut de recherches pédologiques, Ottawa. 1971–72	Genèse des sols

1. Affectation à Ottawa pour une année en août 1971.
2. Détaché de la Direction de l'économie du ministère de l'Agriculture du Canada.

INTRODUCTION

Durant l'année 1971, nous avons réalisé des progrès importants dans l'organisation de la recherche par programmes avec des équipes multidisciplinaires. Ce rapport ne donne qu'un bref résumé des résultats obtenus dans les domaines des plantes fourragères, des céréales et des sols. Pour obtenir des renseignements plus amples, adresser les demandes à la Station de Recherches, Ministère de l'Agriculture du Canada, 2560 Chemin Gomin, Sainte-Foy, Québec 10, Qué.

S. J. Bourget
Le directeur

LES PLANTES

Endurcissement au froid

Métabolisme des acides aminés. Après une période d'endurcissement de 4 semaines à -1.5°C, c'est la variété d'orge d'hiver Kearny qui a résisté le mieux au gel comparativement à Dover et Hudson. A -12°C, les pourcentages de survie ont été de 80, 67 et 60 respectivement pour les variétés Kearny, Dover et Hudson. A -8°C, le pourcentage de survie pour les plants non endurcis a été de 50 pour Kearny et de 13 et 0 pour Hudson et Dover. Des résultats préliminaires ont montré que le contenu en proline des variétés d'orge d'hiver diminue au début de l'endurcissement, à la fois dans le feuillage, le collet et les racines pour augmenter considérablement par la suite jusqu'à 10 à 12 fois à la fin de l'endurcissement. L'augmentation n'est cependant pas égale pour toutes les variétés.

Changements dans les lipides de la luzerne. Une augmentation de la teneur en acides gras totaux, en phospholipides et en triglycérides a été observée dans tous les organes, surtout la racine. Le degré de désaturation des acides gras a augmenté; cette augmentation a été légère dans les phospholipides et forte dans les triglycérides. Les galactolipides ne semblent pas avoir augmenté pendant le traitement. La teneur en acide trans-3-hexadécénoique, acide présent uniquement dans le phosphatidyl-glycérol, a fortement diminué. Nous cherchons actuellement à savoir si la baisse de cet acide gras est causée par la baisse de la température ou de l'intensité lumineuse.

L'étude de la synthèse des lipides de la luzerne à basse température est en cours, en collaboration avec le Département de phytotechnie de l'université Laval et le Laboratoire de physiologie végétale appliquée de Paris (l'équipe de P. Mazliak). Nous marquons les lipides de la luzerne à partir de l'acétate-^{14}C (morceaux de racines et racines de plantes entières) et du $^{14}CO_2$ (plantes entières). Les résultats préliminaires indiquent que l'abaissement de la température jusqu'à 1°C stimule la synthèse de l'acide linoléique, et que cette stimulation est beaucoup plus forte dans le cas d'une variété rustique (Rambler) que dans le cas d'une variété tendre (Caliverde).

Le chlorméquat. A une concentration qui arrête la croissance de la luzerne pendant plusieurs jours, le chlorméquat semble peu affecter la composition lipidique de la luzerne. Ce composé semble cependant causer une augmentation de la phosphatidyl-choline. Nous avons pu séparer la phosphatidyl-choline marquée à partir de la choline-1,2-^{14}C en quatre espèces moléculaires sur couche mince de gel de silice imprégnée de nitrate d'argent. Cette séparation est une condition préalable à l'étude de l'effet du chlorméquat et de l'endurcissement au froid sur le métabolisme de la phosphatidyl-choline et de l'incorporation du chlorméquat-^{14}C dans la phosphatidyl-choline.

On a démontré que le chlorméquat est biodégradable dans le sol. A l'aide du chlorméquat marqué au ^{14}C, on a constaté que plus de 80% du chlorméquat est biodégradé en 28 jours. Après une période de latence de 8 à 10 jours, pendant laquelle la microflore du sol est induite à utiliser le chlorméquat comme source de carbone, la biodégradation devient rapide et linéaire. Il semble que la choline soit un premier intermédiaire de la biodégradation du chlorméquat.

Les légumineuses

Tache zonée du trèfle rouge. En vue de déterminer les pertes causées par *Stemphylium* sp. sur le trèfle rouge, nous avons fait un relevé hebdomadaire du pourcentage d'infection du trèfle rouge dans les parcelles établies en 1970 à La Pocatière et à Normandin. Afin d'assurer divers degrés d'infection, certaines parcelles ont été inoculées d'une culture de *Stemphylium sarcinaeforme* au début de la saison et après la première coupe. En outre, chaque semaine la moitié des parcelles ont été arrosées au Dyrène (Chemagro Corporation). A la récolte, on a déterminé le poids sec des plantes par parcelle de même que la proportion de feuilles par rapport aux tiges, dans le but d'obtenir un indice de la qualité du fourrage. Les données ont été soumises au Service de recherches statistiques pour analyses par ordinateur. Des expériences ont également été conduites en serres dans le but de déterminer l'effet du Dyrène, du mancozèbe et du manèbe sur le trèfle rouge et comme défense contre le *Stemphylium.* Les premiers résultats indiquent que de ces trois fongicides, le Dyrène est celui qui offre la meilleure défense contre la tache zonée. Cependant, les trois fongicides ont réduit de façon appréciable le rendement en fourrage du trèfle rouge. Dans tous ces essais, la variété Hungaropoli s'est révélée moins susceptible que les variétés Dollard, Lakeland et Ottawa, surtout au cours de la période végétative.

Pathogénécité des champignons du sol. Les observations en champ sur des plants de trèfle rouge (cv. Dollard, Lakeland, Ottawa et Hungaropoli) ensemencés au printemps de 1970, montrent une progression considérable du nombre de plants atteints de pourriture de la racine en 1971, en comparaison avec l'année du semis. La pourriture, dans la plupart des cas, semble progresser du collet vers le bas de la racine pivotante. Dans d'autres cas, la pourriture semble provenir de racines latérales et s'étendre à la racine pivotante.

En serre, l'infection du feuillage a augmenté le degré d'infection des racines du trèfle rouge par le *Pyrenochaeta terrestris* et le *Rhizoctonia solani.* Toutefois, des traitements antiparasitaires (huile) ont causé la perte d'un grand nombre de plants et l'analyse complète des racines n'a pu être effectuée.

Nématologie. Nous avons entrepris au Québec une enquête afin d'acquérir une meilleur connaissance des types de nématodes parasites des plantes associés aux principales légumineuses fourragères dans l'est du Canada. Cette enquête porte sur la luzerne et le lotier semés en 1969 et 1971, et sur le trèfle rouge semé en 1970 et 1971. Pour être représentatif de la superficie totale de chacune de ces cultures au Québec, l'échantillonnage doit se faire en gardant les proportions suivantes: luzerne 70%, trèfle rouge 25%, lotier 5%. Ayant parcouru cet été 600 ha de champs fourragers répartis dans 11 comtés, nous avons à ce jour recueilli 74 échantillons de sol et de racines répartis comme suit: luzerne, 44; trèfle rouge, 30; lotier, 5. Ces échantillons ont été expédiés à la Station de recherches de Vineland, Ont., pour y être analysés. Les types de nématodes rencontrés le plus souvent sont:

Sol: *Pratylenchus* (lesion) 73.4%, densité de population par kilogramme de sol 433; *Helicotylenchus* (spiral) 68.3%, 300; *Paratylenchus* (pin) 55.6%, 270; *Meloidogyne* (root-knot larva) 15.2%, 553.

Racines: *Pratylenchus* (lesion) 63.3%, 57; *Meloidogyne* (root-knot larva) 26.6%, 158; *Helicotylenchus* (spiral) 25.3%, 170; *Paratylenchus* (pin) 11.8%, 4.

Les graminées

Tallage chez le mil. On a commencé en 1970-71 à étudier l'effet de l'Éthrel (acide 2-chloroéthylphosphonique) sur le mil et surtout l'action de ce produit chimique sur le nombre de drageons, les poids sec et frais, et la hauteur des plants. Une faible concentration (2 500 ppm) d'Éthrel a produit une légère augmentation du poids frais et sec des plants, tandis qu'une diminution de ces mêmes paramètres s'est révélée à des concentrations plus élevées (7 500 ppm). Le stade de croissance aussi a eu beaucoup d'influence sur les résultats. Les plants jeunes (3 à 6 feuilles) ont répondu aux traitements plus que les plants âgés (7 feuilles jusqu'à l'épiaison). La hauteur des plants a diminué à mesure que la concentration d'Éthrel augmentait, mais le nombre de drageons a démontré une tendance contraire. On a observé l'apparition d'un grand nombre de drageons courts et une diminution de poids à hautes concentrations. Ces travaux indiquent qu'il y a possibilité de faire varier le nombre de drageons chez le mil en utilisant l'Éthrel, un composé qui affecte le transport des auxines.

Cette propriété peut être employée pour étudier les mécanismes du drageonnage.

Vernalisation du mil. On a entrepris des travaux au sujet de la vernalisation du mil, afin de trouver les conditions les plus favorables au développement normal de la plante en chambre de croissance. L'étude a porté sur trois clones qui diffèrent dans leur capacité de produire des talles. L'analyse statistique des données n'a pas été faite, mais il semble que les traitements au froid (3°C la nuit et 5°C le jour) et les journées courtes (8 heures) pendant 2, 4 ou 6 semaines ont permis d'augmenter le nombre de drageons et la production de matière sèche chez les clones à fort potentiel de tallage, tandis que l'inverse s'est produit chez le clone à faible potentiel de tallage.

Hespérie européenne. La larve de ce papillon, *Thymelicus lineola*, attaque le mil et l'agrostide. Des dégâts sérieux avaient été observés en 1970 dans la région du Lac St-Jean. En 1971, l'infestation a été moindre, sauf à Normandin où elle a été forte. Les pertes en matière sèche causées par 330 larves/m^2 ont été estimées à environ 17%, sur des parcelles de mil et de trèfle. Comme les larves étaient à 99% exemptes de parasites et de maladies, il semble que le climat soit l'agent de limitation principal. L'hespérie demeure une menace assez sérieuse pour mériter l'introduction de parasites qui pourraient en empêcher des explosions de population. En collaboration avec l'Institut de recherches de Belleville, Ont., nous avons mis au point une méthode pour obtenir des oeufs d'hespérie en quantité au laboratoire, et il nous reste à briser la diapause des oeufs.

L'orge

Évaluation. La variété d'orge Conquest continue d'être la meilleure orge brassicole pour le Québec. L'orge Champlain demeure cependant une variété à rendement supérieure en grain alimentaire. Quatre lignées à pailles fortes ont néanmoins donné des rendements supérieurs à ceux de Champlain dans l'est du Canada. Un essai préliminaire des dates de semis indique une interaction possible entre les variétés d'orge de printemps et les dates de semis.

Amélioration. Environ 2 000 lignées de la collection internationale d'orge ont été semées et sélectionnées selon les critères date d'épiaison, maturité, verse ainsi que la largeur et la longueur de la feuille étendard. Des introductions tolérantes au «barley yellow dwarf virus» (BYDV) ont été évaluées comme matériel parental. Deux croisements utilisant CI 08119 ont montré des ségrégants transgressifs pour la hâtiveté et la tardiveté à l'épiaison et à la récolte.

Une étude de sélection pour le caractère rendement en gros grain en deuxième génération d'auto-fécondation, nous a permis de choisir les croisements à fort potentiel et de sélectionner des plants à l'intérieur du groupe des meilleurs. Cinq différentes statistiques ont servi à évaluer ce potentiel de sélection à l'intérieur de, et parmi, les croisements. Un essai de rendement des lignées sélectionnées nous a permis de vérifier l'hypothèse que ce caractère peut être sélectionné effectivement dès la première génération à l'état de ségrégation.

Transmission du BYDV par les pucerons. Macrosiphum avenae, Rhopalosiphum maidis et *Rhopalosiphum padi* ont été reconnus comme vecteurs du BYDV dans la région de Québec. Le *R. padi* est le plus important. La lignée de virus étudiée en 1971 appartient au groupe PAV. C'est une lignée modérément virulente sur l'orge et extrêmement virulente sur l'avoine. Des dégâts sérieux ont été observés dans des champs de plusieurs régions.

L'avoine

Évaluation. La variété Dorval continue d'être au premier rang pour le rendement à l'hectare. Deux lignées semblent prometteuses dans les Co-op. de l'Est. Ces deux lignées produites à La Pocatière, QO 115-1-2 et QO 115-2-2, sont issues d'un croisement visé originellement à la résistance à la septoriose. Le manque d'une technique adéquate pour vérifier la résistance à la septoriose se fait sentir. L'alternative qu'il nous reste vient de l'inoculation naturelle en plein champ avec les risques inhérents.

Amélioration. Quarante lignées d'avoine provenant de croisements faits à La Pocatière ont été évaluées selon leur rendement, résistance à la verse et comportement général d'adaptation à des conditions de croissance différentes. La verse et un rendement inadéquat permet d'éliminer tout le matériel Lamozygote inférieur, et de ne conserver que le matériel génétique supérieur. Dix-sept lignées en ségrégation ont été sélectionnées pour satisfaire aux objectifs choisis. De plus,

environ 240 croisements ont été réalisés de parents méthodiquement choisis pour combiner leur potentiel génétique, en vue de répondre aux objectifs établis.

Septoriose. Au cours d'expériences préliminaires, cinq souches de *Septoria avenae* furent isolées de plants d'avoine au Québec. Plusieurs milieux de culture furent essayés dans le but de produire une sporulation rapide et abondante des isolats pour fin d'inoculation. Un milieu de culture à base de feuilles de plantules d'orge s'est avéré très propice à cette fin. Après deux semaines de croissance des colonies à la noirceur et à 24°C, les populations de pycnides ont été de 10 fois supérieures à celles des colonies croissant sur milieu à base de feuilles de plantules d'avoine, ainsi qu'à celles des colonies croissant sur milieu à base d'un mélange de feuilles d'orge et d'avoine. La croissance diamétrale des colonies sur le milieu à base d'orge était le double de celle des colonies sur les deux autres milieux de culture. Ces résultats suggèrent la présence de composés à action inhibitrice dans les plantules d'avoine et tendent à démontrer indirectement la résistance plus grande qui existe en nature dans les plantules d'avoine relativement aux plants plus âgés.

Le blé

Évaluation. Les variétés de blé de printemps Opal et Pitic 62 continuent à donner des rendements en grain supérieurs à ceux de Selkirk. Elles ont aussi réagi à une application supplémentaire de 168 kg/ha de 34-0-0 en 1970 et de 100 kg/ha de 23-23-0 en 1971, ceci après une fertilisation de base adéquate pour l'argile Kamouraska. Une seule lignée 714A semble montrer une interaction variété × fertilisation.

LES SOLS

Critères de classification

Caractérisation. Au cours de l'année 1971, nous avons terminé, en collaboration avec la Faculté d'agriculture de l'université Laval, un travail sur certaines propriétés physiques, chimiques et minéralogiques des séries La Pocatière et St-Pascal. Ces deux séries, classées respectivement comme gleysol éluvié peu humique et gleysol orthique, se sont développées sur des sédiments marins à l'origine calcaires. De fortes variations texturales attribuées au mode de déposition ont été observées dans la série St-Pascal ainsi que dans la partie inférieure de la série La Pocatière. La présence d'argillans notée dans l'horizon Btg1 du profil La Pocatière a confirmé également des phénomènes d'illuviation d'argile dans cet horizon.

Le lessivage a affecté tous les horizons de la série La Pocatière, tandis que dans le profil St-Pascal, il s'est manifesté surtout dans les horizons Ahe et Bg1. Le matériel calcaire s'est recontré à 76 cm dans ce profil. Malgré l'origine marine de ces sols, qui pourrait engendrer de fortes teneurs en sels solubles, la conductivité n'était que de 0.32 mho/cm dans les horizons inférieurs de ces deux profils. Le calcium était le cation échangeable dominant dans tous les horizons et le taux de saturation en bases était très élevé. On a observé des différences très marquées dans les quantités d'oxydes de fer et de manganèse.

L'analyse minéralogique qualitative et quantitative de la fraction argileuse a montré la dominance de l'illite. D'autres phyllosilicates étaient présents dans la majorité des horizons et un interstratifié possible de type illite-smectite se retrouvait dans les horizons Ap et Ahe. Le quartz était présent dans la fraction argileuse de tous les horizons, tandis que les feldspaths et les amphiboles étaient limités aux horizons de la série La Pocatière ainsi qu'aux horizons C1g et C2k de la série St-Pascal. L'hématite se retrouvait également dans ces deux derniers horizons.

La fragipan. En terminant la description des séries de sol Leeds, Ste-Marie et Brompton, qui se sont développés dans les Hautes Terres des Appalaches sur des tills dérivés principalement de schistes, nous avons pu observer que le degré de développement du pan était affecté par la compacité de la roche-mère. Le dépôt contenait une très grande majorité d'illite, il était peu perméable et vraisemblablement les particules d'illite étaient orientées par suite de la structure lamellaire des schistes. De ce fait, les fentes de retrait caractéristiques du fragipan, et qui se forment lors de l'alternance de périodes de dessication et d'humidification du sol, étaient moins développées que dans des tills constitués de quartzites. Il était d'ailleurs caractéristique que le profil le moins bien drainé

était encore inondé au mois de juin et ne présentait aucun horizon induré. Par contre, dans les profils mal drainés développés sur sols quartzitiques, le fragipan s'observe.

Nous avons aussi vérifié sur le terrain l'influence de la compacité du sol en opérant un sondage à intervalles réguliers le long d'une ligne recoupant deux types de dépôts: l'un, un till glaciaire compact et l'autre, du matériel fluvio-glaciaire, de la même nature que le précédent mais moins dense. Dans le premier dépôt, le fragipan se retrouvait d'habitude beaucoup plus près de la surface (50 cm) que dans le second (85 cm).

Enfin, lors d'échantillonnages de sols dans la région de Thetford-Black Lake, nous avons prélevé des échantillons dans des profils développés sur till mais dont la surface a subi l'influence de retombées de poussière basiques issues des exploitations minières. Le pH des sols s'en est retrouvé quelque peu relevé mais n'a pas atteint la neutralité. L'altération podzolisante caractéristique dans le till a été ralentie et nous n'avons pas trouvé de fragipan. Par contre, on l'a observé dans un autre profil qui ne semblait pas affecté par les poussières. Il est encore trop tôt pour savoir si le fragipan était présent à quelque moment dans ces profils et s'il a été redissous, puisque les exploitations minières de grande envergure datent de 50 ans au maximum.

Fertilité

On a complété un premier travail portant sur le développement des profils dans la région de Thetford - Black Lake et plus particulièrement, l'action du matériel basique sous forme de poussière à la surface du sol. Quatre profils ont été analysés, parmi lesquels trois étaient développés au moins en partie sur du till glaciaire. L'apport de poussière était variable et s'est traduit par: 1) un relèvement du pH par rapport aux sols non affectés; 2) un apport plus ou moins important de Mg à la surface de sols qui sont généralement déficients en cet élément; 3) un taux de base égal à 100% dans tous les horizons des profils, même les B spodiques; et 4) un effet retardateur de l'action podzolisante.

Ces observations, jointes au fait que même dans un till profond (125 cm) dans lequel on aurait pu s'attendre à trouver un fragipan, celui-ci était absent, nous ont convaincu d'entreprendre quelques essais sur l'utilisation possible des déchets miniers comme amendement pour les sols acides. Jusqu'à présent nous avons observé que l'incorporation de cet amendement est favorisée par la présence de plantes, car après 8 semaines le pH du sol sur lequel poussait une plante s'élevait plus rapidement que dans le sol témoin.

FERME EXPÉRIMENTALE, LA POCATIÈRE

La luzerne

Date et mode de semis. Il n'y a à peu près pas de différence dans le rendement de la luzerne semée à trois taux différents (6.7, 13.4 et 20.1 kg/ha), l'année du semis. On a constaté même une légère diminution de rendement avec l'augmentation du taux de semis. La date de semis semble avoir eu une influence importante sur le rendement de la luzerne lors de l'année d'implantation. En effet, des semis de luzerne effectués les 28 avril, 12 et 28 mai nous ont montré que c'est le semis du 12 mai qui donne le meilleur rendement. La date la plus tardive a donné les résultats les plus faibles. Les semis effectués les 2, 17 et 27 août ont démontré qu'il ne faut pas semer après la première date, si l'on veut que la plantule puisse acquérir un développement et une préparation à l'hiver convenables avant le gel.

Les résultats de l'année d'implantation nous ont montré que le semis en rangs donne un rendement supérieur au semis à la volée, particulièrement chez la luzerne. L'effet d'association de la légumineuse et la graminée ne s'est pas fait sentir l'année de l'implantation.

Hivernement. La date de la deuxième coupe est déterminée à partir d'un certain nombre de degrés-jours (750, 900, 1 050, 1 200) accumulés depuis la première coupe. Les résultats ont indiqué que c'est de 750 à 900 degrés-jours que l'on obtient le meilleur hivernement pour les variétés hâtives, tandis que les variétés tardives exigent plus de 900 degrés-jours. L'enlèvement de la troisième coupe même après la gelée semble diminuer la capacité de la luzerne de survivre à l'hiver.

Essais de variétés fourragères

Luzerne. Dans un essai d'élimination de la luzerne semée en 1970, les lignées T-4, AT-1P, OD-17, OED-4 et OR-24 ont donné un rendement supérieur à nos variétés standards.

Trèfle rouge. Des 83 variétés de trèfle rouge semées en 1970, ce sont par ordre décroissant de rendement moyen les variétés Ultana, Tilo, Juno, Hungaropoli, Teroba, Lakelon et Lasalle qui ont été les meilleures.

Mil. Climax, TM60-101 et Climax F_2 ont donné le meilleur rendement en foin. Pour le pâturage, Clair, Champ et TM60-101 se sont montrées supérieures.

Brome. Après 5 années de récolte ce sont les variétés Saratoga, Manchar et Baylor qui viennent en tête pour le rendement.

Alpiste roseau. Cinq années consécutives de récolte ont montré que Rise donne un rendement bien supérieur à Frontier et S-5573.

Les fruits

Pommiers. La greffe en tête, pratiquée sur *Malus robusta* 5, a été efficace parmi 59% des variétés et semis greffés du verger sud-est et de 77% dans le verger nord.

Fraisiers. Les variétés de fraisiers plantés en 1969 ont donné en deuxième année de production un rendement moyen qui a atteint le double de celui de 1970. Les variétés les plus productives en 1971 furent: Vibrant, Redcoat, Sparkle, Veestar et Cavalier. Les variétés les plus hâtives furent Veestar et Cavalier en première et deuxième années de production.

Les pommes de terre

Variétés. Le cultivar hâtif F57048 s'est avéré très prometteur en sol minéral et organique, ainsi que le cultivar tardif F61013 en sol organique. La variété rouge Chieftain offre de grandes possibilités. Monona et Norchip, très avantageux pour les croustilles, ont donné des rendements variables selon les régions.

Flétrissure bactérienne. De petits tubercules entiers dont la moitié avec blessures, trempés dans une suspension bactérienne, ont donné une récolte exempte de symptômes. Les cultivars résistants Saranac et B725-61, inoculés par racines, ont été peu infectés à La Pocatière en 1971 comparativement aux plants à Normandin et Ragueneau, dont la plupart ont été infectés. Les solanacées *Solanum acaule* OCH S-83 et *S. infundibuliforme* PI 320295 sont apparus résistants à la maladie. Les 120 semis de la série F68 de Fredericton ont tous montré des symptômes sur tubercules après inoculation au couteau.

Mode de culture. Les trois méthodes de culture suivantes ont été comparées au point de vue activité herbicide et rendement: 1) semis à plat et buttage à la floraison, 2) buttage au semis et à 5% de levée, 3) buttage au semis et à la floraison. Les herbicides linuron et prométryne ont été employés aux taux respectifs de 1.1 et 1.7 kg/ha. Plantée à plat, la pomme de terre a eu une levée plus rapide, une tubérisation plus hâtive et un rendement plus élevé à condition qu'il n'y eût pas de mauvaises herbes. Les deux herbicides se sont avérés efficaces à réprimer les mauvaises herbes. Ces dernières étaient présentes en plus grand nombre dans le cas du semis à plat qu'avec les autres méthodes de culture, lorsque l'on n'utilisait pas les herbicides.

Les sols

Drainage. Dans une étude de l'influence du réglage de la nappe phréatique sur les propriétés du sol, la dynamique de l'humus, et le rendement des plantes, une variation de la nappe phréatique de 45 à 75 cm a amené une diminution des rendements, tandis qu'une variation de 75 à 120 cm en a produit une augmentation. Le brome, le mil et la luzerne ont bénéficié grandement du drainage, et d'autres espèces, telles le maïs, l'avoine et l'orge ont également accusé une augmentation de rendement lorsque le niveau de la nappe phréatique baissait.

FERME EXPÉRIMENTALE, NORMANDIN

Les plantes fourragères

Régie de la fléole. Les résultats d'une première année d'exploitation de la fléole soumise à divers taux et périodes de fumure azotée, indiquent que 56 kg/ha de N contribuent à un meilleur rendement en matière sèche, à la première coupe, que les taux respectifs de 112 et 224 kg/ha. A la deuxième coupe et pour le rendement saisonnier cependant, la production de matière sèche augmente proportionnellement aux taux de N. La fléole a mieux répondu à un seul apport

de 224 kg/ha de N sous forme d'urée, à l'automne avant la récolte, qu'aux autres traitements à base de nitrate d'ammoniaque; il semble toutefois que l'urée occasionne un déséquilibre de la disponibilité des autres éléments, manifesté par une croissance végétative accélérée causant la verse et un retard de la maturité.

Régie de mélanges à foin. Après 3 années d'exploitation d'un mélange de fléole, trèfle rouge et luzerne, fauché dans une série de coupes hebdomadaires en juillet et d'une coupe uniforme en août, on peut conclure que la meilleure production de matière sèche a été obtenue quand la première coupe a été effectuée au début de juillet.

A l'encontre des résultats précédents, un nouveau semis identique et exploité de la même façon a démontré, après 2 ans, que les meilleurs rendements saisonniers sont obtenus quand la première coupe est faite à la troisième semaine de juillet. Ce fait serait attribuable à une couverture végétale différente de celle de l'essai précédent.

Une étude sur le comportement d'espèces de légumineuses et de graminées en semis pur, par comparaison avec des mélanges de ces espèces, a révélé, après 2 ans de résultats, que les mélanges sont plus productifs que les espèces pures. Les graminées en semis pur ont un rendement plus ample que dans les mélanges où elles se trouvent.

Fumure du maïs fourrager. On a comparé l'influence de trois formules d'engrais sur le rendement et la qualité de trois hybrides de maïs fourrager, soit Pride 101, 109 et 116. Aucune différence significative entre les formules d'engrais n'a été décelée par la production totale de matière sèche; les hybrides différaient en production des épis sur une base de matière sèche, différence attribuable à leur maturité respective. La formule 6-12-12 a contribué à hâter la maturité des trois hybrides de plus que le 5-20-20 et le 7-27-12, par ordre décroissant de maturité.

Le chou fourrager

Fumure azotée et dates de semis. L'effet de trois semis effectués à une semaine d'intervalle et d'une fumure respective de 80, 160 et 190 kg/ha de N, apportée en deux fois au cours de l'été, a été étudié durant 3 ans. Le semis le plus hâtif, soit à la fin de mai, a contribué à l'obtention de près de 2 400 kg/ha de matière sèche de plus que celui de la mi-juin. Les taux de fumure azotée n'ont pas donné de différences marquées en production de chou fourrager aux trois dates respectives, et il semble que le niveau intermédiaire soit le plus économique d'utilisation.

Dates de récolte. La production de matière sèche de cette crucifère s'accroît de près de 1.8 tonnes métriques/ha quand on la récolte à la mi-octobre au lieu de la mi-septembre. Un semis sur sol drainé ou à teneur moyenne (50% et moins) en argile favorise davantage la croissance du chou fourrager que la culture sur sol plus lourd, où le phosphore semble être moins facilement disponible.

Les fruits et légumes

Fraisiers. De la plantation de huit variétés de fraisiers faite en 1969 nous avons constaté que la production de fruits est fonction de la rusticité des plants. Les variétés Veestar, Redcoat, Vibrant et Guardsman ont montré une rusticité et une productivité appréciables; Veestar a surpassé de 1 000 kg/ha la variété Redcoat, au second rang avec 6 018 kg/ha. Vibrant a produit un fruit peu sucré.

Framboisiers. Les framboisiers plantés sur sol plutôt sablonneux ont atteint plus rapidement leur maturité végétative que ceux plantés sur sol argileux lourd. Cette maturation plus hâtive réduit la dessication des tiges par le froid et améliore la persistance.

Les céréales

Blé de printemps. La variété Pitic 62 a de nouveau rapporté plus de grain/ha que les variétés Opal et Selkirk. Sur sol drainé, Pitic 62 a produit 1 957 kg/ha (71.9 mt/acre) en 114 jours de végétation.

Orge. Une moyenne de 1 502 kg/ha (69 mt/acre) a été obtenue de neuf variétés ensemencées à quatre endroits de la région. Champlain et Paragon se sont classées au premier rang, suivies de la lignée QB 46127.

Avoine. Un rendement impressionnant de 1 858 kg/ha (120.5 mt/acre) a été obtenu de sept variétés semées en parcelles sur sol drainé. La moyenne des quatre essais ensemencés dans la région a démontré que la variété Dorval est la meilleure productrice à la condition qu'elle soit semée tôt. La nouvelle avoine Fraser est plus tardive que Dorval et produit un peu moins que celle-ci.

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Station de recherches Saint-Jean, Québec

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Scientifique en séjour d'étude

D. V. FISHER, B.S.A., M.S.A., Ph.D. — Pomologie
Station de recherches, Summerland, C.B.,
octobre 1970 à octobre 1971.

INTRODUCTION

Ce rapport donne les résultats saillants des principaux travaux de recherches poursuivis en 1971 sur les cultures fruitières et maraîchères qui font l'objet de nos programmes de recherches.

Au cours de l'année nous avons consolidé davantage nos équipes de chercheurs en recrutant deux nouveaux professionnels, MM. P. Ricard et M. Lareau. D'autre part, nous avons accéléré le déménagement à notre ferme de Frelighsburg du matériel pomologique en pépinière à la Station de recherches d'Ottawa. Cette opération a été commencée en 1970 par suite de la discontinuation de ces projets à cette dernière Station.

L'aménagement général de notre ferme fruitière à Frelighsburg a été poursuivi d'une façon satisfaisante, surtout par la construction d'un bâtiment de service et d'un caveau à racines.

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 comme suit: Station de recherches, Ministère de l'Agriculture du Canada, Casier postal 457, Saint-Jean, Qué.

A. A. Beaulieu
Le directeur

POMME

Entomologie

Phéromones sexuelles de synthèse. Ces phéromones ont été employées dans sept vergers commerciaux pour le dépistage de la pyrale de la pomme, *Laspeyresia pomonella* (L.), et de la tordeuse à bandes rouges, *Argyrotaenia velutinana* (Wlk.). Dans chaque verger, les captures de la pyrale se sont avérées en étroite relation avec les estimés subséquents de pommes attaquées par cet insecte. Concernant la tordeuse à bandes rouges, la phéromone synthétique s'est montrée excessivement attractive puisque, même dans un verger où nous avons capturé 33 mâles, nous n'avons décelé aucun dégât larvaire sur les pommes et pas plus de 1.7% des feuilles légèrement affectées. Il s'ensuit que ces composés peuvent être des moyens rapides et efficaces pour déterminer la densité de ces ravageurs dans les vergers commerciaux.

Mouche de la pomme. D'après des échantillons de sol prélevés au printemps, les populations de pupes de la mouche de la pomme, *Rhagoletis pomonella* (Walsh), étaient concentrées presque exclusivement sous les pommiers de variétés hâtives et n'avaient été réduites que de 16.5% par l'action des prédateurs, au cours de l'hivernement. Telle que mesurée à l'aide de pommes engluées, l'activité des adultes a débuté à la fin de juin, s'est intensifiée dès le début de juillet et est demeurée forte jusqu'à la mi-août pour cesser à la fin de septembre. L'infestation a été nettement plus sévère qu'en 1970, en raison d'un taux de survie plus élevé des pupes, d'une récolte de pommes moins abondante et de conditions climatiques plus favorables à l'activité des adultes.

Dans la lutte contre la mouche de la pomme, quatre applications des insecticides trichlorfon, tétrachlorvinphos, phosmet ou pirimiphos-méthyl ont fourni de 99% à 100% de fruits sains à la récolte comparativement à 85%, dans les parcelles non traitées. Les dates des traitements basées sur l'activité de l'insecte ont contribué à l'excellence de ces résultats.

Punaise terne. A Frelighsburg, Qué., les premiers adultes de la punaise terne, *Lygus lineolaris* (Beauv.), ont été observés sur les bourgeons des pommiers vers la mi-mai, lorsque la température de l'air atteignait 21°C. Après des activités plutôt sporadiques jusqu'en juillet, l'insecte est alors disparu du verger pour n'y revenir qu'à la fin d'août. Parmi les insecticides mis à l'essai contre ce ravageur, seul le DDT a fourni 100% de fruits sains à la récolte.

Lutte intégrée contre les acariens phytophages. Dans une parcelle de pommiers de 1.6 ha affectée aux études écologiques où il y eut, en 1971, uniquement des traitements fongicides, les prédateurs ont maintenu le tétranyque rouge, *Panonychus ulmi* (Koch), à une densité très faible durant tout l'été; seule

la population du phytopte du pommier, *Aculus schlechtendali* (Nal.), a accusé une augmentation en juillet. Les prédateurs observés se classent dans les groupes suivants: arachnides, phytoseiides, coccinelles, pentatomides, thrips et neuroptères. Par ailleurs, 17% des pommes étaient attaquées par la mouche de la pomme, *R. pomonella,* et 14% par d'autres insectes.

Lutte chimique contre le tétranyque rouge du pommier. Dans des essais de lutte préventive contre le tétranyque rouge du pommier, *P. ulmi,* le produit chlorphénamidine s'est montré aussi efficace que l'éthion-huile et l'endosulfan-huile mais a été inférieur au quinométhionate qui a eu une rémanence plus prolongée. Contre ce même acarien, des essais curatifs ont démontré l'efficacité des acaricides Plictran (Dow Chemical), Fundal Forte (Niagara Chemicals) et quinométhionate; en serre, l'action de Bayer 80530 (Chemagro Ltd) a été similaire à celle du propargite.

Action des fongicides sur les acariens. Dans des parcelles traitées aux fongicides Cela W524 (Cie Cela), Dikar (Rohm and Haas, Co.) captane et UniRoyal 101 (UniRoyal Chemical), des décomptes, effectués régulièrement durant toute la saison estivale, ont démontré que Dikar et captane ont définitivement tenu en échec le phytopte du pommier, *A. schlechtendali,* durant presque toute la saison.

Phytopathologie

Tavelure du pommier. Pour une deuxième année consécutive, une application de captafol effectuée à dose massive (5.7 litres/450 litres) sur des pommiers de la variété McIntosh au stade du débourrement avancé et une application de dodine, effectuée à dose normale un mois plus tard, ont assuré une protection complète des feuilles et des pommes contre la tavelure du pommier, *Venturia inaequalis* (Cke.) Wint.

Dans des essais de traitements réguliers contre la tavelure du pommier sur la variété McIntosh, 10 applications des fongicides captan, Dikar, bénomyl et thiophanate de méthyl, employés aux doses recommandées par les fabricants, ont eu un taux d'efficacité de 98% et plus. La dodine, dans les mêmes conditions, n'a pas enrayé de façon satisfaisante la tache d'automne.

Génétique

Cultivars et pommiers à lambourdes. Les croisements effectués en 1971 dans le but de créer des cultivars de pommiers résistants à la tavelure ont fourni suffisamment de semence pour permettre, au début de 1972, l'inoculation de 80 000 semis dont 40 000 à Purdue University, Lafayette, Ind., et 40 000 à Saint-Jean, Qué. Toutes les sélections trouvées résistantes seront maintenues et suivies dans notre ferme fruitière à Frelighsburg, Qué. Dans l'évaluation de variétés de pommes propres aux conditions du Québec, plus de 50 cultivars ont été bouturés ou greffés sur des porte-greffes Ottawa 8 pour être l'objet d'observations suivies et d'évaluation systématique. Dans une première tentative d'introduction de pommiers à lambourdes (spur-type) au Québec, 8 000 jeunes arbres de cette catégorie ont été plantés, en 1971, dans une dizaine de vergers commerciaux.

Physiologie et nutrition

Régulateurs de croissance. Appliqués en 1969 et 1970 sur de jeunes pommiers Imperial Allred McIntosh (qui avaient été greffés en 1968 sur des porte-greffes *Malus robusta* 5), le chlorméquat et le chloroflurenol n'ont pas semblé affecter la croissance végétative de ces arbres mais en ont, de toute évidence, hâté leur première fructification, relativement abondante, en 1971. Dans les mêmes conditions, les applications de dimazide (Alar-85) ont sensiblement réduit la croissance des jeunes arbres, retardé de 7 jours l'époque de leur floraison et n'ont pas favorisé leur fructification qui a été inférieure à celle des arbres non traités.

Sur des pommiers McIntosh adultes, les applications annuelles et consécutives de dimazide, effectuées à la mi-juillet au taux de 700 ppm, ont retardé la chute des pommes et augmenté leur fermeté sans réduire sensiblement la grosseur des fruits; au taux de 1 400 ppm, les effets de retention et de fermeté ont été plus marqués mais la grosseur des fruits a été nettement réduite dès la deuxième année d'application.

Dans des essais visant à corriger les carences de magnésium dans les vergers, une application foliaire de cet élément s'est avérée nettement insuffisante.

Régie des pommeraies

Action de la taille des pommiers sur leurs rendements. Parmi les six traitements de taille à l'essai sur des pommiers McIntosh adultes, celui comportant la suppression de branches charpentières selon la méthode de Crowe a fourni les plus fortes récoltes, soit 534 kg en moyenne par arbre; chez les arbres soumis aux autres traitements, les rendements moyens ont varié de 228 à 438 kg. Par ailleurs, la meilleure pigmentation des fruits est résultée d'une taille sévère effectuée en juin.

PETITS FRUITS

Entomologie

Punaise terne. Dans certaines fraisières commerciales, les fruits attaqués par la punaise terne, *Lygus lineolaris* (Beauv.), représentaient 40% de la récolte. Dans la lutte contre cet insecte, le trichlorfon a fourni 86.2% de fruits sains et a été nettement supérieur à l'endosulfan qui en a donné 81.4%. Dans un deuxième essai, le phosalone, le tétrachlorvinphos, le malathion et l'endosulfan ont eu un taux d'efficacité variant de 80.7% à 83.7%. Le phosmet s'est montré inférieur avec un taux de 77.4%.

Insectes pollinisateurs. Des fraisiers des variétés Earlidawn, Redcoat et Guardsman, cultivés en plein champ mais gardés sous cages en l'absence de tout insecte durant la floraison, ont fourni à la récolte de 78% à 100% de fruits nains, difformes et invendables. Ces résultats démontrent l'importance des insectes pollinisateurs.

Tétranyque à deux points. Des essais de traitements acaricides ont été effectués sur des plants de fraisiers cultivés en serre pour enrayer des populations du tétranyque à deux points, *Tetranychus urticae* Koch, d'une densité de 700 à 900 oeufs et formes libres par feuille. Les résultats ont démontré l'efficacité des produits quinométhionate, propargite et Animert (N.V. Philips-Duphar).

Phytopathologie

Blanc du fraisier. Dans des essais de fongicides pour la répression du blanc du fraisier, *Sphaerotheca humili* (DC.) Burr., le soufre (Kolospray, de Niagara Chemicals), le thiophanate de méthyl et le dinocap, appliqués l'année de la plantation et une fois avant la récolte, ont augmenté légèrement les rendements de la variété Earlidawn, tandis que chez la Guardsman, variété plus résistante, seul le dinocap a contribué à une légère augmentation des rendements.

Génétique

Évaluation de lignées et de cultivars de fraisiers. Parmi 14 lignées de fraisiers provenant de la Station de recherches d'Ottawa, Ont., 10 ont eu un rendement supérieur à celui du cultivar Redcoat. Leurs rendements ont varié de 7.4 à 13.2 tonnes métriques/ha. Parmi le matériel fourni par la Station de recherches de Kentville, N.-É., le cultivar Guardsman a donné les meilleurs résultats, soit 10.9 tonnes/ha comparativement à 9.3 tonnes/ha fournies par la Redcoat. Le cultivar Vesper s'est classé au premier rang des plants provenant de Salisbury, Md., avec 10.3 tonnes/ha. Enfin, six cultivars, fournis par la Station de recherches de Vineland, Ont., ont eu des rendements de 9.3 à 11.2 tonnes/ha, s'avérant supérieur à la Redcoat.

Régie des cultures

Densité de plantation des framboisiers. Les cultivars Comet, Newburgh, Latham, Carnival et Trent ont été plantés en 1968 ainsi qu'en 1969 dans deux séries de parcelles adjacentes, établies à l'Acadie, Qué. A leur première année de fructification, ils ont été éclaircis aux taux de 50, 75, 100, 125, 150 et 175 tiges par rang de 9.14 m et, à la deuxième année, aux taux de 75, 100, 125, 150, 175 et 200 tiges par même unité de rang. Les rendements obtenus en 1971 dans les deux plantations ont été directement proportionnels aux densités, soit 7 414 g en moyenne par rang pour la plus faible densité et 9 749 g, pour la plus forte densité. Ces plantations à l'essai ont été sérieusement affectées, en 1970-71, par la gelure ainsi que par le tumeur du collet, *Agrobacterium tumefaciens* (Sm. & Towns.) Conn.

OIGNON

Régie des cultures

Densité des semis. En réduisant l'espace entre les rangs et le taux de semis, on a augmenté d'une façon appréciable le rendement de la variété d'oignon Autumn Spice. Ainsi, les plus hauts rendements d'oignons

vendables ont été de 43 tonnes métriques/ha. Ils furent obtenus dans trois semis différents, soit de rangs espacés de 15 cm à raison de 8.8 plants/m, ou espacés de 22.5 cm à raison de 11.8 plants/m, ou espacés de 22.5 cm à raison de 15.9 plants/m. Ces rendements étaient de 25% plus élevés que ceux des témoins où les rangs étaient espacés de 42.5 cm à raison de 39 plants/m.

Traitements herbicides. Le propachlore fut encore l'herbicide qui donna les meilleurs résultats dans la lutte contre les mauvaises herbes lorsqu'il fut appliqué dans les semis d'oignons au stade de la préémergence. Néanmoins, des essais faits en serre et en plein champ ont révélé que le produit BAS 2903 [2-chloro-*N*-(1-méthyl-2-propynyl) acétanilide] (BASF Canada Ltd) était aussi très efficace. De plus, des recherches ont démontré que ce produit n'affectait que très peu le développement physiologique des plants d'oignon produits dans des solutions Hoagland.

Phytopathologie

Charbon de l'oignon. Dans un sol très infesté du charbon de l'oignon, *Urocystis magica* (Pass.), des 11 traitements fongicides, seuls les traitements de semence contenant du Pro-Gro 80% D à 2.5% (UniRoyal Chemical) ont donné une répression efficace de 81% à 94%. D'autre part, le thirame 75-W à 37.5% a été encore le meilleur traitement contre la fonte des semis. Néanmoins, dans les parcelles traitées les pertes causées par le charbon et la fonte ont été de 20% à 40% comparativement à 90% dans les témoins. Dans un sol non infesté, la récolte fut de 52 tonnes/ha d'oignons vendables, soit 13 tonnes/ha de plus qu'en sol infesté où on utilisa les meilleurs traitements.

Par ailleurs, les 11 cultivars d'oignon utilisés dans des essais de résistance au charbon réalisés en serre se sont tous révélés très susceptibles.

CAROTTE

Régie des cultures

Densité des semis. A la suite des essais encourageants poursuivis les années précédentes, on a confirmé en 1971 que les rangs espacés de 15 cm et comportant en moyenne 25 plants/m de longueur ont donné le plus haut rendement de carottes, soit 99.6 tonnes métriques/ha. Un tel rendement représente 30% de plus que celui des témoins avec des rangs espacés de 45 cm et de 55 plants/m de longueur.

Variétés hâtives. Chez les quatre cultivars et les trois variétés de carottes à l'essai le rendement total a varié de 36 tonnes/ha pour Waltham Hi Color à 49.8 tonnes/ha pour Hy 9182. Le témoin, Waltham Hi Color, a donné le plus bas rendement dont 18.2% de qualité n°2 et de rebus. Si l'on considère le rendement de carottes vendables, les cultivars Hy 9182 et Hi Pak Elite possèdent les meilleurs caractéristiques. Ils ont un rendement élevé, les carottes ont une surface lisse, une belle couleur, une longueur uniforme, et sont très attrayantes pour l'ensachement dans le cellophane.

Variétés tardives. Chez les huit cultivars de carottes à l'essai, le rendement total moyen fut de 73.2 tonnes/ha et a varié de 47.6 à 98.0 tonnes/ha pour Canuck Hy et Nantesa Superior, mais le pourcentage moyen de carottes de qualité n°2 et de rebus s'élevait à 35% chez ce dernier. C'est pourquoi le Nantesa Superior, malgré son rendement élevé, ne peut être considéré que pour la transformation. Les cultivars Canuck Hy et Spartan Delite sont définitivement éliminés à cause de leur faible rendement et du taux élevé de 57% de qualité n°2 et de rebus. Les deux cultivars Gold Pak et Gold Pak 28 ont donné un rendement vendable intermédiaire de 22 tonnes/ha et seulement 8% de qualité n°2 et représentent la meilleure qualité de carottes tardives pour l'ensachement dans le cellophane.

Désherbage chimique. Les essais d'herbicides effectués au cours des années précédentes dans les semis de carottes ont démontré les avantages des traitements de préémergence comparés à ceux de postémergence. Cependant, les résultats obtenus en 1971 ont démontré l'inefficacité relative des traitements de préémergence. Ceci est probablement attribuable aux faibles pluies qui ont suivi les traitements.

Entomologie

Charançon de la carotte. Deux méthodes d'élevage ont permis de maintenir en serre et en insectarium un élevage permanent du charançon de la carotte, *Listronotus oregonensis* (Lec.), et d'obtenir une population

suffisante d'adultes afin de créer une infestation artificielle au printemps 1972 dans les parcelles de répression chimique. En serre, le temps requis en moyenne pour compléter une génération, de l'oeuf à l'adulte, a été de 34 jours. Les résultats de la répression chimique obtenus en 1971 ont démontré une différence significative entre les différents traitements, variant de 0.3% à 2.65% de racines endommagées comparée à 9.6% chez les témoins. A l'instar de 1970, les dégâts aux semis hâtifs ont été plus élevés que ceux aux semis tardifs à raison de 8.3% et de 2.8% de racines avariées, respectivement.

Nématodes Une enquête préliminaire sur les nématodes s'attaquant aux principales cultures dans des sols organiques du sud-ouest du Québec a été faite en collaboration avec la Station de recherches de Vineland, Ont. Le dénombrement des 17 champs visités et des quatre espèces différentes de nématodes collectionnés est le suivant: nodosité des racines, *Meloidogyne,* 14 champs; nématose des racines, *Pratylenchus,* 8; rabougrissement nématique, *Tylenchorhynchus,* 2; nématose des racines, *Paratylenchus,* 2. La nodosité des racines surtout a causé des dégâts considérables dans les champs de carotte.

CHOU

Génétique

Résistance du chou à la hernie. L'électrophorèse sur gélose amidonnée a servi à la détermination de la peroxidase contenu dans la semence de la lignée de chou 8-41, résistante à la hernie, *Plasmodiophora brassicae* Wor., et de la variété susceptible Pennstate Ballhead. Les résultats démontrent que seule la lignée résistante contient de la peroxidase qu'on peut soupçonner de jouer un rôle important dans la résistance à la hernie.

Chou hybride. Six populations (P_1, P_2, F_1, F_2, B_1 et B_2) à contenu génétique différent, résultant de croisements entre le cultivar Golden Acre à fendillement hâtif et le cultivar Baby Head à fendillement tardif, ont démontré l'hérédité du fendillement du chou. Ce caractère, transmis surtout selon le mécanisme de l'action additive des gènes, implique au moins deux gènes majeurs.

MAÏS

Génétique

Résistance à la pyrale du maïs. Sous l'influence d'infestations naturelles et artificielles de la pyrale du maïs, *Ostrinia nubilalis* (Hbn.), 12 variétés hybrides et 15 lignées de maïs grain furent mises à l'essai pour leur maturité, sensibilité aux pontes de l'insecte, tolérance ou résistance à la pyrale, ainsi que pour leur rendement. Ces lignées et hybrides furent évalués selon les critères suivants: criblure du feuillage, attaques sur tiges (nombre de galeries), dégâts sur l'ensemble de la plante et populations larvaires dans les plantes. Tous les hybrides et lignées ont montré très peu de criblure du feuillage, critère important de résistance, et certaines lignées canadiennes (Ottawa 190, 6124-44-1, 152-10) ont semblé plus résistantes à la pyrale que certaines lignées américaines mondialement reconnues pour leur résistance. Il semble y avoir chez les hybrides et lignées une corrélation assez étroite entre les populations larvaires et les dégâts dans les plantes. En général, la survivance des larves et leurs dégâts a été moindre chez les lignées que chez les hybrides. Quelques lignées (Ottawa 103, 303-1-1-2, 625-14-2) et hybrides (United 108, Stewart 2605) se sont avérées sensibles à la pyrale. La plupart des hybrides ont donné de bons rendements, variant de 53 à 76 q/ha et notamment, les hybrides de l'Etat de New York, nouvellement crées pour distribution commerciale, furent parmi les plus résistants à l'insecte sous infestation artificielle. Cependant, la perte de récolte due à cette infestation a varié de 15% à 75% chez les hybrides et de 2% à 49% chez les lignées. Certains de ces hybrides ont aussi produit de forts rendements, mais les plus précoces ont donné, en général, des rendements plus faibles.

Lutte chimique

Pyrale du maïs. Dans le but de trouver un substitut du DDT, les essais de lutte chimique en plein champ contre la pyrale du maïs, *O. nubilalis,* sur une variété précoce commerciale de maïs sucré ont comporté l'insecticide bactérien Dipel (*Bacillus thuringiensis*) et les insecticides chimiques dialifor, méthomyl, carbofuran, tétrachlorvinphos, carbaryl et leptophos. Tous ces produits n'ont pas réduit d'une façon significative, par rapport aux parcelles témoins, les populations de pyrales. Le dialifor a été le produit le plus efficace,

avec 8% d'épis atteints de pyrales. Toutefois, ce dommage est encore supérieur au seuil de 5% de tolérance généralement accepté par les producteurs de maïs sucré pour la vente à l'état frais au Québec. Une seule application de carbaryl ou de trichlorfon (Dylox) effectuée sur cinq hybrides commerciaux de maïs grain en présence d'une infestation légère de pyrales n'a eu aucun effet sur l'augmentation des rendements.

DIVERS

Pommes de terre

Variétés hâtives. Le cultivar F-5748, à l'essai depuis 8 ans, a toujours donné un rendement supérieur à celui des variétés Irish Cobbler, Avon et Pungo. Cependant, son rendement vendable est inférieur de 3.5 tonnes métriques/ha à celui de Norland et de 5.8 tonnes/ha à celui de York. En sol organique, la variété York garde une excellente apparence, un fort rendement et un poids spécifique élevé.

Variétés tardives. Sur une période de 5 ans, le cultivar F-6113 a donné un rendement égal ou supérieur à celui de Kennebec. Dans des parcelles de 1/63 ha, il a produit 5.6 et 8.4 tonnes/ha de tubercules n°1 de plus que Sebago et Kennebec, respectivement. En 1971 ce cultivar s'est révélé en sol organique un bon choix pour une prochaine homologation.

Pois

Maladies du pois. Une enquête sur les maladies du pois de conserve cultivé dans le sud-ouest du Québec a été faite dans 48 champs représentant une superficie totale de 660 ha répartis entre les quatre principaux conserveurs. Le dénombrement des champs infestés par les différentes maladies s'est établi comme suit: pourriture des racines, 41 champs; rouille, 28; ascochytose, 19; brûlure ascochytique, 15; flétrissure fusarienne, 4; maladies à virus, 4. La pourriture des racines s'est révélée responsable des pertes les plus considérables.

Herbicides

Effet de la température des racines sur l'absorption et la transmission des herbicides. Les plants de tomate sont très susceptibles au métobromuron et même à une température de 8°C les racines absorbent cet herbicide et il est partiellement transmis jusqu'aux feuilles. Aux températures plus élevées de 14° et 20°C, le taux de l'absorption et de la circulation augmente d'après une projection linéaire, mais il s'accumule alors en plus grande quantité dans les feuilles que dans les racines.

D'autre part, le chlorbromuron est absorbé par les racines à la température de 8°C mais il n'est pas transmis au feuillage. Cependant, aux températures de 14° et 20°C la quantité de chlorbromuron diminue dans les racines pour augmenter rapidement dans le feuillage.

Par contre, la coriandre qui est modérément résistante au métobromuron révèle également un taux d'absorption et de circulation plus élevé lorsque la température des racines augmente, mais l'accumulation de cet herbicide est toujours plus grande dans les racines que dans les feuilles.

Par ailleurs, la coriandre s'est révélée très résistante au chlorbromuron dont le taux d'absorption par les racines n'a pas augmenté sensiblement par suite d'une élévation de la température; la circulation jusqu'aux feuilles en a été très faible quelle que soit la température des racines.

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INTRODUCTION

The Research Station at Delhi, Ont., is responsible for research on flue-cured tobacco in Ontario. Studies are conducted on nutrition, plant breeding, diseases, insects, cultural practices, plant growth, chemicals, and tobacco and health. All the research is directed toward the tobacco and health program to improve the quality of tobacco to meet current demands. During 1971 a new smoke laboratory equipped with smoke analysis equipment was opened; tobacco samples are being tested for smoke tar and smoke nicotine. Fumigant nematocides were found to increase yields of flue-cured tobacco by preventing damage from root-lesion nematodes and by delaying nitrification. Also, total particulate matter of smoke collected from varieties showed a positive correlation with lamina weight and percent total alkaloids, and a negative correlation with days to flower and filling capacity. Correspondence should be addressed to: Research Station, Research Branch, Canada Department of Agriculture, Delhi, Ontario, Canada.

L. S. Vickery
Director

SOIL SCIENCE

Soil Fertility

Nitrification. Fumigant nematocides may increase yields of flue-cured tobacco by preventing serious damage from the root-lesion nematode *Pratylenchus penetrans* (Cobb) Filip. & Stek. 1941, and by delaying nitrification. Where no fumigant was applied, the amount of N in the NO_3^- form in the top 0–20 cm of soil was significantly higher until 4 weeks after transplanting. The effects of the fumigant on the NO_3^- level had disappeared by 11 weeks after application (7 weeks after transplanting). A delay in nitrification could benefit plant growth by allowing a slow release of available N and preventing loss of N by leaching particularly in years with excessive rainfall in June.

Nitrogen. A comparison of four rates of N, 0, 22.4, 44.8, and 67.2 kg/ha (0, 20, 40, and 60 lb/acre), showed that each increment of applied N increased total N and total alkaloids. The highest grade index was obtained when N was applied at 22.4 kg/ha, but each increment above this level decreased grade index.

Seedbed. After the first pulling of seedlings, fertilization with a high-analysis fertilizer, soluble in water, gave lower soil conductivity than a 2-16-6 analysis tobacco seedbed fertilizer applied at a rate to give equivalent N.

Potassium depletion. In a Fox loamy sand in which four consecutive crops of tobacco had been grown with K omitted from the fertilizer, the level of K declined to about half the initial soil test value. Extremely low levels of K were found in the leaves from the lower stalk positions, and cigarettes made from these leaves had very poor burning qualities.

PLANT SCIENCE

Transplants

When transplanting was delayed during the period May 25 to June 8, days to flower and level of total alkaloids decreased, and level of reducing sugars increased. Yield decreased with size of transplant, but level of total alkaloids and susceptibility to frost damage increased.

Well-hardened transplants flowered up to 10 days sooner than unhardened transplants and were more uniform in days to flower. Hardiness was enhanced by reduction of seeding rate within the range of 30 g/170 to 300 m^2 (1 oz/1,800 to 3,000 sq ft), and by restriction of watering and extensive exposure of transplants to outside air during the 10 days before transplanting. Pulling some of the transplants also helped to harden the transplants remaining in the beds.

Frost Control and Paper Mulch

Protein foam for frost protection was less effective with mulched than with unmulched plants.

Chemical Control of Weather Fleck

Effectiveness of the systemic fungicides Vitavax and Plantvax diminished when application was delayed during the period July 21 to August 5. Effective control was achieved with one spray application to the lower two-thirds of each plant.

Ethephon

Acceleration of leaf ripening with sprays of ethephon (Ethrel; 2-chloroethylphosphonic acid) was apparent 2 to 3 days after treatment. Immature leaves were unaffected, and certain parts of leaves, particularly along midribs and close to leaf axils, also were unaffected. Treated leaves were cured in less time than untreated leaves, but grade index was adversely affected by treatment.

Curing

Studies in 1971 were concerned with the design and construction of curing facilities, and the development of methods of handling and curing, for tobacco leaves and stalks cut with a forage harvester, in preparation for the use of the cured product in homogenized sheet. A simulated flue-curing process was utilized to cure the chopped material, and the dried product appeared to be satisfactory for the purpose intended. Final acceptability will depend on characteristics of the product after homogenization.

Filling Value

Width of tobacco shred and moisture content of leaves at shredding were found to have a pronounced effect on subsequent levels of filling value, thereby indicating a need to standardize preparation techniques.

Sucker Inhibitors

Five fatty alcohol formulations, Delspray T-148, Emtrol 1630B, Green Cross Sucker Spray, Pentrete 148, and Sucker Plucker 148, were accepted as a sucker inhibitors for use on flue-cured tobacco in Ontario on a trial basis for 1 year only. Over 80% of the 1971 crop was treated with these materials and most of them were applied before topping, which controlled suckers more effectively than application after topping.

PLANT PHYSIOLOGY

Gibberellic Acid

Canadian (Ontario) flue-cured tobacco is characteristically high in reducing sugars as the result of starch hydrolysis during curing. The application of gibberellic acid (GA) to the plant after the inflorescence and top two or three leaves had been removed (topping) decreased the starch content of mature leaves and the reducing sugars in the cured tobacco. This is considered a favorable factor in increasing quality.

All varieties do not respond the same to GA. Of the two varieties Delhi 34 and Virginia 115, the former responded least consistently to GA treatment. The use of GA at rates up to 1 mg per plant were studied.

Research at Delhi has established that chemicals used to inhibit secondary bud growth (sucker-control chemicals) tend to increase the already high levels of reducing sugars. The addition of GA to the sucker-control chemicals could help maintain high quality by counteracting this increase in reducing sugars.

The use of GA has been shown to reduce total particulate matter (TPM), which is that portion of the smoke that is trapped by a controlled porosity filter, a "Cambridge filter", and is now considered to be positively associated with hazards of smoking. Gibberellic acid lowers the reducing sugars of cured tobacco without causing significant changes in other major chemical constituents and physical properties. Treated tobacco was considered to be excellent material for studying the contribution of reducing sugars to TPM formation. Tests by two commercial firms and ourselves have established that a decrease of 8% to 9% in TPM is possible, thereby offering a possible means of reducing the harmfulness of cigarette smoke (biological activity).

Uptake of DDT

Pesticide residues of DDT have been consistently detected in all parts of tobacco plants even where the use of DDT has been restricted to cover crop treatment. It was essential to establish to what extent *Nicotiana tabacum* L. was able to take up and translocate DDT. It has now been shown that up to 90% of the pesticide added to nutrient solution is taken up by the plant. Uptake studies from soil are now under way.

Leaf Position Analysis

Paired-leaf harvesting of Delhi 34 revealed that leaf reducing sugars, yield, and return index increase from the bottom of the plant to peak values in leaves 11–14 and then decline slightly to the tip leaves. This suggests that under normal growing conditions leaf reducing sugar content is directly associated with yield and return index. Also, leaf total alkaloid and lamina weight exhibited a similar pattern of change with increasing plant position, indicating a direct relationship between these two leaf characters.

Plant Maturity

Increasing leaf ripeness was associated with significant increases in grade index, yield, return index, lamina weight, and reducing sugars. Total alkaloids and petroleum ether extractives were not influenced by increasing leaf ripeness.

GENETICS AND PLANT BREEDING

Canadian vs. American Seed Sources

Seed of the flue-cured variety Virginia 115 from two Canadian and five American sources were compared in quadruplicate plot tests. No significant differences were obtained in grade quality, returns per hectare, leaf number, topping height, leaf length or width, lateral and ground sucker production, leaf turnover, color, body, texture, and tolerance for black root rot. The use of imported seed of Virginia 115 for the production of flue-cured tobacco in Ontario does not appear to be justified.

Correlations of Tar Content and Varietal Characteristics

The total particulate matter (TPM) content of smoke collected from cigarette smoking tests of 13 varieties of flue-cured tobacco grown over a 3-year period showed a significant positive correlation with lamina weight, total alkaloid percent, and company buyer rating, and a negative correlation with days to flower and filling capacity. TPM was not related to yield, quality index, leaf number, leaf size, and other less important agronomic characters. These data indicate that the breeding program to develop varieties of flue-cured tobacco with lower TPM in the smoke should be primarily concerned with reducing lamina weight and alkaloid content, and increasing filling capacity. Since filling capacity is negatively correlated with reducing sugar content, selection for lower reducing sugar content should be emphasized.

Quality of Tobacco From Burley × Flue-cured Crosses

The hybrids gave considerably higher yields, and lower values for lamina weight and reducing sugars, than the flue-cured parents. The number of days to flower and the content of total alkaloids was intermediate in the hybrids. The subjective rating of the hybrids for body, color, and texture of the cured leaf gave lower values than those assigned to the flue-cured parent.

PLANT PATHOLOGY

Black Root Rot

Three- to 7-week-old tobacco seedlings of the immune variety Burley 49 had a higher level of chlorogenic acid than those of the tolerant Delhi 34 and Hicks Broadleaf, and the susceptible White Mammoth. Roots of all varieties had a higher level of chlorogenic acid than the shoots. Fumigation with chloropicrin at 22.4 liters/ha in the row in sandy loam heavily infested with *Thielaviopsis basicola* (Berk & Br.) Ferr. reduced root damage of Hicks Broadleaf by 50% and increased yield by 80%. Soil mulch with paper coated with black plastic reduced root damage by 50%, and tobacco matured faster. Benomyl (Benlate) at 1,000 ppm in the planting water reduced root damage to 50%, and a reduction of 75% was obtained by further addition of

the surfactant Tween 20 at 100 ml/18 liters of treated planting water. Benomyl treatment in the greenhouse did not protect tobacco transplants later in the field against black root rot.

Damping-off

More races of *Rhizoctonia solani* Kuhn were isolated. Dressing tobacco seed pellets with benomyl or thiophanate-methyl (NF44) or applying benomyl to the muck at about 0.1 g/0.1 m^2 were satisfactory in controlling the disease.

Pole Rot

Under favorable conditions of pole rot infection of flue-cured tobacco caused by *Rhizopus arrhizus* Fischer, injury of leaf midrib caused by the string tying the leaf to the lath increased the percentage number of infected leaves from 10% for noninjured to 40%. Percentage germination of *R. arrhizus* sporangiospores in the sap of leaf midrib was higher than that in water. From samples of cigar tobacco collected from Quebec, *Fusarium tricinctum* (Cda.) Sacc. was isolated in addition to previously reported *Botrytis cinerea* Pers. and *Rhizopus reflexus* Bain.

ENTOMOLOGY

Cutworms

There was no significant difference between the weight of male and female pupae of *Euxoa messoria* (Harris). Adult food significantly increased the longevity and oviposition period and reduced the preoviposition period. Female pupal weight was highly correlated with the oviposition period; the number of eggs laid; the longevity, except for moths fed on honey solution; but not the preoviposition period, regardless of food taken as adults. Females fed on honey mated successfully. When fed water or nothing, the number of mated females was reduced. Adult food accelerated the development of eggs and increased the fecundity potential.

To control *E. messoria* in the greenhouse, six chemicals were tested but only trichlorfon showed potential as a substitute for DDT for use directly on seedlings.

In a field heavily infested with cutworms, granulosis virus protected tobacco seedlings as well as did nuclear virus. Both viruses were less effective than Dursban, and better than the untreated control.

Root Maggots

Diazinon, bromophos, carbofuran, and Dursban applied as planting-water treatment gave good control of *Hylemya* spp. on flue-cured tobacco. All the diazinon and Dursban treatments and the high rate of bromophos significantly stunted plant growth during the first 2 weeks after treatment; thereafter the treatments had no effect. Carbofuran stunted plant growth and also was phytotoxic to seedlings.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Benlate	Du Pont of Canada Ltd.
Delspray T-148	The Proctor and Gamble Co.
Dursban	Dow Chemical of Canada Ltd.
Emtrol 1630B	Emery Industries (Canada) Ltd.
Ethrel	Amchem Products Inc.
Green Cross Sucker Spray	The Ansul Co.
NF44	Ciba-Geigy Canada Ltd.
Pentrete 148	Pennwalt Corporation
Plantvax	UniRoyal Chemical
Sucker Plucker 148	The Ansul Co.
Tween 20	Atlas Chemical Co.
Vitavax	UniRoyal Chemical

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EXTENSION SERVICES[1]

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

INTRODUCTION

The program of the Research Station, Harrow, is directed toward solving the most important problems of the diversified agricultural industry of southwestern Ontario. This report summarizes some of the principal results of our research programs in the production of tree fruits, field crops, field and greenhouse vegetable crops, and in related fields. Detailed results may be found in the journals and reports listed under Publications. Reprints are available from the authors. Correspondence should be addressed: Research Station, Research Branch, Canada Department of Agriculture, Harrow, Ontario.

G. C. Russell
Director

FIELD CROPS

Cereals and Forages

Herbicide activity on annual grass weeds. The control afforded by preemergence application of herbicides that inhibit photosynthesis was correlated with their ability to reduce sucrose levels in grass seedlings. Postemergence application of these herbicides resulted in greater reductions in sucrose, but control was often poorer because of seedling recovery. Preemergence treatment with nonphotosynthetic inhibitor herbicides gave better weed control without large decreases in sucrose levels.

Insects. A sampling procedure has been developed at Harrow to assess the density of the cereal leaf beetle in fields of small grains. In 1971, in an oat plot at Amherstburg, Ont., mean density per m^2 (per sq ft) of the various stages of the cereal leaf beetle was eggs, 137 (12.80); 1st and 2nd instar larvae, 39.3 (3.65); 3rd instar larvae, 29.2 (2.70); 4th instar larvae, 11.1 (1.03); and adults, 5.1 (0.47). These densities did not warrant control measures.

A cereal leaf beetle parasitoid, *Tetrastichus julis,* was introduced into the Harrow region in July of 1971.

Viruses. The average incidence of wheat spindle streak mosaic virus in the spring of 1971 was 30% in Essex County, 38% in Kent County, and 25% in Lambton County. Benlate soil treatment at rates up to 10 g/m^2 did not control the disease. In a variety trial, Genesee and Talbot showed 100% infection in the spring. Varieties that showed resistance or tolerance were WW1001-1, 0% visible infection; Blueboy, 13%; Frederick, 41%; WW1-7, 28%; and WW8-7, 36%. One field of winter wheat showed 30% infection with wheat streak mosaic in June, probably due to infective mites from volunteer wheat in a late-plowed field to the south.

Most of the alfalfa mosaic isolates from forage legumes are systemic in *Phaseolus vulgaris* L. and many of the bean yellow mosaic isolates are severely necrotic in this species. Tobacco ringspot virus has been isolated from red clover in two areas. White clover mosaic and red clover vein mosaic viruses have been tentatively identified from clovers.

Corn

Breeding. Production rights to the three Harrow hybrids declared eligible for license and the recommended list in 1970 were granted to commercial seed corn companies. The hybrids are marketed as Stewarts 2913, Pride R552, and Pride R252. Based on performance in Ontario Corn Tests in 1971, a modified single cross hybrid developed at Harrow was declared eligible for license by the Ontario Corn Committee.

Insects. Three granular systemic insecticides used for rootworm control suppressed the corn leaf aphid during the prepollination period in 1970, when 9.8 cm (3.86 inches) of rain fell in the 3 weeks preceding pollination, but the same insecticides were ineffective in 1971, when only 0.66 cm (0.26 inch) fell during a similar period. Dimethoate, malathion, and endosulfan provided excellent control when applied as sprays to the tassels and inner area of whorl leaves 9 days before pollination.

Predators and parasites were ineffective when most aphid injury occurred.

Nematodes. Population levels of the lesion nematode *Pratylenchus* sp. were followed in fumigated vs. nonfumigated and irrigated vs.

nonirrigated corn plots for the past 2 years. Nematode populations were significantly higher in the nonfumigated areas under both moisture regimes. No correlation could be established between nematode population levels and corn yield.

Root and stalk rot. Pith of both resistant and susceptible hybrids stained very little with tetrazolium chloride even as early as 2 weeks before mid-silk. At mid-silk, the stems of resistant plants showed more pith deterioration at ear level than those of susceptible plants, but the stem pith of resistant plants was in better condition at ground level. Sidedressings of N at 3 weeks before mid-silk and halfway between mid-silk and physiological maturity, intended to reduce pith deterioration, did not affect stalk rot. Fumigation with Vorlex (Nor-Am Agricultural Products, Ltd.) before planting slightly reduced eventual stalk rot.

Soil fertility. Continuous cropping with corn has made Tuscola fine sandy loam deficient in P and K, but not Fox sandy loam or Brookston clay. Although progressive yield reductions occurred on Fox sandy loam between 1965 and 1970, even with high fertility and irrigation, these reductions cannot be attributed to nematodes or soil-borne diseases.

Southern corn leaf blight. Helminthosporium maydis Nisik. & Miyake survived through the winter in southwestern Ontario in corn residues in the field and could be isolated until the following August, the last date tested. The Plant Products Division found that many seed samples were infected with the fungus. However, apart from one infected seedling, southern leaf blight was not seen in the field until it was found in several fields near grain elevators at the end of June. To prevent these fields from becoming sources of infection, five of them were sprayed twice and one was plowed in. Although *H. maydis* became general during August, it caused no significant losses in Essex County.

Weed control. S.6176 (Gulf Canada Ltd.) showed promise as a new preplanting mixture. A mixture of M.097 (Monsanto Canada Ltd.) with atrazine was the most effective new preemergence treatment evaluated. M.097 used alone gave complete control of all annual grasses but had little effect on either lamb's-quarters or ragweed. A mixture of 0.28 kg/ha (0.25 lb/acre) each of atrazine and alachlor, applied postemergence in an oil–water emulsion, resulted in decreased soil residues of atrazine and lower herbicide costs.

Soybeans and White Beans

Breeding. Tests in the greenhouse on white beans indicated that the promising line 7793-629 is resistant to the alpha, beta, and gamma strains of *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. and to strains 1 and 15 of bean common mosaic. It had significantly higher resistance to root rot than the varieties Sanilac, Seaway, and Seafarer in a root rot nursery. The Great Northern types Tara and GN1-27 were used in crosses as sources of tolerance to bacterial blight. Segregating populations were grown in the field among susceptible spreader rows, which were inoculated with *Xanthomonas phaseoli* (E. F. Sm.) Dowson. However, the spread of blight was not satisfactory in 1971 because of very dry weather.

Genetics. Seeds of cultivated varieties of soybeans contain urease with either a fast- or slow-running major isoenzyme. In contrast, a urease-free type has been found in the wild soybean, *Glycine ussuriensis* Regel & Maack., that may be of value in developing urease-free varieties.

Pathology. Rhizoctonia root rot of soybeans was unusually severe in 1971. Dying plants were still being found in early August, whereas the disease normally stops killing plants in early July.

Low concentrations of ozone prevailed in southwestern Ontario this year. Few bronzing symptoms were found on white beans, which supports our contention that atmospheric ozone is the cause of bronzing.

Epidemics of common bacterial blight on white beans are reported to begin from systemically infected primary leaves on seedlings grown from infected seeds. *X. phaseoli* was found only in the cotyledons of seedlings grown in growth chambers or in the field. The latter are probably the first source of airborne inoculum in bean fields.

Benomyl sprays were effective against white mold on white beans when applied with drop nozzles directed at the base of the plants. Less control was obtained with low volume (30 gpa) air blast sprays. Yield losses of 10% occurred when more than 40% of the

crop was infected. This level of disease was present in 10% of commercial crops in recent years.

Physiology. An apparatus has been developed for the estimation of the photosynthetic rate of soybean plants growing in the field. This involves determination of the quantity of $^{14}CO_2$ fixed by a small area of leaf enclosed in a plastic chamber during a 20-sec period. The method appears to be rapid and sensitive enough to be used in selection of soybean strains with high rates of photosynthesis.

HORTICULTURAL CROPS

Field Vegetables

Cabbage

Insect pathology. Plot tests at Harrow showed that applications of Dipel HD-1 and Thuricide HPC, new formulations of the bacterium *Bacillus thuringiensis,* are as effective as the chemical insecticide methomyl for control of the cabbage looper and imported cabbageworm on late cabbage. Application of the nuclear polyhedrosis virus of the cabbage looper, *T. ni* NPV, and the granulosis virus of the cabbageworm, *P. rapae* GV, controlled the respective host larvae satisfactorily. Mixtures of low dosages of a chemical insecticide and the viruses controlled aphids and diamondback larvae as well as the cabbage looper and cabbageworm. Test plots of up to 1.2 ha (3 acres) in growers' fields in Kent, Elgin, and Middlesex counties demonstrated the efficacy of the viruses for control of the cabbage looper and cabbageworm.

The period of activity of *T. ni* NPV and *P. rapae* GV applied to leaves of cabbage in growth room and field tests was extended to 25 and 15 days respectively from 7 and 5 days after application by addition of mixtures of charcoal and yeast extract or charcoal and skim milk to the spray.

The *T. ni* NPV produced by epizootics of the disease in populations of the host larvae accumulated in soil. In nontreated plots, sufficient virus accumulated in 4 years to protect the crop significantly.

Cucumber

Breeding and testing. Breeding was continued to purify lines for shape, quality, and resistance to cucumber mosaic virus, *Marmor cucumeris* var. *vulgare* Holmes, scab, caused by *Cladosporium cucumerinum* Ell. & Arth., bacterial wilt, caused by *Erwinia tracheiphila* (E.F. Sm.) Holland and to powdery mildew caused by *Erysiphe cichoracearum* DC. ex Mérat and *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll. Angular leaf spot, caused by *Pseudomonas lachrymans* (Sm. & Bryan) Carsner, severely infected all breeding lines and commercial cultivars.

Crosses were made to introduce improved quality and earlier maturity, and selections were made for white-spined pickling types that appear to better withstand the stresses of dense plantings (247,100 plants/ha).

Segregation in 511 F_2 and B_1 plants involving the rare combination ivory skin, black spine showed that orange skin was dominant to yellow and ivory, and yellow to ivory; also, that black spine segregates independently of ivory skin.

Eggplant and Tomato

Control of verticillium wilt with a systemic fungicide. Benomyl (Benlate) applied as a drench (4.5 kg/ha, each application) to partially bared root systems of eggplant before field planting and subsequently at 21, 42, and 63 days, delayed the onset of wilt and increased yields. Although none of the treatments delayed wilt as much as similar ones in 1970, all gave 4- to 5-fold increases in fruit yields. The fungicide application made before field planting caused slight phytotoxic symptoms.

Similar applications of benomyl to the roots of wilt-susceptible tomatoes, cv. Trellis 22, appreciably delayed the onset of wilt but failed to give a significant response in yield. Results of greenhouse experiments with cv. Michigan–Ohio hybrid differed from those in the field in that fungicide applications not only delayed wilt, but doubled yields.

Muskmelon

In 1971, a thiophanate-methyl formulation, NF-44, 70% WP was shown to be equally or more effective than benomyl (Benlate) and thiophanate (NF-35, 50%) in controlling fusarium wilt, stimulating growth, and increasing yield of muskmelon. These

results indicate that NF-44 and other systemic fungicides might be used commercially to augment the inherited resistance of wilt-resistant cultivars. Treatments inhibited fungus colonization of the host, but were somewhat phytotoxic at effective dosages.

Soil fumigation. Fall and early spring fumigation of sandy loam field soils with Vorlex at 560 liters/ha effectively controlled root rot, root lesion nematodes, and weeds in muskmelon. Moreover, "sudden wilt," a conditon that develops at harvest and is associated with severe root rot, was conspicuously absent in fumigated plots. Nematode populations were lower than in similarly treated plots in 1970, and did not correlate with root rot severity or yield of melons.

Peppers

Corn borer control. Twice-weekly sprays of carbaryl, applied with a 3-row sprayer in demonstration plots, gave good borer control and infestations were less than 2% in all pickings. Five other materials gave good to excellent control in small plots where the natural infestation caused 83% damaged fruit.

Potatoes

Green peach aphid. Studies showed that the increase or decrease of aphids could be predicted from the number of embryos per adult female. The correlation between the number of embryos per female and the increase factor over 3 to 4 days was $r = 0.82$ and over 7 to 8 days, $r = 0.70$; both correlation coefficients were significant at the 0.1% probability level. When the number of embryos was less than three per female, the population decreased. The number of embryos per female was negatively correlated ($r = -0.79$) with the percentage of parasitism in field samples.

Verticillium wilt. Field experiments in which tubers of the susceptible cultivars Irish Cobbler and Kennebec were inoculated with a 1970 isolate of *Verticillium albo-atrum* Reinke & Berthe. and the 1966–70 stock culture showed that the 1966–70 isolate had mutated during the 1969–70 winter season and lost much of its virulence. These two isolates showed consistently high and low virulence, respectively, in early and late plantings of both cultivars in the 1971 plantings.

Seed pieces inoculated with *V. albo-atrum* in 1969 gave rise to some infected plants when their progenies were planted in the summers of 1970 and 1971. Significantly fewer stems were found showing visual wilt in plants that originated from 2-year than from 1-year, locally grown stocks. The presence of the leaf roll virus in locally grown stock appeared to mask the wilt and reduced yields by more than 40%.

Sweet Corn

Insect control. European corn borer was controlled by twice-weekly sprays of carbaryl, methomyl, Phosvel (Velsicol Chemical Corp.), tetrachlorvinphos, and trichlorfon. Phosvel at one-half the suggested rates was the best of the five sprays.

In the laboratory, 28 materials were evaluated against corn borer eggs, and six gave good control at 100 ppm. Tests on first instar larvae indicate they are quite susceptible to a number of insecticides.

Tomatoes

Depths of field-seeding processing tomatoes. Two-year average yields of marketable fruit were 29.37, 46.88, and 51.54 metric tons/ha, where tomatoes were field-seeded on Brookston clay at depths of 1.9, 3.2, and 4.4 cm, respectively. The decrease in tomato yields with decreasing depths was attributed to slower germination and emergence at the shallower planting depths.

Flood protection of tomatoes under black plastic mulch. Black plastic mulch has been shown to increase yields of processing tomatoes over treatments without this material. The favorable effect was most pronounced during years when severe soil flooding injured tomatoes at one or more times during the season.

Measurements in a small monitor test established in 1970 and 1971 indicated that soil temperature was the main factor in crop response to the plastic mulch. In late spring, soil temperature under black plastic was greater at the 30-cm depth than for all depths without plastic for the entire day, except for a 6-hour period in the afternoon when temperature at the 7.5-cm depth without plastic was slightly higher.

During periods when excessive rainfall caused flooding, oxygen diffusion rates were the same under plastic as under the control,

with values less than 20×10^{-8} g 0 cm^{-2} min^{-1} indicating inadequate aeration for plant growth. Soil moisture was also similar under both treatments.

Nitidulid beetles in processing tomatoes. Some females of *Glischrochilus quadrisignatus* (Say) became fertilized in midsummer and a second generation was obtained in outdoor cages when rotting ears of corn were supplied. Beetles were not a problem when tomatoes were delivered to factories within 24 hours of harvest. Moderate control of the beetle was obtained in hampers of damaged tomatoes left in the field for over 24 hours, providing the hampers used were dipped in insecticide several days before harvest.

Soil physics. Irrigation experiments with processing tomatoes established that yield of this crop is not restricted by soil moisture supply until the available soil moisture 20 cm below the surface drops to 25% or less. Even with less than normal rainfall in 1971, the unirrigated plots produced more than 52 metric tons/ha and irrigation increased the yield by 10 metric tons/ha. Maintenance of soil moisture at the optimum level for tomato production requires about 5 cm of water every 20 days.

Evapotranspiration increased directly as the level of soil moisture increased. However, available soil moisture in excess of 25% 20 cm below the surface did not increase yield. Thus, water use efficiency dropped sharply at higher levels of available soil moisture.

Weed control. Weed control with BAY 94337 (Chemagro Canada Ltd.) was increased if applied postemergence rather than preemergence or preplanting. Barnyard grass, yellow foxtail, and crabgrass were the first weeds observed to reinfest plots treated with this herbicide. None of the currently recommended herbicides used in single applications gave adequate control at harvest.

Greenhouse Vegetables

Cucumber

Breeding. HG72 was selected as a potential distinctive variety of greenhouse seedless cucumber. It is 32 to 36 cm long, blunt at both ends, dark green, and has thick skin for improved shipping and shelf-life quality.

Having confirmed the resistance or immunity of Ottawa 47 to infection in the greenhouse with powdery mildew in 1970 and 1971, it was crossed with HG72 to transfer its complement of genes for the bitter-free, cucumber mosaic virus resistance, and mildew resistance traits. F_2 selections from that cross and from the Harrow 70.74 cross were combined to pool genes for optimum traits in a seedless cucumber. The combining ability of other lines was tested for their possible use as seedless F_1 hybrids for the greenhouse industry.

Whitefly control. Widespread adoption of an integrated control schedule in greenhouses brought increased requests for the whitefly parasite. Nearly 1 million parasites were distributed in 1971 in 124 shipments.

Integrated control of the greenhouse whitefly and certain foliage diseases was achieved in a spring crop of tomatoes by three sprays of maneb and release of the parasite *Encarsia formosa.* Better whitefly control resulted with parasites and three oxythioquinox sprays. Residues of oxythioquinox were less than 1 ppm the day after application, and registration of this use was sought.

Tomatoes

Cultivar comparison. A study of nine cultivars grown in a fall crop showed that Michigan–Ohio hybrid and Veegan gave the highest yields, had the largest fruit, absorbed the largest quantities of the nutrient elements N, P, K, Ca, and Mg, and had the highest taste panel ratings, with the two exceptions that Ohio WR25 rated high on yield and absorption but low on taste, and Vendor rated higher than Veegan on taste but lower in production. Vantage gave the lowest yield and had a low taste panel rating. Moto-Red was also rated low. Other cultivars tested were Vinequeen, Ohio WR7, and Tuckcross 0.

Nematodes. Soil samples were taken to a depth of 140 cm (55 inches) for the Southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood. The soil was sterilized by steam, chemical, or a combination of both before each crop. Nematodes were reduced to low or nondetectable levels in the upper 100 cm (40 inches) of soil following such treatments. Effective control

seems to be cut off at about this depth. During the growth of the subsequent crop, nematode population densities built up to damaging levels through all sample depths. Nematodes escaping control below the 100-cm (40-inch) depth moved upward rapidly to infest the subsequent crop.

Nitrogen metabolism. KNO_3 and NH_4NO_3 fed to tomato seedlings in soil were rapidly absorbed and metabolized in 24 hr. Total N increased in all tissues but nitrate tended to accumulate more in conductive tissue. Conversion of NH_4NO_3 to amino acids proceeded faster than that of KNO_3 and produced higher levels of most of the 16 free amino acids measured. However, proline, aspartic acid, and some other amino acids in some tissues were produced more abundantly from KNO_3.

Reaction to tomato mosaic virus (TMV). The cultivars Michigan–Ohio and R-25 (susceptible) and Vendor (tolerant) reacted to inoculation with a TMV mixture of local isolates by showing prominent leaf mottles but no fruit blemishes, and yielded well. The reaction of resistant genotypes MR-9 and MR-12 depended on the age of plant at inoculation and ambient greenhouse temperatures subsequent to inoculation. After two trusses of fruits had formed, and at temperatures below 26 C, inoculations caused no leaf mottle and only a small amount of necrotic spotting of fruits. However, when young plants were inoculated, 50% of both resistant genotypes developed severe stunting, distortion of leaves and stems, and produced no marketable fruits. Also, a large percentage of plants that showed no stunting or leaf symptoms developed necrotic spotting of fruits.

Tree Fruits

Apricots

Breeding. Twenty-four new selections were made that varied in ripe date from July 13 to August 12. Emphasis in selection was placed on productivity and resistance to bacterial spot, caused by *Xanthomonas pruni* (E.F.Sm.) Dowson, and brown rot, caused by *Monilinia fructicola* (Wint.) Honey. Each selection had attractive fruits that ripened uniformly, were medium to large in size, freestone, and had good quality. Trees of eleven selections previously made were released to growers and research stations for advanced trials.

Threshold temperatures for floral development. Meteorological base temperatures that were best for predicting meiosis and tetrad development in apricots were -4 C and -3 C. Accuracy of prediction decreased as base temperatures were increased from -2 C to 5 C. Differentiation to the tetrad stage could be predicted with greater accuracy than meiotic induction. The optimum base temperature for predicting date of full bloom was 1 C for six of eight cultivars tested and 3 C for the remaining two cultivars.

Peaches

Breeding. A new cultivar named Harbinger, tested as H0640, was introduced. This cultivar ripened 8 days before Earlired and 28 days before Redhaven. It was introduced on account of its extreme earliness combined with good appearance and qulaity, field resistance to bacterial spot, caused by *X. pruni*, and peach canker, caused by *Cytospora cincta* (Fr.) v. Hohnel, and coldhardiness of flower buds and wood as determined by natural and controlled freezing tests.

Fifty-four hybrid combinations, providing 15,761 hybrid seeds, were made to increase coldhardiness, yield, size control, and fresh and processing quality, introduce the red foliage character into peach seedling rootstocks, and transfer the nonmelting flesh character to freestone cultivars.

Coldhardiness.. Deacclimation studies with peach and apricot cultivars representing coldhardy, intermediate, and cold tender genotypes showed that the rate and extent of deacclimation of flower buds at 7 C were closely related to previously established levels of hardiness of these cultivars, with maximum separation of cultivars being obtained after 3 days at 7 C. At 17 C, the rate of deacclimation was very rapid and the difference between hardy and tender cultivars was slight by the 3rd to 7th day.

Comparative hardiness of peach rootstocks was established in a grower planting where several rootstocks were under test. Siberian-C was the only rootstock to survive soil temperature of -14 C at the 20-cm depth without root injury. Harrow Blood and Muri sustained moderate to moderately severe injury. Elberta, Rutgers Red Leaf, and Halford

were severely injured, resulting in 90% to 100% tree mortality.

Microbiology. In microbiological assays of peach orchard soils, the pathogens *Phytophthora* spp., reported to be serious in other peach-growing areas, were not recovered. *Pythium* spp. were found to be an important part of the microflora, but were controllable by fumigation with either Vorlex or methyl bromide.

Peach canker and bacterial leaf spot. Epidemiological studies of peach bacterial spot, caused by *X. pruni*, showed that the pathogen lived epiphytically on the host through survival in the winter buds and then on the successively unfolding foliage during the growing season. The epiphytic population of the pathogen was not related to the field reactions of the cultivars Loring (tolerant), Redhaven (intermediate), and Babygold-5 (susceptible). Prominent among other microflora of the buds and leaves were *Erwinia herbicola* and *Aureobasidium pullulans* (de Bary) Arn.

Of 29 peach cultivars and 19 advanced selections tested for resistance to peach canker, caused by *Cytospora cincta*, cultivars Redhaven, Harbelle, Dixired, Velvet, Harken, Harbrite, and Madison, and selections H2091, H373, H580, H593, H2049, H781, and H1102B were more resistant than others. Many of these have also been shown to possess a high degree of cold-tolerance.

Peach X-disease. An incidence of peach X-disease was recognized in an area of high orchard density in southwestern Ontario. The disease is new to the area. A number of infected choke cherry trees, a wild host of the disease agent, were found in nearby fence rows. The area has been mapped and steps are being taken to eradicate the wild host.

Bacterial crown gall of peach. Evidence was obtained that winter conditions could predispose at least 10% of the nursery stock to infection by the crown gall bacterium, *Agrobacterium tumefaciens* (Smith & Town.) Conn, a wound pathogen, through bark-splits at ground level.

Rootstocks. Peach rootstocks significantly influenced the yield of the Loring cultivar planted in 1968. The highest yields were obtained with Veteran and Siberian-C and the lowest with Harrow Blood. Siberian-C promoted the fastest rate of defoliation and Harrow Blood the slowest. Harrow Blood promoted the most dwarfing in terms of trunk circumference and tree spread; Veteran promoted the greatest vigor. In a similar experiment with Babygold-5 as the scion variety, Bailey promoted the most terminal growth and Siberian-C the least. Trees on Harrow Blood were tallest, those on Siberian-C were shortest. Defoliation was fastest for trees on Siberian-C and slowest for those on Halford. Tree vigor was greatest on Halford and least on Siberian. Rootstock effects on yield were not significant.

Weed control in peach orchards. Soil temperatures at the 20- and 50-cm depths in the profile have been monitored for the past 3 years in a trial orchard where herbicides have been integrated with different soil management systems. In February 1971, creeping red fescue sod protected the root system of peach trees from winter injury when a minimum air temperature of −21 C was recorded. The minimum soil temperature at the 20-cm depth under sod was −6 C, whereas under a weed cover crop the temperature dropped to −14 C.

Pears

Breeding. Eight fire blight selections from the Harrow breeding program were propagated for planting in advance trials in 1973. All of the selections were rated resistant to fire blight after inoculation with the causal organism, *Erwinia amylovora* (Burr.) Winslow et al., at the seedling stage in the greenhouse, and were found to be resistant when exposed to natural infection in the field when the fruiting trees were reinoculated. All selections ripened from mid-August to early October and had acceptable size, appearance, and quality.

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Research Station
Ottawa, Ontario

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D. P. PIELOU, B.Sc., Ph.D. Resigned September 1971	Ecology

INTRODUCTION

The program at the Research Station, Ottawa, Ont., is being reoriented to give greater emphasis to research on feed crops including cereals, corn, and forage crops. The main part of the research on horticultural crops was concluded during 1971 and experimental material and stocks were transferred to other research stations for continued development.

This report summarizes some of the more important research results from the Station during 1971. Requests for further information on any of the subjects covered should be directed to: Research Station, Research Branch, Canada Agriculture, Ottawa, Ont., K1A 0C6.

Dr. A. W. S. Hunter, Director of the Research Station since October 1964, retired on September 3, 1971, after 35 years of dedicated service to Canadian agricultural research.

F. K. Kristjansson
Director

CEREAL CROPS

Wheat

Winter wheat. The semidwarf, lodging-resistant strain 7453-4-3-3 was licensed under the name Fredrick. Its yield potential, winterhardiness, disease resistance, bushel weight, and milling quality are equal or superior to the commercial varieties Yorkstar, Genesee, and Talbot.

Several "stable" aneuploids ($2n = 41$ to $2n = 56$) have been identified in wheat × rye hybrids. They resemble wheat, but possess much of the winterhardiness and disease resistance of winter rye.

Hybrid winter wheat. Small amounts of hybrid seed of winter wheat will be available in 1972. Considerable improvement has been made in the seed set of cross-pollinated male sterile (A) lines. Several lines whose seed sets average 90% of the parental (B) lines are now available. A few lines exceeded the parents in yield.

Spring wheat mixtures. In 1969, a synergistic effect on yield was reported at Ottawa in mixtures of Opal and Pitic 62. Small concentrations of either variety present in the other resulted in significant increases in yield. Repetition of these experiments in 1970 and 1971 failed to produce significant results, although the same trend was apparent. Growing varietal mixtures of this type to raise yield levels does not appear to be warranted.

Barley

Winter barley. Good progress has been made in attempts to improve hardiness and other agronomic characters of winter barley through the use of interspecific hybrids involving *Hordeum vulgare* L., *H. murinum* L., *H. bulbosum* L. (2x and 4x), and *H. spontaneum* C. Koch. Several promising strains are being compared in hardiness and yield trials. It has been established that haploids, and ultimately completely homozygous plants (2x or 4x), can be easily derived from crosses between *H. bulbosum* and *H. vulgare.* This discovery has already had a profound effect on barley breeding in Ontario and will almost certainly aid all barley breeders. Many homozygous strains have been prepared and are being used to evaluate this new method of breeding. Productive dwarf-type plants that exhibit profuse tillering, strong straw, and long spikes have been isolated from some of the complex interspecific crosses.

Spring barley. The Ontario Cereal Crops Committee and the Canadian Committee on Grain Breeding have sponsored an application for licensing the Ottawa Research Station selection OB95-21. It is a superior-yielding 6-rowed white-aleurone feed barley, mildew-resistant and well adapted to conditions in Eastern Canada.

Oats

Spring oats. The Ontario Cereal Crops Committee and the Canadian Committee on Grain Breeding have sponsored an application to license the Ottawa Research Station selection, OA18-35, under the name Scott. It is well adapted to Eastern Canada, but is primarily needed in Ontario where it has stronger straw, larger kernels, thinner hull, and higher yield than the cultivar Garry, which is grown extensively.

The development of a high-protein oat

cultivar, OA123-33, has been completed and seed is available for animal feeding trials. This cultivar produces approximately the same yield of protein per hectare as standard cultivars such as Victory, but its total yield of grain is less.

Genes conditioning flowering under short photoperiods have been successfully transferred from *Avena byzantina* K. Koch (CW544) to agronomically desirable strains of *A. sativa* L. These strains can be grown in Canada in summer and in California in winter, thus reducing the breeding time for oat cultivars by one-half. Several strains will be tested widely in Canada in 1972 to assess their yield potential and adaptability.

Dormoats. The main factor limiting the development of dormoats as a commercial crop is the low emergence in spring of fall-sown seeds. In 1971, spring emergence was increased to acceptable levels (40% to 60%) by forcing the seeds into a state of secondary dormancy before planting in fall. We induced secondary dormancy by attempting to germinate seeds of 30% to 40% moisture content at reduced oxygen tensions (2% to 3% O_2) in closed bins.

Yield and straw strength. Quantitative genetic studies on the relationship between yield and straw strength have revealed that simultaneous selection for large seeds and shorter straw should give the most improvement in yield and lodging resistance. Maximum breeding progress for yield can be achieved by crossing high-yielding cultivars. The New York cultivar Orbit and the Dutch cultivar Bento have been identified as outstanding parents for yield.

Growth and Development

Apical development of wheats and rye. The origin of the distinctive pattern of early spike development characteristic of the Mexican hexaploid wheats, in which an extremely elongated apex with prominent single ridges precedes the relatively synchronous development of a large number of spikelet primordia, has been traced to Norin 10, a common ancestor of the Mexican dwarf wheats. Norin 10 is a dwarf Japanese wheat developed in 1924 from a native dwarf field variety. The presumed sources of the A, B, and D genomes, *Triticum monococcum* L., *Aegilops speltoides* Taush., and *A. squarrosa* L., did not have development patterns similar to those of Norin 10 or of its Mexican progeny.

Morphological evidence suggests that the chromatin of rye, *Secale cereale* L., has become incorporated into Norin 10. The early spike development of rye exactly parallels that of Norin 10 and its derivatives. Triticale inherits the rye type of development with no indication of wheat morphology during early spike development, which shows the dominance of the rye developmental type. Norin 10 exhibited a high degree of sterility in crosses with common wheat, and showed considerable self-sterility. Earlier selections of triticales exhibited varying degrees of sterility, of a type probably similar to that of Norin 10. Dwarf ryes with the Norin 10 type of dwarfism have arisen spontaneously from normal types of rye. These and other observations make it seem probable that rye genes have entered the Mexican wheat-breeding program through Norin 10. Since the developmental pattern of Norin 10 has been bred into durum (AB genome) wheats, the rye genes should be situated in chromosomes of the A or B genomes, but not in the D genome. These observations indicate the narrow genetic base of the Mexican wheats for this character.

Environmental effects on apical development. Results from studies on apical development in contrasting wheat cultivars (Marquis and Pitic 62) grown under a range of photoperiods, and at different N and P levels, showed that even a comparatively small difference in the duration of primordia formation could have a substantial effect on the numbers produced, and hence on the final spikelet number per head. The cultivar and photoperiod combination in which this duration was shortened (Marquis and long days) also accelerated the rate of primordia formation, but not enough to counteract the reduction in primordia due to the shortened period of formation. Therefore fewer primordia were formed by Marquis than by Pitic 62, and fewer were formed on long than on short days.

Low N level markedly reduced the rate of primordia formation in Pitic 62 in long and short days, to a lesser extent in Marquis in short days, and not at all in Marquis in long days. The duration of primordia formation was reduced by low N level because of (a) an acceleration in development rate, and (b)

earlier cessation of primordia formation. Increasing the photoperiod reduced the duration by (a) only; termination of primordia formation coincided approximately with the stamen primordia stage of inflorescence development in Marquis in all photoperiods at high nutrient levels, and the termination was slightly delayed past this stage in Pitic 62 under these conditions.

Growing plants in controlled environment. A screening procedure was developed to predict yield of oat cultivars under field conditions from early vegetative growth in growth chambers. The fresh weights of shoots after 4 weeks growth ranked similarly to seed yields normally obtained in the Eastern Cooperative Tests (Dorval > Garry > Stormont > Victory), with no significant difference between Garry and Stormont.

Pathology

Septoria tolerance. A 3-year cooperative study with the Research Station at Charlottetown has shown that certain strains from the world oat collection have good tolerance for the septoria disease caused by the fungus *Septoria avenae* Frank f. sp. *avenae.* Strain CI8175 had the best tolerance at both locations, had the highest yield at Ottawa, and was acceptable at Charlottetown.

Septoria growth-room development. Septoria developed well on two oat cultivars in the growth room at 15.6 C to 26.7 C (60 F to 80 F) with the optimum at 26.7 C (80 F). Seed yields were highest at 15.6 (60 F). At 21.1 C (70 F), yield losses of 25% occurred when leaves were infected and 18% when only stems were inoculated. The yield of stem-infected plants would have been lower, but often the death of the inoculated main culm stimulated the production of disease-free secondary tillers, which produced more seed than the few secondary tillers on the healthy plants.

Seedling blight of oats. Seed samples of the oat strain OA123-1 are occasionally infected with *Drechslera avenacea* (Curt. in Cke.) Shoem. Treatment of infected seed with Ceresan M completely controlled the disease, and Agrox NM (a mixture of maneb and hexachlorobenzene) effectively controlled it in growth-room tests. However, seed yields were not increased to any extent in field tests by either seed treatment, because of compensating tillering of infected plants.

Septoria disease loss. The significance of septoria disease on oats was much less in 1971 than last year when its prevalence was estimated at the same four locations in Eastern Canada using the same cultivars and fungicide as previously. The greatest varietal yield increase from spraying was 30% this year compared with 60% in 1970, and the average increase was 4% compared with 20% previously. The greatest yield benefit from spraying continuously every 10 days occurred at Charlottetown, amounting to an average of 10% compared with 40% in 1970. A series of early or late treatments gave better yields this year than did the continuous treatment every 10 days. The cultivar Dorval again showed the least benefit from spraying, indicating that it has considerable tolerance for the disease. This year the test crop was grown at Lacombe, Alta., where no disease occurred, and a 4% yield increase resulted from spraying every 10 days.

Wheat spindle streak mosaic. Survival and transmission of the virus appear to depend on a fungus that reproduces only in living roots, but persists as resting spores in soil. The spores may remain dormant for at least 8 years, but germinate when temperatures and moisture are favorable. Maximum and optimum temperatures are about 20 C and 15 C for infection, but 15 C and 6–12 C for disease development on wheat. Foliage symptoms disappeared on diseased plants in 1–2 weeks at 20–30 C, and the virus was no longer transmissible from them manually. However, symptoms reappeared on new leaves, and the virus could be transmitted from the plants 1–2 weeks after they were returned to growth cabinets at 6–12 C. The control of wheat spindle streak mosaic by heavy applications of poultry manure or other N fertilizers appears to result from a temporary interference with infection, and not from suppression of symptoms after infection.

Cultivars from Arkansas (Monon), Japan (Aka-Komugi, Hatakeda Komugi, Oita-Komugi), and Russia (Miro) are apparently immune to the virus when grown in infected soil.

FORAGE CROPS

Alfalfa

Breeding for resistance to bacterial wilt. In trials at seven locations, the two most promising synthetics of six tested were OD-17, a 17-clone Flemish type, and OR-16, a 16-clone standard type. Their forage yields were equal to or better than those of the control varieties Saranac and Vernal, and two independent studies of their reaction to bacterial wilt revealed a high degree of resistance.

Hybrid alfalfa. In yield trials involving about 300 hybrid combinations between male-sterile and pollinator lines, about 10% of the combinations outyielded control varieties by 10% to 39%.

Orchardgrass

New variety recommended. The variety Kay was placed on the recommended lists in Ontario and in the Atlantic Provinces for 1972, and Breeders seed was produced. It yielded approximately 7% more forage than Rideau under Ontario conditions. Foundation and Breeders seed will be available for distribution in 1972. Vigorous clones with high rust resistance have been identified.

Corn

Development of hybrids. Two experimental hybrids, OX388 and OX389, qualified for licensing in 1971 Ontario Corn Committee trials, and seed production rights have been assigned to two Canadian companies. These hybrids have maturity ratings of 2,650 and 2,700 heat units respectively, and will be grown primarily for grain in central and eastern Ontario and southwestern Quebec.

Increasing attention is being paid to the development of still earlier hybrids. One of these, OX401, a flint × dent double cross, had an average grain moisture content of 21.4% at the time of harvest in three Manitoba Corn Committee trials. It was the most mature entry in these trials, and in silage trials at Quesnel, B.C., and Normandin, Que.

The dry-matter production of profusely tillered hybrids is much greater than that of single-stalk hybrids at low population densities because the tillers contribute substantially to the yield. At a density of 33,000 plants/ha, one-half of the stover dry-matter production of a highly tillered hybrid was from the tillers. However, because of a lower grain-to-stover ratio the tillers produced only one-third of the grain. At more than 60,000 plants/ha, tiller production was negligible.

Corn diseases. Southern leaf blight, caused by *Helminthosporium maydis* Nisikado & Miyake, was observed in September and October in several corn fields in eastern Ontario. Infection ranged from light to very heavy; in 4 of 58 fields examined, all the plants were infected. The pathogen was isolated from overwintered stalks, seeds, and shelled cobs near corn cribs. Variation in cultural characteristics was observed among 26 isolates from Ontario, and 6 obtained from various locations in the United States. Pathogenic variation is being studied.

Under humid conditions, profuse sporulation of *H. maydis* on pollen deposited on corn leaves was observed both in the greenhouse and in the field. Severity of the disease was correlated with pollen deposits.

Of 47 corn inbreds tested for resistance to race T of *H. maydis,* 18 showed high tolerance, 20 were intermediate, and 9 were susceptible. All lines containing Texas male sterile cytoplasm were susceptible.

Three *Fusarium* species were very common on corn in eastern Ontario in 1971. *F. moniliforme* var. *subglutinans* Wr. & Rg. was isolated from partially rotted cobs in several fields. This fungus was also associated with lesions on stalks. *F. moniliforme* Sheldon was common on ears and stalks, as was another species not yet identified. The amount of damage from *Fusarium* species varied from light to moderate.

Soybeans

Breeding for high oil and high protein. Extensive use has been made of early-maturing Swedish lines crossed with Canadian varieties in the development of high-oil varieties. Strains considerably earlier than the earliest existing Canadian varieties have been identified, but yields have not been as high as expected. Later-maturing but more productive Canadian and United States varieties are now being used.

High-protein selections from the collection of the U.S. Regional Soybean Laboratory, Urbana, Ill., have been crossed with licensed varieties of Group 00 and 0 maturity. High-protein (48% to 50%) strains have been established, but yields have been low.

Plant spacing. A spacing experiment involving the varieties Altona, Morsoy, and Merit showed that the optimum arrangement as measured by grain yield was 35 cm (rows) × 7 cm (plant spacing within the row) for Altona, and 18 cm × 7 cm for Morsoy; Merit was unaffected. The substantial amount of lodging that occurred with Merit may have obscured any effects of the spacing.

Pathology

Fusarium root rot. Coumestrol accumulated in alfalfa in response to infection by *F. oxysporum* Schlecht. emend Snyd. & Hans. and *F. solani* (Mart.) App. & Wr. emend Snyd. & Hans. The amount of coumestrol in the foliage increased by 77% because of infection by *F. oxysporum,* and by 114% because of *F. solani.* The root of the alfalfa plant contains 20 times more coumestrol than the foliage. A yellow fraction that inhibits growth in both *Fusarium* species has been extracted from alfalfa roots. It has a molecular weight between 1,000 and 5,000, and shows fluorescence under ultraviolet light.

In the alfalfa cultivars Vernal and Rhizoma, plants grown from dark seeds and showing purple hypocotyls showed more resistance to fusarium root rot during the seedling stages than did those with white hypocotyls and green seeds.

Introductions

Promising material identified. Screening trials have identified two alfalfas, *Medicago sativa* L. and *M. falcata* L.; one sainfoin, *Onobrychis viciaefolia* Scop.; a cicer milkvetch, *Astragalus cicer* L.; a flat pea, *Lathyrus sylvestris* L.; an orchardgrass, *Dactylis polygama* Horvat.; and a timothy, introduced from Europe and Asia. All appear to have considerable promise under Ottawa conditions. The flat pea had a protein content of between 30% and 35%.

HORTICULTURAL CROPS

Apples

Resistance to apple scab. Six scab-resistant selections, O-521, O-522, O-531, O-533, O-544, and O-561, are now available for limited commercial trial. Twelve additional seedlings were selected in 1971 for advanced trial at the research establishments at St. Jean, Que., and Smithfield, Ont. Analysis of juvenile leaf material showed positive correlations between various sugars, acids, and phenols, but no correlation with scab resistance. In descendants of scab-resistant parents, phenol levels were much lower when selection was based on flavor than when it was based on scab resistance only. Specific combining ability was high for reducing sugars and general combining ability was very high for acids; this indicates simple inheritance for acids.

This program is being discontinued at Ottawa, but the breeding research will be maintained at St. Jean, and evaluation will be continued there and at Smithfield.

Hardy rootstocks. The fully dwarfing clonal rootstock Ottawa 3, when used with either McIntosh or Quinte as the scion variety, produced smaller, higher-yielding trees than Malling Merton 26, and was very effective when used as an inter-stock on *Malus robusta* 5 roots. Genetic studies with the clonal rootstocks showed relatively simple inheritance of precocity, fruit size, and date of leaf fall, but more complex inheritance of fruit color.

Hybrid seedling rootstocks from selected parentage have the advantages of comparative uniformity and relative freedom from latent viruses. Growth analysis of Ottawa hybrid seedling rootstocks showed that OH-2 had an unexpected, but favorable, increasing tendency to produce a rather uniform semidwarfing effect.

New cultivar. The Ottawa selection O-2312 from an earlier breeding program has proved successful in Finland. Permission has been given to the Agricultural Research Centre, Piikio, Finland, to assign the name Raike to this selection.

Strawberries

Reciprocal recurrent selection. The last experiment in this program with Sparkle and Valentine as parents was completed in 1971. Results confirmed the importance both of general and specific combining ability and of the need for a two-step breeding program. Additive variance contributed by Valentine was greater than by Sparkle. Progeny averages were greater than for all control cultivars, indicating the presence of some very high yielding plants. This research is now

discontinued at Ottawa and resulting selections have been transferred to the Research Station, Kentville, N.S.

Virus diseases of strawberries. A 5-year study of the effect of virus diseases on yield of strawberries was concluded. A combination of veinbanding, latent C, and latent A reduced yield by 17% the first year and 35% the second year, and caused complete production loss the third year. Veinbanding alone reduced yield by 12%, 21%, and 26% over the 3 years. Strawberry mottle caused reductions of 0%, 6%, and 12% during the same period. Other combinations were intermediate in their effects.

Raspberries

Combining ability for yield and ascorbic acid. Inbred line × tester analysis of ascorbic acid inheritance gave results similar to yield data, indicating the importance both of general and specific combining ability, and of the need for a two-step breeding program. The yield of inbred line × tester crosses was often less than that of noninbred crosses and cultivars, but ascorbic acid content was higher, indicating little previous selection for this compound.

Fall-fruiting habit. In 4 × 4 diallel crosses, fall fruiting was due to a single recessive gene, as found by Lewis (Proc. 7th Int. Genet. Congr. 1941) and in contrast to later reports; but if this is associated with late flowering, the expression of the gene may not be manifested. Reciprocal differences in fruit color were found and can be explained by a linked gene for pollen tube growth, as reported by Lewis (J. Genet. 38:367-379. 1939). Relatively early flowering was found in some fall-fruiting types, indicating that it should be possible to select a fall-fruiting cultivar for eastern Ontario.

Tomatoes

Verticillium-resistant Rideau. Rideau, introduced in 1962, is a high-quality, multipurpose cultivar for eastern Ontario and southern Quebec, but its usefulness has become restricted because of its extreme susceptibility to verticillium wilt. A backcrossing program has now produced a line similar to Rideau but resistant to verticillium wilt and outyielding Rideau at Ottawa. It is now available for trial as Rideau VR.

Processing tomatoes. Ottawa 78, a new verticillium-resistant line, shows promise for whole-pack canning in commercial trials in southwestern Ontario. Selections from the breeding program for machine harvest combine many of the genetically based characteristics essential for once-over machine harvest. Ottawa 91, the most advanced of these, is resistant to verticillium wilt, yields well, and has fruit that is firm, thick-walled, and crack-resistant. Other advanced lines carry such features as extremely tough but easy-peeling, crack-resistant skin; very intense flesh color, very solid flesh, very firm fruit, resistance to verticillium wilt, and various fruit shapes from globe to long pepper.

Potatoes

Potato breeding and testing. Fredericton-bred potato clones F58010, F61051, and F59094 significantly outyielded the principal main-crop variety Kennebec in regional trials in Ontario in 1971. F59094 is especially well adapted to organic soil production. The variety Abnaki, introduced from the USA, was equal to Kennebec in yield, but has the advantage of high resistance to prevalent races of verticillium wilt. Guelph-bred clones G6549-7 and G6551-7y, both with promising processing potential, were significantly higher in solids content than the main processing variety, Kennebec. Clone G6551-7y has bright yellow flesh. For "first early" summer harvesting, the USA introductions Onaway, MS709, and B5236-8 all outyielded Irish Cobbler. All are scab resistant. MS709 has good processing potential.

CYTOGENETICS

Oats

Avena *gene pool.* Our computerized catalog now contains 3,462 original collections of wild oat species. Of these, 2,100 samples of the latest collections have been classified and screened cytologically; thus, this unique collection is now available for interested workers in Canada and abroad.

Primary trisomics. A set of homozygous primary trisomics of *Avena strigosa* Schreb. has been produced by exposing desynaptic plants to a large amount of pollen from synaptic wild-type plants. A total of 240 seeds

(29%) were obtained, of which 168 germinated and yielded 18 trisomics, 4 double trisomics, and 2 telocentrics. This set will allow major rust resistance genes to be associated with their linkage groups, and facilitate a more precise transfer of these genes to hexaploid common oats.

Interspecific gene transfer. Utilizing a Moroccan genotype of *A. longiglumis* Dur., a diploid, as donor of a major stem rust resistance gene, a number of monosomic and disomic addition lines have been produced. Another group of plants with chromosome numbers between $2n = 45$ and $2n = 47$ serve as a source for new addition lines and recombinants. Cytological studies in Ottawa and rust tests in Winnipeg are now in progress.

Esterase studies in Avena. Variation in leaf esterase isozymes was studied in geographically representative samples of various species populations. The A genome diploids *A. hirtula* Lag., *A. strigosa,* and *A. longiglumis* had common and species-specific bands in the slow as well as in the fast mobility regions, whereas the C genome diploids *A. pilosa* M. Bieb. and *A. ventricosa* Bal. had common and different bands of fast mobility only. *A. ventricosa,* which is a relic species of the most limited distribution, was also the least polymorphic. *A. barbata* Pott, an AB genome tetraploid, resembled the zymotypes of the A genome diploids but exhibited a wider range of polymorphism, which gave further support to its quasi-autoploid origin from the A genome diploids. The two new tetraploids, *A. magna* Murphy & Terrell and *A. murphyi* Ladizinsky, contained zymotypes similar to a combination of those of the A and C genome diploids and possessed the distinctive prominent band of *A. pilosa.* The hexaploids had few isozymes not present in the diploids and tetraploids. It is noteworthy that homologous zymotypes were found in plants of *A. pilosa* and *A. ventricosa* collected from the same site in Oran, Algeria. Even the marker band, characteristic for *A. pilosa* but missing from *A. ventricosa,* was absent from *A. pilosa* plants from the *A. ventricosa* site. Similarly, *A. sterilis* L. plants coexistent with *A. magna* in Morocco had the marker band characteristic for *A. magna* but missing from other *A. sterilis* populations.

Bromegrass

Hybrid plants have been obtained from crosses between *B. inermis* Leyss. ($2n = 56$) and *B. pumpellianus* Scribn. ($2n = 56$) and several potential hybrids from crosses between *B. pumpellianus* and *B. pumpellianus* subsp. *dicksonii* Mitchell & Wilton ($2n = 28$). Meiosis in *B. pumpellianus* subsp. *dicksonii* is characterized by bivalent formation, most plants forming a maximum of only one quadrivalent per cell. However, one plant formed a maximum of two and one a maximum of three quadrivalents per cell. The frequency and morphology of the quadrivalents suggest that quadrivalent formation is not random over the members of the genome. The meiotic data plus the karyotype of this subspecies indicate that it contains two different, but closely related, genomes that are under some mechanism of control for meiotic chromosome pairing.

CROP LOSS ASSESSMENT

Methodology

Disease assessment keys. A manual of disease assessment keys was developed in an attempt to standardize assessment methods on various crops. The manual consists of definitions and illustrations of host growth stages, as well as instructions for using the standard area diagram typifying the various diseases. The manual is pocket size and printed on durable plastic so that it can be used repetitively under field conditions.

Potatoes

Potato late blight and aerial photographs. Microdensitometer traces were made from false color aerial photographs of potato plots infected with various levels of late blight. Their transmission densities compared closely with levels of late blight infection in the various plots as determined by ground-truth studies by plant pathologists. The correlations between levels of infection and microdensitometer readings suggest that this technique will be useful in complementing ground-truth surveys for disease estimation.

Tomatoes

Tomato early blight. Losses due to natural infection of early blight disease, caused by *Alternaria porri* (Ell.) Ciferri f. sp. *solani*, for nine tomato varieties ranged from 0% to 12%, whereas losses due to artificial infection ranged from 0% to 32%. The variety Mini-Rose was practically immune to infection; Jetstar showed considerable resistance. The artificial infection was considered to be the epiphytotic level of the disease.

Surveys

Pea diseases. Fusarium root rot, ascochyta foot rot, and downy mildew were the three main diseases encountered in 147 ha (362 acres) of peas surveyed in eastern Ontario. The estimated loss due to root rot was less than 6% in the area surveyed. In Prince Edward Island ascochyta foot rot and fusarium root rot were the most important diseases of peas grown commercially for freezing and canning. However, improvements in crop rotation resulted in less damage from these diseases than in 1970. Downy mildew was more prevalent in 1971, but was of minor importance.

Dwarf bunt. Sixteen of 53 fields of winter wheat were infected in western Ontario. The highest level of infection was less than 0.5%, and most infected fields contained only trace infections. Dwarf bunt, at present, is causing negligible losses in Ontario.

Peach canker. The levels of peach canker observed in 1969 and 1970 in the Niagara Peninsula provide evidence that canker is a very serious problem. Approximately 10% of the bearing area was removed because of canker and this loss is equivalent to approximately $1,000,000 a year. It is also probable that canker decreases fruit production by decreasing tree longevity. The project was a joint program with the CDA Research Station at Vineland Station, Ont.

ENTOMOLOGY

Insect Population Dynamics

Alfalfa weevil. Populations of the alfalfa weevil, *Hypera postica* (Gyll.), were much higher than in 1970; the numbers of eggs increased about eightfold, and those of the other stages about twentyfold. Peak numbers per sample unit of 12 alfalfa stems were: eggs, 84: larval instars 1 to 4, 43, 43, 39, and 33, respectively; prepupae, 25; pupae, 21; and adults, 20. Trends in mortality were consistent with those observed in 1970. Loss of eggs due to parasitism and infertility was 9%. Loss of first-instar larvae due to misadventure during movement to the terminal buds was 45%. During the second to fourth instars there was further mortality of 40%, partly attributable to parasitism. Numbers declined by 76% from egg to adult eclosion. Appropriate transformations for stabilizing the variance of field counts of immature stages were determined. The number of eggs per oviposition puncture did not differ significantly between dates and years. The mean for all counts was 8.96 $\pm$ 0.32, indicating that a record of the number of punctures will provide a satisfactory estimate of egg populations.

Tarnished plant bug. Sampling techniques were devised for six age intervals of the tarnished plant bug, *Lygus lineolaris* (Beauv.), on birdsfoot trefoil. There were two generations in 1971. Adults of the first generation peaked at mid-July and those of the second at mid-September. Nymphal mortality approximated 50% in both generations.

In legume crops, *L. lineolaris* is closely associated with four other mirids, *Adelphocoris lineolatus* (Goeze), *A. rapidus* (Say), *Polymerus basalis* Reuter, and *Plagiognathus chrysanthemi* (Wolff). Morphological characters for separating immature stages of the five species were established. A study of allometric growth revealed that the growth ratios of antennal and leg segments in *A. lineolatus* and *A. rapidus* varied in a parellel fashion in homologous segments of both *L. lineolaris* and *P. basalis,* and that the ratios for rapidly growing segments were more alike than those for slowly growing segments.

Colorado potato beetle. Laboratory experiments on the role of food plants in the life system of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), showed that larvae reared on a secondary host, such as tomato, feed longer, consume more foliage, and allocate less energy for growth than for maintenance. Potato (with higher ECI and ECD values) was more efficient in terms of food conversion to body matter, as shown by increased weight gain of the larvae and greater pupal size. Adults from larvae reared on tomato were smaller and less fecund, and

required less energy to maintain body functions. This appears to be an adaptation for survival in the absence of its principal host.

Diamondback moth. Instability in the life system of the diamondback moth, *Plutella maculipennis* (Curt.), results mainly from the density-independent influence of weather, which controls flight behavior of the adult and is the key factor in determining population change. Stability in the system results from the density-related response of the parasite *Diadegma insularis* (Cress.), which provides sufficient compensation to dampen population oscillations from generation to generation.

Cabbage maggot. Long-term phenological studies in eastern Ontario showed that the cabbage maggot, *Hylemya brassicae* (Bouché), begins to lay its eggs each spring on about May 12, following the accumulation of 198 degree-days above 4.4 C (357 degree-days above 40 F). This corresponds closely to the date of full bloom of a common and conspicuous native tree, wild Canada plum, a useful plant indicator. Oviposition is greatest on calm, sunny days with intermittent cloud cover and daily maximums reaching 22–23 C (the low 70s F). The average date of peak egg laying is May 25. This date corresponds to full bloom of McIntosh and Cortland apples; postplanting control measures are required if egg densities during this period exceed 25 per plant.

Honey Bees

Pheromones and attractants. The queen pheromone, 9-keto-*trans*-2-decenoic acid, was found to be attractive to worker bees during swarming, keeping them constantly aware of her. If the queen is lost in flight, the workers form a restless cluster where she was last known to be and engage in "breaking dances," which cause some of them to fly off and search for her. When they locate the queen, the workers alight around her, expose their Nassanoff scent glands, and fan their wings to disperse the queen pheromone and Nassanoff pheromone. The pheromones synergistically attract more workers, and the new arrivals also emit scent. Some workers, still emitting scent, return to the queenless cluster, where they activate the bees for further searching. Continued "scenting," "scent-fanning," and "breaking dances" at the new location, and at the cluster, finally culminate in general mobilization when all bees suddenly become airborne and settle around their queen.

By using natural extracts and synthetic pheromones, it was demonstrated that cluster formation is initiated by worker bees. They release the Nassanoff pheromone, which attracts other workers and the queen. The queen pheromone acts as a behavioral stabilizer after the cluster is formed.

Experiments showed that a substance is effective as a releaser of alarm behavior if its molecular weight, shape, and polarity resemble the natural alarm substances isopentyl acetate and 2-heptanone.

PLANT GENE RESOURCES

Cultivar and genetic stock collections. A survey to determine the location and species content of cultivar and genetic stock collections in Canada has established that at least 159 individuals or institutions maintain collections of plants or seeds, or of both. Sixty-nine percent of these are stored as seed. Two hundred and forty-eight species are represented in the collections by a total of more than 86,000 cultivars and genetic stocks. A computerized system for the recording, storage, and retrieval of information on the cultivar and genetic stocks in Canadian collections is being developed. An information form for barley stocks was distributed to individuals maintaining barley collections.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Apples

Color improvement of apples. Ethephon (Ethrel) combined with naphthaleneacetic acid (NAA) or 2,4,5-trichlorophenoxypropionic acid increased the red color of Melba, McIntosh, and Red Delicious apples. The improved color was associated with the mature fruit as measured by starch content, acidity, soluble solids, pressure, flavor, fruit abscission, ethylene production, and respiration rate. Fruit must be harvested approximately 2 weeks after spraying in order to retain quality and limit fruit abscission. A color response was observed on apples in the shaded portions of the tree if the spray had contacted the fruit.

New apple cultivar. The selection T-397, a Delicious × Linda cross, was named and released as Lindel. Lindel is a large-fruited, attractive, dual-purpose cultivar that matures about 1 week later than Delicious and stores well until March. In processing tests it rated good to very good in various processed packs.

Thinning apples. The average diameter of developing fruit proved to be an accurate index for timing NAA thinning sprays, but the index varied among cultivars. Maximum response resulted from NAA sprays applied when diameters of McIntosh, Red Delicious, and Spy fruits averaged 8.0 to 9.5 mm, 6.5 to 8.5 mm, and 10 to 11 mm respectively.

Seed samples collected before, during, and after maximum thinning revealed no readily apparent anatomical difference that would simplify identification of the NAA-sensitive stage in other varieties. Although onset of cytokinesis in the endosperm, for example, did not necessarily signal the end of all response to NAA, maximum response always coincided with the late free nuclear stage.

Currently recommended amounts of dimazide (Alar 85) (3.4 kg/ha) applied to McIntosh trees one season before thinning tended to reduce response to a given thinning treatment, though not significantly. Excessive amounts of dimazide (6.8 kg/ha), which induced severe clustering the next season, necessitated increased dosage of thinning chemicals to effect fruit abscission.

Tomatoes

Growth regulators on tomatoes. Dimazide applied to seedlings in the third true-leaf stage, and ethephon applied when three fruit were ripe per plant, increased yields of ripe fruit in a once-over harvest of the tomato varieties Trimson and H-1350. Yield increases over untreated plants with dimazide at 1,250 ppm, and dimazide at 1,250 ppm plus ethephon at 4,000 ppm, were 11.7 and 31.0 metric tons/ha respectively for the mid-season Trimson and 4.8 and 11.0 metric tons/ha for the late variety H-1350. The adverse effect of dimazide on late varieties was due to delay in development of fruit on the treated plant.

Ethephon applied at 4,000 ppm to various populations of transplant tomatoes when three fruit per plant were ripe produced once-over harvests on August 31 of 24.6 to 89,7 metric tons/ha, as the population increased from 1.1 to 9.9 plants/m^2.

Cucumbers

Growth regulators on pickling cucumbers. In a 2-year trial, ethephon applied at 400 ppm at the third-leaf stage to the variety Pioneer increased returns by an average of $445 per ha ($180 per acre). At populations of 10, 16, and 43 plants/m^2 (1, 1.5, and 4 plants/sq ft), returns were $447, $790, and $1,489 per ha ($189, $320, and $603 per acre) respectively. Applications of a morphactin (Merck and Co. Ltd.) at 50 ppm on August 9 increased returns to $1,983 per ha ($803 per acre) 10 days after application.

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Departure

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VISITING SCIENTIST

A. M. SHAABAN, B.Sc., M.Sc., Ph.D. National Research Council postdoctorate fellow	Insect toxicology

INTRODUCTION

Significant progress was made at this Station during 1971 in developing methods for reducing the use of chemical pesticides for control of insect, disease, and nematode pests of horticultural crops. Participation in a collaborative systems approach to research, in cooperation with provincial and university scientists, was extended to apples, grapes, and stone fruits. An extensive survey of nematode problems in forage crops in eastern Ontario, Quebec, and the Maritimes was carried out in collaboration with the stations at Sainte-Foy and Charlottetown.

A spray droplet generator capable of producing spray deposits within a narrow size range was developed and used in spray deposit toxicity studies.

Economic thresholds of nematode numbers for several vegetable crops and tobacco were established and will greatly assist in deciding the necessity for fumigation treatments. Methods of monitoring insect and mite numbers to determine the necessity for spray applications received considerable attention, and a number of traps and sampling methods were tested in orchard and vegetable crops.

Plans for the nuclear stock program for pome and stone fruits, grapes, raspberries, and strawberries were advanced and two large screenhouses were built. A greenhouse for propagating and holding nuclear stock is under construction.

Dr. G. M. Weaver, Director of the Station for the past 2 years, was transferred to Fredericton at the end of October 1971.

For more information on our research projects, please write: Director, Research Station, Research Branch, Canada Department of Agriculture, Box 185, Vineland Station, Ont.

A. J. McGinnis
Director

PESTICIDES

Application

Assessment of conventional sprayer. Field testing of a conventional air-blast sprayer in an apple orchard yielded comparative coverage and drift data. Vertical sampling to 9.1 m above ground 15.2 m downwind showed that most drift was at 6–7.6 m above ground, and still significant at 9.1 m. Drift from 4× sprays of captan at 8 hl/ha (75 gal/acre) was greater than from dilute sprays at 34 hl/ha (300 gal/acre) and both uniformity and amount of deposits within the target trees were better from the 34 hl/ha sprays. Cascade Impactors and cards were used for downwind sampling, and cards for measuring tree coverage. Samples were assessed by visual and fluorometer reading of dye and by gas chromatographic analysis of captan.

Biological relationships of droplet size. A spinning-disc droplet generator was designed and made to produce droplets of a predetermined size from 90 μ to 500 μ. Spread factors were established for Kromekote papers and peach leaves. The stain ratio increased as droplet diameter increased in a straight-line relationship. With a random distribution of 200 μ droplets of nigrosine dye on peach leaf discs, female European red mites moved randomly, and their number of contacts per min with droplet stains bore a straight-line relationship to the number of stains per cm^2. When the miticide formetanate hydrochloride (Carzol) was added, a similar relationship was obtained, but mite activity decreased. The feasibility of measuring dye deposits with a fluorometer to assess rapidly the amounts of chemical deposit was investigated and results were compared with those from analyses of actual pesticides by gas chromatography.

Chemical Control

Deposit–mortality relationship. The deposit–mortality relationship as well as the dose–mortality relationship between major insecticides and larvae of the oriental fruit moth and the codling moth were studied. The minimum effective deposits, fresh and weathered, can now be suggested. Deposits that produced 90% mortality (not 90% lethal

dose) ranged from 0.1 to 2.0 μ g/cm^2 depending on which insecticides were used and the length of time lapse after spraying.

Toxicity and persistence of dicofol deposits applied alone and with phosmet. Dicofol was applied alone and combined with phosmet (Imidan) as a dilute spray to mature peach trees by handgun. Both materials were used at the recommended rate. Bioassay and gas chromatographic analysis confirmed that spray deposits of dicofol and phosmet were more toxic to the European red mite for longer periods than were deposits of either material used alone. However, the increase in toxicity did not occur until the deposits had weathered for about a week. The mechanism of the interaction of these two chemicals is being investigated.

Fumigation of winter eggs of the European red mite on Canadian apples for export. In a cooperative experiment with the Research Institute, London, Ont., replicated lots of McIntosh and Delicious apples were fumigated at two exposure periods with five concentrations of ethylene dibromide, and several concentrations of ethylene oxide. One lot of each variety was treated immediately after harvest, and another lot after 5 weeks of cold storage. Treated apples were held at 0 C until May. The winter eggs on the calyx end of the fruit were killed by ethylene dibromide at rates that did not injure the fruit. Ethylene oxide was toxic to the eggs, but also caused excessive injury to the fruit. Residue levels of ethylene dibromide were well below the tolerance of 5 ppm, even at the highest dosage of 10 mg/liter for 4 hr. It was also determined that in controlled-atmosphere storage winter eggs did not hatch on apples held until April.

Control of the European red mite. Dosage–mortality tests with a laboratory strain of the European red mite showed that formetanate hydrochloride is an excellent fast-killing acaricide for dicofol-susceptible and -resistant adult mites. Despite a very slight cross-resistance from dicofol to formetanate hydrochloride, the lethal dosage for resistant and susceptible mites was low and well within the economic range. It was found that cyanamid compounds AC 84484 and AC 72841 are relatively weak ovicides, especially for winter eggs; 500–1,000 ppm are needed to give high mortalities. Female mites that survived to the adult stage on residues of both compounds appeared normal and laid viable but slightly fewer eggs than did untreated mites. AC 84484 at 1,000 ppm killed developing larvae.

Acaricides were applied at the petal-fall stage to the same apple trees for the second consecutive year. No indication of resistance was shown to formetanate hydrochloride (Carzol), chlorphenamidine (Galecron), propargite (Omite), dicofol (Kelthane), quinomethionat (Morestan), Plictran, or Animert. All acaricides except Animert gave excellent control until late August. Predacious mites were scarce but Animert, propargite, and formetanate hydrochloride appeared to be least toxic to the *Zetzellia mali* Erving, one of the most common predacious mites.

Control of insects of carrots. Granular formulations of carbofuran and chlorfenvinphos applied in the seed furrow controlled first-generation carrot rust fly injury in a planting in the Holland Marsh in which 56% of the untreated carrots were damaged. Carbofuran has been registered and recommended for control of the carrot rust fly. Diazinon at twice the currently recommended rate was unsatisfactory. A single drench spray of carbofuran or four weekly sprays of either bromophos or chlorfenvinphos did not control damage by the second-generation rust fly.

Granular formulations of carbofuran and chlorfenvinphos applied to the surface of the soil before carrots were seeded did not control the carrot weevil in small field plots.

Evaluation of fungicides for control of fruit disease. Benomyl was effective for the control of brown rot of peach, gray mold of strawberry, and powdery mildews of both grapes and raspberries. Thiophanate-methyl, El-273, and Cela W524 were also effective against raspberry powdery mildew, but only benomyl and thiophanate-methyl had any effect on spur blight. Sclex effectively controlled peach brown rot, but did not control gray mold of strawberry. Hoe 2873 gave fair control of grape powdery mildew but not of downy mildew.

Control of Cytospora *canker on peach.* Each of phenylmercuric acetate, captafol, and benomyl applied as three fall sprays and three spring dormant sprays gave 55–70% control of *Cytospora* infections at leaf scars. Lead arsenate plus lime applied at similar times gave 94% control with only slight wood injury. Dodine, captan, sulfur, dichlone, and

dichloran were each ineffective (gave 0–42% control), whereas Bordeaux mixture, DNOC, or ferbam were phytotoxic and the incidence of canker increased by 10–172% on treated trees.

Oil sprays for prevention of stylet-borne viruses in peppers. Light oil emulsion sprays applied weekly at concentrations of 1%, 2%, 3%, and 4% reduced the incidence of stylet-borne virus infection in replicated field plots of the pepper cv. Vinedale to approximately half that in unsprayed control plots of the same unit area. In the sprayed plots, the total yield did not increase significantly, but the amount of marketable fruit increased slightly. Culls due to virus infection were reduced from 15% to about 5% of the total yield.

INSECTS AND MITES

Ecology and Integrated Control

Effect of temperature on codling moth oviposition and fecundity. In the laboratory, female moths laid an average of 180 eggs at 24 C and 60–75% relative humidity. At 15.5 C and 36 C and the same relative humidity, an average of 43 and 88 eggs were deposited. The maximum number of eggs deposited by a single female was from 152 at 15.5 C to 388 at 30 C. At 15.5 C, 62% of the females oviposited, whereas at higher temperatures 89–98% oviposited. Egg hatch did not vary significantly throughout the life of individual females, but it was reduced at 15.5 C and above 27 C.

Integrated control of peach pests. A reduced spray program designed to make maximum use of parasites for control of the oriental fruit moth and predators for control of the European red mite was used in two 10-acre commercial orchards in 1971 and compared with the regular spray programs used by growers. The numbers of oriental fruit moths in both orchards were very low till early September, when they increased rapidly. Insect injury to early and midseason peach cultivars was light with both spray programs. Injury to late peaches in orchards on the reduced spray program was about 2% greater than in the adjacent sprayed orchards, but the fruit was still commercially acceptable. One spray of propargite in mid-July in the orchards with reduced sprays gave the same control as two mite sprays, one at green-tip stage and the other in early July, in the sprayed orchards. The amount of pesticide used in the experimental orchards was about two-thirds that used in the sprayed orchards and two-fifths the quantity currently recommended for insect and disease control.

Monitoring fruit insects. Seasonal activity of adult apple maggots began on June 25 at London, June 29 at Bowmanville, and July 3 at Meaford. The onset of activity was shown earlier on yellow sticky board than on red sticky ball traps. However, five times as many flies were caught on the red balls, and only the latter recorded late seasonal activity.

Codling moth sex pheromone traps indicated the onset of seasonal activity 1 and 2 days earlier than black light traps at Meaford and Vineland. Significant differences in the seasonal rate of capture were found between the two kinds of traps and between the pheromone traps in different locations in the orchards.

The oriental fruit moth sex pheromone *cis*-8-dodecenyl acetate, supplied by the New York State Agricultural Experiment Station, Geneva, N.Y., was used in traps in two peach orchards to monitor fruit moth numbers. Results were compared with those from bait traps containing a brown sugar and terpinyl acetate solution. Though the pheromone traps caught only male moths, they indicated moth emergence and moth numbers the same as the ball traps. The numbers of moths caught in different pheromone traps varied significantly. This difference in numbers appeared to be related to the location of the traps in the orchard.

Monitoring carrot rust fly in the Holland Marsh. A program for monitoring the emergence and occurrence of adults of the carrot rust fly in the Holland Marsh led to improved recommendations for the timing of sprays for its control. In 1970 and 1971 trapping demonstrated that the presently recommended dates for beginning spray applications are too late. Each year monitoring also showed differences in the pattern of seasonal development that affect the timing of control sprays. Monitoring for rust fly offers the possibility of reducing the number of sprays in areas of the marsh where rust fly occurs seldom or in low numbers.

NEMATODES

Ecology

Association with forage–legumes and grasses. Eight genera of plant parasitic nematodes were associated with forage legumes in eastern Ontario and Quebec. Four genera predominated. The percentage of fields examined that were infested with *Pratylenchus, Paratylenchus, Helicotylenchus,* and *Meloidogyne* were 100%, 91%, 84%, and 67%, in eastern Ontario and 75%, 67%, 58%, and 39% in Quebec.

At Elora, Ont., the following associations were observed: cultivars of alfalfa and red and sweet clover with large numbers of *Helicotylenchus digonicus* Perry and small numbers of *Pratylenchus minyus* Sher & Allen; trefoil with large numbers of *P. projectus*; Ladino clover with large numbers of *H. digonicus* and *P. projectus,* and cultivars of orchardgrass with large numbers of *H. digonicus,* medium numbers of *P. minyus,* and small numbers of *Paratylenchus projectus* Jenkins. Bromegrass supported only *P. minyus,* but trefoil did not. All cultivars of timothy supported populations of the three nematodes. Data from turf plots showed that timothy cv. Fusa was a good host for *H. digonicus,* timothy cv. Nugget for *P. minyus,* and perennial ryegrass cv. Kent for *P. projectus.* All grasses examined supported populations of *H. digonicus.*

Population densities and crop loss. Vegetables were grown in field microplots consisting of 20-cm clay tiles having 0, 666, 2,000, 6,000, and 18,000 *P. penetrans*/kg of soil. At densities of 6,000 and 18,000/kg of soil, losses of marketable produce in summer-maturing crops were cabbage cv. Market Prize, 26% and 38%; cauliflower cv. Idol, 15% and 58%; tomatoes cv. Veecrop, 14% and 45%; lettuce cv. Pennlake, 39% and 46%; potatoes cv. Sebago, 32% and 43%; onions cv. Copper Gem, 41% and 71%; and corn cv. Buttervee, 32% and 49%. In fall-maturing crops at densities of 6,000 and 18,000 *P. penetrans*/kg of soil, losses were beets cv. Detroit Dark Red, 7% and 27%; lettuce cv. Great Lakes 6238, 27% and 43%; and spinach cv. Cold Resistant Savoy, 8% and 21%. At similar densities of *Meloidogyne hapla* Chitwood, the losses were beets 13% and 21%, lettuce 68% and 81%, and spinach 9% and 13%.

At Delhi, in microplots of 40-cm concrete tiles, the losses of flue-cured tobacco cv. Delhi 34 with densities of 2,000; 6,000; and 18,000 *P. penetrans*/kg of soil were 5.8%, 10.9%, and 27.5% or $248, $407, and $1,025/ha.

Nematode survival in soil. The survival of *Pratylenchus penetrans* (Cobb) Filip. & Stek. and *P. minyus* in soil was correlated directly with soil moisture, and inversely with soil temperature. Survival decreased as time increased, under all conditions. Both species survived better in Fox than in Vineland loam, but neither survived sub-zero temperatures in these soils. Adults and fourth stage larvae survived better than the second and third stages.

For two successive winters, the ability of *M. hapla* and *M. incognita* to survive at various depths in the soil under annual or perennial hosts was studied in field microplots. *M. incognita* did not survive under any crops. *M. hapla* survived under alfalfa at 0–91 cm deep, but survival was best at 15–30 cm, that is, in the root zone just below the frost line. Under red clover and tomato, survival was best at 8–30 cm deep and 15–30 cm. *M. hapla* survived at 0–61 cm in both frozen and unfrozen soil under both crops.

Control

Nematocidal action of DuPont 1410. A soil drench application of DuPont 1410 (*s*-methyl-1-(dimethylcarbamoyl)-*N*-(methylcarbamoyl)oxy thioformimidate) at 6 kg of active ingredient per ha (6 lb/acre) reduced numbers of *Heterodera schactii* Schmidt cysts on cabbage by 50–90%. A soil drench plus a post-transplant foliar spray of 0.36 kg of active ingredients per 100 liters of water (3.6 lb/100 gal) reduced cysts per root by 95–98%. Drench applications did not kill larvae in the soil, but reduced the number that penetrated the roots and retarded the rate of development of those that did enter the roots. Pretransplant foliar sprays of the chemical seemed to prevent larval penetration of roots or to kill larvae during penetration; after 9 days no larvae had entered roots, even though active larvae were numerous in the soil.

Although greenhouse tests indicated that post-transplant foliar sprays of DuPont 1410 reduced the number of developing larvae in the roots, it did not give sufficient protection against *H. schactii.* Field tests with flue-cured tobacco, however, showed that a postplant

foliar application at 3 kg of active ingredients per ha (3 lb/acre) at 1 and 3 weeks after transplanting gave excellent protection against *P. penetrans* throughout the growing season.

PLANT DISEASES

Fruit Mycology

Root rot of cherry. Wood samples collected from declining cherry trees in 13 farms distributed throughout the major growing areas of Ontario yielded over 70 fungi, only 21 of which caused any degree of injury in inoculated mahaleb seedlings. Fungus identifications are incomplete but include *Diaporthe, Trichoderma, Alternaria, Phomopsis,* and *Rhizoctonia* species and Mycelia Sterilia forms. An isolated occurrence of rhizomorphic root rot (*Armillaria mellea*?) in the Niagara region is causing high losses of trees (4% in 1971). Tree losses due to root rot, in general, continue at the yearly level of 2-5% with additional yield losses occurring on trees in the early stages of decline. It appears that better crop management rather than direct fungus control is the most effective way to reduce these losses.

Peach canker survey. In 1969, the incidence and severity of peach canker was assessed in 250 bearing trees in 93 orchards in the Niagara Peninsula. In 1970, the same trees showed a 10%, 7%, and 14% increase in the average cankered area on trunk, crotch, and scaffold branches. Also 10% of the bearing branches were removed because of extensive cankers.

Fruit Virology

Virus and virus-like diseases of grape. Grape fanleaf virus was isolated in the Niagara Peninsula from most Pinot Chardonnay and Pinot Noir vines that showed leaf abnormalities, mosaic, and poor growth. All isolates produced severe symptoms in the indicator *Chenopodium quinoa* L. Heat treatment of the cultivars Concord, Delaware, Elvira, Fredonia, Pinot Chardonnay, and the rootstocks 5BB 44-53 and 16-16 was successful; healthy clones were then established from treated stocks by shoot culture. Heat-treated vines were reindexed to confirm their freedom from virus.

Graft inoculations in the greenhouse showed that Concord and Delaware reacted severely to peach rosette mosaic virus within 90-120 days. No effect was apparent in other prominent Ontario cultivars during the first year nor could the virus be isolated from these plants. It was confirmed that *Xiphinema americanum* Cobb is the virus vector; larvae or adults were equally efficient as vectors.

Nematode-transmitted viruses. A type strain of tomato ring spot virus (TRSV) isolated in Ontario was transmitted by *X. americanum* to cucumber and raspberry but not to peach or grape. In contrast, an imported peach strain (peach yellow bud mosaic) was transmitted to cucumber and peach but not to grape. It was not possible to transmit yellow bud mosaic virus to grape or the type strain to peach or grape either by mechanical inoculation or by approach grafting. These results suggest a strain-host specificity uninfluenced by the vector, and may explain the absence of TRSV in peach and grape plants in Ontario, even though the type strain often occurs in those soils.

Synergism among virus strains. Three biologically distinct strains of tomato bushy stunt virus were isolated from a single seed of systemically infected sweet cherry. Only one strain readily became systemic in petunia; one strain occasionally became systemic and the third failed to move from inoculated leaves. However, inoculations with the strain mixture resulted in systemic invasion by all three strains. Systemic symptoms induced by the two strains were distinct from each other and from those induced by the strain mixture; the latter symptoms were the most severe. The results suggest that many failures to reproduce original disease symptoms may be due to failures in isolating or maintaining all strains responsible for the disease syndrome.

Ontario nuclear stock program. Accessions to the program include 173 commercial pomological (apple, apricot, cherry, peach, pear, plum), 27 ornamental *Malus* and *Prunus,* and 37 grapevine selections. One hundred and thirty tree fruit selections are ready for registration pending trueness-to-name certification; all grapevine selections have been certified. Progress was made toward establishing certification programs in nurseries with grapevine stock but not with tree fruit stock, because available quantities

of tested understock are inadequate. The Ottawa raspberry and strawberry certification programs will be transferred to Vineland in 1972–73.

Vegetable Mycology

Effect of temperature on fungus–virus interaction on Brassica chinensis *seedlings.* Temperature influenced the interaction between *Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyd. & Hans. and turnip mosaic virus on *Brassica chinensis* L. seedlings. When seedlings of *B. chinensis* inoculated with both *Fusarium* and virus were grown at 21 C or 28 C soil temperature, the doubly inoculated plants weighed less than plants inoculated with either pathogen alone. This effect was not observed on similarly treated plants held at 14 C or 35 C. Check plants grew very well at 21 C or 28 C and poorly at 35 C. The type of interaction produced by these pathogens on this host was additive at 21 C and 28 C.

Vegetable Virology

Viruses of umbelliferous plants. Field transmission of a virus isolated from the roots of carrots grown in muck soils has been associated with a carrot-infecting chytrid, probably *Olpidium brassicae* (Woron.) Dang. Preliminary determinations of morphology, size, thermal inactivation point, dilution end point, host range, and symptom response suggest that it is tobacco necrosis virus (TNV). Antisera against authentic strains of TNV from Ontario and British Columbia soils reacted with the purified virus. A survey of muck soils in the Bradford Marsh in Ontario showed that TNV was present in only 3 of 30 random soil samples, whereas the chytrid was found in 18. There was complete correlation between virus infection and the presence of the chytrid in the roots of seedling carrot bait plants grown in these various soil samples.

A recently detected celery virus appears to be western celery mosaic, hitherto unreported in this crop in Canada. It is sap-transmissible and limited to species of the Umbelliferae. It has been partly purified, but better procedures of purification must be developed. The particle is a long, filamentous rod ca. 775 × 14 nm. The virus has an end point of 10^{-3}–10^{-4} and a thermal inactivation point of 50 C.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
AC 72841	American Cyanamid Co.
AC 84484	American Cyanamid Co.
Animert	N. V. Philips - Duphar
Carzol	Morton Chemical Co.
Cela W524	Cela Landw. Chemikalien-G.m.b.H.
EL-273	Elanco Products Company
Galecron	Ciba Co. Ltd.
Hoe 2873	Farbwerke Hoechst AG., Canadian Hoechst Ltd.
Imidan	Stauffer Chemical Co.
Kelthane	Rohm & Haas Co. of Canada Ltd.
Morestan	Farbenfabriken Bayer A.G.
Omite	Uniroyal Chemical Division of Uniroyal Ltd.
Plictran	Dow Chemical Co.
Sclex	Sumitomo Chemical Co.
1410	DuPont of Canada Ltd.

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Departures

F. K. KRISTJANSSON, B.S.A., M.S., Ph.D. Appointed Director, Ottawa Research Station, September 1971	Chief of Genetics Section; serum protein polymorphisms
A. J. LEE, B.S.A., Ph.D. Resigned November 1971	Dairy cattle breeding
V. S. LOGAN, B.S.A., M.Sc. Retired May 1971	Assistant to Director

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National Research Council postdoctorate fellows

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V. BUVANENDRAN, B.V.Sc., Dip.An.Gen., Ph.D., 1970–71	Dairy cattle and poultry quantitative genetics
T. C. SMEATON, B.A.S., Ph.D., 1969–71	Reproductive physiology
S. O. THORLACIUS, B.S.A., M.Sc., Ph.D., 1970–72	Ruminant nutrition

[1]Seconded from Data Processing Service.

[2]On transfer of work at Harvard University, Cambridge, Mass., September 1970 to September 1971.

[3]On transfer of work at the Animal Research Station, Rurakura, New Zealand, September 1970 to August 1971.

INTRODUCTION

The Animal Research Institute is the main center of research in Canada for the breeding of dairy cattle, sheep, and poultry. It is also the main center for research in reproductive physiology and in several areas of animal and poultry nutrition as well as for the study of fat metabolism in domestic animals as it relates to ketosis and other problems in animal production. A new program on pesticide residues in animal tissues and products has been developed to help ensure that animal products reaching the consumer do not contain harmful pesticides or their metabolites.

In 1971, a comprehensive computer system for poultry pedigree data was completed and put into operation. It has been adopted by the large Canadian poultry breeders and the Poultry Division of the Production and Marketing Branch, besides being used for poultry breeding research in the Research Branch. A start was made on developing a similar comprehensive system for dairy cattle breeding data.

This report reviews briefly the main accomplishments of 1971. It is available on request as are reprints of the research publications listed in the report. Correspondence should be addressed: Animal Research Institute, Headquarters Building, Research Branch, Canada Department of Agriculture, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

BIOCHEMISTRY

A Study of Ruminant Ketosis and Fatty Acid Metabolism

The effect of adding glucose precursors to the ration of lactating cows has been evaluated. A preliminary experiment illustrated that propylene glycol and glycerol were equal in gluconeogenic potency to glutamic acid and succinic acid when added to the ration. The results of a large-scale experiment disclosed that propylene glycol added to the concentrate ration at 3, 6, or 9% resulted in fewer incidences of ketosis than the control ration.

Studies on secretion of carnitine in milk have been extended to cover the first 2 months of lactation. Milk carnitine is high at the onset of lactation and gradually decreases thereafter. Animals that become ketotic maintain elevated milk carnitine content. Changes in milk carnitine secretion are positively correlated with plasma free fatty acid (FFA) levels. It is yet to be determined if increased carnitine excretion causes elevated plasma FFA or vice versa.

An integral part of the ketosis project is the metabolism of fatty acids in vitro. Studies on factors controlling uptake and metabolism of long-chain fatty acids by the liver cell are continuing. Isolated liver cell suspensions were shown to metabolize 1-^{14}C-palmitic acid to $^{14}CO_2$ efficiently. It was established that the early lag in production of CO_2 from palmitate by these cell preparations was due not to any lag in β-oxidation but to an accumulation of the label in organic acids. These are subsequently oxidized to CO_2 through the citric acid cycle. More detailed studies on factors that regulate oxidation of acetyl groups in these cells are in progress.

In further studies on the mechanism of transport of long-chain fatty acids across rat liver plasma membrane, it was found that uptake and metabolism of long-chain fatty acids by liver cells can be inhibited by a variety of uncouplers of oxidative phosphorylation without affecting the capacity of cells to take up and metabolize short-chain fatty acids such as octanoic acid. These results showed that the uptake and metabolism of long-chain fatty acids are dependent on metabolic energy. Previous indirect evidence indicated that proteins of plasma membrane might be involved in the transport process. To clarify this point work is in progress on solubilization, fractionation, and characterization of fatty acid binding proteins from liver cell plasma membrane.

Etiology of Nutritional Muscular Dystrophy in Farm Animals

Experiments with chick erythrocytes disclosed that selenite (but not selenate or selenomethionine) is actively metabolized in red blood cells. SeO_3 reacts with intracellular reduced glutathione (GSH) to form glutathione selenotrisulfide (GSSeSG) and with globin (of hemoglobin) to form globin-glutathione selenotrisulfide (PSSeSG). The GSSeSG was actively released from erythrocytes and identified in cell extracts. Evidence is growing that protein sulfhydryls and glutathione are related to the biochemical functions of Se in animals.

As a measure to prevent nutritional muscular dystrophy (NMD) in lambs, ewes or their lambs or both were implanted with a vitamin E pellet in place of Se, to avoid possible unacceptable residues of the element. Implantation of both the ewe and its lamb, or of the lamb alone, prevented NMD. However, implantation of the ewe alone provided only partial protection. In beef cattle the same vitamin E pellets were rejected and therefore ineffective.

Studies on the metabolism of selenocompounds in the gastrointestinal tract of mature sheep have revealed that passage of selenite, selenate, and selenoamino acids through the rumen markedly diminished their subsequent absorption in the small intestine.

Pesticide Residues and Metabolism

The addition of 1% activated charcoal to chicken diets containing chlordane, DDT, lindane, ethion, atrazine, and linuron did not affect uptake or elimination of low levels (0.1 and 0.5 ppm) of pesticides fed. Neither charcoal nor pesticides affected mortality, body weight changes, feed consumption, egg production, egg weight, or shell quality. Atrazine, linuron, and ethion were not detected in eggs, abdominal fat, or tissues. Prior to feeding trials, *o,p'*-DDT and *p,p'*-DDT and the metabolite *p,p'*-DDE were detected in eggs at 25, 65, and 120 ppb ($b = 10^9$), and in abdominal fat at 58, 183, and 282 ppb respectively. After 6 weeks of feeding lindane and chlordane were detected at 50 and 150 ppb respectively in eggs, and 75 and 330 ppb in fat, whereas *p,p'*-DDE and *p,p'*-DDT had increased twofold and threefold respectively. Three weeks after normal feeding was resumed, lindane and chlordane were not measurable, *p,p'*-DDT had decreased significantly, whereas *p,p'*-DDE had increased twofold. After 7 weeks of normal feeding, *p,p'*-DDT had decreased to control levels and *p,p'*-DDE was approaching control levels.

In vitro degradation of lindane (gamma-BHC) by an enzyme or enzymes from chicken liver yielded metabolites tentatively identified as gamma-PCCH (pentachlorocyclohexane), 1,2,3- and 1,2,4-trichlorobenzene and dichlorobenzene. Of a number of metabolites found during in vivo studies of the laying hen, only unchanged lindane-^{14}C has been positively identified to date.

In addition to showing that methoxychlor did not produce an estrogenic effect in the chicken when incorporated in the diet at levels as high as 10 ppm, an investigation was initiated into the metabolism of this insecticide in farm animals and poultry. Its suspected metabolites are being prepared and characterized employing thin-layer and gas chromatography and by ultraviolet, infrared, nuclear magnetic resonance, and mass spectroscopy. Procedures for the complete extraction of these metabolites from excreta, eggs, milk, and tissues are being developed.

GENETICS

Dairy Cattle

Age of breeding on heifer growth. Differences in breeding age of heifers had no effect on their growth rate during pregnancy nor was the percentage increase in body weight from the first to second lactation affected by age at first freshening. The only factor that had any effect on weight change from the first to second lactation was calving interval which caused a 1.5% increase in body weight for every month of increase in calving interval. On the other hand it was found that when age of freshening was used to estimate milk yield, the yields of heifers of different skeletal sizes at a fixed age were not affected proportionately by changes in age at freshening. Small heifers tended to be affected less in their milk yield by freshening age than large heifers. These results indicate that standards for adjusting milk yield to a common freshening age should account for the rate of heifer development.

Responses to selection in dairy cattle. Selection in Holstein and Ayrshire breeds, for 180-day total milk solids created a genetic increase in only the early part of lactation. This result did not confirm theoretical expectations from high genetic correlations between early- and late-lactation yields. It was concluded that major genetically controlled physiological processes affecting milk yield are quite different between early and late lactation.

Correlated responses in feed consumption, feed efficiency, growth, and body size differed in the two breeds. Whereas growth from 180 to 240 days increased in both breeds, this was associated with increased feed efficiency in Holsteins but increased feed consumption in Ayrshires. Holsteins showed an improved efficiency of total digestible nutrient utilization for fat-corrected milk production, but Ayrshires did not.

Within-breed analyses of phenotypic relationships indicated that the faster-growing heifers were taller, lighter, and consumed more feed. Animals that produced the most milk were heavier at calving, gained more weight during lactation, and consumed more feed.

During the selection experiment there was a genetic trend toward a presumably optimum body size; the Holsteins decreased and the Ayrshires increased. It was concluded that genetic changes in body size related to increased milk production cannot be predicted, but are dependent on the initial characteristics of the animals under selection and the management applied to the population under selection.

Mouse research. Mice are useful in testing breeding plans for large animals because of their extremely short generation interval. A cross-fostering experiment with mice was performed to determine whether their milk yield could be accurately determined by measuring the body weight of their suckling progeny. It was found that 66% of the variance in body weight could be accounted for by differences in milk production of their mothers, which indicates that this is a satisfactory technique for measuring phenotypes for milk production.

A diallel crossbred experiment involving four inbred strains showed that both heterosis and maternal effects were important in determining litter weights. It was also demonstrated that in both inbreds and crosses, litter size was almost twice as important as individual body weight in determining total litter weight.

Sheep

Performance of Finnish Landrace and Finnish crossbred ewes at 2 years of age. Fifteen Finnish Landrace (F), 25 MM line (an Ottawa four-breed synthetic strain), and 24 Finnish × MM (FX) ewes were exposed to rams at 1.5 years of age. Ninety-three percent of the F ewes, 92% of the FX ewes, and 88% of the MM ewes lambed subsequently; the number of lambs born per ewe averaged 2.5, 1.9, and 1.3 respectively. The crossbred ewe was midway between the parent breeds in prolificacy.

More twins saved in artificial rearing. Of 231 lambs born in a flock assigned to natural rearing (nursing of their dams), 14.1% died before 28 days of age, whereas only 11.5% of 615 lambs born in a flock assigned to artificial rearing from 8 to 36 hr after birth died before 28 days. Mortality of twins was 18.5% in natural rearing and 11.5% in artificial rearing. Fifty-five percent of the mortality in natural rearing and 48% of the mortality in artificial rearing occurred during the first 36 hr after birth. The artificially reared lambs were kept on expanded metal mesh floors and given milk replacer via a nippled pipeline system, whereas the nursing lambs were kept with their dams on solid bedded floors. Artificial rearing techniques are being developed to facilitate increased levels of growth rate and prolificacy in an intensive sheep-production program.

Poultry

Genetic resistance to Marek's disease. All investigations on Marek's disease were conducted in cooperation with the Animal Diseases Research Institute, Hull, Quebec.

Inbred lines of chickens, developed during 1965–69 from two highly selected egg production strains, were tested for Marek's disease (MD) resistance in a 54-day challenge test. MD incidence ranged from 0% to 89% among 33 inbred lines. Their rankings for resistance agreed well with those from a "field" test under natural conditions of exposure. Six of these high-resistance lines were crossed with each other and backcrossed to the two strains from which they were derived

to form 10 crosses. These were tested in a 91-day challenge test (males) and in a 140-day "field" test (females) based on natural exposure. In the male test, MD incidence was 0% in two crosses and less than 9% in all others in contrast to 36% in a known susceptible strain (Cornell S). In the field test, rearing mortality due to MD ranged from 1% to 7% for the crosses compared with 17% for the Cornell S strain.

The production of precipitating antibody against Marek's disease herpesvirus (MDHV) was studied in five strains of chickens. A known MD-resistant strain (Cornell K) consistently had higher titers than a MD-susceptible strain (Cornell S), but on the other hand the titers of the three other strains did not reveal a relationship between titer level and MD resistance. Whereas on a strain basis, the overall results indicated no predictable relationship between ability to produce precipitins and ability to resist MD, there was a definite tendency within strains for those birds that died from MD to survive longer if they had higher titers.

To gain further information on genetic resistance while conducting investigations of vaccines, five strains of chickens were vaccinated with attenuated MD virus or herpesvirus of turkeys, cell-associated or lyophilized, and compared with nonvaccinated controls. All vaccines improved resistance to MD. However, resistance to the disease was greater in vaccinated birds of resistant strains than in vaccinated birds of susceptible strains.

Selection response for high early body weight. Data on 13 generations of selection for high early body weight were analyzed to determine the nature of the direct response. The selected lines consisted of four replicates that originated from the Ottawa meat control strain. One line was discontinued after six generations. The remaining three lines were interbred at the sixth generation to form another control strain from which two more selected lines were derived.

The heritability for early body weight estimated in the Ottawa control strain was 0.39. Realized heritabilities for the selected lines (0.46) were higher than the expected estimates for the first seven generations and lower (0.25) for the last six generations. Expected heritabilities derived from variance components in the selected lines showed that during generations 0–6, heritabilities in the selected lines were lower than those of the control strain by only 11%, whereas in later generations they were lower by nearly 37%. These results showed that genetic variance as a proportion of the total variance declined with selection.

Realized selection intensity also decreased with advancing selection, thus limiting the rate of progress per generation. Two important factors causing this decline were identified as lowered reproductive rate and increased mortality. The regression of progeny number per breeder on generation was −1.2 and −0.2 for sires and dams. The mean difference in mortality between selected and control lines was 3.0% during generations 0–4 but increased to 13.5% in later generations.

Inbreeding increased at 0.89% per generation in the selected lines and at 0.18% in the control strains. The regression of inbreeding on juvenile body weight was −3.1 g in males and −2.0 g in females.

The total response in 56-day body weight at the terminal generation was estimated to be 430 g in males and 372 g in females of the selected lines.

Correlated responses in egg quality traits in meat-type lines selected for high early body weight. Seven populations comprising five lines selected for high early body weight and two control lines were studied for correlated responses in egg quality traits. When the realized correlated responses were judged by their influence on a broiler enterprise some responses, such as an increase in egg weight, were beneficial; whereas others, such as decreased specific gravity, changes in egg shape, and an increase in double yolks, would be expected to lead to fewer and lower-quality hatching eggs. Correlated changes of principal interest as quality factors in eggs for consumption were mainly beneficial; albumen height and Haugh units increased whereas blood spots decreased.

Genetic study of plasma cholesterol levels. Selection response over three generations for high and low plasma cholesterol levels was determined in lines derived from a Single Comb White Leghorn base population. Two unselected lines, one from the same base as the selected lines, were maintained as controls. The plasma cholesterol was measured at 9 weeks of age in the first two generations and at 19 weeks in the third generation because of a disease outbreak. A total of

9,800 birds of both sexes were measured over the three generations of the experiment.

Intra-year and intra-strain estimates of heritability based on sire components of variance varied from 0 to 0.30 with a median value of 0.10 in the females and from 0 to 0.46 with a median value of 0.16 in the males. Limited selection responses were also consistent with a relatively low heritability of cholesterol level.

Genetic correlations were obtained between cholesterol and production traits. They were negative with age to first egg, negative in the first two generations and positive in the third with egg production, negative in the first generation and positive in the next two with housing body weight, and almost without exception were zero with all egg quality traits.

Cholesterol levels were compared between birds that died and survivors. There were 30 intra-strain, sex, period, and generation comparisons. Of these, 24 had higher cholesterol levels in the birds that died. The differences between means were greatest in the third generation when mortality was greater.

NUTRITION

Dairy Cattle

Efficiency of energy utilization from the diet vs. body reserves. Results for the first 16 weeks of lactation are complete for cows given one or other of two feed allowances for 6 weeks prepartum and all fed hay and concentrates ad lib. postpartum. The lower prepartum feed allowance (submaintenance) resulted postpartum in greater concentrate feed intake, reduced weight loss, higher peak milk yield, and lower milk fat percentage than the higher prepartum allowance. In all production characteristics the two groups reached uniformity by 10–12 weeks of lactation, and overall efficiency of energy utilization was the same for both.

Barley silage for lactating cows. Wholecrop barley was ensiled at the milk (B), soft-dough (C) and firm-dough (D) stages of maturity and compared with barley hay (A) as a roughage source for lactating cows. Digestibilities of dry matter (DM), crude protein, and fiber were lower for D silage than any other treatment. Average daily DM intakes were 9.0, 9.7, 11.0, and 10.6 kg, and average daily milk yields were 17.1, 18.4, 17.7, and 18.2 kg for treatments A to D respectively. Milk protein and lactose percentages were higher and lower respectively ($P < 0.05$) for cows fed B silage than for those fed C or D silage. Barley hay gave the highest acetate and lowest propionate levels in rumen fluids ($P < 0.05$). The C stage of maturity (30–33% DM) for barley silage gave best overall productivity in lactating cows.

Calves and Dairy Beef

Heat treatment of skim milk in milk replacers for calves. Calves fed a milk replacer containing 25% protein in the dry matter, all from skim milk powder dried at low temperature, grew more rapidly (440 g/day) than those fed milk replacers containing powder dried at moderate or high temperature (330 g/day). An interaction involving fat level (16% vs. 22% in the DM) and diet treatment indicated that fat had an adverse effect on growth when used with the powder treated at the highest temperature, but a positive effect when fed with powder treated at moderate heat. Three of five calves fed the moderately heat-treated powder and low-fat diet for 4 weeks failed to grow when subsequently fed whole milk, whereas calves on all other treatments grew rapidly (> 1,000 g/day) during this period.

Optimal economic diets for Holstein-Friesian steers. Holstein steers reared from birth to 477 kg liveweight in confinement on slatted floors have graded 'Good' or 'Choice' (the two highest grades), when fed corn silage at up to 60% of the dry matter in the diet. At lighter market weights (386 kg), animals fed similar rations were graded 'Good' or 'Standard' (the third grade). The growth rate was somewhat lower for steers fed 60% of the DM as corn silage (1.20 kg/day) than for those given no silage or 30% of the diet DM from silage (both 1.25 kg/day).

Beef Cow Nutrition and Management

Formic acid as a silage additive. In an experiment at the Experimental Farm, Kapuskasing, Ont., silage was made from grasses cut at the early-bloom stage and ensiled in horizontal silos with no tractor consolidation, but with the following differences: silage 1 was wilted in the field; silages 2, 3, and 4 received 0.2, 0.4, and 0.6% (by weight) respectively of 85% formic acid added to the

crop at ensiling. Recoveries of ensiled DM from the silos were 83.6, 88.5, 86.4, and 90.6% for silages 1 to 4 respectively.

In a subsequent growth trial, Shorthorn calves gained 0.29, 0.33, 0.45, and 0.65 kg/day after consuming 4.7, 4.8, 5.3, and 5.9 kg of DM per day from silages 1 to 4 respectively. Digestibility was similar for all silages at about 63%.

Swine

Nutrition of the sow and piglet. A study comparing the self-selection of feeds (cereal and protein) and water by pregnant and nonpregnant gilts showed a consistent decline in the voluntary intake of total feed and water with advancing pregnancy. Nonpregnant gilts followed similar trends with advancing weight and age but to a much lesser extent. A marked increase in the consumption of the protein feed was exhibited by the pregnant gilts about 3 weeks before parturition; feed consumption was markedly depressed at each estrus period in the nonpregnant animals. The inclusion of 10% corn oil, in place of starch, in the diet of lactating sows appeared to reduce the creep feed consumption (639 vs. 1,270 g) of the suckling piglets from 14 to 35 days of age and their 5-week gain (209 vs. 219 g daily). FFA levels in the plasma were higher for piglets sucking dams fed the corn oil diet prior to the introduction of creep feed. Subsequent growth and carcass characteristics at market weight were unaffected by any preweaning differences.

Poultry

Protein sparing effect of complementary cereals. All-grain laying rations based on wheat versus a 50:50 mixture of wheat and buckwheat supported 44% and 63% egg production respectively. When protein supplements were added to these diets, birds on the wheat-buckwheat mixture needed about 3 g less protein per day to support maximum egg production (over 70% for 47 weeks). Buckwheat is very high in lysine and arginine but low in some other amino acids; hence, its protein sparing action is likely to be greatest when it forms about 50% of the grain component of the diet.

Growth restriction of broiler breeding stock. In a comparison between the restriction of protein (14% vs. 11%) or of total feed intake (full-fed vs. skip-a-day) as a means of retarding the growth rate of broiler breeding stock in the rearing period, there was no interaction between the two methods of restriction in subsequent laying performance. For egg production, the low-protein diet so delayed sexual maturity that the birds completed the 40-week laying test with 8% fewer eggs laid. For total feed restriction the reduction in eggs laid was only 3%. The two strains of birds in this test responded differently to total feed restriction; one strain laid more eggs if reared under a restricted program, whereas the other laid more eggs after a full feed program. Restricting the 14% protein diet resulted in eggs that were about 1 g heavier than those from the other three treatments. The type of restriction did not appear to affect laying house mortality.

Subsequently, other methods of restricting growth were tested. Pullets of two commercial strains of broiler breeders were reared to 6 weeks of age on a 14% protein diet given free-choice, and four dietary treatments were imposed from 6 to 21 weeks of age: (i) a 14% protein diet fed on alternate days; (ii) a corn-oat diet containing 10% protein, fed free-choice; (iii) a rye diet containing 12% protein, fed free-choice; (iv) a rye plus 15% linseed oil meal diet containing 15% protein, fed free-choice. Total mortality between 6 and 21 weeks of age was less than 1%. At 21 weeks, mean body weight was practically the same for all treatments and ranged from 1.59 to 1.68 kg. Feed consumptions (0–21 weeks) were 6.7, 7.8, 8.3, and 8.4 kg per bird for treatments 1 to 4 respectively; corresponding figures for protein intake were 818, 636, 773, and 1,045 g per bird. There were no problems with sticky droppings or wet litter associated with the feeding of rye grain, indicating that this is a problem only with chicks under 6 weeks of age.

Effect of excess dietary sodium on shell quality. Sodium bicarbonate or sodium acetate at levels up to 3% of the diet of laying hens resulted in poorer shell quality. Egg production tended to be depressed as dietary Na level increased, whereas feed consumption and egg weight were unaffected. These findings substantiate the indication from our previous results that elevated dietary Na is detrimental to good shell quality.

PHYSIOLOGY

Quantitation of Steroid Hormones

The development of methods for identifying and quantifying the levels of steroids in blood and the application of these methods has progressed along two main lines. A method based on a combination of TLC and gas–liquid chromatography (GLC) has been used to separate up to 100 and to identify and estimate up to 60 of these in plasma samples from the pregnant ewe and sow at different stages of pregnancy. Preliminary compilation of these data indicated the gross inadequacy of current GLC methods in estimations at the low nanogram and subnanogram levels, resulting in up to 100% error. Consequently, studies on the behavior of steroids during GLC were resumed and led to the determination of an exact function of peak height (or area) applicable to all steroids over the whole range of detectability. This has improved the identification of the steroids and their quantitation.

To date the compiled data has yielded much valuable information that may lead to a little understanding of enzymic regulatory mechanisms affecting such factors as the level of progesterone in the pregnant ewe.

The identification of multifunctional steroids has resulted, in general, in a choice between two possible structures that can only be resolved by mass spectrometry. Preliminary steps towards this goal have been made. The second approach has been the development of methods capable of estimating specific steroids at the picogram level (10^{-12} g). To this end, work has continued on the estimation of the free estrogens and their conjugates in the blood of the ewe and sow.

Biosynthesis of Steroid Hormones

As part of an investigation on the role of steroid hormones in the maintenance of pregnancy and the initiation of parturition in the sheep, it has been shown that pregnenolone and progesterone, when incubated with fetal adrenal tissue obtained at different stages of gestation, are metabolized principally to 11-deoxycorticosteroids, i.e. 11-deoxycortisol and 11-deoxycorticosterone. The capacity of the fetal adrenal gland to form cortisol and corticosterone increases with gestational age. These results agree with the concept that increased cortisol secretion by the fetal adrenal gland is involved in the initiation of parturition in the sheep.

In an attempt to gain an understanding of the role of steroid sulfates in mammalian reproduction, studies have been started on the capacity of the fetus and placenta of the sheep and pig to synthesize and cleave steroid sulfates. By the use of a standard in vitro assay it has been shown that sheep placenta, fetal liver, and fetal kidney tissue can cleave steroid sulfates; the placenta exhibited the greatest activity. In contrast, the most active source of steroid sulfatase activity in the pig appears to be the fetal liver. The principal sites of steroid sulfate synthesis in the sheep appear to be the fetal liver and placenta.

Light Cycles and Reproduction

Studies are continuing on the effect of maintaining ewes in different light regimes on their seasonal breeding characteristics. A number of groups are being maintained at a constant environmental temperature in order to evaluate the importance of environmental temperature on the seasonal nature of breeding.

Preliminary experiments on the effect of light regimes of different durations on the productivity of geese, as assessed by the total eggs laid and the distribution of the time of egg laying during the year, showed that considerable variability exists between breeds in the response to different light systems.

Physiological and Behavioral Changes in the Ewe Associated with Estrus

A multichannel automatic data acquisition system has been put into full operation while improvements continue to be made. Infrared photo-cell detectors and signal conditioning equipment have been constructed and tested to monitor several behavioral parameters. Transducing systems for monitoring drinking and copulation have also been constructed.

Physiological, environmental, and behavioral parameters (a total of 35) were monitored continuously on six ewes for about 4 weeks. Computer programs are now being developed for summarizing and analyzing these data on large scale computers.

Mating patterns associated with one male running free with six females were recorded during several periods of estrus activity.

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Chemistry and Biology Research Institute
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PROFESSIONAL STAFF

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H. V. MORLEY, B.Sc., Ph.D.	Organochlorines
R. PURKAYASTHA, B.Sc., M.Sc., Ph.D.	Herbicides

Departure

R. M. D. SUTTON, B.A., M.A., Ph.D. Transferred March 31, 1971 to Environmental Secretariat, National Research Council, Ottawa, Ontario	Bacteriophage and bacterial diseases

VISITING SCIENTIST

H. ROHLEDER, B.Sc., M.Sc., Ph.D., 1971–72	Pesticide analysis

National Research Council postdoctorate fellows, 1971–72

U. RAPP, B.Sc., M.Sc., Ph.D.	Fungal metabolism
G. THOTTAPPILLY, B.Sc., M.Sc., Ph.D.	Virus and mycoplasma vector relationships

INTRODUCTION

The Chemistry and Biology Research Institute was established on March 23, 1971. The professional, technical, and administrative staff represents an amalgamation of the former Analytical Chemistry Research Service with the former Cell Biology Research Institute. The new Institute is responsible for conducting a balanced program of research and development oriented toward winter survival of plants and related seed dormancy, reduction of plant diseases, and the host-parasite interactions of viruses, mycoplasmas, bacteria, and fungi with related crop plants. The Chemistry and Biology Research Institute continues to provide Branch establishments with a comprehensive service in analytical chemistry, covering a wide spectrum of chemical elements, pesticide residues, and constituents of agricultural materials. Research is also conducted into new methods of analysis and recovery. In addition, the sophisticated equipment and experience of the staff of the Electron Microscope Centre and the Instrumentation Centre are made available to research scientists and technicians of the Branch.

This report records the highlights of our progress in research and the analytical services provided during 1971. Detailed information is available in the published papers listed at the end of the report. Reprints are available on request from the Chemistry and Biology Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ont. K1A 0C6.

Regrettably, Dr. R. M. Hochster, who had successfully guided the Institute during its amalgamation and development of the research program, passed away on September 16, 1971.

J. W. Rouatt
Acting Director

AGRICULTURAL MICROBIOLOGY

Growth Inhibition of the Soil-borne Alfalfa Pathogen, *Fusarium oxysporum*

Alfalfa varieties exhibit a range of disease resistance to the soil-borne root pathogen *Fusarium oxysporum,* which determines the agricultural usefulness of these forage crops.

An inhibitor of the growth of *F. oxysporum* was extracted from Vernal, an alfalfa variety highly resistant to fusarium disease. The partially purified, active inhibitor fraction was obtained from a Sephadex gel column. It produced one band, which stained with amido black, in acrylamide disc electrophoresis. The molecular weight of this protein was estimated to be in the range of 1,000 to 5,000. The fraction was found to retain inhibitory activity after 1 hr in agar at 90 C. The ultraviolet spectrum showed absorption peaks at 220, 260, 280, and 320 mμ.

Biospecific isolation techniques are being developed to locate and purify the particular enzyme system affected in the pathogen.

Biochemistry of Fungal Pathogens

Superoxide dismutase, a metalloenzyme, was recently shown to have a major protective and antioxidative function in all aerobic organisms. This enzyme removes free radicals of oxygen (superoxide anion), which arise through a number of mechanisms in living tissues. It appears to have a function and importance analogous to those of catalase, which protects against excessive concentrations of hydrogen peroxide. The superoxide anion has a marked toxic effect on a number of vital cell processes, and its control is essential for normal growth. Superoxide dismutase has been identified in plant and pathogenic fungal cells, and procedures are under development for detailed studies of the mode of action, cofactor requirements, and inhibitors of this important metalloenzyme. If differential inhibition of the dismutase of fungal pathogen can be achieved, the organism will be killed or its growth will be attenuated greatly by a naturally occurring product (superoxide anion) of its own aerobic metabolism.

Copper is known to act as prosthetic group for the dismutase of fungi, and fungicidal

agents such as thiram are thought to inhibit fungal growth by inhibiting essential copper-containing enzymes. In this respect, the electron spin resonance spectra of thiram-treated cells were shown to be altered in comparison with spectra of normal cells.

A key enzyme of pyrimidine and nucleic acid biosynthesis, dihydroorotate dehydrogenase, was isolated from two fungi, *Fusarium oxysporum* and *Neurospora crassa,* and isolates were compared in a search for methods of differential inactivation. The lability of the enzyme from the pathogenic and nonpathogenic organisms was markedly different. The enzyme of the pathogen became inactivated more rapidly in the absence of the protective substrate at temperatures above 15 C. This phenomenon, which also may apply to other metabolic pathways, may provide a molecular basis for the preference of the pathogenic cultures for a lower temperature range.

Orotate biosynthesis was found to be under respiratory control in the mitochondrial membrane of fungi. Evidence of linkage of the oxidation of dihydroorotate with oxidative phosphorylation was obtained. This metabolic pathway may represent an important site of respiratory control over pyrimidine and nucleic acid biosynthesis. Inhibitors of this metabolic step that show both in vivo and in vitro activity are piericidin A (a ubiquinone analogue), antimycin A (an antibiotic), potassium cyanide, detergents (such as Triton-x-100), orthophenanthroline, and other agents that interrupt the electron transport process.

Host-specific Toxins

Crops bred for desirable characters often inadvertently carry linked genes for susceptibility to host-specific toxins of fungi. In view of the recent outbreak of the epiphytotic southern leaf blight of corn, caused by *Helminthosporium maydis,* we reexamined the possibility of similar epiphytotics occurring in Canadian cereal crops. It was shown that *Cochliobolus sativus,* the fungus causing common root rot of cereals, was able to produce toxins in culture that were more toxic to certain varieties and lines of wheat than to others.

During the past year, studies were continued on the chemical structure of the host-specific toxin of *H. carbonum,* a fungus that produces a leaf-spot and ear-rot disease of corn. An α,β-unsaturated amino acid, 2-amino-2,3-dehydro-3-methyl-pentanoic acid, was identified as one of the products of acid hydrolysis of the toxin. This could explain the instability of the toxin and also account for its specific toxicity.

Root Rot of Cereal Crops

As part of a study of factors affecting development of root diseases in cereal crops, root exudates and root extracts from three varieties of spring wheat differing in the degree of susceptibility to *C. sativus,* an agent of common root rot, were analyzed for amino acid content. Although 23 different amino acids were identified, neither quantitative nor qualitative differences between exudate samples were found. Quantitative differences were noted in the root extracts from the three varieties. Extracts from the most resistant variety contained 6 to 20 times more of the basic amino acids, histidine and arginine, than did extracts from the most susceptible variety. Higher concentrations of proline were also found in root extracts of the most resistant variety. Concentrated exudates from the roots of 3-week-old seedlings of the three wheat varieties stimulated germination of *C. sativus* conidia in vitro by approximately the same degree. No evidence of germination inhibition was noted. No differences between varieties were detected when the rates of spore germination in the root zone were determined in natural soil by a buried slide technique. The pattern of seedling root colonization by fungi in natural soil was also found to be essentially the same for the three varieties, although there was a slightly higher incidence of *C. sativus* on roots of the root-rot-susceptible line than on those of the more resistant variety.

Induction and Fine Structure of Chlamydospores of *Fusarium oxysporum*

Methods were developed for the production of high-density populations of chlamydospores. *Fusarium* isolates were readily induced by transferring washed, pregerminated conidia after 12 to 18 hr of growth in Czapek-Dox to shallow layers of a 2-salt solution. Concomitant production of conidia and chlamydospores was prevented by stopping vegetative growth before the mycelium became committed to conidial formation. Chlamydospore differentiation appears to be the result of endogenous metabolism, hence

the use of actively growing tissue (with high levels of endogenous reserves) made it unnecessary to add a supplemental carbon source. These methods have a distinct advantage over previous methods, where only very limited amounts of starved tissue could be used for chlamydospore induction.

Electron microscope studies were undertaken to determine the fine structure of mature chlamydospores as well as that of developmental stages. In the developing chlamydospores, swelling was closely followed by deposition of new cell-wall material at the inner surface of the original cell wall. Continued growth resulted in the formation of the thick, multilayered wall typical of mature chlamydospores. Two distinct types of outer wall surfaces were found in isolates of *F. oxysporum.* In the first, the electron-dense outer layer was smooth-surfaced and appeared to be the modified original wall of the cell. In the second type the external surface of the spore was a fibrillose mat. Thin sections of the early stages of chlamydospore development of this type also exhibited fibrillose material on the surface of the developing spore, at a time when the outer spore wall was continuous with the adjacent vegetative cells. It appears that in certain species of *F. oxysporum,* cells committed to chlamydospore formation elaborate enzymes that break down or modify the original fungal cell wall.

ELECTRON MICROSCOPE CENTRE

Root surfaces and root tips were examined in the scan microscope, in collaboration with Dr. G. Leppard, Department of the Environment. The surfaces were carefully washed and the roots were then freeze-dried. This appears a promising new approach to the study of root–parasite relationships. Insects and larvae examined in the scan microscope included bark beetles, mites, saw flies, nematodes, Lepidoptera, Microlepidoptera, and Hymenoptera.

Milk proteins were examined both by transmission and by scan microscopy, in collaboration with Drs. Kalab and Harwalker of the Food Research Institute.

The Electron Microscope Centre contributed to work on viruses, mycoplasmas, and their vectors, within the Chemistry and Biology Research Institute. Dr. Dhanvantari from the Research Station at Harrow started a study of mycoplasma-infected peach leaves at the Centre. Dr. Gates, also from the Research Station at Harrow, visited us to examine the flagellae of plant pathogenic bacteria. Dr. Harris from the Research Station at Fredericton examined the tarsal claws of peach and potato aphids by scan microscopy, and Dr. Wong from the Fredericton Station used scanning in a study of soil morphology.

Other plant material examined by scanning microscopy included wheat glume surfaces, pollen, and the fungi *Ciboria acerina, Pleospora herbarum,* and *Helminthosporium* species.

FROST HARDINESS AND DORMANCY

Growth Efficiency of Wheat Under Hardening and Nonhardening Conditions

Aspects of growth capacity and efficiency of two cultivars of spring wheat and four of winter wheat were compared under environments controlled for summer and early winter conditions. These growth conditions had pronounced effects; the maximum-growth coefficients independent of light intensity were reduced fourfold by the winter-hardening conditions, and the efficiencies of utilization of light for growth were doubled. The individual cultivars differed markedly from one another, but the groups of spring and winter wheats did not differ significantly under either hardening or nonhardening growth conditions.

Environmental and Respiratory Control Factors in Wheat Hardening

Studies on the course of development of frost hardiness in three varieties of winter wheat and one of spring wheat, under natural field conditions, demonstrated a greater degree of hardening in plants sown in late September than in those sown in early September. Growth chamber studies conducted in conjunction with the field work produced a hardening pattern similar to that observed in the field; however, overall plant development varied considerably between naturally and artificially conditioned plants. The difference was particularly conspicuous with respect to

the development of tillers, which were abundant by late autumn on field-grown plants but which failed to develop to the same extent on plants grown under artificial hardening conditions.

Oxidative phosphorylation characteristics were investigated in isolated mitochondria from developing young winter wheat seedlings grown under both light and dark conditions. Both respiratory control and the ratio of ADP utilized to oxygen consumed declined with increasing age of seedlings and were, in general, lower in seedlings grown in light than in darkness. Preliminary results further suggested that an uncoupler of oxidative phosphorylation was produced during development of the seedlings.

Simulation of Freezing and Osmotic Stresses by Pure Lipid Membrane System

Studies of the effect of freezing and other osmotic stresses on closed model membrane systems (liposomes) constructed from pure lipids showed that the systems behaved under these stresses much as do living cells. Thus, both extracellular and intracellular freezing was induced at will in these liposomes, according to the rate of cooling. Damage to the membranes, as revealed microscopically and by loss of semipermeability (measured by release of trapped markers), closely resembled the injurious effects sustained by living cells under these conditions. Osmotic dehydration produced by strong salt solutions elicited similar stresses and damaging effects in liposomes. It appears, therefore, that pure lipid membranes can experience freezing and osmotic damage in the complete absence of proteins. Further, variations in the physical properties of the model membranes produced by changes in the kind of lipids used to construct the liposomes markedly alter their physical properties and their responses to freezing and osmotic stress.

The combined observations suggest that freezing and osmotic injury could be due to the effects of freezing and dehydration on the lipid components of membranes, rather than on proteins. Also, changes in the lipids of the membranes may be important in the mechanism of frost resistance. The long-observed association between increases in phospholipids and hardening strongly supports this view.

Control of Dormancy in Dormoats

Dormancy of dormoat seeds was reduced at low incubation temperatures (2–10 C) and was expressed most strongly at high temperatures (25–30 C). Germination potential at either temperature range was fixed by a short exposure (2–3 days) to that temperature. The failure of seeds with primary dormancy to germinate induced a secondary dormancy, which was not reduced by low chilling temperatures. In this state, seeds remained ungerminated throughout the fall at low soil temperatures. A seed treatment was developed that maximizes the expression of secondary dormancy in a seed population before planting in soil, and this treatment was shown to be effective in greatly increasing winter survival of seeds.

Secondary dormancy could also be broken by 2 to 3 weeks of exposure to a temperature of −10 C, though not by 4 months at +2 C. These observations suggest that under field conditions, secondary dormancy is broken during winter by freezing, so that germination may proceed in spring.

Storage Protein Bodies in Resting *Rhododendron* Flower Buds

Cytological studies of *Rhododendron* flower development showed that storage protein bodies accumulated in the epidermal and subepidermal petal cells during pre-rest. At the same time, the mesophyll cells accumulated large amyloplasts that had small protein bodies on their periphery. The protein bodies and amyloplasts remained intact throughout the rest period. Shortly after the rest period was broken, all of the protein bodies were hydrolyzed and were probably used to support the initial phase of cell elongation. The amyloplasts remained intact until the cells attained about one-half their normal size at anthesis and then were hydrolyzed and probably used to support the final phase of cell elongation.

Scopoletin Peroxidase Interactions in Relation to IAA Oxidation

Kinetic studies were performed to explain the in vivo observation of the dual effect of scopoletin in promoting or inhibiting IAA-mediated growth, an effect that appears to depend on the respective levels of each substance in the tissue.

The kinetic studies, utilizing spectroscopy

and spectro-fluorometry performed in a pure system, showed that scopoletin reacted 10 times more rapidly (in milliseconds) with peroxidase than did IAA. It formed a detectable scopoletin–peroxidase complex that was unreactive with molecular oxygen, and therefore inactive also in the degradation of IAA. However, if the IAA concentration in the system was increased to more than 10 times the scopoletin concentration, the scopoletin–peroxidase complex was converted to compound III, a species of peroxidase active in IAA oxidation.

HOST-PARASITE RELATIONSHIPS

Antibiotics

Oxytetracycline HCl, tetracycline HCl, and doxycycline HCl were applied as single postinoculation foliage sprays at concentrations of 100, 400, 600, 800, and 1,000 ppm to aster plants inoculated with a celery-infecting strain of aster yellows (CAYA) and clover phyllody (CPA). The results obtained with the three antibiotics were similar. The length of time for symptom expression increased with increasing concentration of antibiotic, reaching a maximum at about 800 ppm. Symptom appearance at this concentration was delayed by approximately 21 days for both CAYA and CPA.

Similar tests were conducted with a non-celery-infecting strain of aster yellows and included an additional tetracycline, methacycline. Maximum delay in symptom appearance with this last antibiotic was 8 days, whereas delays of 16 to 18 days resulted from use of the other three tetracyclines.

Three formulations of oxytetracycline were applied as single foliage sprays at 100 and 1,000 ppm to plants inoculated with CAYA or CPA. Oxytetracycline HCl and oxytetracycline amphoteric were equally effective in delaying the appearance of CP symptoms and were slightly more effective than calcium dioxytetracycline. Against CAYA, the order of effectiveness was HCl, amphoteric, and Ca type of oxytetracycline, although the differences were small.

The following non-tetracycline antibiotics were applied as single postinoculation sprays at 1,000 ppm against CAYA and CPA: triacetyloleandomycin, dihydrostreptomycin sulfate, polymyxin B sulfate, neomycin sulfate, and hyamine. No effect was observed on symptom development.

Clover Phyllody Host Range

The clover phyllody agent was experimentally transmitted by the leafhopper vector, *Macrosteles fascifrons*, to 34 additional species in 12 families, four of them new, bringing the total number of known CPA hosts to 68 species in 17 families. The four new families were Labiatae, Papaveraceae, Polemoniaceae, and Tropaeolaceae.

Acquisition tests were conducted with *M. fascifrons* from 27 of the infected species. Species that proved to be excellent source plants were *Calendula officinalis, Carum carvi, Leontodon autumnalis, Papaver somniferum,* and *Prunella vulgaris.* Poor source species included *Daucus carota, Gilia capitata, Lepidium campestre,* and *Thlaspi arvense.* Although the number of male insects that become infective is normally lower than females, opposite results were obtained with such hosts as *Potentilla recta, Spergula arvensis,* and *Trifolium repens.*

Wheat Striate Mosaic Virus

Leafhopper-borne wheat striate mosaic virus (WSMV) was purified from infected wheat plants, *Triticum durum* Desf., and its biological, biochemical, and biophysical properties were studied. One hundred grams of infected leaves yielded only about 4 mg of virus, but it was highly infective as demonstrated by injection of vector leafhoppers, *Endria inimica* (Say). Examinations of ultrathin sections of virus pellets showed that although most of the particles were of two types, bacilliform (250 × 75 nm) and bullet-shaped (200 × 75 nm), a few long bacilliform particles (415 × 75 nm) were found occasionally. Schlieren patterns of purified virus showed one main component with a sedimentation value (S_{20},W) of about 900 S, and two minor components, one of which had a higher and the other a lower S value than the main component.

By particle weight, the virus contained about 68% protein, 24% lipids, 5% RNA, and probably 3% carbohydrate. Molar percentages of nucleotides were guanine 27, adenine 20, cytosine 24, and uracil 29, indicating that RNA is probably single stranded. Amino acid analysis of the virus protein showed that

it contained, in nmoles/mg, alanine 536, arginine 175, aspartic acid 601, cysteine 90, glutamic acid 550, glycine 438, histidine 63, isoleucine 320, leucine 431, lysine 299, methionine 126, phenylalanine 258, proline 300, serine 484, threonine 451, tyrosine 235, and valine 376. Analysis of lipids showed the presence of both neutral and polar lipids, with and without phosphate. Neutral lipids identified were sterols, free fatty acids, and diglycerides. Phospholipids present were phosphatidylethanolamine, phosphatidylglycerol, phosphatidylcholine, phosphatidylserine, phosphatidylinositol, phosphatidic acid, and lysophosphatides. The polar lipids without phosphorus were sterolglycoside and digalactosyl glyceride.

Clover Phyllody Disease

Five different media were tried in an attempt to culture in vitro a mycoplasma species found associated with this disease. Only one medium would support growth of the mycoplasma, and all attempts to obtain secondary cultures failed. Electron microscopic examinations of primary cultures that did show some growth of the organism revealed typical mycoplasma cells. Suspensions containing such cells were infectious, as demonstrated by injection of healthy leafhopper vectors.

Mechanism of Transmission of Cereal Viruses by Eriophyid Mites

An inefficient mite vector–virus system and two additional nonvector systems were investigated during 1971. Although the eriophyid mite *Abacarus hystrix* transmitted agropyron mosaic virus (AMV) inefficiently, ultrathin sections of the mites reared on AMV-infected plants did not reveal virus particles in any of the tissues of the mite. Clarified homogenates of such mites were noninfective and showed no serological activity against an AMV antiserum. This suggests that AMV ingested by mites while feeding on virus-infected plants may be quickly degraded in the digestive system of the mites, and supports the hypothesis that AMV transmission by *A. hystrix* is of the "stylet-borne" type.

Wheat streak mosaic virus (WSMV) is transmitted efficiently and in a "persistent" manner by the eriophyid mite *Aceria tulipae,* and can be easily observed in large concentrations in the lumen of the alimentary tract of vector mites. However, it was not transmitted by another wheat-infesting mite, *A. hystrix.* In ultrathin sections of *A. hystrix* reared on WSMV-infected plants, a small number of WSMV particles were observed in the gut lumen of two out of 13 mites examined. Homogenates of these mites were not infective and did not react against WSMV antiserum.

When *A. tulipae* mites were reared on wheat plants infected with brome mosaic (BMV), a cereal virus quite different in morphology and physicochemical properties from WSMV and AMV, the mites contained a massive amount of BMV in fore- and midgut cells as well as in the gut lumen. Gut cells were full of round, apparently membrane-bound bodies densely packed with spherical virions of BMV in crystalline arrangements. In repeated tests, however, *A. tulipae* containing large quantities of infective and serologically active virus failed to transmit BMV to wheat plants. The cytoplasmic infection of gut cells by BMV suggests that the virus may multiply in the gut tissues.

To obtain further evidence, virus-free mites were given an acquisition feed on BMV-infected plants. They were examined for BMV virions immediately after the acquisition access period, held on virus-free plants and examined at 4 and 7 days after the beginning of acquisition access. In mites examined immediately after the acquisition feed, BMV virions were found scattered in the gut lumen and occasionally a few scattered ones or small groups of unarranged virions were seen in the gut tissue. However, a progressive increase in virus concentration was observed in mites sectioned at 4 and 7 days after the beginning of the acquisition access. On the 7th day, the entire gut wall tissue was full of large crystals made up of BMV virions, suggesting that multiplication of the virus took place in the gut tissue. No virions were ever observed in virus-free control mites.

Cereal viruses, both filamentous and spherical, may be detectable in small quantities, may accumulate in large concentrations, or perhaps may even multiply in the mite body, but still may not be transmitted to plants by mites. Ability of the virus to pass through membranes in various internal organs of the mite (especially salivary glands) may determine whether or not a mite species will act as a vector. Conclusive evidence is

still lacking, however, as to whether cereal viruses that can survive in the alimentary tract of eriophyid mites are "circulative" in the mite body.

Spotted Wilt Virus (SWV)

Thrips of a vector type were selected from a population of *Frankliniella fusca* collected in Ontario 2 years ago. There was no evidence of segregation for ability to transmit SWV when progeny lines of several individual females were developed and tested. Two biotypes of *F. fusca* seem to occur in nature in Ontario, of which the vector type so far appears to breed true.

Mode of Action of Myxin on Bacterial Cells

Experiments to characterize the type of damage sustained by the intracellular DNA of *Escherichia coli* after exposure to myxin have been completed. In order to differentiate between double- or single-strand breaks in the DNA, cells previously labeled with ^{14}C (in the DNA moiety only) were exposed briefly to myxin, disrupted by sonication, and centrifuged on both neutral and alkaline sucrose density gradients. Analysis of the gradients showed that the earliest damage consisted of single-strand breaks in the double-stranded, helical DNA. By the use of chloramphenicol, which inhibits new protein synthesis, it was established that these breaks were repaired by an increase in the amount of normal repair enzyme synthesized.

This result explains our previously reported enhanced effect of chloramphenicol on myxin-induced DNA degradation and its lethal effect. Cells exposed to myxin synthesize increased amounts of this repair enzyme, which accounts for the metabolic recovery of cells exposed to myxin for short intervals only. If protein synthesis is blocked by chloramphenicol this recovery does not materialize. In the continued presence of myxin, DNA degradation extends from the original breaks along each strand of the DNA. The appearance of double-strand breaks at later periods in all probability represents an overlapping of single-strand breaks in the two chains, and inability of the cells to repair this damage results in their death.

Similar experiments showed that cells exposed to myxin for a short period of time, sufficient to kill 70% of the cells, synthesized new DNA at a normal rate. The newly synthesized DNA, however, contained segments in which the repair of damaged DNA was incomplete, resulting in subsequent death of the cells. The sequence of events after exposure of *E. coli* to myxin is the occurrence of single-strand breaks in DNA during the 1st min followed by inhibition of new DNA synthesis and, at 10 min, the start of DNA degradation and finally the death of the cells.

Genetic Manipulation of Plant Cells

To initiate this program, cells of tobacco, soybean, bush bean, and barley were propagated on three different media and their growth characteristics are currently under study. These cells will be used to produce plant cell protoplasts for experiments in plant cell fusion. Various commercial preparations of pectinases and cellulases were screened for their effectiveness in removing plant cell walls from both leaf pallisade cells and the above callus cells in culture, and the effective ones were selected for use.

Several promising new methods for the production of haploid plants from anther cultures are being investigated, using *Nicotiana tabacum* as a model system.

GENERAL ANALYTICAL CHEMISTRY

Maleic Hydrazide in Tobacco and Vegetables

A distillation/spectrophotometric procedure for the determination of microgram amounts of the herbicide maleic hydrazide in tobacco and vegetables was developed. Concentrated solutions of hydrochloric acid and sodium hydroxide were used to extract maleic hydrazide from plant tissue and aid in the destruction of tissue and interfering compounds. This prompted a redetermination of the stability of maleic hydrazide to acid and base. From the results, reagent concentrations (3 N HCl and 16.5 M NaOH) and techniques were chosen that were conducive both to suitable recoveries of the herbicide and to efficient removal and destruction of interferants. This project is nearing the stage for submission to the Association of Official Agricultural Chemists for collaborative study.

Pheromones of the Honey Bee

A number of the components of queen mandibular gland extract were isolated and some were identified and tested as possible synergists of "queen substance."

Organomercury Residues

A gas-chromatographic method utilizing an electron capture detector has been developed for the analysis of both dimethyl and methyl mercury in the presence of each other and of inorganic mercury.

Acid Dissociation and Metal Ion Binding Equilibria of Fulvic Acid

The experimental technique for potentiometric titration of fulvic acid was further refined, and an iterative calculation method was developed for the two titration equivalence points. This calculation scheme is based directly on the chemical nature of the system rather than on purely mathematical assumptions. It consists of the simultaneous calculation of Gran's Functions and acid dissociation equilibrium functions, followed by evaluation of the equivalence points. The method takes into account the nonconstant nature of the acid dissociation equilibrium functions, and the nonlinearity of some of the Gran's Functions. The Gran's Functions are corrected for the effects of buffering and water dissociation. The chemical and mathematical conditions required for proper convergence of the iterations have been established, and the Fortran V computer program for this calculation is available to anyone wishing to characterize fulvic acid in this way.

The following results have been obtained from this work to date:

I. Titration equivalence points. This problem was solved for the important case of the first equivalence point determined in the presence of 0.1 M KCl. The exact nature of each chemical problem was defined and partial solutions were found for the second equivalence point and the first equivalence point in the absence of alkali metal salt.

II. Fulvic acid chemistry. The previously developed mathematical formulation of the fulvic acid problem was extended and applied to new data, to yield more detailed information about the acidic functional groups and to permit calculation of the degree of ionization of a selected portion of acidic functional groups before the first equivalence point. The potentiometric titration results indicated that in 0.1 M KCl, electrostatic attraction of K^+ to the charged polymer molecules not only increases the effective acid strength, but also displaces the first equivalence point to a higher value.

The chemical information obtainable by this analytical chemical method should be relevant to fulvic acid – heavy metal ion chelation, sorption of fulvic acid by clays, and chemical investigations of higher-molecular-weight humic materials.

PESTICIDE RESIDUES

Analyses for Residues

In soil. The third check sample program for pesticide residues in soils was concluded and the results were evaluated statistically. A report was submitted to the Canadian Committee on Pesticide Use in Agriculture.

In plant material. An investigation into the levels of methoxychlor and breakdown products resulting from use of methoxychlor instead of DDT for the control of Dutch elm disease was concluded. Results showed the coverage to be nonuniform over individual trees, regardless of the spraying technique. Helicopter spraying was the most variable technique and the mist-blower the least variable in both uniformity of coverage and efficiency of deposition. After 10 weeks, the level of methoxychlor on elm tree bark had dropped to approximately 50% of the level present just after spraying (460 ppm).

In animal tissue. Analysis of beef fat from cattle treated by back drench with various levels of lindane established that treatment with lindane at the recommended dosage levels does not result in actionable levels of lindane in the meat.

It was shown that methoxychlor, like DDT, can interfere with trout fingerlings' ability to select temperatures in a horizontal temperature gradient. Time-course studies established, however, that the effect of methoxychlor wears off more rapidly, which is in agreement with its faster metabolism and detoxification. Toxicity studies established methoxychlor to be as lethal as DDT to trout

fingerlings. Of the total methoxychlor removed from the water by fish, only 30% could be accounted for as *p,p'*- and *o,p'*-methoxychlor, and *p,p'*-methoxychlor-DDE.

Organophosphorus Residues

Irradiation of crufomate in hexane with a mercury vapor lamp resulted in its transformation to a compound with a retention time of 0.67 relative to that of crufomate. The product was isolated and its structure deduced to be 4-tert.-butyl-methyl-methylphosphoramidate, from its ^1H nuclear magnetic resonance and mass spectra. The *t* value for the reaction depended on the solvent used, and increased in the order hexane, methanol, ethyl acetate, benzene, water, and acetone. Secondary reactions were observed in benzene, acetone, and water. Irradiation provides a simple confirmatory test for crufomate at the residue level.

The response of a Pye thermionic detector (rubidium chloride annulus) was compared with that of the Coulson electrolytic conductivity detector for 25 organophosphorus and carbamate pesticides, herbicides, and fungicides. The response to nitrogen differed by a factor of two in favor of the Coulson detector; this detector also had a higher specificity. The phosphorus-to-nitrogen ratio of the thermionic detector varied from 64 to 320, depending on the hydrogen flow. The response of the thermionic detector to phosphorus compounds appeared to depend on substitution at the phosphorus atom. A qualitative correlation was obtained between the mesomeric effects of these substituents and the response.

Several organophosphorus pesticides containing aryl chloro groups, such as Dursban (Dow Canada), ronnel, Gardona (Shell Canada Ltd.), Bay 37,289 Nemicide (Chemagro Corp.) and the oxon derivatives, were irradiated in hexane. All underwent sequential dechlorination, the rate being faster for phosphates than for phosphorothioates. The kenetics of photolysis of diethyl 2,4,5-trichlorophenyl phosphate and corresponding di- and mono-chlorophenyl isomers have been studied in hexane. The reactions all show pseudo-first-order kinetics, the ortho-chloro group being more labile than the meta- and para-groups. The reaction products were detected by a gas–liquid chromatographic (GLC) – thermionic system and identified by GLC – mass spectra. The mechanism is thought to involve formation of aryl radicals, with proton abstraction from the solvent as the step that determines the rate.

Atrazine Residues in Field Soil

A new method of electron-capture gas chromatography has been developed for the analysis of atrazine residues in soil. A corn field treated with atrazine at 1.1 kg/ha (1 lb/acre) showed atrazine residues of 0.15 ppm in soil 4 months after application. Methanol, acetone, and acetonitrile were found to be good extracting solvents.

Comparison of Detectors

Coulson electrolytic conductivity (CCD) and electron-capture detectors (ECD) were compared for the analysis of triazine herbicides in water, soil, and corn. Water and soil samples could be analyzed without cleanup with CCD, but cleanup was necessary with ECD. Corn samples required a simple cleanup for CCD but a rigorous one for ECD. Seven triazines gave a 50%-full-scale deflection in the 10- to 30-ng range. Five chlorine-containing triazines required 1 to 2.5 ng to give a 50%-full-scale deflection with ECD.

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T. N. FREEMAN, B.S.A., M.Sc., Ph.D. Retired	Lepidoptera; leaf miners
K. C. SANWAL, B.S.A., M.Sc., Ph.D. Transferred to Research Station, Charlottetown, P.E.I.	Heteroderidae, Aphelenchoidea

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National Research Council postdoctorate fellows

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R. E. LEECH, B.Sc., M.Sc., Ph.D., 1971–72	Taxonomy of spiders (Araneida)
C. WILKINSON, B.Sc., A.R.C.S., Ph.D., M.I. Biol., 1970–71	Taxonomy and biology of leaf miners (*Stigmella*)

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INTRODUCTION

The Entomology Research Institute provides the National Identification Service for Canada on insects, arachnids, and nematodes. To meet this responsibility, the Institute carries out extensive research in taxonomy, biosystematics, and faunistics. The Institute is also responsible for developing and curating the Canadian National Collections of Insects, Arachnids, and Nematodes.

In late October, the Entomology Research Institute welcomed a delegation of American insect taxonomists to Ottawa. The visiting scientists included Unit Leaders of the United States Department of Agriculture personnel working with the insect collections at the United States National Museum in Washington, D.C., and was headed by Dr. Curtis Sabrosky, Director of the Entomology Research Laboratory. A wide variety of topics of mutual interest were discussed including coordination of effort and possible areas of cooperation in field surveys, publication of handbooks, and data retrieval.

Dr. A. Smetana joined the Coleoptera group to strengthen our programs on beetle taxonomy. Dr. K. C. Sanwal, of the Nematology Section, transferred to the Research Station at Charlottetown to undertake nematological studies in the Atlantic Provinces. Dr. T. N. Freeman, of the Lepidoptera and Trichoptera Section, retired after 35 years as a systematic entomologist. Mr. J. F. Sharp, Administrative Officer of the Institute, retired at the end of 1971 after 36 years with the Department.

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W. B. Mountain
Director

THE NATIONAL IDENTIFICATION SERVICE

During the year approximately 830 shipments of insects, arachnids, and other arthropods, comprising some 65,000 specimens, were received for identification. The Department of Agriculture submitted 215 shipments containing 5,450 specimens (8% of total submissions) and the Department of the Environment submitted 113 shipments containing 6,110 specimens (9%). This showed a considerable decrease in the amount of material submitted by both departments. Canadian universities submitted approximately 18,000 specimens (28% of this year's total), a marked increase over 1970.

Insect and other arthropod material identified and returned comprised 77,500 specimens. The accompanying table shows the number of specimens identified, their various sources, and the distribution within groups. A total of 154 samples of soil and plants for the extraction and identification of nematodes were submitted from Department research stations, the Plant Protection Division, and outside sources: about 3,200 specimens were identified.

THE CANADIAN NATIONAL COLLECTION

In addition to the approximately 196,500 specimens added to the Canadian National Collection by staff members, about 19,500 Diptera from California, Chile, Eurasia, and Uganda and 5,000 Lepidoptera from Arizona were purchased; 50,000 Coleoptera in liquid from Mexico were donated. Collections from the Research Institute, Belleville (except the spiders), and the Mission Flats section of the Research Station, Kamloops, were transferred to Ottawa. These collections added some 300,000 specimens to the National Collection and are of primary importance, especially the E. R. Buckell Collection of Orthoptera from Kamloops. Thus, over 571,000 specimens were added to the Canadian National Collection.

Curation (mounting, labeling, spreading, and sorting to family or genus) on the Canadian National Collection continued with 8,000 Acarina, 10,000 Araneida, 85,000 Coleoptera, 49,000 Diptera, 89,000 Hymenoptera, 20,000 Lepidoptera, and 10,000 miscellaneous insects being curated. In addition, the 300,000 specimens from Belleville and

Number of specimens received for identification during 1971

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonaptera	Other insects	Acarina	Other arthropods	Araneida	Total
Canada												
Department of Agriculture	1,181	433	75	1,118	566	830	7	593	592	55	–	5,450
Department of the Environment	570	1,113	20	1,325	1,581	960	–	174	96	–	268	6,107
Other federal departments	10	403	14	5	22	74	–	17	–	–	1	546
Provincial departments	379	2,724	76	135	78	93	251	168	205	–	2	4,111
Industry	227	39	2	–	1	–	–	–	5	–	–	274
Universities	1,168	6,528	364	133	1,916	1,748	71	778	1,278	6	3,959	17,949
Private inquiries	1,292	163	114	174	113	108	22	191	26	39	233	2,475
United States												
Government departments	1,550	540	–	9	–	139	194	–	60	–	500	2,992
Universities	2,461	13,689	1,433	–	25	173	–	–	68	–	382	18,231
Private inquiries	1,040	36	–	1	–	307	–	–	–	–	–	1,384
Industry	3	5	–	–	–	–	–	11	–	–	–	19
Other countries	52	4,178	110	15	135	271	285	44	23	–	146	5,259
Total	9,933	29,851	2,208	2,915	4,437	4,703	830	1,976	2,353	100	5,491	64,797

Kamloops were incorporated into the National Collection, bringing the total to some 571,000 specimens.

Approximately 3,200 specimens of nematodes were curated into the Canadian National Collection of Nematodes. About 12,000 pieces of Canadian amber were collected but only a small number are expected to contain arthropod inclusions.

Some 167 loans, covering 46,185 specimens, were made from the Canadian National Collection to scientists throughout the world.

FIELD STUDIES, FAUNAL SURVEYS, AND MUSEUM TRAVEL

Ten scientists devoted about 40 man-weeks to field studies in Canada. They conducted surveys in the Yukon, Northwest Territories, British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. These surveys added approximately 50,000 Coleoptera, 24,000 Diptera, 50,000 Hymenoptera, 5,000 Araneida, and 10,000 other insects to the Canadian National Collection.

Field studies outside Canada were conducted by three scientists for 22 man-weeks. Approximately 20,000 Coleoptera were collected from Mexico; 2,500 Hemiptera from Wyoming, North Dakota, and South Dakota; 5,000 Acarina from New England; and 5,000 Homoptera (aphids) from England, The Netherlands, Switzerland, and France.

The cutworm moth survey of western North America continued; some 10,000 specimens of Noctuidae were collected in Arizona, Colorado, New Mexico, and Utah. About 15 species of *Euxoa* were reared in connection with biosystematic studies of this group.

About 15,000 specimens of insects were collected in the Ottawa area for biological exhibits in the "Philosopher's Walk" of the National Museum of Canada.

Members of the Nematology Section collected about 200 soil and plant samples from agricultural areas in Prince Edward Island, Ontario, and Alberta.

Dr. E. E. Lindquist participated in the third International Congress of Acarology, at Prague, Czechoslovakia, and studied type material in mite collections in Munich, Nuremberg, Vienna, Prague, Basel, Paris, and Leiden. Three scientists visited the British

Museum to study type-specimens, type-species, and other representatives of European and Asiatic genera. Seven scientists visited the U.S. National Museum, Washington; the Philadelphia Academy of Sciences; the American Museum of Natural History, New York; the Museum of Comparative Zoology, Cambridge; and several major collections at U.S. universities. One scientist visited the laboratories of Entomology and Forestry in Western Canada to determine the status of collections. Dr. J. R. Barron devoted several months to the study and rearrangement of the type material (1,051 Hymenoptera types) in the Provancher Collection in Quebec City.

RESEARCH

Coleoptera and Miscellaneous Orders

Handbooks. Work continued on a handbook of the Scolytidae of Canada and Alaska. Analyses of 10 genera representing 25 species were completed and 35 distribution maps were prepared. A literature search for all published records of the 180 species of fleas (Siphonaptera) known to occur in Canada, Alaska, and Greenland was completed.

Acarina. Two papers on mites were published: one was a revision of the larvae of the Neotrombidiinae (parasites of bat flies and subcortical beetles) with three of the eight species described as new; the other paper included three new species of predatory mites associated with forest insect pests. A paper on the conifer-feeding eriophyid genus *Nalepella* and another one on the gnathosomal characters useful in the classification of genera of tarsonemid mites are in press.

Coleoptera. A monograph and a supplement on the Nearctic species of the staphylinid tribe Quediini were published; the taxonomy, zoogeography, and bionomics of 125 species (in 6 genera) were treated including 2 new subgenera, 47 new species, and 7 new subspecies. A comprehensive manuscript on the Nearctic *Tachinus* (Staphylinidae) was nearly completed; 8 of the 43 species were described as new. Two papers on bark beetles were published, including one with distributional and host data for 21 species that occur in Newfoundland. Three papers on the Elateridae of Nepal are in press and include descriptions of one new genus and eight new species.

Siphonaptera. A paper describing three new species of *Pygiopsylla* from Australia was published.

Collaboration with other agencies. The research projects of Mr. J. Robillard, a graduate student at Carleton University, and of Dr. R. E. Leech, Postdoctorate Fellow of the National Research Council of Canada, were supervised by Dr. E. E. Lindquist.

Comparative Morphology

Biosystematics of Euxoa. The rearing program developed last year has been reasonably successful, although fertility was low in some species. The influence of nutrition in this problem is being investigated. Twenty-one species have been reared and some of these are in their second and third generations. Eggs, larvae, and adults from these rearings provide all the experimental material for the biosystematic program. Large-scale rearings of the *Euxoa declarata-campestris* complex were begun to provide material for electrophoresis, for immunological and serological testing, and for hybridization experiments. Prepupal aestivation, characteristic of most *Euxoa,* was found not to occur in some northern and montane species. Subsequently, it was found that last-instar larval hemolymph could not be used for comparative electrophoretic analysis because its protein content was age-dependent. Tests indicated that thoracic muscle and fully developed ovarian eggs were more stable sources of protein. Comparative examination of the larval hemocyte complex from several additional *Euxoa* species confirmed that hemocytes from certain species were distinctive. Examination of the sensillae on the adult proboscis indicated that individual variation was too great to permit the use of this feature as a taxonomic character at the specific level; significant differences did occur at the generic level. Some generic differences were observed in amino acid chromatograms of adult hemolymph, but interpretation was complicated by variability caused by diet. The standard chromosome number for the genus was established as 31, although two of the nine species examined were distinctive in having 32 and 35. The number of coils in the spermathecal duct appeared to be species-specific, and ranged from one to five. The

fifth- and sixth-instar larvae of all species reared were photographed and examined to find consistent species characteristics; patterns of maculation on the head capsule and prothoracic shield and the morphology of the hypopharynx appear to be useful characters.

New structures and functions. The external morphology of eggs of 45 geometrid species in 33 genera, and 59 noctuid species in 34 genera, were examined by scanning electron microscopy. The fine structure of the chorion in eggs from both families was examined.

The karyotype for the three main genera of Bombinae, *Bombus, Megabombus,* and *Pyrobombus,* was established from breeding colonies as $n = 18$ with short rod-like chromosomes. Although the karyotype for one colony of *Pyrobombus* (*C.*) *rufocinctus* (Cr.) conformed to this pattern, the karyotype for another colony, identified as the same species, was $n = 6$ with long metacentric chromosomes. This discrepancy indicates a species complex within this group.

Examination of the spermathecae in three tabanid genera, *Chrysops, Hybomitra,* and *Tabanus,* showed that each was characteristic of the genus. Differences found in two species of *Tabanus* suggest that they may be misplaced in that genus. A rather wide range (4–9) in the haploid chromosome number of seven species of *Chrysops* may also be of taxonomic interest.

The third draft of a monograph on the morphology and evolution of the insect abdomen was completed.

Diptera

Handbooks. About 250 drawings in 48 plates were prepared and texts for seven families were received for a manual on the genera of North American Diptera, to be completed by 1975; 800 of a projected 2,300 drawings have been completed, and reviews of 40 of 111 families have been received. Further progress has been made with handbooks on the genera of Ceratopogonidae, the Nearctic species of the black fly genus *Simulium,* the Canadian Chironomidae, the blowflies of Canada, and the larvae and pupae of flies that live under tree bark.

Biting flies. A paper describing new species of black flies from Alberta has been completed. The medically important biting fly genus *Phlebotomus* has been found for the first time in Eastern Canada, near Perth, Ont. Larval diagnoses have been prepared for all genera of the *Cnephia* complex of black flies and a system of numbering the teeth of the hypostomium has been perfected that can be applied throughout the family.

Parasites and predators. A revision of adelgid predators of the chamaemyiid subgenus *Neoleucopis* (12 species, 7 newly described) was completed. A study of the bat flies of Cuba, including the descriptions of five new species, is under way.

A revision of the Nearctic tachinid genus *Phorocera,* subgenus *Pseudotachinomyia* (eight species, four new), was completed. A paper has been completed validating the generic name *Agria* R.-D. over its synonym *Pseudosarcophaga* Kram. and describing a new Nearctic species of the genus.

Other dipterà. Dissection and examination of genitalia of Canadian blowflies is continuing in order to establish limits within groups of closely related species. Generic characters are also being examined and redefined in the difficult *Calliphora–Acronesia–Cynomyia* complex. Descriptions of new species of a Mexican phorid and a Nearctic chironomid were completed. A paper was prepared on the identity of 25 nominal species of a genus of aphid-eating flower flies. A catalog of the flower flies of the Oriental region was prepared.

Biosystematics. Two papers on the seasonal and diel emergence of High Arctic Chironomidae were completed. Fundamental studies of feeding habits have shown that a basic pattern of two complementary meals and two methods of feeding exists in the Diptera. The sugar meal, from nectar or honey dew, is fairly stable, and has been lost in only a few families; the protein-containing meal is very variable (blood, insect prey, pollen, carrion, and other foods) and has often been lost in individual species and in families and even larger groups.

Hymenoptera and Hemiptera

Taxonomy of aphids. A review of the Chaitophorinae of Canada has been completed; host associations, distributions, and keys to 48 species are given. Sixteen species of aphids associated with goldenrod, *Solidago* spp., in Canada have been studied. New species of *Aulacorthum, Dactynotus,* and *Acyrthosiphon* were described.

Taxonomy of Heteroptera. Two large Nearctic genera of Miridae, *Trigonotylus* and *Lygocoris,* were revised and new species described. The revision of *Lygocoris* constitutes a well-illustrated handbook with notes on the biology of component species.

Taxonomy of parasitic Hymenoptera. A revision of Nearctic species of the ichneumonid genus *Euceros* (20 species) is well under way. A new species of the aquatic genus *Agriotypus* was described and the higher classification of Agriotypidae was discussed. Six species of *Apanteles* that parasitize the spruce budworm in Canada were described and keyed. New species of the chalcidoid genera *Achrysocharis* (Eulophidae) and *Stemmatosteres* (Encyrtidae) were described from Canada. A new family of primitive Chalcidoidea was recognized from Asia and Malaya. In the Proctotrupoidea, the tribes Thoronini and Embidobiini (Scelionidae) of the world were revised and several new genera and species described. A new species parasitic on the eggs of the bloodsucking bugs of the medically important genus *Triatoma* was described. Nearctic species of the subfamily Gryoninae (Scelionidae) are being reviewed.

Taxonomy of bumblebees and sawflies. Part 2 of the *Monograph of the Western Hemisphere Bumblebees* has been completed and Part 3 is in progress. A new species of the sawfly genus *Susana* is described from Canada.

University collaboration. Dr. Ferdinando Bin, a Canada Council postdoctorate fellow from Italy, studied proctotrupoid wasps and completed three papers on Diapriidae and Scelionidae. Dr. Miloje Krunic, a National Research Council postdoctorate fellow from Yugoslavia, spent 2 months at the Institute studying solitary bees of the genus *Megachile.*

Lepidoptera and Trichoptera

Handbooks. A handbook on Canadian species of two tribes in the Ennominae has been completed and forwarded for publication. Similar studies of three additional tribes, Melanolophiini, Boarmiini, and Bistonini, are in progress.

Taxonomy. A study of the Nearctic *Rheumaptera,* based on rearings from gravid females in Quebec, Alberta, and British Columbia, has been completed. Adult females and larvae of the two Canadian species of the genus, as well as the adult males, can now be distinguished. In turn, erroneous data on food plants, behavior, and distributions can now be corrected.

Analyses of the *cineropallida, obeliscoides,* and *declarata* groups of the cutworm genus *Euxoa* revealed a number of previously unrecognized species in the North American fauna.

A review of North American *Dioryctria* has resulted in the recognition and definition of seven species-groups. Research on three of these groups has been completed.

In research on the Trichoptera, four taxonomic papers were published, in which 20 new species were described. In cooperation with L. Botosaneau, a study of the Trichoptera in the Geneva Museum was completed; the status of type material of species described by Pictet in 1834 was reviewed and six lectotypes were designated.

Evolution. Studies on the evolution of the female genitalia among the primitive Microlepidoptera have been completed. Similar investigations of the male genitalia in the same groups are under way.

Developmental studies. A series of papers reporting on the life histories of North American Heliothidinae has been completed. The group is of particular interest because the larvae feed almost exclusively on the flowers and fruits of their host plants.

Nematology

Handbooks. Some progress is being made on the preparation of illustrated taxonomic keys to the Canadian species of several plant-parasitic Tylenchida. The preparation of a key to the world genera of plant-parasitic nematodes has been abandoned because adequate reference material is already available.

Biosystematics. A comprehensive taxonomic treatment of the cyst-forming nematodes of the genus *Heterodera,* including an illustrated taxonomic key to the more than 50 described species, 38 of which were studied and photographed, is in the final stages of preparation for publication. The key, based on cyst cone-top and terminal structures, will

facilitate identification of species by specialists and field workers. Morphometric studies of three populations of *Pratylenchus penetrans* (Cobb) from Vineland and Burlington, Ont., and Charlottetown, P.E.I., show that the species exhibit considerable variation. A computer analysis will be conducted to find stable and reliable characters. Morphometric studies of five populations of *Paratylenchus* collected from the Vineland and Ottawa areas show morphological differences that require further investigation.

New structures. Studies of the ultrastructure of the cuticle, of the spear and its protractor muscles, and of the esophagus of *Tylenchorhynchus dubius* (Butschli) have been completed and the results, in part, published. New structural details were revealed that are important taxonomically and contribute to a better understanding of form, function, and behavior, particularly as related to feeding.

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M. M. AREF, B.Sc., M.Sc., Ph.D. Resigned October 1971	Rape protein technology
J. J. GETHER, Dipl. Biochem. Ingr. Resigned April 1971	Flavor-producing organisms
G. B. LANDERKIN, B.S.A., M.S. Retired August 1971	Molds and yeast
P. A. POAPST, B.Sc., B.Sc. (Agr.) Transferred to Research Station, Kentville, N.S., August 14, 1971	Vegetable storage
N. W. TAPE, B.S.A., Ph.D. Appointed Research Coordinator (Food), June 1, 1971	Rape protein technology

VISITING SCIENTIST

C. KANNO, B.S., M.S., Ph.D. National Research Council postdoctorate fellow, 1969–71	Studies of milk protein

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[1]On transfer of work at Reading, England, August 1971 to August 1972.

INTRODUCTION

During 1971, research on meat was organized in a Meat Program. In addition to continued sensory evaluation of meat to measure the impact of breed or diet on eating quality and storage life, the Program includes studies of the rigor mortis - associated factors on the manufacturing properties of beef muscle and the evaluation of milk replacers for calves and lambs to be used in cooperative nutritional experiments. Not all aspects of the Program have progressed sufficiently to warrant inclusion in this report.

The Special Research Program, which had previously served for programs soon to be terminated as well as the focal point for genuine utilization research, became more clearly identified with utilization research to help outside organizations. In 1971, help was given to various marketing boards, private industry, product divisions of the Production and Marketing Branch, the International Development Research Center, and the Canadian Hunger Foundation.

The mailing address of this establishment is: Food Research Institute, Research Branch, Canada Department of Agriculture, Central Experimental Farm, Ottawa, Ont. K1A 0C6.

R. P. A. Sims
Director

OILSEED PROGRAM

Rapeseed and Mustard Seed Preparations

Various fractions, including flour, hull plus cotyledon fines, purified hulls, lyophilized water extracts, and crude-oil preparations, were prepared in quantity from seed of Bronowski, Oro, Echo, Yellow Sarson, and Target varieties of rapeseed. The preparations satisfied our own needs as well as the requests from nutritionists studying milk replacers for calves and lambs, and poultry and mink rations.

Flours prepared from Bronowski and Echo seed by the procedure mentioned in last year's report contained more crude protein (60–65%) than previously prepared flours (50–55%). Nutritionally, their performance consistently equaled casein in Protein Efficiency Ratio tests. These flours contained detectable amounts of glucosinolates when analyzed by a gas–liquid chromatography (GLC) system of improved sensitivity. Oxazolidinethione (goitrin) contents, however, were less than in previous samples.

Flours prepared by hexane extraction of dehulled rapeseed, followed by aqueous-acetone and acetone extraction, yielded white products containing 60–70% crude protein. The higher nitrogen-containing preparations met criteria for protein "concentrate" preparations (65–70% crude protein).

Flours and lyophilized water-extract preparations were prepared from yellow mustard, *Brassica hirta* Moench = *Sinapis alba* L. The flour preparation contained 70% crude protein.

Rapeseed Carbohydrates

Further work with the water-soluble fraction of rapeseed cotyledons yielded a crude polysaccharide that was fractionated successively on DEAE-cellulose (borate, carbonate, and phosphate forms) to yield a purified acidic arabinogalactan. The fractionation procedure showed that the two main polysaccharides in the water-soluble fraction, namely the amyloid and the acidic arabinogalactan, occurred in an approximate ratio of 1:2. The latter polysaccharide, found to be largely homogeneous by moving boundary electrophoresis and sedimentation analysis, contained L-arabinose-D-galactose-D-glucuronic acid in a molar proportion of 1:1.05:0.13. Methylation and periodate oxidation results showed good agreement and disclosed a highly branched structure. Of the 45 sugar residues that comprise an average repeating unit, there was one terminal, nonreducing end group of D-galactose; 14 terminal, nonreducing end groups of L-arabinose; and three terminal, nonreducing end groups of D-glucuronic acid. There were 13 residues of D-galactose, one of L-arabinose, and two of D-galactose in which branching through the 3 and 6, 2 and 5, and 3, 4, and 6 positions occurred in the polysaccharide. The remaining 11 nonterminal residues consisted of two

(1→6)-linked galactose residues, four (1→3)-linked galactose residues, and five (1→5)-linked arabinose residues.

The highly negative specific optical rotations (-49.2° and -80.6° respectively) for the unmethylated and methylated polysaccharide strongly indicated that the anomeric linkages involved were predominantly of the β-D-galactosydic and α-L-arabinosydic types.

These structural features further disclosed that the acidic arabinogalactan of rapeseed was distinctly different from the arabinogalactan of the oilseed soybean, but was similar to the arabinogalactan of the coffee bean and those isolated from the wood of conifers.

A new reagent, butane boronic acid, was found to be potentially useful for GLC and combined GLC – mass spectrometric analysis of some common monosaccharides. Of the sugars investigated, several gave single peaks. The procedure allows a simple, rapid, qualitative analysis of some common monosaccharides on a microgram scale. Reaction conditions have been studied. GLC retention data on different liquid phases and mass spectra were obtained.

Rapeseed and Mustard Seed Phenolics

Rapeseeds and mustard seeds were examined for phenolics. Seeds with light-colored testa did not yield cyanidin pigment with butanol-acid treatment as did the testa of dark-colored seeds. Traces of unidentified simple phenols were detected in rapeseed testa. The dark testa pigment was insoluble in all solvents tested.

Extracts from hexane-extracted rapeseed and mustard kernels contained several phenolics. Sinapine was a major component present in all seeds examined. It was isolated from rapeseed and characterized.

Sinalbin, a glucosinolate combined with sinapine and a well-known compound in yellow mustard, was not detected in any rapeseed or brown mustard, *B. juncea* L. However, *p*-hydroxybenzyl alcohol and *p*-hydroxybenzyl nitrile derived from the enzymic degradation of sinalbin were readily detected in aqueous-acetone extracts of yellow mustard. These compounds were absent from all rapeseed extracts, but other unidentified phenolics were present.

Chlorogenic acid was identified in extracts of Yellow Sarson and Oro varieties of rapeseed. It was not detected in the mustards.

Extracts contained no detectable hydrolyzable tannins.

The flavonols kaempferol, isorhamnetin, and quercetin were identified in extracts of *Brassica* sp. seedlings.

Rapeseed and Mustard Seed Protein

The hexane-extracted cotyledon protein component of rapeseed and mustard seed was characterized as to water solubility from pH 3 to 11. Preliminary experiments explored the effects of various salts and pretreatments (e.g., heat) on protein solubility. Estimations of the molecular weight distribution of the protein solubilized under various conditions were made by polyacrylamide gel electrophoresis.

Protein isolates previously prepared contained 80% or less crude protein (N × 6.25).

Crude myrosinase preparations were made from Echo, Oro, Bronowski, and Yellow Sarson rapeseed varieties, and from two selections of *B. hirta* from different sources. Myrosinase prepared from rapeseeds had 0.1 to 0.01 of the activity of that made from *B. hirta*. Of the rapeseeds tested, Yellow Sarson yielded myrosinase with the highest activity. All myrosinase preparations were activated by ascorbic acid. Rapeseed myrosinase preparations were more sensitive to ascorbic acid and were activated up to tenfold, whereas *B. hirta* myrosinase showed twofold to threefold activation.

Acetone dehydration of myrosinase preparations was consistently superior to lyophilization for preserving myrosinase activity in dried preparations.

Rapeseed Lipids

Newer thin-layer chromatographic techniques have disclosed an additional component in the polar lipid fraction of Yellow Sarson. It is suspected to be *N*-acyl phosphatidyl ethanolamine.

Examination of separated rapeseed coats (hulls) showed that most of the oil originated from contamination by oil-rich cotyledon fragments. Hand-separated seed-coat fractions contained 1.75% oil, whereas the cotyledon-contaminated fraction from which they were prepared had 5.5% oil.

DAIRY PROGRAM

Cheddar Cheese Flavor

Volatile flavor components. A main problem in the study of Cheddar flavor is avoiding destruction or adsorption of flavor components by GLC columns while retaining satisfactory resolution of the components. Therefore, columns showing minimal adsorptive effects were selected and flavor components were silylated to improve resolution and reduce tailing. GLC – mass spectral data obtained on unsilylated and silylated volatiles from Cheddar cheese indicated the presence of a number of compounds whose spectra have not been published or that are not commercially available for preparing confirmatory spectra or both.

Columns selected for minimal adsorption generally resolve mixtures of flavor compounds incompletely, making interpretation of the resultant mass spectra difficult or impossible. Glass capillary columns with high resolution and low adsorption effects are therefore being made and evaluated.

Fruity flavor. This is the most serious flavor defect in Canadian Cheddar cheese. Moreover, the character of the fruitiness differs among cheeses, suggesting that the chemical compounds responsible for the defect are different. GLC techniques were developed for defining the profile of the volatile compounds and computer programs were written for grouping and for multiple discriminant analysis to associate GLC peaks with fruitiness. Flavor scores and GLC data were obtained for 120 samples of normal and fruity commercial cheese.

Control of Bacteriophage

Bacteriophage may be inactivated by a variety of methods including adsorption on isolated cell walls and on heat-killed cells. Attempts were therefore made to isolate and purify specific phage receptor site material from cell walls and cell membranes. To date, the materials isolated have had only very low neutralizing capability.

A number of rabbits were vaccinated to produce antiphage serum. This serum was used to classify phages, to show interrelationships, and to study the blocking of the phage attachment mechanism.

Several starter-culture strains were made resistant to their homologous phages by using the spermine treatment of Erskine. These starters are now resistant to all phage races in the Food Research Institute (FRI) collection. Additions to the FRI collection of phage races and host strains are being made.

Milk-coagulating Enzymes

Mixtures of rennet and hog pepsin are now used commercially in making Cheddar cheese in Canada. As a result, methods were developed to measure the content of rennin, swine pepsin, and bovine pepsin in commercial mixtures of milk-coagulating enzymes. Bovine pepsin is present because the stomachs of older bovine animals are used increasingly to produce rennet. A study of inactivation rates of crystalline swine pepsin, crystalline rennin, and the extracts of adult bovine stomachs showed that the effective concentration of these enzymes in a mixture can be determined quantitatively as follows: swine pepsin by rate of inactivation at pH 6.3 at 30 C; rennin by activity remaining at pH 7.7 at 30 C; and bovine pepsin by difference. The rennin content of rennet sold in Canada was shown by this procedure to vary widely.

Samples of milk-coagulating enzymes from microbial and animal sources were tested for their effect on the flavor of cheese curd by using the procedure of Raadsveld and Klomp. Enzymes from *Endothia parasitica* and *Bacillus polymyxa* produced bitter curd, whereas rennet, swine pepsin, extracts from adult bovine stomachs (bovine pepsin), and enzymes from *Mucor pusillus* and *M. miehei* produced relatively nonbitter curd. Significant differences were found among the panel members, however, indicating the need for further refinement of the test method. Nevertheless, the Raadsveld and Klomp procedure showed potential as a control method for evaluating milk-coagulating enzymes.

Lipoproteins in Skim Milk

The defects of sediment, poor quality, and slow acid production in cottage cheesemaking were shown previously to be influenced by homogenization-labile components in skim milk, possibly lipoproteins. Lipoproteins were therefore isolated from skim milk using preparative ultracentrifugation at two densities of milk and NaBr solutions (d = 1.06 and 1.20). The fractions isolated at these densities were characterized by gel filtration, analytical ultracentrifugation, and

chemical methods. Euglobulins and pseudoglobulins were isolated from acid whey by using $(NH_4)_2SO_4$ precipitation, immunoelectrophoresis, and ultracentrifugation; agglutination of *Streptococcus cremoris* was caused by the IgM-immunoglobulin. The isolated lipoprotein fraction had little effect on the agglutinating titer of the immunoglobulins.

Thermal Gelation of Skim Milk

Concentrated skim milk (50% total solids) was gelled at 100 C under a variety of conditions to assess properties beneficial in formulating new foods. Added divalent cations generally increased firmness; added calcium-complexing anions generally decreased firmness; cross-linking compounds increased firmness; reducing and oxidizing agents were not consistent in their effect on firmness. Using the criteria of firmness, elasticity, and chewiness, it was shown that persulfate, borohydride, and thiomalate affect the structure of gelled milk protein most favorably with respect to the prospective use of the gels as a food base.

The nutritional quality of thermally gelled milk was tested in collaboration with Dr. G. H. Anderson, Department of Nutrition, School of Hygiene, University of Toronto. Gelation at 100 C for 10 or 30 min did not diminish the biological value (protein efficiency ratio compared with casein) of the milk proteins for albino rats, although the total and available lysine contents decreased and the histidine was partly destroyed. Gelation at 120 C for 90 min decreased the biological value of the proteins by 80% and the total and available lysine content by 50% and 60% respectively. Heating for shorter times at 120 C and for 90 min at 100 C had intermediate effects on the nutritional quality, suggesting that additional heating of milk gels such as by baking or roasting should be avoided.

UTILIZATION PROGRAM

Polysaccharides of the Potato Tuber

Tubers grown in an Eastern Canada location gave a low-protein polysaccharide fraction eluted by water from DEAE-cellulose. Fractional precipitation with ethanol gave a polysaccharide that was homogeneous by sedimentation analysis and had a galactose-to-arabinose ratio of 16:1. The polysaccharide was methylated and the methylated fragments obtained after hydrolysis were analyzed by paper chromatography and electrophoresis, and by GLC – mass spectrometry of the derived alditol acetates. Optical rotations of the unmethylated and methylated polysaccharide, and analysis with D-galactose oxidase provided strong evidence for a large proportion of β-linked D-galactopyranose residues. Periodate oxidation confirmed the methylation data and it was concluded that the polysaccharide was a $\beta(1\rightarrow4)$-linked galactan of about 60 D-galactopyranose units containing two to three $(1\rightarrow 4,6)$ branch points. Arabinose was thought to be a contaminant.

The cell-wall and intercellular fractions obtained from the tubers grown in four eastern and four western locations in Canada showed considerable variation depending upon the area of growth. This locational variance precluded definite conclusions as to the influence of region (east or west) on any of the parameters examined. No conclusions as to the influence of cell-wall polysaccharides on texture could be drawn. This project has been terminated.

New Snack Foods

Most of the snack foods have been developed through U.S. corporate research and are based on corn flour or cornstarch. The utilization of wheat, barley, oats, and rapeseed flours in human and pet foods of this type is being studied by using extrusion cooking techniques. The proper combinations of moisture, heat, and pressure for gelatinizing the cereal portion of several wheat-based formulations have been determined and extruded products made. The preparation of a textured form of rape protein by the direct extrusion of rapeseed flour is being investigated.

Mayonnaise Storage Stability Studies

At the request of a Japanese importer of rapeseed, storage stability studies were carried out in Japan and at the FRI on mayonnaise made with pure rapeseed oil. The oils were extracted from seeds of the varieties Echo (*B. campestris* L.) and Oro (*B. napus* L.) at the FRI and refined. The experimental mayonnaise prepared from each of the oils

was stored at 13 C and 24 C. Physicochemical and organoleptic analyses were performed at monthly intervals for 8 months.

Mayonnaise made from each oil showed considerable browning and poor general appearance after storage at 24 C for 4 months. When stored at 13 C, samples of each mayonnaise deteriorated equally as the storage time increased, but were acceptable to the FRI taste panel up to 6 months after manufacture. Because the mayonnaise was formulated to suit Japanese tastes, it was judged rather harshly by the FRI panel and Japanese taste panel results may indicate longer shelf life.

Soybeans for Japanese Products

At the request of the Ontario Soybean Growers Marketing Board the suitability of Canadian soybeans for use in two Japanese products, tofu and miso, was studied. Although Canada is a net importer of soybeans, the supplying of identity-preserved varieties to Japan has attractive financial possibilities.

Japanese evaluation of varieties suitable for making tofu and miso is carried out by practical testing. However, some technical information is available on the desirable range of the phytic acid content, on the ratio of the two main proteins (7S and 11S), and on the protein content of the soybeans. For miso, the main criteria are moisture absorption and hardness after cooking.

In 1970, four varieties were obtained from Japan that had given good products, two for each product. Ontario-grown material was supplied by the research stations at Harrow and Ottawa. In 1971, more cultivars were obtained. Nine Ontario cultivars all conformed to the Japanese samples in regard to the above factors, and also in oil, fiber, sucrose, stachyose, and raffinose contents. Accordingly, no clear-cut answer can be given from these data as to the suitability or unsuitability of these cultivars for either tofu or miso in spite of the Japanese statement that varieties suitable for tofu are not suitable for miso. However, measurements of curd strength, being made in collaboration with Engineering Research Service, may be useful in evaluating Canadian material for tofu making.

Apples

Inheritance of chemical constituents. Positive correlations were found between sugar, acid, and phenol contents of juvenile leaves, which were similar to those found in earlier work on adult leaves. There were no correlations with scab resistance characters. Phenol levels were as low in these descendants of selected scab-resistant parents as in nonresistant cultivars; high levels were found in unselected scab-resistant seedlings.

Effect of rootstocks on fruit composition. Fruit from the varieties Quinte and McIntosh grafted onto new Ottawa clonal rootstocks were analyzed. Quinte showed a range of 17.0 to 24.9 mg of ascorbic acid/100 g fresh weight compared with 1.1 to 8.7 mg for McIntosh. The values for Quinte were among the highest recorded for an apple cultivar. Quinte was also higher in free acid and phenol contents and pH but lower in sugars. None of the size-controlling rootstocks had significant influence on any of these factors. The work on these materials has been finished.

Tomatoes

Frozen storage. Examination of eight selected strains of tomatoes from the Ottawa Research Station was completed. After freezing in liquid N and storage at -20 C and -46 C, all were superior to the control, Rideau, in retention of color and most were superior in texture. No consistent relationship was found between loss of lycopene and change with time from redness to yellowness, or between the lycopene-to-carotene ratio and redness of the fruit. These studies are now terminated.

Color grades. At the request of the Fruit and Vegetable Division, Production and Marketing Branch, further experiments were conducted to evaluate the present subjective methods of judging the color of canned whole tomatoes by comparing them with objective instrumental methods. Fair correlation was obtained between visual and colored glass comparator methods and good correlation between Agtron and Hunter color difference instruments. However, the desired objective of obtaining a good correlation between visual and instrumental determinations was not obtained. Further work will be done.

Byssochlamys nivea

A continuous centrifugation technique for detecting small numbers of *B. nivea* ascospores in juices was developed. Three concentrates out of a group of 16 grape concentrate and 22 grape juice samples were found to contain *B. nivea*. The technique, though very satisfactory, was somewhat tedious and time-consuming, and thus not well suited to survey work.

In a series of 18 apple fruit samples, 1 contained *B. nivea* and 6 others were apparently contaminated with *Paecilomyces* sp., the imperfect stage of *Byssochlamys*.

As a possible control measure, the effect of ultraviolet light (2537 A) on the ascospores was tested and several survivor curves were obtained. The results indicated that these heat-resistant spores are quite sensitive to this form of radiation.

A good knowledge of the characteristics of *B. nivea* has now been obtained. In view of its current slight incidence in Canada, further work will not be undertaken.

MEAT PROGRAM

The Multiple Myoglobins of Beef Muscle

The existence of three myoglobin charge-isomers was established; charge-isomers are protein molecules of the same molecular weight with identical properties except net charge. Their previously observed instability was shown to be due to artifact production by previous electrophoretic techniques. The kinetics of the conversion of beef myoglobin into three homogeneous charge-isomers were studied under various conditions of temperature, pH, ionic strength, and denaturation. First order kinetics of deamination were not observed. Instead, the reaction was characterized by a long, slow induction period; an assumed denaturation step; and the rapid production of charge-isomers. The isomer bands were consistently homogeneous on reelectrophoresis. The isoelectric points of the three myoglobin isomers, and their oxidized, oxygenated, and cyanide derivatives were measured.

Milk Replacers for Calves

Research on the enzymic coagulation of milk protein for cheesemaking has been extended to include studies of the coagulation of milk replacers; essentially the same reactions are involved. In addition, for this series of experiments, special low-, medium-, and high-heat skim-milk powders were prepared in quantity. The following variables affecting curd firmness were studied: total solids in the reconstituted powder, pH, amount of enzyme, reaction time, and the degree of heat treatment that the milk received during prior processing. From this study, an objective test for measuring curd strength was developed. Low-heat skim milk gave the strongest curd.

Milk replacers must contain other cheaper protein if their use on a cost basis is to be justified. However, the presence of nonmilk protein affects curd firmness and thus the transfer of the protein from the rumen to the intestine. For example, the addition of whey powder and fish protein reduced curd firmness, but 4% soy flour or 2% soy protein isolate prevented coagulation of the skim milk. The addition of Ca ions, as $CaCl_2$, restored coagulability. Defatted rapeseed flour, however, when added to reconstituted skim milk as a component of a milk replacer, had little or no effect on curd strength relative to the depression caused by soy protein.

The effect of added citrate and phosphate on the coagulation of skim milk was tested. Citrate prevented coagulation whereas phosphate, at the pH values tested, had little effect.

Nutrition Practices and Turkey Carcass Quality

In cooperative research on poultry nutrition, the effects on carcass quality of rapeseed oil, soybean oil, and tallow, present in the diets as energy sources, were studied. Turkeys fed diets containing these fats at the 10% level were slaughtered, frozen, and stored at -12 C (10 F) and -23 C (-10 F). Sensory evaluation conducted after 7 months frozen storage showed no differences in flavor among the samples. Differences in tenderness and juiciness were noted, however. Turkeys fed diets containing soybean oil and stored after slaughter at -23 C (-10 F) were more tender than those fed tallow or rapeseed oil and stored at -12 C (10 F). Meat from turkeys fed rapeseed oil and stored at -23 C (-10 F) was more juicy than that from birds fed rapeseed oil and stored at -12 C (10 F).

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INTRODUCTION

Our agroclimatic research work has received both national and international recognition for its methodology on how to determine moisture regime criteria for soil climate maps and by the election of Dr. W. Baier as President of the Commission for Agricultural Meteorology of the World Meteorological Organization.

Research on plant biosystematics was very active and productive. It is interesting to note that requests for plant identification were almost double that of previous years. This increased demand appears to be due to a greater emphasis on environmental research by various agencies.

Although we were only able to support two delegates to the International Mycological Congress in England, four members of our Institute participated both as organizers and participants. Major contributions were made by all four.

The ornamental plant research program is being revitalized. Dr. J. Molnar has been transferred from Morden and a sharper focus is being placed on the relevancy of individual projects.

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Allan Chan
Director

AGROMETEOROLOGY

Agroclimatic Data

The national agroclimatic data program, which comprises about 40 agricultural establishments, has been upgraded through rigid data quality control. Verified records are published in the monthly bulletin "Daily Agrometeorological Data." The soil moisture network is operational and has added several new contributors. Preliminary work has been completed for a mesoscale soil temperature data collection program, which will commence in 1972. Two new instruction bulletins, *Soil moisture reporting network* (CDA No. 23) and *Soil temperature data program* (CDA No. 24), and new computer-compatible reporting forms were published.

Micrometeorology

Much effort was put into the development and construction of instruments for measuring the effects of various meteorological elements on the energy balance of crops. Some measurements were taken with our newly developed gas exchange meter in relation to water use efficiency of barley and corn crops. A sensible-heat detector is in its final stage of construction.

Computer Techniques

New methods of data analysis and automated plotting techniques were developed to produce shaded and multicolored maps of various agroclimatic variables. A pilot project demonstrated the application of these techniques, when used with an agroclimatic data bank, in preparing a map showing the spatial distribution of a plant species. A send-receive (ASR) Model 33 teletypewriter terminal was installed and connected to a Nova 800 mini-computer as part of the Eastern Time-sharing System of the CDA Data Processing Division.

Model Development

A biophotothermal time scale for barley based on photoperiod and maximum and minimum temperatures was derived.

A crop–weather analysis model that uses standard climatic data is in the testing stage. It quantitatively evaluates, at any time during the life cycle of annual plants, the effect of selected weather elements and derived agroclimatic variables on the development of crop yields and crop yield components.

The analysis of mean annual cycles of air and soil temperatures, particularly with respect to solar radiation, soil moisture, and snow cover, was completed. Regression-type

models that predict monthly soil temperatures at six different depths were developed.

Applications

The climatic moisture index has been successfully used to represent the moisture regimes in the Soil Climate Map of Canada. The moisture classes relate to those in the Soil Climate Map of North America prepared for the FAO by the USDA.

Using the Soil Map of Canada, a soil suitability mapping system for barley was devised and applied. The resulting map showed that large areas have suitable climates for barley production, but they have insufficient edaphic resources, particularly along the Canadian Shield.

The biophotothermal time scale model for barley development gave good results in parts of Canada with a continental climate. It was used successfully with spatial models and computer graphic methods for mapping the climatic resources for maturing barley on the Canadian Great Plains. Barley requires a shorter growing season than other cereals and the potential maturing zone was much more extensive than for wheat. This technique is particularly useful in determining the agricultural potential of the undeveloped fringe areas of Canada.

A concept developed earlier for determining daily evapotranspiration from standard climatic data was evaluated. Its application in climates different from those in Canada was successful.

MYCOLOGY

Taxonomic Research

Phycomycetes. Morphological studies of the Chytridiales revealed new and useful criteria for distinguishing taxa and resulted in a major taxonomic revision of the genus *Entophlyctis.* Some criteria used formerly to separate the large, complex genera *Rhizophydium* and *Phlyctochytrium* proved invalid, but a previously undescribed character was found to separate these genera. Cultural and physiological studies of Chytridiales isolated from various habitats and host plants revealed the presence of physiologically different ecotypes within some species.

Basidiomycetes: rusts and smuts. Two theoretical papers were published that explain the coevolution of the rusts and their host plants and support earlier use of rust relationships to indicate relative age or degree of relationship of various flowering plant families, a prerequisite to any phylogenetic system. A short paper revising the generic disposition of three rusts was published. Revisionary studies of rusts of Cyperaceae revealed that the group is much more complex than earlier treatments suggested, and much remains to be resolved. An article was prepared to record the first occurrence in North America of a systemic rust, *Puccinia hysterium* (Str.) Roehl., on the introduced weed meadow goat's-beard, *Tragopogon pratensis* L.

Basidiomycetes: Hymenomycetes. The fourth and fifth parts of the series titled "The Genus *Merulius*" were published. The microscopic features of type specimens for 52 species were presented, in some instances for the first time. The papers *Merulius* I–V are the basis for a generic monograph that is now in manuscript form and will contain photographs, drawings, and keys for more accurate and quicker identification of the species of *Merulius.* The basis for a monograph of the genus *Coniophora* is well established: type specimens for nearly 50 species have been redescribed and illustrated and the cultural characters of 10 species have been critically studied. Studies on bulbil-producing basidiomycetes have disclosed that at least two form genera are involved, *Burgoa* Goidanich and *Minimedusa* Weres. & LeClair gen. n. Studies on the characterization of the species of these form genera and of *Sistotrema brinkmannii* in nature and culture were continued. Studies on the sclerotia produced by *Typhula* spp. (Clavariaceae), which attack grains and lawn grasses in Canada, disclosed that published information provides inadequate guidance for the identification of these species. A detailed study of sclerotia in nature and culture has been initiated.

Ascomycetes: Discomycetes. "Notes on fungi from northern Canada VI. Additional records of Discomycetes" was published. Descriptions and comparisons of the microanatomy of the apothecium of *Ciboria acerina* has been completed using the scanning electron microscope and the light microscope, and a paper has been prepared. Examination of specimens of the *Peziza badia* complex is nearing completion.

Ascomycetes: Pyrenomycetes. Three papers on correlations of Pyrenomycetes and Fungi Imperfecti were prepared and presented at a symposium at the First International Mycological Congress, held at the University of Exeter. A survey of *Rhododendron* leaf spot diseases in the Ottawa nursery led to the discovery of several pathogens new to Ontario. A comprehensive study of 47 taxa of hyperparasitic fungi, including 6 new genera, 20 new species, and 17 new combinations, was completed jointly with F. C. Deighton, Commonwealth Mycological Institute (C.M.I.). Two papers on Tanzanian fungi (new hyphomycetes and oil palm fungi) were prepared for publication. The morphology, development, and cultural characters of *Melanodothis caricis* R.H. Arnold gen. n., sp. n., a fungus that parasitizes florets of *Carex* and *Kobresia*, were described and illustrated.

Fungi Imperfecti: Hyphomycetes. Gemmae of algae, bryophytes, and pteridophytes often bear a striking resemblance to various conidia. Accordingly, the methods of gemma production on mononematous stalks were considered in the light of those methods of conidium formation distinguished in Fungi. Except for the gemmae in a few Hepaticae, all gemmae are exogenous. An interesting observation is that gemmifers of Hepaticae do not proliferate or extend, whereas those of Musci can. In all groups the methods of producing a number of gemmae from a single gemmifer have their counterparts in the production of conidia in Fungi. Investigations on North American and New Zealand species of sooty molds indicated that Capnodiaceae, as currently circumscribed, includes genera that must be assigned to two new families in two orders. A monotypic genus *Microdochium* was investigated jointly with B. C. Sutton and F. C. Deighton, C.M.I., and broadened to include two new species.

Fungi Imperfecti: Coelomycetes. A rare monotypic genus *Geastrumia* was redescribed from recently collected specimens. A new genus *Vestigium* Pirozynski & Shoemaker was proposed for an acervular fungus, which is parasitic on young twigs of *Thuja plicata* in British Columbia and Oregon. Examination of bulk specimens in the John Dearness collection revealed a leaf spot of crabapple, caused by *Marssonina coronaria* (Ell. & Davis) Ell. & Davis, which had not been reported previously in Canada.

Arctic fungus flora: A monograph on arctic adaptations, including a substantial section on fungi, will be published early in 1972. The section on fungi provides the foundation for future experimental studies.

ORNAMENTAL PLANTS

Physiology of Greenhouse Roses

The work on the development of formulations to extend the life of cut roses was continued and a patent application is pending. The histochemical evidence showed that the material blocking xylem vessels of senescing rose stems is composed of carbohydrates, pectin, lipid, and protein-like compounds. The use of an effective preservative solution prevented the deposition of these compounds in the xylem vessels.

Under circumstances where the turgor pressure in the rose pedicel tissues decreases, a condition commonly known as "bent neck" develops. This condition may be ameliorated to some extent by increasing the mechanical strength and chemical composition of these pedicel tissues. Increasing the lignin content of the rose pedicels by spray applications of 1,4-naphthoquinone resulted in a measurable increase in resistance to "bent neck" in greenhouse-grown roses.

The growth of lower buds and the development of bottom breaks for the rejuvenation of greenhouse-grown roses were induced by treating these buds with 6-benzylamino purine and adenine in lanolin paste.

Germination of *Rosa rugosa* Seeds

To test the effect of growth hormones and low temperature on the breaking of dormancy, excised seeds from *R. rugosa* were placed on a filter paper that had been treated with one of the following: gibberellic acid (150 μ g/ml), benzyl adenine (10 μ g/ml), or distilled water. These seeds were placed for 3 weeks at 20 C, for 3 weeks at 4 C, for 1 week at 20 C, and for 2 weeks at 4 C.

Seeds that had been treated with the hormones germinated at 20 C, but seeds treated with distilled water germinated only when after-ripened at 4 C. This indicates that the seeds of *R. rugosa* were dormant. Dormancy can be broken either by application of appropriate hormones or by after-ripening at low temperatures. The differences in percentage

of germination between the seeds treated with hormones, the seeds after-ripened at 4 C, and the seeds that received both treatments were not significant.

Evaluation and Identification of Ornamental Plants

Evaluations of 973 woody plants, 584 herbaceous perennials, 349 bulbous, cormous, and tuberous plants, 448 garden annuals and related plants, and 62 outdoor chrysanthemums were made in 1971.

Selected for intensive testing were 157 *Antirrhinum,* 126 *Zinnia,* 60 *Begonia semperflorens,* and 11 *Limonium.* Compared with those observed in 1967–68, all showed a wider selection of colors and more compact forms. The most outstanding was the *Begonia semperflorens* group, which included cultivars with extremely large flowers and many that had an unusually long blooming period.

Propagation experiments were conducted to find a reliable method of propagating the disease-resistant Quebec elm and a new *Prunus tenella* hybrid that was rated an outstanding ornamental shrub.

Turfgrass

Because of the rapid uptake of chloride ions by turfgrasses, the possible use of Ca in reducing injury was investigated. Kentucky bluegrass, creeping red fescue, and perennial ryegrass were grown in nine nutrient solutions that contained various concentrations of chloride and calcium sulfate. The chloride content of leaf tissue ranged from 1.17% to 3.30% when plants were grown in 1 mmole of Cl and 10 of Ca, but no suppression of chloride uptake was noted. Chloride uptake by the grasses was only slightly suppressed when solutions contained 1.9 mmole of Cl. Thus, increased soil Ca levels or applications of Ca salts cannot be expected to substantially reduce turfgrass damage from road salt.

Container-grown Nursery Stock

Biotelemetric studies showed that the relationship between the hardening capacity of roots and shoots of container-gorwn roses and evergreens can be quantitatively expressed as a ratio. These ratios approach unity with advancing winter. This criterion of hardiness may be of primary importance in establishing suitable conditions for overwintering of container stock.

No visible growth differences were observed during the growing season between roses in containers plunged into the ground with runner roots protruding through the drainage holes into the subsoil, and roses in containers maintained on ground surface without such roots. The soil temperature of the containers plunged into the ground was about 6 C higher.

VASCULAR PLANT TAXONOMY

Taxonomic studies

A classification and identification scheme for oat (*Avena*) cultivars on a worldwide scale has been developed. This utilizes some new taxonomic techniques, and as a result 14 groups of cultivars have been recognized. The international register for oat cultivars now contains 4,000 cultivar names, pedigrees, synonyms, translations, and transliterations. Through worldwide cooperation, this is now virtually complete and is being prepared for publication. A computerized system of recording and documenting the oat gene pool maintained by the Canada Department of Agriculture in cooperation with the Welsh Plant Breeding Station has been developed. This gene pool is largely made up of the material collected in recent Department expeditions to the Middle East.

During morphological research aimed at delimiting species of *Avena,* a hitherto-overlooked species of oats, *A. occidentalis* Dur., which occurs in southwestern Europe and the Canary Islands, has been rediscovered and its potential importance to oat improvement stressed. New characters have been found to distinguish between *A. sativa, A. fatua,* their F_1 hybrids, and fatuoids, using features observed by scanning electron microscopy.

Biosystematic studies on wind-pollinated plants in the families Chenopodiaceae and Urticaceae are continuing. In the genus *Suaeda,* a chromosome count of $n = 45$ has been made, the highest number ever reported in the Chenopodiaceae. It appears that *Urtica dioica* L. subsp. *gracilis* (Aiton) Solander ($2n = 26$ and 52), the taxonomy of which has been poorly understood, is widespread and indigenous in North America; *Urtica dioica* subsp. *dioica* ($2n = 52$), an introduced

taxon, is found mainly in eastern North America.

The pollen of all species of *Clarkia* (Onagraceae) has been investigated by light and scanning electron microscopy. Fifteen characters have been scored and analyzed by numerical taxonomic methods. The resulting dendrogram successfully separates several of the natural groups of *Clarkia*.

Cytotaxonomic studies of two groups of *Draba* in Canada and Alaska were completed. *Draba cana* Rydb. ($2n = 32$), *D. cinerea* Adams ($2n = 48$ and 64), and *D. groenlandica* E. Ekman ($2n = 64$) have the base number $x = 8$, whereas *D. ventosa* A. Gray ($2n = 36$), *D. ruaxes* Payson & St. John ($2n = ca.\ 72$), and *D. paysonii* Macbride ($2n = 42$) have basic chromosome numbers of $x = 12$ and $x = 14$. Evidence has been presented that *D. paysonii* and *D. ventosa* are triploids that reproduce by agamospermy and that *D. ruaxes* is a hexaploid sexual outcrosser.

A study of speciation in native North American species of *Linum,* section *Hesperolinum,* showed that evolution in this section occurs by the gradual buildup of small genic changes and that sterility barriers are formed at a relatively slow rate.

In response to the need for basic knowledge of the widely used illicit drug marijuana a biosystematic study of *Cannabis* was conducted. Seeds of 350 strains obtained from 50 countries as well as a number of hybrids were grown. Plants were analyzed by the Department of National Health and Welfare for their "cannabinoids," a group of closely related chemicals, including "THC," which is responsible for the psychoactive effects of marijuana. Several distinct classes of plants were discovered, including races containing very limited psychoactive materials, races containing large amounts of THC in both male and female plants, races containing THC predominantly only in the female plants, and races containing high amounts of THC, part of which was in the form of a chemical isomer known as Δ^8-THC.

The taxonomic revision of *Trifolium*, section *Lupinaster*, in North America has been completed and it has been found that for the most part the species of this section can be divided into two groups characterized by the presence or absence of pubescence on the ovary. It has been suggested that a group of species with multiple veins on the calyx tube is closest to the ancestral form of the section.

In numerical taxonomic work at and above the generic level, considerable inapplicability of characters because of missing organs cannot be avoided, and by distorting the character-space this can lead to serious problems in interpreting results. A method of overcoming this difficulty has been successfully tested.

Floristic Studies

Two accounts in the series of family monographs on the flora of Canada have been completed and are in press. These cover the Plantaginaceae, or plantain family, and the thistles, tribe Cardueae of the Compositae.

In connection with the work of the International Biological Program (IBP-CT, Panel 10), seven sites in the Mackenzie District were surveyed floristically. Checklists were also prepared of the vascular plant species of the southern interior of Banks Island and of the south Nahanni drainage area of the Mackenzie mountains. The third volume of *Flora of the Prairie Provinces,* which covers the gamopetalous families, has been completed and is in press; the work is planned to be complete in four volumes.

Ecophysiology

Apparatus constructed for the rapid determination of rates of photosynthesis and transpiration in large populations of plants was used to survey the natural rates of these processes in plants of bogs and several other habitats. It was found that bog plants maintain high rates of photosynthesis and transpiration despite the stresses of bog substrate. This appears to be an important mode of adaptation of bog species.

Reproductive Biology

Preliminary results from extensive collecting and experimentation point to some hitherto unknown or unexpected relationships between pollinators and the plants whose flowers they visit. In particular, it has been discovered that poison-ivy, *Rhus radicans,* and thistle, *Cirsium muticum,* as well as some other species, although self-compatible, seem to be partially dependent on insects for seed set. In studies on insect nutrition, it has been confirmed that in the Ottawa region some bristle flies (Tachinidae) and hover flies (Syrphidae) eat pollen and that some horse

flies (Tabanidae) feed on nectar; the first two groups of insects are important or potentially important in the biological control of insect pests.

Herbarium, Index Seminum, and Plant Identification

The vascular plant collection contains 582,506 mounted herbarium specimens, an increase of 6,934 during the past year. Approximately 500 permanent slides were added to the pollen identification collection. Loans of 4,197 specimens were made to cooperating institutions in North America and Europe, and 4,140 specimens were received on loan for our research staff.

Over 6,500 packets of seeds of native and adventive plants were sent to more than 300 research centers through the Index Seminum program, and in return approximately 12,000 samples were received for Canadian scientists and agriculturists, almost double the number received in recent years.

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Soil Biochemistry

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Soil Classification and Genesis

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Ontario Soil Survey (Guelph)

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INTRODUCTION

This is a report of the work carried out by the Soil Research Institute in 1971.

As in previous years, the main concerns of the Institute continued to be investigations of the chemical, physical, and biological factors that control the availability and supply of nutrients and soil moisture. These included studies of the reactions of aluminum compounds, structure of hydroxide-clay complexes, behavior and structure of soil organic matter, characterization of the reactions of organic matter with metals and other soil constituents, movement and redistribution of soil moisture, behavior of soil potassium, and a number of associated problems.

The Institute has continued to correlate the activities of the Canada Soil Survey and to carry out field and laboratory investigations on the taxonomic and interpretive classifications of soils. Through associated soil survey units in Ontario and Alberta, cooperative soil survey work was carried out with provincial institutions and close association was maintained with all soil survey units throughout the country. The Cartography Section prepared and published soil maps for the Canada Soil Survey program as well as soil capability and computer input maps for the Canada Land Inventory.

Reprints are available from the authors. Correspondence should be addressed: Soil Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ontario K1A 0C6.

J. S. Clark
Director

SOIL FERTILITY

Lime and Other Amendments

Liming of six acid soils to raise the corrected lime potential (CLP) to 3.40 resulted in raising the base saturation to approximately 95% when the soils were extracted with 1 N KCl. Raising the CLP to about 3.70 resulted in base saturation values of over 99%. The corresponding pH values (H_2O) were approximately 4.7 and 5.2 respectively. Liming the soils to a pH between 5.1 and 5.3 reduced the amount of Al extracted with 1 N KCl to less than 0.13 meq Al/100 g of soil. The amounts of Al in 0.01 M $CaCl_2$ extracts of the soils were 0.17 ppm soil or lower. Liming reduced the amounts of Mn and Zn in the $CaCl_2$ extracts but had a variable effect on the $NaHCO_3$-soluble P, depending on the soil and rate of application of lime. Rates of liming beyond those required for base saturation resulted in marked increases in the amounts of NO_3-N in the soils.

Application of gypsum to the soils increased the amounts of Al, Mn, and Zn in the $CaCl_2$ extracts, but decreased the amount of Al extracted with 1 N KCl in four of the soils. The addition of P at a high rate (500 ppm soil) reduced the amounts of Al, Mn, and Zn in the $CaCl_2$ extracts.

In a corresponding pot experiment using the same rates of application of lime, the yield of alfalfa in most cases and the yield of barley in a few cases tended to increase with rates of lime above those required for complete base saturation of the soil. There was a significant correlation between the uptake of Mn by alfalfa and the amounts of Mn found in the soils limed to different pH levels ($r = +0.93$). In general, gypsum markedly increased the concentration of Mn in the plants, whereas phosphate slightly reduced it. The results from the plant study were in accord with measurements obtained from the soil extracts.

Phosphorus Availability in Some Gray Luvisolic Soils from the Peace River Region of Canada

In a greenhouse study carried out with Dr. P. B. Hoyt of the Research Station at Beaverlodge, Alta., on P availability in Gray Luvisol soils of the Peace River region, the yield of oats was increased by 21% and there was a greater recovery of added P when it was applied at seeding rather than 2 months before. It was concluded that an annual topdressing of P on forage crops would be more effective than a single application made at the time of establishment. Resin-extraction

of P was the best method for predicting the availability of the element in these soils based on the correlations obtained with yield and P uptake. The dominant form of inorganic P in the soils was the NaOH-soluble fraction, which was correlated significantly with yield and the uptake of the nutrient. Estimates of available P, including resin, $NaHCO_3$, NH_4F, NaOH-soluble P, and surface P (as measured with ^{32}P after 14 days shaking) were significantly interrelated with soil properties such as total C, oxalate-extractable Fe and Al, and P retention and adsorption.

Potassium Release in Selected Canadian Soils

Selected horizon samples of widely distributed Canadian soils released different amounts of K to oats in accordance with the amount and capacity of the clay component of the soils to release K to plants. Data on the latter were available from a previous study on the clays separated from these soils (MacLean and Brydon 1971). The plant uptake of K from the soils plotted against the expected relative contribution of K from the clay component showed a nearly linear relationship ($r = +0.99$) for 10 of the samples used. An apparently anomalous sample contained large quantities of K feldspar and mica in its coarser fractions which evidently supplied additional K to the plants. The results suggested that the procedure used in the earlier study to separate the clay had no major effect on the K-releasing properties of the clays.

In most instances, most K taken up by plants was derived from the nonexchangeable form. In fact, the sample that released most K to the plants (0.545 meq/100 g) showed no change in its exchangeable K content with cropping. This observation was in accord with the low activity ratio ($AR_e^k = 0.0003$) and high buffering capacity ($PBC^k = 500$) of the soil. It was concluded that B and C horizon clays may be an excellent source of K for plants.

Distribution of Selenium in Selected Gray Luvisol Profiles in Relation to Plant Uptake

The Se distribution in the Gray Luvisol profile sampled in the Kapuskasing area was found to be at a minimum in the Ae horizon and at a maximum in the Bt2 horizon. In this respect, the distribution of Se in the profiles corresponded to the distribution pattern for P, Fe, and clays. The Se content of the varved calcareous clay parent material was low, which indicated that the high Se content in the surface organic horizons might not have been derived entirely from the subsoils.

The average Se content of soils from a number of locations in Eastern Canada was 0.274 ppm, which is considerably lower than values reported in New Zealand. Soils from eastern Ontario, however, had significantly higher Se contents, probably as a result of heavier fertilization rates.

The Se content of alfalfa plants grown in selected soils to which no Se was added was 0.029 ppm. The addition of 1.5 ppm Se to the soil raised the content of the element in alfalfa to 1.251 ppm. This level of Se in the plants decreased only slightly over a period in which 10 cuttings were made. Application of fulvic acid to the soils decreased the Se content in alfalfa, indicating that this soil constituent may prevent excess Se accumulation in plants grown in soils high in Se.

In soils that had a low Se content, poor correlation was obtained between Se uptake and the Se concentration in a water extract. The failure to obtain a good correlation was evidently caused by the presence of small amounts of organic matter in the water extract. Water-soluble Se was still the most useful means of determining the level of soluble and available Se in the soils.

SOIL ORGANIC MATTER

Distribution of Nitrogen in Selected Canadian Soils

The effect of pronase and papain on organic matter extracted from a Brunisolic soil by relatively mild reagents was studied. Pronase released 2% to 10% of the aspartic acid, threonine, serine, glutamic acid, glycine, and lysine and 15% to 35% of the alanine, valine, leucine, isoleucine, phenylalanine, and tyrosine. Asparagine and glutamine were also released by the enzyme. Leucine aminopeptidase treatment of the pronase hydrolysate increased the yield of amino acids, especially proline and glycine. Papain released very little amino acid, but leucine aminopeptidase treatment of the papain hydrolysate released about 10% of the amino acid of the organic matter fraction.

The N distribution in the A, B, and C horizons of a Black Solonetz, a Black Solod, and a Black Chernozemic soil was determined. The N distribution of the fulvic acids and water-soluble organic matter was also studied. The proportion of soil N present as amino acid and amino sugar N in the profile of each soil decreased with depth, whereas the proportion present as ammonium N increased. In general, the amino acid and amino sugar composition of all the soil samples and of the humic acid extracted from them were alike and close to those of many other soils and soil organic matter extracts that have been examined. The fulvic acids and water-soluble organic matter from the Ah horizons contained only a small fraction of the soil N; they were alike in amino acid composition, but the fulvic acids were higher in glycine, alanine, and the acidic amino acids and lower in the basic amino acids than the humic acids or the soils. The proportion of glycine and alanine in the water extracts was higher than in the fulvic acid. It was concluded that the differences in the salt regime in the soils had little effect on the composition of the N-containing fraction of the organic matter.

The thermal stabilities of the amino acid components of the humic acid from the Solonetzic and Chernozemic soils were determined by heating them in a current of air for periods of time up to 600 hr. Serine and threonine were the least stable, and glutamic acid, aspartic acid, glycine, alanine, valine, isoleucine, leucine, tyrosine, phenylalanine, and histidine were the most stable.

Chemical Structure of Humic Substances

The alkaline permanganate oxidation of methylated humic acids, fulvic acids, and humins originating from a wide variety of soils (Chernozem, Solod, Solonetz, Podzol, and Gray Wooded, and soils from volcanic ash and alluvial deposits) yielded over 20 phenolic and benzenecarboxylic acids as major products. Smaller amounts of aliphatic dicarboxylic acids were also identified. The oxidation products were fractionated by chromatographic methods and identified by mass spectrometry and micro-infrared spectrophotometry. There were quantitative differences in the yield of individual products, but similarities in the quality of the oxidation products and in analytical characteristics suggested that all humic substances examined had similar chemical structures that yielded benzenecarboxylic and phenolic acids on oxidation. These compounds may have originated from more complex structures; another possibility, as proposed earlier for fulvic acids, is that they existed in the humic materials in the forms in which they were isolated, except that they were held together by hydrogen bonds in very stable polymeric structures. These polymeric structures may adsorb or fix organic compounds of appropriate molecular dimensions on external surfaces or in internal voids. The adsorption behavior of humic substances, therefore, has practical significance in connection with environmental and geochemical properties related to retention and adsorption of toxic pollutants.

Permanganate oxidation of methylated humic substances was also found to be useful for assessing the degree of humification of these materials and for diagnosing changes in chemical structure that result from different cropping systems and fertilizer treatments.

Characterization of Soil Humus Through Biological Degradation

The results of an enzymatic depolymerization study indicated that fulvic acid (FA) from a Podzol Bh horizon contained as much as 4 meq of quinoid carbonyl groups per gram. Attempts were made to verify the presence of these groups using both chemical and spectroscopic techniques. Infrared spectra of methylated and acetylated soil FA and humic acids (HA) contained peaks that were clearly due to quinones. In addition, $SnCl_2$–I_2 reductometric titration methods gave values of 4.2 and 3.5 meq quinoid carbonyl per gram for the FA and a Chernozemic HA, respectively. Results of the enzymatic study were confirmed by infrared spectroscopy of the FA and HA products after $SnCl_2$ reduction and after other treatments.

Humus Organic Complexes

The intimate association of organic materials with humic substances has been studied extensively. However, the analogous association of humus with organic compounds has not been investigated to any degree. A dialysis technique was used to obtain information sites of activity in a soil humus as well as to distinguish between strongly bound and weakly bound compounds. The application

of the dialysis technique to humic acids prepared from organic soils resulted in the following scale for binding tendencies: sugars (e.g., sucrose) < aromatic acids (e.g., naphthoic acid) < amino acids (e.g., tyrosine) < phenolic acids < condensed polyphenols (e.g., tannic acid).

Of the phenolic acids, the dihydroxylated catechol derivatives, for example, protocatechuic acid, appeared to be more strongly bound than the monohydroxy compounds, such as *p*-hydroxybenzoic acid. Conversion of the phenolic compounds to the methyl ethers rendered compounds more mobile. Furthermore, the partial methylation of the humic acids increased the mobility of the compounds tested. The dialysis experiments, therefore, indicated preferential adsorption of some organic compounds by humic acid. The stability of the humic–organic molecular complexes may have important implications in soil chemistry as well as in soil pollution.

SOIL PHYSICAL CHEMISTRY

Effect of Temperature on the Hydrolysis of Aluminum from Aqueous Solutions

Preliminary studies were made to assess the effect of temperature on the hydrolysis of Al from aqueous salt solutions. Under neutral to slightly alkaline conditions, the final product was bayerite when the temperature was not greater than 35 C. Between 25 C and 35 C, pseudo-boehmite was the first product identified, but it gradually disappeared as bayerite formed. When the temperature was kept below 20 C, bayerite was the only product that was identified. Above 35 C, pseudo-boehmite was always the only identifiable product. Under acid conditions, the final product was usually gibbsite. If the solution were made slightly alkaline initially and then allowed to become acid at temperatures below 35 C, bayerite and sometimes pseudo-boehmite formed but eventually disappeared, and gibbsite was the only form of hydrous aluminum oxide identified at temperatures below 35 C. At temperatures greater than 35 C, pseudo-boehmite was usually the only product that could be identified. If the pH of the solution remained below 5, polynuclear hydroxyaluminum cations formed and then gradually disappeared as gibbsite crystallized. Thus, temperature, at levels usually found in Canadian soils, appears to affect the rates of reactions rather than the actual nature of the final products.

Effect of Temperature on the Ion Activity Product (Al) $(OH)^3$ and Lime Potential

Equations were derived for the relationship between corrected lime potential (CLP) and degree of base saturation at temperatures of 15, 25, and 35 C. At 15 C the equation was: $pH - 1/2pCa - 1/3(34.50 - py) = 3.10 + 1/6 \log (Cax_{2_2}{}^3)(Alx_3C)$. At temperatures of 25 C and 35 C, the numerical constants on the right hand side are 2.92 and 2.76 respectively, and the pK_2 values on the left side are 34.0 and 33.5 respectively.

In Wyoming bentonite and in soil preparations, solution properties were affected markedly by varying temperatures. The exchange properties were not sensitive to temperature within the range used in this study. The ion activity product (Al) $(OH)^3$ increased with increasing temperature. As a result, the pAl + 3 pOH values of the soil solutions decreased by an average of 0.5 unit for each 10 C increase in temperature. The CLP values decreased 0.15 unit over the same temperature range. As determined from the equation, the CLP difference of 0.15 unit accounted for about 20% error in the base saturation range between 30% and 75%. It was concluded that the temperature at which measurements were made must be known in order to calculate the degree of base saturation from the corrected lime potential. In laboratories where the temperature may range from 20 C to 32 C during the year, an error of ±15% may be introduced into these measurements unless temperature is controlled.

SOIL MINERALOGY

Crystal Defects in Microcrystalline Muscovites

In microcrystalline muscovites, a marked correlation was found between the crystal defects involving variable interlayer spacings and the total number of interlayer cations (= K + Na + Ca). It is suggested that the distortion resulted from a lack of uniformity in the spaces between silicate layers caused by irregular distribution of the interlayer cations. Because previous explanations of mica weathering reactions were based on broad

assumptions, the correlation provides an important clue for understanding the mechanism of mica weathering during early stages.

Potassium extraction experiments were also useful for obtaining a better understanding of weathering reactions. X-ray data of products sampled at various stages of the K extraction process indicated that K was released initially at preferential layers, then at adjacent layers; its release was completed without providing evidence of any ordered arrangement among interlayer cations. Electron diffraction studies suggested that the extraction of K was not a simple exchange reaction, but rather induced certain structural disturbances that altered the composition of the silicate layers themselves.

SOIL CLASSIFICATION AND GENESIS

Soil Climate Map for North America

A scheme for classifying the soil climates of North America in terms of soil temperature and moisture regimes was prepared and accepted for use in the interpretation of the Soil Map of North America. Terminology for describing the soil climates of Canada has been revised so that it is more closely related to North American usage. The written sections on soils, soil climates, vegetation, physiography, and geology as well as an inventory of soil units and morphological and analytical data for selected profiles have been prepared for the FAO/UNESCO soil map and report of North America.

The Soil Map of Canada has been prepared for cartographic reproduction and the preliminary work was initiated for the production of the other sections of the report, including a soil inventory and a soil climatic map and charts. Soil correlations were conducted mainly in the Burns Lake – Smithers area of British Columbia, where two map sheets were completed by the provincial group. Other completed survey areas visited were those covered by the Vancouver, B.C., and Cold Lake, Alta., map sheets.

Work was continued on the classification of organic soils; the classification was rewritten and experiments were started to evaluate the relationships between shear strength and fiber contents, bulk density and water-holding capacity. A study tour of organic soils in Eastern Canada was conducted in September and a number of proposals for modifying the classification of organic soils have been made.

Resource Satellite and Airborne Sensing

During the past year, a program was organized to undertake remote sensing studies in 16 test areas in or bordering on various important agricultural regions across Canada. This program on remote sensing was organized as part of an integrated national undertaking of the Canada Centre for Remote Sensing (CCRS), which was established by the Canadian Government in February 1971 to coordinate and develop an information system for resource management and environmental control. The test areas were selected in cooperation with administrative and research personnel from universities and federal and provincial agencies interested in developing and evaluating remote sensing technology. The areas selected were generally those where field studies related to soils and crops were already being conducted or planned, so that the remote sensing imagery could be identified and evaluated. The program was initiated in anticipation of the launching in 1972 of the first Earth Resource Technology Satellite (ERTS A) under the international earth resource program of the National Aeronautical and Space Agency of the United States.

The 1971 program was carried out with conventional aircraft as part of the experimental airborne program of the CCRS, and full photographic coverage of the test areas was obtained from 11,600 m (38,000 ft) above ground level, to provide a scale of 1:123,000. For these studies, a multi-camera system of selected film–filter combinations was used to provide imagery at wave bands corresponding to those that will be used in the ERTS A satellite (green, red, and reflective infrared) as well as standard visual color and reflective color infrared photography. Imagery was also obtained at lower altitudes from selected sites in test areas in order to provide multistage samplings for comparisons at other scales with the same multi-band coverage. Thermal infrared scanner imagery was also obtained over selected sites in a number of test areas.

Ontario Soil Survey Unit, University of Guelph, Guelph

Soil survey projects in both Halton and Waterloo counties were completed and the soil reports for these regions published. The Waterloo County report was the first of its kind in Ontario and was conducted on a detailed scale of 1:20,000, with the soil map published on an aerial photomosaic base. Correlation of field work with soil sampling continued during the year in Brant and Peterborough counties. Field mapping of the bog areas within the organic soils mapping program was completed in southern Ontario. A new project was started in Middlesex County in southern Ontario, where three mapping parties were working. This project involves remapping, on a semidetailed scale, areas where earlier soil surveys are inadequate and out of print. Compilation of soil maps for areas in northern Ontario was continued and ozalid prints of preliminary soil maps for many areas in northern Ontario are now available on request, pending final publication of maps and reports.

Alberta Soil Survey Unit, University of Alberta, Edmonton

The report for the Tawatinaw map sheet has been completed and is to be published in 1972. The field work and correlation for the Sand River map sheet and the final sampling for the Odeon sheet have been completed. Preparation of both reports is in progress. A detailed reconnaissance survey of the Suffield Military Reserve in the Medicine Hat area was started and is to be completed in 1973. A detailed survey was carried out in 500 km^2 (200 sq miles) of Waterton National Park for recreation and other park planning purposes. The soil survey of the Mackenzie Valley transportation corridor was undertaken to make a broad survey of the soil, to develop terrain descriptions of the geological map units, and to note ecologically sensitive features of the area that might be important for the development of a terrain sensitivity rating for the area. Approximately 60,000 km^2 (23,000 sq miles) were covered in 1971, and the work is to be continued. Supporting research is being done to characterize some of the permafrost soils in the area. A survey of Truelove Lowland Island was undertaken in conjunction with the International Biological Program (IBP). The soils were mapped, characterized, and related to the ecological characteristics of the area. This work is to be completed during the short field season of 1972.

CARTOGRAPHY

In 1971, the Cartography Section prepared 21 maps. Of these, 17 have been published and 4 are awaiting printing. During the year, 120 Canada Land Inventory capability maps were prepared, and of these 68 were published. In addition, 13 miscellaneous multicolored maps for the Canada Land Inventory program were printed.

PUBLICATIONS

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Research Institute
Belleville, Ontario

PROFESSIONAL STAFF

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H. G. WYLIE, B.A., D.Phil.	Host-parasite interactions

Departures

G. L. AYRE, B.S.A., M.S.A. Transferred to Research Station, Winnipeg, Man., July 16, 1971	Ant behavior
P. S. CORBET, B.Sc., Ph.D., D.Sc., F.I.Biol. Resigned October 20, 1971	Director

VISITING SCIENTISTS

M. R. NATHANSON, B.S., M.S., Ph.D. Ford Foundation Fellowship, University of Chicago, 1971–72	Manipulation of pathogens
S. M. SMITH, B.Sc., M.Sc., Ph.D. National Research Council postdoctorate fellow, 1970–71	Biology of predatory mosquitoes
S. YAZGAN, B.Sc., Ph.D. Sponsored by University of Ankara, Turkey, 1969–71	Development of synthetic diets for beneficial insects

INTRODUCTION

The Research Institute at Belleville closes in September 1972. It will then have the dubious distinction of being the largest establishment closed by the Research Branch. The closure arises from a combination of financial, organizational, and geographic problems; it is not meant to reduce biological control in Canada, but to increase its use through integration with other methods.

The Institute has had a varied and illustrious career. Its progenitor was founded in 1929, under the directorship of A. B. Baird, as successor to the European Corn Borer Parasite Laboratory based at St. Thomas, Ont., in 1923 and later at Chatham, Ont. It soon acquired the name of Dominion Parasite Laboratory and the role of introducing and distributing parasites throughout Canada. Parasites were distributed on a massive scale (millions of some species were reared and released) for a wide range of forest and agricultural pests. There were some agricultural successes, but results on forest insects were outstanding. For example, the European spruce sawfly, *Neodiprion hercyniae* (Htg.), which threatened to devastate white spruce and severely damage black spruce in Eastern Canada, was apparently reduced and kept at its present status of an unimportant insect by an introduced virus disease and several parasites. This and other successes led to the founding of the Insect Pathology Research Institute at Sault Ste. Marie and to the operation of biological control programs from most federal forest-research stations across the country, all of which stimulated biological control throughout the world and achieved an international reputation for Canada. The program, which has evolved toward integrated control, in its early phase provided ready and cheap solutions worth many millions of dollars to a backlog of insect problems amenable to biological control.

The consequence of the Institute's achievement in promoting biological control in the forest environment was the loss of the exclusiveness of its role in Canada. With the inception of the Department of Forestry, the work was divided and the Institute's staff no longer worked on forest-insect problems, which had previously been their main concern. Under the direction of A. Wilkes and then B. P. Beirne, biological control of weeds was started as a partial substitute for these practical problems; but the main emphasis was on elucidating the principles of biological control. Investigations basic to applied studies were made into host–parasite and pathogen interactions, the nutritional needs of insects, the taxonomy of various parasites and predators, and similar areas. The Institute's research was acclaimed internationally. However, the Institute's applied role was largely reduced to a passive parasite supply function.

The Program of the Institute was changed under the direction of P. S. Corbet to that of discovery and development of ways of reducing pest damage with the least possible use of chemical pesticides. This program allowed freedom and ingenuity for adapting previously acquired expertise to nonforest-insect problems. For example, a pheromone was discovered that affects the choice of oviposition site in the main mosquito vector of western encephalitis in Canada; silica was shown to be a synergist that could lower cost as well as dosage of some insecticides; combinations of pathogens and insecticides were evaluated as alternatives to insecticide treatment on tobacco; the autocidal control of mosquitoes under field conditions was demonstrated as a promising alternative to the use of insecticides under certain conditions; practical field manipulation of parasite and pest populations was investigated; an artificial diet and host for an internal hymenopterous parasite was developed. This latter development should permit 'factory' propagation of parasites for inundative release, and could be the most important development in biological control since the sterile-male technique.

The problem remained that the Institute was not effective at integrating activities across the country to exploit such findings, nor had it the facilities to develop them itself. However, after September 1972, nine members of the research staff of the Institute will be relocated at the Research Station, Winnipeg, Man., to study integrated control models in the cereal production system. Three scientists are moving to Regina, Sask., to expand the program on biological control of weeds and research on other methods of weed control. Two taxonomists will transfer to the Entomology Research Institute, and the Importation Service also will

move to Ottawa. In addition, two scientists go to Saskatoon, Sask., and one each to the research stations at Ottawa, Harrow, and Smithfield and the Chemistry and Biology Research Institute.

Peter Harris
Acting Director

REPRODUCTIVE PHYSIOLOGY AND BEHAVIOR

The studies on reproduction emphasize the natural factors regulating insect fecundity so that by manipulating these components insect pests may be controlled.

Fecundity of Mosquitoes

For more than a decade students of ovarian development in mosquitoes have disregarded the number of eggs produced and have concentrated on the concept that enlargement of the ovaries is activated by a hormone released under the influence of neurosecretory processes. In 1959, Larsen and Bodenstein, in accord with this opinion, proposed that stretching the mosquito's gut, as when it was filled with blood, triggered the controlling mechanisms. But laboratory work with *Culex pipiens* L. did not support this theory. These findings led to the postulate that mosquitoes can assess available nutrient before egg development to set the appropriate ovarian response.

Aedes trichurus (Dyar), a common snowmelt mosquito at Belleville, matured about half its first gonotrophic cycle oocytes when it fed on donkey blood. When nulliparous females were given no blood, but were kept alive for extended periods, their ovaries retained their characteristic appearance. Therefore, the age-grading techniques for distinguishing females that have matured and laid eggs (parous females) are valid throughout the season of flight. In 1971, only a few *A. trichurus* flew, and these adults disappeared sooner than in previous years.

Mosquito Oviposition Pheromones

A unique attribute of the *Culex tarsalis* Coq. oviposition pheromone is that it attracts as well as drowns the mosquito in concentrations as low as 0.02 mg/cm^2. The substance, a diglyceride, originates in the oviducts of the gravid female; washing the eggs in ether was the best method of extraction. The attractiveness of the pheromone was enhanced by hydrogenation, but three synthetic compounds were inactive. Bioassay with other mosquitoes showed that *Culex pipiens pipiens* L. and *C. p. quinquefasciatus* Say also produced oviposition pheromones *C. p. quinquefasciatus* and *C. p. pipiens* are attracted by all three pheromones.

Parasite Oviposition Stimulant

Studies on the chemical factors that stimulate oviposition by the parasite *Itoplectis conquisitor* (Say) showed that the most effective mixtures contained serine, arginine, magnesium chloride, and one of isoleucine, methionine, or leucine. These mixtures were as acceptable as host hemolymph to the parasite. It was also demonstrated that, during oviposition, the female *I. conquisitor* injects a substance that deters further egg-laying.

Ovary Development and Antimetabolites

The metabolism of methionine and the effects of ethionine were studied during ovarian development in the parasitic fly *Agria housei* Schewel under various dietary conditions. Both transmethylation and the fate of the hydroxyl carbon of methionine were followed. In insects fed a normal diet, 21% of injected radioactivity was incorporated into proteins, 68% in free amino acids, 1% in lipids, and the rest in soluble proteins. When an ethionine-supplemented diet was used, only 11% of radioactivity was incorporated into proteins. It seems that ethionine affects oocyte growth mainly by inhibiting protein synthesis rather than by modifying the proteins by ethylation. Radioactivity in proteins and amino acids was mainly in methionine and methionine sulfoxide.

Egg Development and Laying in Mealworms

In the mealworm, *Tenebrio molitor* L., there is a refractory period of about 2 days

after adult emergence when neither males nor females will copulate. This period is the same at all densities except the lowest, where it appears to be a day longer. Yolk deposition starts between the first and second day, mature oocytes appear about 2 days later, and the first eggs are laid about 4 days after emergence. Before oviposition, the rates of oocyte maturation are the same in virgin and mated females. Both virgin and mated females lay daily, but the rate of laying is much higher in mated females. Therefore, copulation stimulates egg laying and not oocyte maturation as previously reported. Virgin females retain and subsequently resorb many of the oocytes developed. Egg-laying is not inhibited by the presence of larvae, but flour in which the species has bred for extended periods is avoided. Where this is impossible, the rate of egg-laying is reduced and the adults die sooner than those in fresh flour.

Trap-trees for Apple Maggot Control

Additional evidence of the effectiveness of trap-trees in concentrating apple maggot, *Rhagoletis pomonella* (Walsh), in commercial apple orchards was demonstrated. The number of *R. pomonella* on any type of apple tree was higher at the edge of the orchard where the immigrating adults entered than on any other trees inside or on another edge. When trees along the entry edge were modified to maximize attractiveness, the number of adult *R. pomonella* within the orchard was reduced by 90%.

PHYSICAL AND CHEMICAL CONTROLS

The objective of these studies is to identify and determine the effects of selective, nonpersistent chemicals and physical factors that impair the metabolism, behavior, and fertility of insects and thereby to devise ways of manipulating them for insect pest control.

Antitanning Agents

γ-Glutamyl-phenylalanine is a compound involved in hardening and darkening of the cuticle in the fly genus *Musca*. The aim of this study was to find analogues that would kill flies in this important pest genus by preventing formation, or utilization, or both, of the compound. A mechanism for the active transport of phenylalanine in the house fly, *M. domestica* L., was found. It is based on the operation of a γ-glutamyl cycle in which γ-glutamyl transpeptidase effects the translocation step. The mechanism is important to physiology and biochemistry. Also, it allows the selection of metabolic antagonists, analogues, and inhibitors on the basis of their competition with the transport site. The predictability in determining which of 17 analogues of phenylalanine would be most readily transported was tested in vitro. Therefore, phenylalanine analogues with electron-withdrawing substituents in the benzene ring have greater affinity for the transport site and transpeptidase than phenylalanine itself, whereas analogues with electron-releasing groups have lesser affinity. Affinity is related to the Hammet equation, and specifically to the magnitude of the Hammet function sigma. The effects of alpha-amino group substitution and carboxyl group replacement were also studied and systematized.

The sites of γ-glutamyl transpeptidase were located. In the larvae and adults of *M. domestica,* it was mainly associated with the brush border of the Malpighian tubules and the epithelial cells of the midgut, and in anterior cardia, where the peritrophic membrane is formed. In the larvae its association with various glands was also noted; in adults it occurs in the oviducts, spermathecae, and rectal glands. During formation of the white puparium there was a marked reduction in the enzyme's activity in the midgut and an abrupt appearance of activity at the epidermis–cuticle interface. This activity ended 12–18 hr after the puparium had darkened.

Autocidal Control of Mosquitoes

A field trial was made on the control of the mosquito, *Culex restuans* Theob., by autocidal means. Autocidal attempts elsewhere have depended on mass-reared insects for sterilization and release, but *C. restuans* (like many Canadian species of mosquito) cannot be reared artificially. Therefore the only supply of mosquitoes for sterilization was the test area. An essential part of the program was the use of pools treated with capric acid and ammonium nitrate as aggregation sites for oviposition. A few eggs were laid on untreated pools within the sites after late August, but on a seasonal basis the ratio of eggs laid in treated to untreated pools was 9,600:11.

The mosquitoes were sterilized as pupae with buffered thiotepa. In laboratory tests on *Culex pipiens* L., male sterility increased with temperature and dose of thiotepa, but competitiveness was only reduced at the highest treatment levels. The ability of sterile males to confer monogamy was equal to that of untreated males. The amounts of undegraded thiotepa dropped rapidly from 1.2 to 0.4 μg/pupa in 24 hr and to 0.06 μg/adult in 42 hr. Therefore, the hazard to predator food chains was negligible.

The tests were made on two 8-ha (20-acre) sites with a 6.5-ha (16-acre) control area. On the first site, 94,066 sterile males and 44,080 virgin females were released, and on the second site, 115,732 sterile males. This was a rearing efficiency of 15% of the eggs collected. Egg-raft sterility gradually rose through the summer and monthly means increased from 1.5% to 14.1% for site 1 and from 0.2% to 7.1% for site 2. These results indicate, in spite of the smallness of the test sites and the immigration of mosquitoes from adjacent areas, that it is feasible to control mosquitoes autocidally in a nonisland situation provided a large enough area is treated.

Silica as an Insecticide Synergist

Field tests on the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), showed that a silica–carbaryl formulation (5.4:0.6) at 6.7 kg/ha (6 lb/acre) gave superior control and was cheaper than the recommended carbaryl spray at twice the insecticide dose. The lower rate of carbaryl in the silica spray killed insect predators and increased the aphid population. The silica–carbaryl treatment also controlled the tomato hornworm, *Manduca quinquemaculata* (Haw.), and partly controlled the cabbage moth, *Pieris rapae* L. Silica in formulations with many other toxic or repellent substances was tested in the greenhouse against *L. decemlineata.* Some of the more effective products were those containing tyrosine, oleoresin of pepper, and sinigrin. However, silica with tannin (an arrestant for the coccinellid *Coleomegilla maculata lengi* Timb.) quadrupled the number of coccinellid eggs laid on treated corn.

Formulations of silica and additives sprayed on timothy grass reduced the number of eggs laid by the European skipper butterfly, *Thymelicus lineola* (Ochs.), by over 90% and half of those laid were poorly placed for larval establishment. Field application of ultrasil reduced but did not eliminate oviposition; but it is expected that the larval population in 1972 will be greatly reduced by the treatment. Contrary to expectation, large numbers of *T. lineola* eggs were laid on grass stubble. Mowing alone is not an effective means of control.

BIOLOGICAL CONTROL OF INSECT PESTS WITH PARASITES, PREDATORS, OR PATHOGENS

The objective is to control agricultural pest insects by manipulating insect predators, parasites, and pathogens.

Parasites of Plant Bugs

As part of a review of world taxonomy, types and specimens of *Leiophron, Microctonus,* and other euphorine parasites were examined in Europe. It was concluded that the Nearctic *Euphoriana* Gahan is congeneric with *Leiophron* Nees, which consists of two natural groups, one of which will be moved to *Peristenus* Foerst. A complex of Polish *Leiophron* species was identified; one species might be useful in Canada for the biological control of the tarnished plant bug, *Lygus lineolaris* (P. de B.). Lectotypes were designated for various euphorine species described by Thomson, Ruthe, and Wesmael.

Parasites of the Alfalfa Weevil

The parasite *Microctonus aethiops* (Nees), released in 1970 against the alfalfa weevil, *Hypera postica* (Gyll.), was recovered at four out of five sites. This species appears to be the most promising of the introduced parasites, and it is a major cause of *H. postica* mortality in the northeastern United States. An additional 25 releases were made in 22 counties of southern Ontario. The parasite *M. colesi* Drea was not recovered but both *Bathyplectes anurus* (Thoms.) and *B. contracta* (Thoms.) survived from releases in 1970. The egg parasite *Patasson luna* (Gir.) is not likely to control *H. postica,* because it was not recovered until June 6, shortly before the host-larval numbers peaked. Likewise, the number of larval parasites *Bathyplectes curculionis* (Thoms.) and *Tetrastichus incertus* Ratz. remained low until late July, when host

larval populations had mainly completed development.

Parasites of Flies

Rearings of larvae and pupae of the face fly, *Musca autumnalis* DeG., collected in Ontario yielded four species of hymenopterous parasites, including two not previously known from this host. The biology and percentage of parasitism of these species and for parasites of other Diptera in the same habitat as *M. autumnalis* were determined. Techniques were developed for the continuous propagation of three *M. autumnalis* parasites on alternate hosts.

Studies were continued into the effect on egg fertilization by the parasite *Nasonia vitripennis* (Walk.) of a preponderance of parasitized hosts and of the presence of competing parasites.

Parasites of the European Skipper

In Canada attempts to establish the parasites *Phryxe vulgaris* (Fall.) and *Stenichneumon scutellator* Grav. against the European skipper butterfly, *Thymelicus lineola* (Ochs.), failed, either because they were not synchronized with their host, or they could not be held or bred in captivity, or both. *S. scutellator* offered a special challenge because it has a single generation a year, overwintering as a fertilized female. This reproductive diapause was broken by treating the females with ethyl aromatic terpenoid ether, though only a small number of progeny were produced. Attempts to continue propagation with the F_1 generation failed. Part of the problem is that the hormone dose is critical and only small numbers of the female *S. scutellator* are available from Europe.

Predators of Mites on Alfalfa

The acarine predator *Amblyseius fallacis* (Car.) was released in field populations of *Tetranychus urticae* Koch. that were infesting alfalfa. Results were inconclusive, because the year was exceptionally dry, the alfalfa foliage did not develop, and consequently the pest population failed to increase during the summer. It was found in the greenhouse that *A. fallacis* released into a dense population of *T. urticae* would control it, but the same number of predators was unable to prevent a continuous increase in a prey population that was originally small. Manipulation of this predator in the field will depend on the development of self-sustaining colonies of *A. fallacis*. For this reason, various alternative sources of food were investigated: small numbers of *A. fallacis* were reared on a tarsonomid mite, several pollens, and eggs of *Tribolium castaneum* (Hbst.).

Parasites and Predators Integrated with Insecticides

The insecticide carbofuran was applied to kill most of the grassland pests but not the viable populations of parasitoids, predators, and decomposers. Biweekly samples showed that the insecticide reduced chewing insects by 60% and sucking insects by 79% (compared with 61% and 19% increases in check plots). Spraying with carbofuran also resulted in a 69% loss of predators (10% increase in checks) and 28% loss of parasitoids (88% increase in checks). The decomposer fauna (Collembola, Oribatid mites) was reduced 68% compared with 10% increase in checks. Neither the hay nor the crude protein yields were significantly improved by spraying, but there was little alfalfa in the stand, and no insects were in outbreak numbers. Cercopidae nymphs were unaffected in spite of carbofuran's systemic action. The recovery of natural enemies and decomposers was almost completed by September. These results indicate that carbofuran can be integrated into forage pest control. This 5-year study of the insect community in grassland under various management practices is concluded.

Pathogens of Tobacco Pests

The dark-sided cutworm, *Euxoa messoria* (Harr.), causes extensive to total loss of tobacco in Ontario unless the crop is treated annually with an insecticide. A feasibility study was conducted for replacing all or part of the insecticide with insect pathogens. Small plots heavily infested with *E. messoria* sprayed with nuclear virus alone and with a 10th the standard dose of Dursban (Dow Chemical of Canada Ltd.) produced tobacco yields equal to yields from plots with the recommended Dursban treatment. Granulosis virus and a low dose of nuclear virus combined with commercially prepared *Bacillus thuringiensis* Berl. gave similar yields but more than twice the yield of the untreated plots. Large commercially tilled and planted plots sprayed with combinations of low virus

doses with and without low doses of insecticide suffered heavy loss from larvae that immigrated from adjacent areas. The untreated plots were a total loss.

Attempts were made to introduce three viruses and a microsporidian disease into cutworm populations by spraying the pathogens onto tobacco trap-plants growing in a rye cover crop. The *E. messoria* larvae became infected with the viruses and, unexpectedly, the tobacco plants sprayed with nuclear virus escaped damage. A small amount of virus transmission to the filial generation occurred in areas treated with virus last year.

The bacterial–nematode association, DD136, killed many insects in the laboratory, but was not successful in most field trials because it was susceptible to drying. Addition of the DD136 association to the planting water reduced damage to tobacco seedlings by the corn seed maggot, was equal to diazinon, and superior to several other insecticides.

BIOLOGICAL CONTROL OF WEEDS

The objective is to control weeds with plant parasites (insects, pathogens, and so on). This study involves screening biotic agents from abroad to determine their host specificity, establishing them in Canada, determining their effectiveness in controlling the weed, and finally advising on their distribution.

The cinnabar moth, *Tyria jacobaeae* (L.), reduced the density of tansy ragwort, *Senecio jacobaea* L., at Durham, N.S., to 1% of its former density and at Nanaimo, B.C., by 50%. A root-boring beetle, *Longitarsus jacobaeae* (Waterh.), was released to supplement the effects of the moth in British Columbia. It survived, but the seed-head fly, *Hylemya seneciella* (Meade), released in this and former years in Prince Edward Island, failed to breed.

The spurge hawkmoth, *Hyles euphorbiae* (L.), increased on cypress spurge, *Euphorbia cyparissias* L., from 0.4 to 1.0 larva/m^2 at Braeside, Ont. However, the root-boring moth, *Chamaesphecia empiformis* Esp., is a better prospect for most infestations of spurge, which have large numbers of ants. A strain from leafy spurge, *Euphorbia esula* L., was recovered from the release made in 1970, and additional releases of it and the *E. cyparissias* strain were made in Ontario.

The seed-head weevil, *Rhinocyllus conicus* (Froel.), increased fourfold on nodding thistle, *Carduus nutans* L., since its release in 1968 at Craik, Sask. Small populations of the weevil continue to survive on welted thistle, *C. acanthoides* L., in Ontario.

The root-boring weevil, *Ceutorhynchus litura* (Fab.), which in 1970 attacked 72% of the shoots of Canada thistle, *Cirsium arvense* (L.) Scop., spread to occupy 10,000 m^2 and the number of shoots declined from 11.6 to 5.2/m^2. Three times as many weevil larvae were found in thistle stems infected with the rust *Puccinia suaveolens* (Pers.) Rostr. as in healthy stems. This indicates that the weevil spread the rust, thereby increasing its value for biological control. Field collection of the weevil to obtain stock for new colonies and techniques for its propagation were developed.

The seed-head fly, *Urophora affinis* (Frauen.), survived well on spotted knapweed, *Centaurea maculosa* L., at Kamloops, B.C., and contrary to expectations on diffuse knapweed, *C. diffusa* L. It now seems likely to be more effective in restricting seed production in the small heads of this species than in *C. maculosa,* its west European host.

NUTRITION

The objective is to obtain sufficient understanding of insect nutrition to devise control methods for agricultural pest insects and synthetic diets for the mass propagation of beneficial insects.

Food Selection

Studies were made to determine whether an insect changes its food selection (choice) in relation to nutrient balances (proportions) and temperature. Previously it was found that an insect can assess the nutritive value of its food; that food selection is related to the balance of nutrients; and that development rate is related to nutrient balance and temperature. Therefore an insect should choose the diet that is nutritionally superior for development at the temperature involved. A diet was designed on which the insect developed well at 15 C, but not at 30 C.

Artificial Propagation of Parasites

Work continued on the preparation of an artificial 'host', that is, a capsule of synthetic diet that the internal parasite, *Itoplectis conquisitor* (Say), will parasitize and can be reared on. The diet was improved so that individuals reared axenically on it are larger and survival is better than on its lepidopterous host. A useful capsule was made of parafilm. The black coagulum that formed around the egg was avoided by omitting tyrosine. However, despite sporadic hatching, no larvae survived beyond the third instar, possibly because of contamination during oviposition; oxygen exchange and the elimination of metabolic wastes may also be problems.

INSECT IMPORTS AND EXPORTS

Biological control information and living insects were procured from abroad for the departments of Agriculture and the Environment. Over 139,000 living insects were imported from 11 countries. Overseas projects mainly concerned four agricultural, six weed, and seven forest-pest species. Two of the agricultural and the six weed species are mentioned in this report. Other insects handled included cereal leaf beetle, *Oulema melanopus* (L.); birch casebearer, *Coleophora fuscedinella* Zell.; larch casebearer, *C. laricella* (Hubn.); birch leafminer, *Fenusa pusilla* (Lep.); spruce budworm, *Choristoneura fumiferana* (Clem.); smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.); European pine sawfly, *Neodiprion sertifer* (Geoff.); and European pine shoot moth, *Rhyacionia buoliana* (Schiff.). Over 27,000 beneficial insects were shipped to six Canadian provinces and over 5,000 to two foreign countries.

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INTRODUCTION

The highlights of the Institute's research activities for 1971 are summarized here. The research activities emphasize studies on the mode of action and use of toxicants (fungicides, herbicides, and insecticides), possible target sites, and biologically active material such as toxins associated with plant pathogens, phytoalexins, and insect attractants and repellents.

The study of these materials and sites and their utilization often requires a multidisciplinary approach and cooperation with other establishments in the Branch and elsewhere. The current pressure to replace persistent pesticides has made the search for alternatives even more important. The need to determine any deleterious side effects and to reduce them to a minimum continues. Plant protection activities are separated into work on pests, diseases, weeds, and environmental quality; the latter is part of the overall attempt to protect plants effectively and efficiently.

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E. Y. Spencer
Director

PLANT PESTS

Mode of Action of Selected and Potential Insect-control Agents

Emphasis was on a search for potential physiological and biochemical target sites to serve as the underpinning for an effective insect-control program. Much effort was of a probing nature. Research activities also included studies on the effect of DDT replacements on target and nontarget organisms.

One nontarget organism is the earthworm. Two species, *Lumbricus terrestris* and *Eisenia faetida,* were chosen for study because the former is very susceptible to the carbamate insecticide carbofuran, whereas the latter species is not. It has been shown that the toxicity of the carbamate is due to loss of body fluids and sepsis.

Although anticholinesterase inhibition did not apparently play a role in earthworm toxicity, the differential toxicity related to anticholinesterase activity of some dimethyl phosphoryl compounds was found between insects and mammals. Several hypotheses have been suggested to explain this. The most promising theory was that the enzyme-inhibitor complex "aged" and thereby prevented reactivation, which apparently occurs in the mammal.

The active center of insect acetylcholinesterase was shown to be more open and roomy than that of mammalian acetylcholinesterase, especially around the cation-binding site. From this conclusion and the postulate that binding at the active center depends upon the lipid solubility of individual substituents in a ligand, differences in selectivity of a large number of organophosphorus insecticides, reported in the literature, are now easily understood. It is now possible to predict specific chemical modifications of insecticide molecules that should lead to still greater selectivity.

The relatively short-lived insecticides that are being used to replace DDT require greater precision in the timing of application for effective control. As a model for future studies on other species, one project is concerned with the accumulation and quantitation of biological and meteorological information in order to pinpoint the influence of regional climate on the growth and development of the European corn borer. Also, unique biochemical markers were correlated with specific stages of the life cycle to facilitate corresponding and necessary laboratory studies.

It was found that southwestern Ontario contains geographical subspecies determined primarily by temperature and photoperiod, which determine the time necessary to break diapause. A biochemical feature of these subspecies requiring a long time to break diapause was their high sodium levels. Ultrastructural studies with the use of the electron microscope indicated differences between the "wild" and laboratory-reared corn borers and characteristic patterns of lipid droplets,

glycogen, and lysosomes in the life cycle. These may serve as biochemical markers for identifying with greater precision developmental stages of "wild" strains of corn borer.

Alteration of behavioral patterns of insects with the use of chemicals is promising for pest control. In collaboration with the Research Station, Winnipeg, a triglyceride fraction of *Nigrospora sphaerica* (Sacc.) Mason was found to elicit aggregation of the adult confused flour beetle. It was shown that the most active fractions consisted of monounsaturated triglycerides, mainly oleodipalmitin.

In collaboration with the Research Institute, Belleville, further chemical identification of *Euphorbia* constituents, which may be basic to host specificity of *Celerio euphorbia* (L.), was achieved. Although none were particularly selective, the major component of the alcoholic mixture from *E. cyparissias* L. and *E.esula* was confirmed as 1-hexacosanol. Also the phlobaphenic fraction from *Juniperus virginiana* (L.), which attracts ovipositing coccinellids, is being identified. A degraded mixture includes phloroglucinol and substances similar to the components of oil of cedarwood. The active fraction of an egg-associated oviposition pheromone of the mosquito *Culex tarsalis* Coquillett consists mainly of unusual 1,3-diglycerides. The major dihydroxy acid component of the glyceride is 5,6-dihydroxypalmitic acid with acetylated hydroxyl groups.

In spite of the importance of the neuromuscular system in relation to the function of the visceral muscle, the interrelationship between the neurochemical components and insecticidal action has not been studied. During the past year, basic information was gained on the interaction of various ions and inhibitors on this system. From these results, a better understanding of cell membrane excitability has emerged, which will be useful for studies of interaction between insecticides and nerves, muscles, and other membranous systems.

The other fundamental component of the neuromuscular junction that may be affected by insecticides is the neuromuscular transmitter substance. Studies have shown that this impulse mediator is unlike any of the known vertebrate or invertebrate transmitters. Much has been learned about localizing the substance, ways of regulating it, and, through its reaction with known pharmacological blocking agents, its uniqueness. The transmitter substance has been purified about 300-millionfold, and chemical and enzymic analyses have shown that it lacks any sugar moiety, it contains a guanidino group, and it is inactivated by peptidase. The active compound appears to be a small peptide that contains arginine. Assuming a molecular weight of 200–400 based on osmotic properties, the compound at this stage of purification is active at about 10^{-9} M.

A multifaceted approach has been taken to elucidating the effect of several different types of environment-polluting organochlorine insecticides on specific membrane-mediated biochemical processes in mitochondria of insects and mammals. One of the characteristic features of the insect mitochondrial membranes is the low level of lecithin. Such differences may affect their interaction with lipophilic toxicants and partly explain selectivity of action. DDT and dieldrin at toxic doses impair the activity of the respiratory chain and affect transport of certain cations across the mitochondrial membrane. DDT appears to act as an energy-transfer inhibitor, whereas lindane interrupts ATP synthesis by an uncoupling action. Detailed ultrastructural studies on insect mitochondria indicate that they are capable of striking morphological transitions presumably related to their bioenergetic state. The effect of organochlorine insecticides on these transition states is to be studied.

The giant mitochondria of the thoracic muscles of insects is one of the richest sources of the enzyme phospholipase. The fatty acids, mainly oleic and palmitoleic, that it generates in the mitochondria by hydrolysis of membrane-bound phospholipids, are potent inhibitors of various components of the mitochondrial energy-producing system. These fatty acids were therefore examined as potential toxicants. In feeding and spray tests they demonstrated their toxicity to the corn borer and the first-instar cricket, but the locust nymph was insensitive.

Chitin is found only in insects and fungi as a major component of the insect cuticle and fungal cell wall. Hence the biosynthesis of chitin offers a particularly promising potential target site. Previous attempts at chitin synthesis in insects were hampered by very low activities of the preparations. Excellent yields of chitin synthetase were obtained in a

particulate fraction from house fly larvae. The properties of the enzyme, particularly its inhibition and substrate specificity, are being investigated. The enyzme's activity increases considerably at each larval molt and it is particularly active just before pupation. A separate enzymic system in the soluble fraction of the larval homogenate was also discovered to activate chitin synthetase; it is being purified and its properties studied.

Previous studies showed that halodinitrobenzenes are unexpectedly potent inhibitors of sugar transport across erythrocyte membranes, presumably because of interaction with functional thiol groups. Recent studies with a specific thiol oxidizing agent (RN = NCOX) indicate it to have powerful effects on insect behavior. Also, these compounds are closely related to recently discovered antifungal agents. In view of the importance of thiol groups in many metabolic reactions, thiol-dependent enzymes and whole organisms are being examined for their susceptibility to halodinitrobenzene. After an examination of a number of enzyme systems, one was found that was inhibited the same as the sugar transport system.

Soil Insecticides–Ecological and Chemical Behavior

Besides maintaining 12 species of insects including some cyclodiene-resistant and nonresistant species, two new cultures were established, an organochlorine-susceptible strain of the redbacked cutworm and the carrot weevil. From the primary screening of 10 candidate materials, some showed good activity in soil. In-depth studies were begun or continued on the behavior and persistence of two organophosphorus insecticides and two organochlorine insecticides and metabolites in the soil. Baseline toxicity data are being obtained on susceptible (Lethbridge) and resistant (Bradford) strains of the redbacked cutworm to organochlorine insecticides. After primary and secondary screening, microplot field trials showed that two organophosphorus insecticides, Dursban (Dow Chemical of Canada Ltd.) and leptophos (Phosvel), gave excellent control of redbacked and black cutworms. Similar plot trials indicated that methomyl (Lannate), carbaryl (Sevin), or leptophos applied at suitable intervals effectively controlled the corn borer attacking peppers. In sweet corn, methomyl and carbaryl (carbamates) provided effective control of the corn borer in large-scale field trials when timed for application with the appearance of the adult population. From a 2-year study of the effect of some insecticides on earthworm populations in the insecticide–ecology program, some, particularly carbamates, caused sharp initial reductions. However, 1 year after treatment, populations returned to normal. Residue chemistry requirements were coordinated with the above programs. Techniques of extractions, cleanup, and analysis were devised or modified for several of the more promising organophosphorus and carbamate insecticides.

The behavior of soil insecticides is determined by such factors as soil–toxicant interaction and these are influenced by soil type, moisture, temperature, and so on. Initial infrared studies of the organophosphorus insecticide, fensulfothion (Dasanit), with clay systems at low moisture indicated they were relatively stable to changes in relative humidity with no oxidation to the sulfone. The sulfone–clay systems, however, were influenced by moisture changes. From investigations of high-moisture clay–fensulfothion systems, the absorption isotherms indicate a rapid reach of equilibrium and a similar ability to rapidly desorb.

The effect of some nematocides-insecticides on the activities of soil microorganisms was continued. Respiratory studies showed an increase in oxygen consumption for some organophosphorus and carbamate compounds and a decrease with two fumigants. Fumigant activity was negatively correlated with temperature. An improved, less time-consuming method was developed for determining the effect of soil pesticides on beneficial soil microbes. Of the chemicals examined, all showed an effect on bacterial populations for the first 8 weeks of incubation, but then returned to normal. In a cooperative program with the research stations of Delhi and Vineland at Delhi the retardation effect of two soil fumigants on the microbial population was shown to be only temporary.

It was found that when persistent organochlorine insecticides were restricted or banned, the time of application of replacements for insect control was usually more critical. A project has been started to assist in solving the problem of developing and quantitating biological information for predicting the time of insecticide application. The European corn borer is being used as a model.

From field sampling at five locations in southwestern Ontario, various geographical subspecies were found. Therefore, no general predictive equation based on degree-days for all of southwestern Ontario is possible. However, the information was utilized to develop an insecticide spray program for Wallacetown and London.

Fumigants—Mode of Action, Use, and Residue Analysis

One of the most useful fumigants gaining increased use is phosphine. However, it is a slow-acting poison and is toxic only when aerobic respiration is operative. From current studies of its effect on respiration, it has been found to only partly inhibit the respiration of some insects, whereas it totally inhibits the copper-containing enzyme cytochrome oxidase in vitro. Results previously obtained on residues in grain with the use of radioactive labeled phosphine were confirmed by further experiments using nonlabeled fumigant and neutron activation analysis.

From background information and methods developed here concerning resistance to fumigants, the report commercially of the incomplete control of the red flour beetle by ethylene dibromide – methyl bromide treatment is being confirmed as due to toleration or resistance.

In connection with the control of eggs of the European red mite and adults of the McDaniel spider mite in apples for export, results are complete for the conditions of control of the former with ethylene dibromide, but work on the latter is still in progress. This work is being done in collaboration with the research stations at Vineland, Ont., and Summerland, B.C.

PLANT DISEASES

Mode of Action of Selected Fungicides

Current research on chemical methods of controlling plant diseases is being conducted along two main lines. Selected fungicides, particularly those with systemic activity, are being studied to determine their mode of action and the basis for specificity and selectivity. These results will not only assist in the establishment of guidelines for the use of fungicides, but will provide background information for the development of new compounds and treatments. In addition, a search is being made for plant constituents that are responsible for natural resistance to disease. These results provide the potential for the development of new fungicides for which natural means of degradation and disposal are inherent and also the possibility of artificially inducing or enhancing their formation in crops in the field.

Investigation of the response of some 30 species and isolates of *Fusarium* to benomyl and thiabendazole indicated that with the exception of *F. solani* f. *pisi* all had linear dosage response curves with ED_{50} values of 1 ppm or less. Results with the latter were especially interesting in that both fungicides induce a slow-growing resistant form that is unaffected by concentrations up to 10 ppm of either fungicide. Resistance is not related to permeability, because both resistant and sensitive isolates and a number of other species also readily take up both compounds. That they are fungistatic rather than fungicidal was demonstrated when viability was restored by washing the compounds out of treated cells.

In experiments on the control of damping-off of peas caused by *Pythium ultimum* Trow, a mixture of thiram and the systemic fungicide chloroneb showed great promise. A higher level of control was obtained than could be explained from additive effects of either compound or could be predicted from in vitro tests where growth inhibition by mixtures was simply additive.

The mode of action of the systemic fungicide carboxin (Vitavax) and a number of closely related derivatives were studied and found to inhibit succinate oxidation in a preparation from the corn smut fungus, *Ustilago maydis* (DC.) Cda. That the succinic dehydrogenase from this source is particularly susceptible was shown by the relative insensitivity of that from yeast or mung bean.

Mechanism of Disease Development and Resistance

In a development of previous work on cyanide production by low-temperature basidiomycetes, predicted intermediates in the metabolic pathway from glycine are being tested for fungitoxicity, on the hypothesis that noncyanogenic fungi may metabolize these to cyanide and therefore inhibit their

own growth. One compound shows promise against species of *Pythium* and *Phytophthora.* The status of the antifungal compound hordatine as a factor in resistance of barley seedlings to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur remains unclear. Hordatine has been shown to inhibit mycelial growth and respiration of several fungi, but seedling resistance appears to be influenced by other factors including nutrition and light, and no consistent correlation with water-soluble Ca^{++}, which neutralizes hordatine inhibition in vitro, has been demonstrated.

Pepper fruit was used as a model system for testing induction of antifungal compounds by a variety of fungi. A sesquiterpene with phytoalexinlike properties was induced by several fungi. It was isolated, characterized, and named capsidiol. More capsidiol was induced by nonpathogens than by pathogens, and nonpathogenicity could be accounted for on this basis. It is interesting that capsidiol is structurally closely related to phytoalexins described from other Solanaceae. Laboratory synthesis of other phytoalexins has been undertaken with the intention of field testing. To gain a better understanding of the mechanism of phytoalexin production, a study of the biosynthesis of pisatin from suitable intermediates is in progress and has led to the first isolation from peas of the closely related pterocarpin, inermin. The stereochemistry of unique pigment altersolanol B, a pathogen of solanaceous plants, has been completed.

WEEDS

Herbicides and Plant Growth Regulators

Continued work on the effect of N on transpiration indicates that the increase in rate varies with the form of added N. Since it has been shown that atrazine uptake parallels the transpiration increase, this added herbicide in the plant from higher N fertilizer levels may influence its action in the field.

Study of the long-term effect of five herbicide combinations on microorganisms from sandy loam at Harrow was continued. Results of quantitative work on molds, bacteria, and actinomycete showed some strong relationships between certain treatments and the microbial response. In turn, there was a correlation between peach yields and actinomycete populations. Preliminary results indicated a reduction in nitrification by suppression of one species of *Nitromonas* and two of *Nitrobacter.*

After the characterization of two distinct groups of indoleacetic acid oxidase isoenzymes, the interaction of hormone-type herbicides with these and their effect on plant growth were determined. A dual effect was shown with 2,4-D. At low concentrations, an isoenzyme was stimulated, and tumor-type growth in the tissue culture model system increased. At higher concentrations, another isoenzyme was stimulated and was accompanied by growth inhibition. 2,4,5-T and picloram produced a similar effect. The isoenzymes of peroxidase, another enzyme that plays various roles in plant growth, were resolved. Picloram and 2,4-D also have a differential effect on these isoenzymes that results in changes in tissue growth. As part of the study of herbicide selectivity and interaction with tissues, the establishment of tissue cultures of wild oats and Canada thistle is under way.

From microplot trials with new organophosphorus insecticides, a soil insecticide was shown to have an inhibitory effect on plant growth. Incorporation studies with ^{14}C-leucine indicated a differential inhibition between crop plants studied. The inhibition was increased in the presence of 2,4-D or IAA, thereby suggesting an interaction between the organophosphorus insecticide and the auxin.

ENVIRONMENTAL QUALITY

Management of Pesticides

In order to have a measure of the relative contribution of three insecticide uses to water system contamination, three areas of Ontario with differing use patterns were examined for residues in water, bottom mud, and fish. The three areas were Big Creek, Norfolk County (an agricultural area); Thames River near London (an urban area); and Muskoka and Moon rivers (a resort area). To date the following insecticides have been detected: lindane, heptachlor, aldrin, endosulfan, gamma-chlordane, *p,p'*-DDE, *o,p'*-DDT, *p,p'*-DDD, dieldrin, and endrin. Residue levels in water from all three areas have been

low (parts per trillion). DDT in fish from Big Creek was 1.2 ppm or less. Polychlorinated biphenyls (PCB's) were found to mask the peaks for DDT and its metabolites, when attempts were made to analyze mud and fish samples from the Thames River. A method is being developed to overcome this problem.

The studies of the absorptive behavior of an organophosphorus insecticide, fensulfothion (Dasanit), and its oxidation metabolite, the sulfone, with clays indicated that they are probably minor contributors to water contamination from runoff.

In a study of lindane degradation by soil microorganisms, from 136 cultures, 62 isolates were found capable of growth in a lindane-containing medium. The metabolites from five were characterized.

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Engineering Research Service
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INTRODUCTION

Systems engineering and analysis concepts are being introduced into the programs for production research, forage and field crops research, and some areas of livestock management. When satisfactory system models have been developed and simulation studies carried out, significant areas for further research should become evident. Studies on methods of animal waste disposal and odor control have resulted in some improved methods for this aspect of the livestock management system.

One hundred and twenty-five research and development projects were carried out at or for 25 establishments across Canada. Many of these projects were for specialized equipment that reduces technical labor in research programs and for instrumentation and control systems that permit precise research and improved data collection and analysis. An all-terrain vehicle was developed with a special seeder designed for planting cereals in early spring on soft, muddy soils. A pilot-plant fluidized bed freezer-dryer was completed for studying new methods of processing foods. A small unit was developed for liquid-nitrogen freezing of egg melange into a free-flowing form; this provides an efficient method of marketing eggs in bulk for commercial and institutional use. A new instrument was developed to measure pea tenderness for use in pea grading to establish the price to be paid to the grower; commercial manufacture has been arranged. Comprehensive systems for measuring the mechanical and rheological properties of agricultural commodities and the texture of foods were developed for a number of stations.

The technical publication, ERDA, continues to communicate agricultural engineering information of significant interest from around the world, and keeps the agricultural engineering community fully informed on current research and development programs in Canada. For more information, address correspondence to: Engineering Research Service, Research Branch, Canada Agriculture, Ottawa, Ont. K1A 0C6.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

Developmental Research Program

A forage systems research program continued in cooperation with the Research Station at Melfort, Sask. Preliminary results from horizontal silos indicated that dry matter losses from freezing and spoilage were 10.9% in a packed silo and 21.4% in an unpacked silo. Four field-curing treatments for hay showed that the use of a mower-conditioner (in swath mode) could often permit baling to start one day earlier under rapid drying conditions. Drying rates were slower when a mower-rake, mower-conditioner (windrow mode), or self-propelled swather was used, and slowest when the swather windrows were baled. Feed analyzed from these four treatments, followed by artificial drying, field stooking, and shelter storage of bales, showed no significant advantage for any method.

In 1971, new tests were included to evaluate mechanical stackers for long loose hay and a hay tower for chopped, artificially dried, and mechanically handled hay. This forage research is providing systems engineering data for synthesis of mathematical models so that all aspects of forage making can be examined.

Systems engineering techniques are also being used to evaluate western grain harvesting methods, eastern beef production, and intensive production of sheep in confinement.

Structural diaphragm tests were conducted to evaluate various farm building cladding materials for shear resistance (resistance to wind forces). Fir and spruce plywood, galvanized steel roofing, and aspen flakeboard were tested; 10-mm (3/8-inch) aspen flakeboard resisted a shear force of 28.0 kg/cm of panel width (157 lb/inch), compared with 15.1 kg/cm (84.4 lb/inch) for 10-mm fir plywood, and 6.2 kg/cm (34.8 lb/inch) for 28-gage steel roofing. With adequate nailing, even a galvanized steel ceiling can have enough resistance to wind-brace a typical poultry building, measuring 11 × 85 m (36 × 280 ft), for example.

Field studies in cooperation with the Soil Research Institute and Animal Research Institute were initiated to monitor the losses and pollution hazards of nutrients from animal wastes, fertilizers, and plant residues in storage and when applied to cropland.

Canada Farm Building Plan Service

The Canada Farm Building Plan Service (CFBPS) Design Center, cooperating with provincial subcommittees and the Information Division, prepared and distributed 11 sets of new plans for swine buildings. They consisted of 87 plan sheets, in English. French translations of 10 swine building plan sets, consisting of 57 sheets, were completed and distributed as well. Revision of the swine series (English) is now up to date except for three manure-storage plans.

The series on dairy housing and environment is being updated, and one set of plans (nine sheets) for a slotted-floor, free-stall dairy housing system has been distributed. Contract drafting is being introduced to accelerate the preparation of detailed drawings. Engineering was completed for the CFBPS roof-truss plans according to new Canadian Standards Association lumber sizes and grades; a drafting contractor is now preparing the detailed truss drawings.

A new system was introduced for establishing the sequence of plan and leaflet preparation, based on periodic surveys by letter to determine provincial needs; this replaces the former system where one catalogue was prepared at a time, while seven others were going out of date.

Drawings now incorporate a new system of numbered notations in a single typed column at one side of each sheet; this clarifies the drawings, reduces drafting time, and facilitates French translation.

Other Advisory and Consulting Services

Eighteen technical presentations were made at various seminars, symposia, and farm producers' meetings. Audiences included provincial extension engineers, Research Branch work-planning committees, provincial Institutes of Agrologists, university engineering departments, and others.

Special consulting work included 11 jobs for Research Branch stations and institutes in such areas as building design, drainage, irrigation, machinery selection, and erosion control. Seven consulting jobs were carried out for provincial government developments, the construction industry, universities, and others.

Four short technical articles were prepared for publication in ERDA.

RESEARCH SERVICE

Technical problems were solved to assist other government agencies, universities, and industry. The workshop completed 100 fabrication orders.

Equipment for Mechanization of Field and Laboratory Experiments

Machines and apparatus were developed to increase the efficiency of field and laboratory experiments and to facilitate new areas of research.

A potato digger and a single-row carrot harvester were developed to handle test plots with minimum labor. The Hege plot combine for cereal plots was evaluated and modified to operate properly under Canadian conditions.

A seeder was designed for planting cereals in the early spring on soft, muddy soils. An all-terrain vehicle was used to carry the implements so that soil compaction was minimized. A hand-propelled machine was constructed to make equal spaces along rows for hand planting of cereal seed at precise spacings.

A grain scutcher and corn sheller were developed for small-scale processing of breeders' test plot samples.

A plot sprayer was manufactured to apply herbicides to the soil in cereal test plots without contaminating the crop. A mobile burner was assembled for removing debris from test plots and for weed control before crop seedling emergence.

An electric mouse was developed for installing fishlines in field drainage tubes to pull through plug gauges that measure the tube diameter.

Instrumentation

Several traps were designed to collect grain beetles and other pests in grain storages.

A microtome was developed for cutting thicker-than-normal sections of fruits and vegetables.

Commercial equipment was evaluated for

weighing cigarettes and for visual examination with a borescope of plant roots in situ during growth.

A thermoelectric freezing stage for a microscope was developed to study the freezing of small insects and hystological samples. A programmer was designed to control the rate of change of freezing-stage temperature at preselected rates.

An investigation was completed to determine whether inexpensive ground-truth panels for calibrating airborne remote-sensing systems could be manufactured. This was found impossible because a reliable source of constant-color paint could not be found.

Processing and Quality Measurement

A pilot-plant fluidized bed freezer–dryer was completed for the study of new methods of processing food. Precisely programmed drying and freezing rates were achieved over a temperature range of −40 to + 125 C with 15 kg of products such as diced potatoes and apples. Rapid freezing rates, a particular feature of the design, were obtained by use of mechanical or liquid-nitrogen cooling, or a combination of the two.

A bulk milk cooler was designed for operation in Uganda. Delivery of these units by International Agricultural Development is now under way. A prototype of a domestic grain silo was made to determine if such a unit could be used in tropical climates to prevent spoilage.

A pilot plant was developed for liquid-nitrogen freezing of egg melange into a particulate, free-flowing form. The purpose was to provide a more efficient method of marketing eggs in bulk for commercial and institutional use. The prepared product is excellent, and the process has been patented and a company licensed to use it.

A survey of machinery for peeling, coring, and slicing apples was completed. Recently introduced equipment can raise production efficiency considerably.

A technique was developed for measuring the texture of fish products. An investigation has shown that time in storage before processing affects the texture of baked beans. The processed beans become tougher.

A new viscometer was developed for measuring the behavior of starch slurries during cooking, so that quality can be maintained in the food industry.

A new instrument was developed to measure pea tenderness for use in pea grading to establish the price to be paid to the grower. The machine has been shown to the industry, which is evaluating it as a replacement for existing machines. Commercial manufacture has been arranged.

Comprehensive systems for measuring the mechanical and rheological properties of agricultural commodities and the texture of food were constructed for seven Research Branch stations and one provincial research station. Emphasis was placed on achieving operational flexibility in the design, so that a wide range of tests can be accomplished and the measuring techniques developed can be readily adopted in industrial applications. Commercial production of the system was initiated. Three Kramer shear presses were modified to increase the precision of the textural measurements the system can make.

TECHNICAL AND SCIENTIFIC INFORMATION

Through the periodical ERDA and correspondence, we continue to communicate agricultural engineering information to those who can make use of it for development or application. Also, the ERDA Supplement has kept the agricultural engineering community fully informed on current research and development programs in Canada.

Participation in the National Science Library CAN/SDI system of information retrieval has made it possible to assess the potential of the system for this establishment.

A visit to the principal agricultural engineering centers of Europe to promote greater information liaison has resulted in closer ties with these organizations and an exchange of scientific data.

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A. BICKLE, B.Sc.	Systems and programming
M. R. BINNS, M.A., Dip.Stat.	Design of experiments, sampling
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L. M. A. GRAHAM, B.A.	Systems and programming
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D. L. PAULHUS, B.Sc.	Programming
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C. S. SHIH, B.Sc., M.Sc., Ph.D.	Design of experiments, crop-loss studies
D. T. SPURR, B.Sc., M.Sc., Ph.D.	Quantitative genetics, design and analysis
B. K. THOMPSON,[1] B.Sc., M.Math.	Genetics, systems and programming

Departures

A. PETRASOVITS, B.Sc., M.A., Ph.D. Transferred to Department of National Health and Welfare, October 1971	Bioassay, organoleptic tests
P. ROBINSON, B.A., Dip.Math.Stat., Ph.D. Seconded to Department of Communications	Director
A. S. WOOD, B.Sc., M.Sc. Resigned December 1971	Experimental design

[1]On educational leave.

INTRODUCTION

In 1971, the Statistical Research Service provided advice and assistance on some 150 problems; some dealt with non-statistical mathematics, but most of them concerned the design and analysis of experiments and surveys, and the interpretation of the results.

Cooperation with other scientists in the Research Branch has been close, especially on problems arising in subjective assessments, bioassay, animal breeding and nutrition, numerical taxonomy, and ecology. Assistance was given to the Production and Marketing Branch in solving problems of quality control and produce inspection. There was continued cooperation in the crop loss research program.

The addition of further computer programs to the library has considerably improved the versatility and speed of service that we can offer. These additions include programs designed to analyze quadratic forms, to compute coefficients of inbreeding and of common parentage from a given pedigree, to compare ecological diversities, to investigate the relationships between different multivariate analyses of the same data, to investigate transformations to normalize a variable, and to perform a probit analysis on a population containing a mixture of types of individual; special routines for the numerical solution of problems for which analytic solutions are unavailable were also added.

Two studies of problems in operations research have been started. The first of these, on strawberries, is an attempt to combine the agricultural and economic restraints with the desirable qualities of the fruit to form relationships appropriate for an optimization study. The second study is an attempt to do the same for beef; the preliminary focus has been on aspects of forage production.

For more information, correspondence should be addressed: Director, Statistical Research Service, Room E-265, Sir John Carling Building, Research Branch, Canada Agriculture, Ottawa, Ont. K1A 0C5.

L. P. Lefkovitch
Acting Director

Bioassay

The new bioassay programs (see Research Reports for 1969 and 1970) have continued to prove valuable, not only in a strictly bioassay context but also to compare the assessments, made by different judges in an international study, of the chromosome damage due to radiation. The ability to fit and compare different hierarchical models, and, in particular, to allow for individual assessments of the "response" to zero dose, gave useful information. The time-response assay program was used to assess the vitality of *Rumex crispus* seeds. In a study of different herbicide spray procedures, using as response the bending of sunflower seedlings after 2,4-D spray, the contact area was found to be more important than the volume applied, whereas the response to increased concentration balanced the response to increased number of drops per unit area.

In preparation for a requirement to analyze data on bluetongue virus, the general quantal assay program (S104) has been adapted to handle dilution series. Among the many quantal assays analyzed during the year was a large series of experiments on the joint action of insecticides, in pairs or three at a time. This led to some general recommendations on the design of such assays.

A program for analyzing completely randomized unbalanced multiple slope-ratio assays was designed. The program (S070) for weighted multiple regressions, eliminating environmental differences, has been written in such a way that it can handle similar experiments arranged in randomized blocks.

Statistical Ecology and Population Dynamics

Further work on the problems connected with migration between localities where the numbers migrating depend on those at the localities has continued by computer simulation. A stable situation was reached, but it is still not clear how the various parameters

interact so that predictions can be made. Simulation of the interaction between two coexisting species has shown, as expected, that there are some circumstances in which both species can persist for many generations, even though one eventually becomes extinct.

Advisory work on statistical ecology has included cooperation on studies of the attraction of the adult of the apple maggot to apple trees; the distribution of mites, nematodes, and spiders; predator-prey relationships among mites; population increase in nematodes; the effects of various possible quality-control procedures for critical numbers of golden nematodes in potato fields; the distribution of the rusty grain beetle in stored wheat; the effectiveness of trapping mosquitoes, and sterilizing and releasing the males for reducing the numbers of mosquitoes; and the interrelationships among the fauna found in soil samples taken throughout five seasons in two meadows near Belleville.

Analyses were made of two sets of survey-type data: tabulation of data in relation to the prevalence of the merchant grain beetle in private dwellings in Winnipeg, and the tabulation and analysis of survey-type data of the flora in various geophysical "zones" in a region of Quebec.

Plant Science

In order to clarify the basic concepts of stability and adaptability, eight stability statistics suggested in the literature were investigated. It was concluded that these stability statistics can be classified into four groups. There are three types of stability, depending on whether the definition of stability is based on total variation, on deviations from the mean response of all varieties, or on deviations from individual regressions on the environmental index.

In recent years, Nelder's systematic designs for spacing experiments have been used by several research scientists in the Branch. The main advantage of such designs over that of a randomized block is that they can accommodate a large number of spacing treatments using a minimum of land and labor. However, the data obtained cannot be analyzed by a conventional analysis of variance technique because of the systematic arrangement of the treatments. To cope with this difficulty and yet maintain the economy of a systematic design, a new design for spacing experiments was developed. By defining a spacing treatment by the row and within-row distances rather than by density, the design allows the randomization of two factors, thus ensuring that the number of plants for each treatment is kept constant while all treatment plots in a replication fit into compact shape. The design is well suited to the study of spacing experiments on row-planted or space-planted crops, and to situations where both rectangularity and density should be investigated simultaneously.

Regressions of blueberry yield and size on leaf nutrition levels and several on agronomic characteristics were investigated. Much time was spent in developing a comprehensive model for fertilizer requirements of tobacco, based on soil nutrient levels, but no consistent model could be obtained from the submitted data.

Crop Losses

Two models were developed in connection with crop-disease studies. One model was designed to estimate the loss in potato tuber yield due to late blight, a major disease of the potato crop usually controlled by fungicide sprays. This model can be used to estimate gain in yield through a disease control program, and will be the basis for the development of a cost analysis to decide the most suitable sprays and their timing.

Another model described the relationship between severity and incidence of leaf rust and powdery mildew on winter wheat in Ontario. Disease severity could be adequately estimated from the incidence at an early stage of disease development, thus simplifying the procedure for disease survey.

Other studies included a survey of Ontario peach canker, the effects of plot size and shape on plot variability in experiments involving foliage diseases in cereals, the effects of disease on the yield of potato tubers, and surveys on common root rot of wheat and foliage diseases of forage crops.

Animal Science

Our new capability for the analysis of multidimensional contingency tables has made possible the analysis of a number of experiments set up to study the mortality attribute data under different treatments.

The computer program for calculating

genetic parameters from a hierarchical classification of a population was improved and has been used to estimate heritabilities and genetic and environmental correlations for poultry and large animals.

The Statistical Research Service continued to be involved in a computer system (S557, 567, 851) for preparing monthly summary tables of economic returns and other data from various treatments in a large poultry management study. Other poultry management experiments analyzed included studies of effects of bird density and pen size on performance and profits of poultry flocks.

A number of experiments and preliminary surveys on problems associated with animal nutrition were worked on during the year. These included experiments on trace elements (such as selenium, copper, and zinc) in animal feeds, energy sources in swine rations, milk replacers for dairy calves, and effects of chlorinated hydrocarbons on performance of poultry.

Numerical Taxonomy

The large study on cultivars of oats was completed during the year; this study involved devising new computational and decision procedures in order to analyze the data and, having formed groups of cultivars, to provide an identification scheme; papers describing this study are in press.

Studies on the genus *Euxoa* concerning the application of numerical taxonomic techniques to morphological, physiological, biochemical, and behavioral data were started during the year. One so-called species was found to consist of three morphological kinds of individuals, but their status is not yet clear.

Numerical taxonomic techniques were also applied to a faunistic problem; a study was completed that characterized the fauna in various parts of Canada and attempted to recognize or confirm the existence of biological provinces. The same methods were also used in an attempt to classify some plant viruses according to their proportional amino acid content.

Food Research

The collaborative work with the Food Research Institute and with the Production and Marketing Branch included increased involvement with sampling and inspection methods directed toward the sound establishment of tolerances and acceptable quality levels.

Early results on the sampling and laboratory analyses of skim milk powder prompted the design of a more specific variability study, and this was used to develop a two-stage acceptance rule. Simulation studies were required to obtain appropriate operating characteristic curves. Advice was given on the design of further laboratory studies, and on a sampling scheme for a survey of production plants.

Other surveys included shell-egg grading as a basis for an acceptance sampling scheme, and a study on the preferences of consumers of different eating patterns for different cuts of pork roast. The 1970 records of ice-cream product inspection were used in a variability study to assess the performance of current and proposed tolerances. A multivariate one-sided test was developed to provide simultaneous quality control on several characteristics of the products.

Many experiments using subjective assessments of foods were designed, analyzed, and interpreted. These included tenderness and flavor studies on turkey broilers, barbecued chickens, lamb, and pork.

The Rao-Kupper model for paired comparisons, allowing for tied judgments, was extended to include parameters for different preference ratings by individual judges, and a computer program was written to implement this and provide appropriate tests of hypotheses. Other procedures used to compare assessments by individual judges were a maximum likelihood procedure for frequencies in multidimensional tables, and an analysis of combined "relative potency" estimates.

Operations Research

Towards the end of the year, we were involved in the fitting of two models using linear programming methods. The first of these modeled the growth of strawberries, and the other, carried out in cooperation with the Engineering Research Service and the Research Station at Charlottetown, modeled various housing conditions for beef cattle. Modern techniques of model building, including mathematical programming and simulation, promise to be an increasingly important part of our work. In anticipation of this,

we examined several computer package programs now available and began arrangements for evaluation of the potentially useful ones.

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Research Station
Brandon, Manitoba

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Departure

W. H. Johnston, B.Sc., M.Sc., D.Sc. (Hon.) F.A.I.C. Retired December 1971	Group Chairman; Cereal breeding

INTRODUCTION

This report describes the progress in long-term experiments and the main research findings in 1971. The research at Brandon emphasizes animal breeding and physiology; and plant breeding, physiology and management, soil–plant relationships, cultural practice, crop rotation, and weed control.

Dr. E. E. Swierstra, a physiologist in animal reproduction, returned from a year of postdoctoral study at the Department of Physiology and Biophysics, Colorado State University, Fort Collins, Colorado, where he undertook cooperative studies on spermatogenesis in the stallion. Dr. L. D. Bailey completed his postgraduate program leading to the Ph.D. degree and returned to undertake work in forage crop management with emphasis on fertility requirements of grasses and legumes. Dr. W. H. Johnston, a barley breeder, retired in 1971 after 36 years of service at the Research Station.

Highlights for the year include evaluation of feedlot performance, feeding efficiency, and carcass characteristics of crossbred calves sired by bulls of the European breeds imported by the Department; advancement to the final stages of testing of an improved barley line with high potential yield and malting quality; and production of high yields of corn from field experiments.

Enquiries concerning details of the work discussed in this report, or related subjects, should be directed to the Research Station, Research Branch, Canada Department of Agriculture, Box 610, Brandon, Man.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

The Limousin breed. The imported Limousins continued to respond favorably to the environment of Western Canada. They have a quiet disposition and require no special care or accommodation over winter. The original four cows produced their second calves at 3 years of age. Eight young heifers imported in 1969 calved at 2 years, but there was one death loss among the calves so that 11 Limousin calves were raised in 1971. There were no calving difficulties and the average length of 12 gestations was 289.4 days. Birth weights averaged 36.6 and 32.3 kg and weaning weights 218.6 and 230.9 kg for males and females.

In 1971, the breeding herd consisted of one yearling (343 kg at 365 days of age), eight 2-year-olds (average weight 441 kg at 28 months of age), and four 3-year-olds (average weight 519 kg). Subsequent palpation tests indicated that eight were safely in calf, one was questionable, and four were open. After the calves were weaned, the Limousin females were transferred to the Lacombe Station so that their performance could be compared directly with that of the Simmental breed.

Semen production by Limousin bulls. Semen studies with imported bulls commenced when they were 15 months old. Periodically, between 21 months (average weight 631 kg) and 47 months of age (average weight 998 kg), they were placed on 48-hr collection schedules for 3-week periods to measure sperm production. All bulls exhibited good libido and the initial variation among bulls in ejaculate volume, progressive motility, sperm concentration, and total sperm per ejaculate was reduced as age advanced. Semen quality improved until the bulls were 42 months of age, when total sperm per ejaculate averaged 9.9×10^9. At 47 months, the average production was 8.6×10^9 sperm per ejaculate; however this reduction may have been influenced by the severe winter temperatures to which the bulls were subjected during the collection period. This represented 6.7×10^9 motile sperm per ejaculate and, based on 30×10^6 motile sperm per ampule, each bull on the average would produce 223 ampules of semen per ejaculate for storage as frozen semen. Semen production studies are continuing with three home-bred bulls that averaged 434 kg at 1 year of age.

Breed of sire and ease of calving. Thirty-eight 2-year-old Shorthorn heifers produced hybrid calves sired by Limousin, Simmental, and Charolais bulls. Average gestations were 283, 281, and 286 days for the three breeds of sire, and average birth weights were 29.1, 34.2, and 35.3 kg. Of the Limousin, Simmental, and Charolais hybrid calvings, 86%, 78%, and 86% were normal and 14%, 22%, and 14% were difficult, assisted births.

Among the Shorthorn, Hereford, and Aberdeen Angus breeds, 997 cows 3 years old and older produced calves sired by Limousin, Simmental, and Charolais bulls. Average gestations were 286, 284, and 283 days for the three breeds of sire; in every case, gestations that resulted in male births were 2 days longer than those that resulted in female births. The average birth weights were 38.0, 40.0, and 39.7 kg for males, and 34.5, 36.9, and 39.0 kg for females from the three breeds of sire. For the three breeds, 85.7%, 80.8%, and 87.9% of male births and 92.6%, 89.1%, and 93.9% of female births were normal and unassisted while 4.8%, 5.9%, and 3.0% of male and 1.9%, 2.2%, and 6.1% of female births were difficult, assisted calvings.

Weaning weight of crossbred calves. The average weaning weight adjusted to 205 days of age for Charolais-sired bull calves from Shorthorn, Hereford, and Aberdeen Angus cows was 228.2 kg, compared with 221.4 and 212.7 kg for Simmental and Limousin-sired calves. Among heifers the Charolais-sired calves averaged 208.6 kg, compared with 205.5 and 202.3 kg for calves sired by Simmental and Limousin bulls.

Feedlot performance and carcass characteristics of crossbreds. On full feed for 140 days, Limousin-sired bulls and steers gained 1.39 kg/day on 5.94 kg feed/kg gain, and 1.28 kg/day on 6.89 kg feed/kg gain; Simmental-sired bulls and steers gained 1.53 kg/day on 6.22 kg feed/kg gain, and 1.31 kg/day on 7.29 kg feed/kg gain.

When slaughtered at 454 kg, Limousin crossbred bulls averaged 380 days of age, compared with 345 days of age for Simmental crossbreds. However, dressing percentage favored Limousin-sired bulls (59.8% vs. 57.8%) and carcass weight per day of age at slaughter was almost the same (0.72 vs. 0.77 kg). The Limousin-sired bulls had a larger area of rib eye (91.7 vs. 88.1 cm^2), a greater proportion of choice carcasses (72% vs. 50%), and more fat cover (2.52 vs. 2.32 cm). The two breeds of sire were almost identical in the percentage of lean meat in the four primal cuts (chuck, rib, loin, and hip), but Simmental-sired bulls produced slightly more lean meat per day of age (18.2 g). Similar results were obtained when steers were slaughtered at 454 kg liveweight, and when bulls and steers from these two breeds of sire were slaughtered at 544 kg liveweight.

Meat quality. Bulls and steers from Limousin and Simmental sires were slaughtered at 454 and 544 kg liveweight and meat samples were compared for shear value, or the force required to force a dull blade through a 2.5-cm (1-inch) core of cooked meat, and for tenderness as evaluated by a taste panel. In both tests, the meat was found to be significantly more tender from steers than from bulls. When bulls from the two breeds were compared, the meat from Simmental-sired bulls was significantly more tender than meat from Limousin-sired bulls.

The fatty acid composition of intramuscular fat and consumer acceptance of the meat from crossbred bulls and steers are being studied in cooperation with the Department of Food and Nutrition, University of Manitoba.

Response to selection. Based on differences between selected and control lines during 12 years of selection for yearling weight in Shorthorn cattle, the regressions of yearling weight on the mean cumulative selection differential were 0.496 ± 0.426 for males and 0.312 ± 0.092 for females. In carcass evaluation studies, bulls from the selected line had a greater area of rib eye, less fat cover, and a higher percentage of separable lean meat than control line bulls slaughtered at 1 year of age after a 6-month feedlot performance test.

Swine

Response to selection. Response of Lacombe swine to seven generations of mass selection for post-weaning average daily gain was positive, but the observed response was estimated to be 0.33 of that expected. The realized heritability was 0.126 ± 0.029, and the pooled estimate of heritability from variance components and regression of offspring on dam was 0.377 ± 0.058. Litter size was positively correlated with average daily gain (0.4 piglet per litter per generation). The

additive genetic variance was not significantly reduced by selection.

A pedigreed control population of Yorkshire swine was maintained for eight generations without significant change in the genetic value of the population. The effective number of parents per generation was 87.5. The advantages of a pedigreed over a random-bred control were to increase the effective number of parents per generation, to control the effects of inbreeding, and to minimize natural selection among families.

Effect of repeat mating on conception rate and litter size. Conception rates for 156 Yorkshire and 246 Lacombe matings were 65% and 69%, and average litter size in both breeds was 8.9 when gilts were bred once by natural service. In 349 Yorkshire and 312 Lacombe matings in which each gilt was re-bred by the same boar 24 hr after first service, conception rates increased to 78% and 80% and the average litter size in both breeds was 9.2.

Plasma androgen and estrogen levels in boars. Mean androgen levels in the blood from the jugular vein of Yorkshire boars with body weights of 1.4, 12, 29, 39, 48, 56, 65, 75, and 84 kg were 9.4, 6.0, 3.0, 4.4, 5.2, 5.2, 6.8, 7.2, and 8.8 ng/ml as determined by competitive protein binding. Corresponding mean estrogen levels determined by radioimmunoassay were 750, 277, 196, 191, 185, 208, 279, 202, and 423 pg/ml. Levels of androgen and estrogen appeared relatively high at birth, dropped to a low level at 29 kg body weight, then increased gradually with increasing body weight. The increase in androgen level was associated with the normal increase in testes weight as boars developed and matured.

Daily sperm production in boars. Daily sperm production (DSP) was estimated in 46 boars (24 Yorkshire and 22 Lacombe) by measuring changes in epididymal sperm reserves (ESR) after depeletion of ESR on a 72-hr collection schedule. The mean DSP during this time was 10.9×10^9. The mean ESR 5, 24, 52, and 72 hr after last collection were 128.2, 150.4, 142.4, and 165.8×10^9. Regression analysis revealed that ESR were reestablished at 10.1×10^9 sperm per day. By quantitative testicular histology, the mean DSP for these boars was found to be 13.8×10^9. It was concluded that quantitative testicular histology was a more accurate method of measuring DSP in boars, and that because ESR varied among boars, the sample of 46 boars was insufficient to provide an accurate estimate of DSP by using changes in ESR after depletion.

Effect of level of feeding on fetal growth and environment in swine. In a study of 344 fetuses recovered after 60 days of pregnancy from gilts fed 1.5, 2.25, and 3.0 kg of standard sow ration per head daily, the highest level of feeding had a significant effect on all parameters measured. The data for gilts fed 3.0 kg per head daily compared with those for gilts at the 2.25- and 1.5-kg levels of feeding were: weight of fetus 119.0 vs. 102.7 and 99.7 g; weight of uterine implantation area 111.9 vs. 98.8 and 96.6 g; weight of fetal membrane 153.0 vs. 139.6 and 137.0 g; volume of allantoic fluid 201.1 vs. 133.0 and 125.5 ml; and volume of amnionic fluid 89.4 vs. 78.0 and 79.0 ml. There was almost equal recovery of fetuses from the right and left uterine horns (173 vs. 171) and those from the right horn were heavier (111.3 vs. 106.9 g). There were 172 fetuses of each sex and males were significantly heavier than females (110.6 vs. 107.6 g). The female fetuses were surrounded by a larger volume of amnionic fluid than the male fetuses (90.0 vs. 76.3 ml).

Effect of level of feeding on return to estrus in sows. When 117 primiparous sows (64 Yorkshire and 53 Lacombe) were fed 2.25 and 3.75 kg of sow ration per head daily beginning the day of weaning first litters, it was found that level of feeding did not affect the time interval from weaning to return to estrus. One Yorkshire and 26 Lacombe sows were not observed in estrus within 16 days of weaning. Of those observed in estrus, Yorkshire sows averaged 4.4 days and Lacombe sows 5.2 days from weaning to return to estrus. The mean estrual period was 2.6 days for Yorkshire and 2.0 days for Lacombe sows, but the duration of estrus was not affected by level of feeding.

Meat quality in pork. When samples of the *longissimus dorsi* muscle from 25 gilts and 25 barrows of the Yorkshire and Lacombe breeds were subjected to shear tests and taste panel evaluation, the samples from Lacombe gilts and barrows required less shearing force than those from Yorkshire gilts and barrows (18.1 and 16.7 vs. 22.9 and 20.1) and had higher sensory scores for tenderness, juiciness, and flavor than samples from Yorkshire

gilts and barrows. Within breeds, barrows produced more tender pork chops (lower shear values) and had higher scores than gilts for tenderness, juiciness, and flavor.

Horses

Spermatogenesis in the stallion. In a cooperative study with Colorado State University, the cellular composition of the seminiferous epithelium of the stallion was found to be similar to that of the boar, bull, and ram. Hence, the cycle of the seminiferous epithelium was divided into eight stages based on meiotic divisions, shape of spermatid nucleus, and release of sperm into the lumen of the tubules. Stage frequencies for tubules with normal cell populations were established by injecting labeled thymidine-methyl-^{3}H and performing unilateral castration at various intervals from 4½ hr to 35 days after injection. It was found that the most advanced spermatogenic cells incorporating the label were leptotene primary spermatocytes. Labeled spermatozoa were at the point of leaving the testes 35 days after injection. The mean duration of the cycle of the seminiferous epithelium was 12.2 ± 0.2 days. The life span of primary spermatocytes was 18.9 days; secondary spermatocytes, 0.6 days; spermatids with round nuclei, 8.8 days; spermatids with elongated nuclei, 2.2 days; and spermatozoa, 7.9 days.

Poultry

Response to selection in Leghorns. In seven cycles of selection for 273-day egg production, there was a cumulative response of 41.3 eggs for 497-day, or full year, production in birds selected on a full-fed rearing regime, and 30.1 eggs in birds selected on a restricted feeding regime during rearing. Over the same period, there was a cumulative reduction in egg weight (0.8 g) for birds selected under full feeding and an increase (0.4 g) for birds selected under restricted feeding. Thus, selection under a full-fed rearing regime results in more but smaller eggs than selection under restricted feeding.

Performance of reciprocal crosses of Leghorn strains. In reciprocal crosses of two Brandon strains of Leghorns (one selected under full feeding and the other under restricted feeding during rearing), the cross that used males from the restricted feeding line and females from the full-fed line outperformed the reciprocal cross in all important aspects of production: hen housed egg production 251 vs. 245; egg weight, 54.9 vs. 54.6 g; age at first egg, 173 vs. 174 days; laying house mortality, 14.4% vs. 15.3%; and returns over feed cost, $2.99 vs. $2.83 per bird per year.

PLANT SCIENCE

Cereal Crops

Malting barley. Breeding for improved performance in yield, malting quality, and disease resistance continued to show progress. The most advanced breeding line has been in extensive evaluation tests for 2 years. It ranks among the highest for yield and is of intense interest to breeders and industry because of its desirable malting quality. A second line with resistance to net blotch has exciting possibilities in quality, but requires further selection for aleurone color.

Among derivatives from crosses of the most recent Brandon varieties (Conquest, Paragon, and Bonanza) with North Dakota selections, a number showed fair to good resistance to Septoria leaf blotch and several resistant lines had substantial yield improvement over Bonanza. These are being evaluated for malting quality.

Breeding continued in selections for tight hulls, yield, and quality. Forty-six F_4 lines were submitted for quality evaluation. There was progress in breeding for shorter-strawed varieties.

Feed barley breeding. The most advanced line, a selection from a Keystone × Dickson cross, was the highest producer of energy/acre, outyielding both parents and averaging 18% over Bonanza in 3 years of testing at Brandon. Also, it has yielded well in extensive yield tests at various prairie locations in 1971.

Several promising lines that combine good agronomic characteristics, immunity to loose smut, resistance to stem rust and Septoria leaf blotch, and high yield have been identified in derivatives from crosses involving Brandon lines, a North Dakota selection, and Galt.

Progress was made in the development of multiple dominant and recessive marker stocks. A multiple recessive line with one or

more recessive genes on each chromosome has been isolated.

Forage Crops

The "stress wheel" for introduction nurseries. A "stress wheel" design for forage introduction nurseries was developed in which each introduction was planted as a "spoke" of the wheel. Thus, in addition to providing regular data from the nursery, the reaction of introductions to varying interrow spacing from "hub" to "rim" can be measured as a response to competition stress.

Grass-hay production with fertilizer and with alfalfa. Fertilizer supplying 84 to 252 kg N/ha improved hay production in grass stands from 2,556 to 4,596 kg/ha for one cut and from 3,419 to 6,866 kg/ha for two cuts. Hay from unfertilized grass-alfalfa mixtures averaged 5,526 kg/ha.

Fertilizer effects on brome-alfalfa production. Significant yield responses were obtained with stands of brome-alfalfa at two locations on fine sandy loam when P and K were applied annually in spring or fall. At one location maximum yields were obtained with P and K at 37 and 23 kg/ha (average annual yield of dry matter was 7.8 metric tons/ha), and at the other location with P and K at 37 and 46 kg/ha (average annual dry matter yield was 8.6 metric tons/ha).

Corn production. Nine varieties of corn were grown at 19 locations between 49° and 52° N latitude. At all locations south of 50° N and one location at 51° N, some varieties produced No. 1 grain corn (69.8 kg/hl).

At Brandon, 6 of 300 entries matured sufficiently early to produce grain corn. Yields from field-scale tests (0.8 to 2.0 ha) varied from 28.2 to 32.0 q/ha, and weight for volume varied from 50.0 to 65.0 kg/hl. Silage dry matter yields ranged from 6.0 to 10.1 metric tons/ha.

Agronomy

Nitrogen for corn production. On fine sandy loam soil, application of 45 kg N/ha increased yields of grain corn by 92% (26.9 vs. 14.0 q/ha). Fall application of anhydrous ammonia on clay soils at rates of 45 kg N/ha increased grain yields by 109% (32.2 vs. 15.4 q/ha), and dry matter silage yields by 73% (7.3 vs. 4.2 metric tons/ha). Silage yields on clay soils were further increased to 9.1 metric tons/ha with 90 kg N/ha.

Rate and method of fertilizer application for wheat. Anhydrous ammonia and phosphoric acid resulted in wheat yields comparable to those obtained with ammonium nitrate and ammonium phosphate when applied prior to seeding at rates of 45 and 90 kg N/ha and 15, 30, and 60 kg P/ha. With 45 kg N/ha and 0, 15, 30, and 60 kg P/ha, yields were 20.4, 26.1, 28.9, and 29.3 q/ha. With 90 kg N/ha and 15, 30, and 60 kg P/ha, wheat yields were 27.2, 26.0, and 30.6 q/ha. The similar yields with two types of fertilizer indicated that the primary fertilizer products, anhydrous ammonia and phosphoric acid, can be applied directly.

Effect of fertilizers on rapeseed yield. On a silty clay black alluvial soil and a gray till soil at approximately 52° N latitude, yields of rapeseed were increased by 5.4, 3.0, and 5.6 q/ha on the black soil and by 2.8, 1.9, and 2.6 q/ha on the gray soil when N applications were 45, 90, and 180 kg/ha without fertilizer-P, and similar responses occurred within each P treatment. Maximum yields were obtained with N at 180 and P at 15 or 30 kg/ha on black soil (18.3 and 18.7 vs. 4.4 q/ha without P), and with 180 kg N/ha and 15 kg P/ha on gray soil (13.7 vs. 2.2 q/ha).

On the gray soil, 29 kg S/ha with 90 kg N/ha and 30 kg P/ha, and 52 kg S/ha with 180 kg N/ha and 30 kg P/ha increased yields significantly (11.3 vs. 8.1 q/ha and 16.7 vs. 12.8 q/ha).

Crop rotations. Two complete cycles of 3-year crop rotations indicated that summerfallow increased yield and protein content but not net profit of subsequent wheat crops; sweetclover in lieu of summerfallow improved wheat yield, protein content, soil fertility, and net profit. Continuous cropping increased weed problems (green foxtail on sandy soils and wild oats on clay soils).

Preemergence weed control in corn. Sutan at 4.5 kg/ha plus atrazine at 1.1 kg/ha applied in water (180 liters/ha) and incorporated before planting corn achieved 81% control of wild oats and good control of green foxtail and broad-leaved weeds. Dry matter yields of silage were 8.1, compared with 1.3 metric tons/ha for untreated plots.

Postemergence weed control in corn. Atrazine at 1.7 kg/ha plus nonherbicidal oil (6.8

kg/ha) in water at 180 liters/ha applied at the four-leaf stage of corn provided good control of green foxtail, barnyard grass, and broad-leaved weeds. Dry matter yield of silage was 10.6, compared with 5.0 metric tons/ha for untreated plots.

Herbicides for weed control in wheat. Preemergence treatments with trifluralin at 0.84 to 2.24 kg/ha and chloramben at 1.12 to 2.24 kg/ha provided good control of green foxtail, lamb's-quarters, and redroot pigweed. When plots were rototilled and harrowed immediately after application, trifluralin did not injure the wheat crop. A new compound, C-20482, showed consistent selectivity on weeds when applied at 0.84 to 1.68 kg/ha, and wheat was tolerant of the herbicide at rates up to 4.48 kg/ha. When applied at 0.84 kg/ha in a mixture with bromophenoxim (C-9122) at 0.56 kg/ha, this compound provided excellent weed control.

Herbicides for weed control in rapeseed. Good control of broad-leaved annuals and green foxtail was achieved without injury to the crop with TCA at 2.24 kg/ha or with nitrofen (TOK E-25) at 1.34 kg/ha, each combined with alachlor at 1.12 kg/ha. TCA controlled green foxtail but was unreliable against broad-leaved weeds.

Reduction of herbicide residues in cereals by mixing herbicides. In studies of herbicide mixtures, four phenoxy herbicides (2,4-D; MCPA; 2,4,5-T; and fenoprop), all classified as ATP inhibitors, inhibited the accumulation of TCA in wheat by 50% to 65%. In oats, 2,4-D at 10^{-6} and 10^{-5} M reduced TCA accumulation by 26% to 65%, and in barley up to 28%. TCA had no effect on 2,4-D accumulation in wheat, but inhibited accumulation in oats up to 34%. In other tests with wheat, 2,4-D inhibited accumulation of dicamba, chloramben, and amitrole up to 46%, 58%, and 17% respectively. Each of these compounds inhibited 2,4-D accumulation in wheat by 3% to 21%.

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INTRODUCTION

This report summarizes the more important findings in research on horticultural and special crops at the Research Station, Morden, Man., in 1971. Increasing emphasis on special crops continued with the appointment of a plant breeder to devote full time to buckwheat. Work on new crops also increased. New equipment for nondestructive determination of oil content of oilseed has improved the effectiveness of selection programs.

The achievement of the Station was recognized in several ways: an honorary Doctor of Science degree was conferred on W. A. Cumming by the University of Manitoba for his outstanding work in ornamentals; Dr. H. Enns was chosen by FAO to assess research on oilseeds in the Middle East; and Dr. C. Walkof was awarded Honorary Life Membership in the Canadian Society for Horticultural Science.

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Eric D. Putt
Director

SPECIAL CROPS

Buckwheat Breeding

The high-yielding selection CD 7274 was released as the cultivar Tempest. Selections with large seeds are being increased and evaluated for yield and quality.

The inheritance of leaf variegation was determined. A line with several short internodes and solid stems has been isolated, and inheritance of the two characters and value of the line as breeding material are under study. F_1 progenies of intervarietal hybrids exhibited considerable heterosis; however, this was lost in the F_2 generation.

Field Peas

Breeding. The main objectives are to develop a higher-yielding cultivar than Century with similar or larger seeds and good cooking quality, and to develop a high-yielding cultivar with green seeds of good quality. In the 1971 cooperative tests a Hungarian introduction with large seeds, CD 6474, outyielded Century at seven locations across Canada.

Green pea selections MP 698, of unknown origin, and MP 766, a selection from PI 206852, greatly outyielded the control cultivar Delwiche Scotch Green. A European cultivar, Rondo, also yielded well at Morden in a preliminary test. Alaska peas grown in a commercial trial near Morden yielded only 1,345 kg/ha and were susceptible to infection by *Ascochyta*; their low yield and susceptibility to disease make them unsuitable for production in Manitoba.

Quality. Genotype × location interactions for protein content were significant and, as found previously, location differences were highly significant. Analyses of the protein content of peas sampled at three sites on single plants showed significant differences. Generally, the protein content of peas was higher from pods that set earlier than from pods that formed later, near the tip.

The Hunter color difference meter was used to detect differences of color in puree of peas. Analysis with this meter was objective, rapid, and reproducible. The color of puree in both yellow and green peas was significantly affected by genotype, location, and their interaction.

Disease. Commercial fields planted with two lots of seed containing 0% or 8% internal *Ascochyta pinodes* L.K. Jones were all heavily diseased. It was evident that plant refuse from previous crops in neighboring fields was an important source of primary inoculum. *Ascochyta*-infected pea foliage placed in and on the soil remained pathogenic for at least 2 years.

Second-generation selfed plants from selected introductions were further evaluated for their reaction to infection by *A. pinodes*. Plants with a low reaction to disease were selected from 18 introductions that showed a lower average reaction to disease than the cultivar Century.

Forty-eight of 276 introductions appeared to possess greater resistance to bacterial blight than available commercial cultivars.

Flax

Breeding. In regional tests at 10 locations in Western Canada, six lines developed by the modified pedigree method from the crosses Noralta × Redwood 65 and Noralta × F.P. 454 failed to yield significantly more than Noralta. However, at Morden and Portage la Prairie, the lines gave 6% to 18% higher yields than Noralta. In preliminary tests in 1970 at the same two locations, these lines also produced higher yields. Therefore, more extensive testing of the early generations of flax must be done in the areas where flax is grown.

Oilseed quality. Studies on the effect of early swathing indicated that the quantity and quality of oil and the weight and color of seed were not significantly reduced if the plants were cut when the moisture in the capsule was less than 55%. This procedure hastened maturity in late-seeded flax.

To propagate flax by cloning, cuttings were rooted in an atmosphere of intermittent mist enriched with CO_2; many genetically identical plants were produced. This reduced the variation usually found in the quality of seed and oil from different plants.

A potential edible oilseed flax was isolated by single seed selection. The iodine number of the oil was 112.

Diseases. Seven Argentinian selections resistant to all North American races of rust were found to contain unknown genes, or combinations of known genes, for resistance. These selections also offered good resistance to pasmo and wilt.

Data from the study of genes for rust resistance suggested that Raja contains a single, effective gene that differs from the *L6, M3, N1,* and *P3* genes. Both Rocket and Lino Grande were shown to contain the *L6, N1,* and *P3* genes but not the *M3* gene.

Anthracnose, a rare disease caused by *Colletotrichum lini* (Westerdyk) Tochinai, occurred in cultivars from India and probably was carried on imported seed.

Management. A study of time of seeding confirmed earlier results to the effect that early seeding, May 12–18, produced the highest yield in flax. Seeding after June 5 caused sharply decreased yields. The cultivar Linott seeded on all dates except the latest, June 17, outyielded Noralta by 12% to 33%. Noralta, an early-maturing cultivar, is widely grown in Western Canada, particularly for late seeding. Linott and Noralta mature at the same time.

In a 1-year study of the cultivars Noralta and Redwood 65, the effects of row spacings of 15 and 30 cm and seeding rates of 250 to 1,250 seeds per 5.6-m row were determined. Noralta showed no yield response to plant density. The yield of Redwood 65, however, decreased as the seeding rate increased at the 15-cm spacing; at the 30-cm spacing it increased as the rate increased to 1,000 seeds/row, then decreased at 1,250 seeds/row. When the plant density was increased in both cultivars, the number of tillers per plant, number of capsules per plant, yield per plant, and seed-to-straw ratio decreased, whereas lodging increased and the number of seeds per capsule remained the same.

Results with one cultivar susceptible to injury by MCPA and two others resistant to it suggested that differences in the amount of damage do not depend on the area exposed to spray interception, which in turn depends on the growth habit of the plant. The growth curves of three comparatively resistant cultivars, Noralta, Raja, and Redwood 65, showed detectable differences after the application of MCPA.

Corn

Breeding. Two hybrids, Dawson M405 and Morden 7G, were licensed. One experimental hybrid had 4% less moisture and produced 19 q/ha more grain than the hybrid Morden 67.

Sunflowers

Breeding. The ability to restore pollen fertility, identified in two collections of wild *Helianthus annuus* L., and simply inherited, is being incorporated into the cultivar Krasnodarets so that this cultivar and inbred lines with cytoplasmic male sterility can be used to produce male fertile commercial hybrids.

Oilseed quality. Analyses of inbred lines originating from the world collection showed a range of 0.2% to 9.7% in the nonneutral or polar lipid fraction of the oil; in many refining operations this fraction is considered waste material. The oil-free meal from these lines contained from 0.75 to 3.25 mg of chlorogenic acid/g of meal. Chlorogenic acid is the phenolic constituent in the meal that is

mainly responsible for yellowing during alkali extraction of the protein. However, meal with the lowest levels of chlorogenic acid still showed some yellowing.

Inbred lines containing from 17% to 88% linoleic acid, which is an extremely wide range for sunflowers, have been isolated.

Diseases. Sclerotinia sclerotiorum (Lib.) De Bary caused serious root rot in southern Manitoba. The eruption of this root rot as a major disease is associated with the increasing use of susceptible host crops, particularly rapeseed. Many common broad-leaved weeds are also susceptible and contribute to the problem. In another new development, root-rot diseases caused by species of *Pythium* and *Rhizoctonia* have become widespread in Manitoba and Saskatchewan, and have caused premature ripening.

Weed control. Trifluralin applied at half the recommended rate combined with postemergence harrowing controlled weeds as well as, or better than, the herbicide used alone at the full recommended rate. Wild mustard, which cannot be controlled in sunflowers with the present herbicides, was controlled by harrowing. Effects on yields of the crop have not been studied sufficiently to determine if the combination of trifluralin and cultural means of weed control is economically practical. The method would not be suitable for use where wild oats are a problem. One compound, an analogue of trifluralin, showed some promise for control of grass and most broad-leaved weeds except wild mustard.

VEGETABLES

Potatoes

Breeding and assessment. The chipping cultivar Norchip, from North Dakota, has received a temporary license in Canada. The Fredericton seedling F6075 was found to possess high early-yielding ability, and it surpassed Warba in smoothness of conformation. Another seedling, F6212, gave a higher yield than Netted Gem and was of equivalent quality. The Fredericton-Scott seedling FS6339 and two introductions from the United States, Norchief and Chieftain, are promising replacements for Norland, a red variety grown for table stock.

Netted Gem has been crossed successfully with other cultivars or selections to combine the good processing quality of this cultivar with the earlier maturity, good yield, and characteristics of *Solanum andigenum* Juz. & Buk. Success in crossing in an evaporation-cooled greenhouse varied according to the season. In the spring, three times more fruit set and nine times more seed were produced per pollination than in the summer.

Preconditioning. Three potato cultivars were planted and harvested according to a schedule that provided tubers at different stages of maturity from soil at different temperatures. The tubers were preconditioned at 21 C for 5 weeks and stored at 4.4 and 7.2 C. The preconditioning had a differential effect on the subsequent color of chips. Preconditioned Norchip tubers at five different stages of maturity all had good chip color when processed after storage at 4.4 C. Neither F5889 nor Kennebec produced chips of acceptable color after storage at 4.4 C. Norchip and F5889 at all stages of maturity gave chips of good color after storage at 7.2 C, but only the most mature tubers of Kennebec produced chips of good color after storage at this temperature. The results suggest that preconditioning interacts strongly with other factors such as cultivar, stage of maturity, soil temperature, and storage temperature.

Cucumbers

Radiation-induced mutations. Golden cotyledon, induced in seed treated with gamma radiation, was shown to be controlled by a single recessive gene, designated *gc*. The gene was seedling-lethal when homozygous. A form of male sterility, also found after seed irradiation, was characterized by abortion of the staminate blossoms and was controlled by a single recessive gene, designated ms_2. Meiosis was normal; pollen abortion and anther collapse occurred after division of the pollen grain nucleus. One male-sterile line also contained a reciprocal translocation that was not linked with the male-sterile character.

NEW CROPS

Fifty species of plants were observed in a search for new commercial crops. The following plants showed promise as seed crops: white lupine, *Lupinus albus* L.; horse bean, *Vicia faba* L.; coriander, *Coriandrum sativum* L.; lentil, *Lens esculenta* Moench; pinto bean, *Phaseolus vulgaris* L.; black mustard, *Brassica nigra* (L.) Koch; brown mustard, *B. juncea* (L.) Coss.; adzuki bean, *P. angularis* Wight.; and mung bean, *P. aureus* Roxb. Jerusalem artichokes, *Helianthus tuberosus* L., yielded 50% more tubers than potatoes and may have potential for producing industrial alcohol.

Essential oils were extracted from 12 species of plants. Dill, *Anethum graveolens* L., and peppermint, *Mentha piperita* L., produced good yields of high-quality flavoring oils. A strain of *Monarda fistulosa* L. var. *menthaefolia* (Graham) Fern. produced high yields of oil with a high percentage of geraniol.

ORNAMENTALS

Breeding and Selection

A compact, oval-shaped, upright-growing, late-flowering lilac selection has been named 'Minuet' and will be released to the Canadian Ornamental Plant Foundation in 1972. This new lilac is from the cross *Syringa josiflexa* McKelvey 'Redwine' × *S. prestoniae* McKelvey 'Donald Wyman'. Mature plants, 1.75 m high and 1.35 m broad, are considerably smaller in stature than other cultivars of this group. Medium-sized spikes of light purple (75, Royal Horticultural Society color chart) flowers are born annually and profusely. Propagation is readily accomplished from softwood cuttings or by grafting scions to pieces of roots of green ash.

The objective in breeding hardy chrysanthemums is to produce lines that can be grown from seed. Selection, for almost 20 years, has produced lines with reasonable uniformity of stature and season of bloom, but uniformity in some flower colors is more difficult to obtain. Records of the color of 2,195 chrysanthemum seedlings indicated that petal color is controlled by multiple factors for yellow and two anthocyanin pigments. Yellow is a component of bronze and red, and the anthocyanins occur in pink, purple, bronze, and red flowers. Seedlings from controlled crosses were more uniform in plant stature, season of bloom, and flower color than seedlings grown from open-pollinated seed.

Seedlings of lupines highly tolerant to calcareous conditions have been obtained. They have a good portion of flowers in the three ranges of color: red to pink, blue to violet, and white to yellow.

Mildew caused by *Erysiphe polygoni* DC. ex Mérat was severe on *Monarda* species in 1971, but from observations among the many seedlings under test it appears that some degree of resistance is present.

Evaluation

Material is developing satisfactorily for a test of boulevard trees under street conditions; two cities are cooperating in the study. The first planting to produce trees of the selected strains, made in the spring of 1971, contains 671 plants of 21 taxa. In 1972, 942 plants of a further 25 taxa will be added.

The Research Station supplied 1,504 plants in 105 taxa to seven institutions cooperating in the Prairie regional trials for woody ornamentals. A report on the hardiness of 345 taxa of trees and shrubs, under this project, was given at the 1971 annual meeting of the Western Canadian Society for Horticulture; copies are available.

Propagation

As a result of research on poplar rootstocks, the hybrid *Populus* selection Brooks No. 6 is recommended as a rootstock for *Populus tremula* L. 'Erecta', a hardy upright cultivar of European aspen.

Studies with the seeds of *Prinsepia sinensis* (Oliv.) Oliv. and *Syringa amurensis* Rupr. var. *japonica* Franch. & Sav. have shown that the length of time required from sowing to emergence can be reduced by stratifying the seed for a period at 4 C followed by a warm period at 22 C. Seeds of these two species when sown outdoors in either fall or spring germinate late in the summer, and the small seedlings are subject to winter injury. When they germinate earlier, as a result of stratifying, they produce stronger seedlings that are more resistant to winter injury. *P. sinensis* requires 1 month of stratification at 4

C followed by 2 months at 22 C; *S. amurensis* var. *japonica* requires 2 months at 4 C followed by 2.5 months at 22 C.

Taxonomy

The distribution and genetics of a variant of the native *Monarda fistulosa* L. var. *menthaefolia* (Graham) Fern. have been examined. It is morphologically similar to the common type but is distinguished by its sweet smell caused by the geraniol content of 70% to 90% in its oil. An extension of the previously reported range of *Fraxinus nigra* Marsh. has been observed. Information on the morphology and chemotaxonomy of *Populus* has been obtained.

Currently, 2,798 native and cultivated plants are represented in the herbarium; 554 of these were added in 1971. Duplicate herbarium sheets of many of these are available for exchange. The Station's second *Index Seminum* listing seed of 240 taxa of native and cultivated plants has been distributed. It offers the seed for exchange with that of other scientific institutions.

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P. L. THOMAS, B.S.A., M.Sc., Ph.D.	Microbial genetics
P. H. WESTDAL, B.Sc., M.Sc., Ph.D.	Virus vectors

Pedology Section

R. E. SMITH, B.S.A., M.Sc.	Head of Section; Soil genesis and classification
G. J. BEKE, B.S.A., M.Sc., Ph.D.	Soil genesis, classification, and interpretation
P. HALUSCHAK, B.S.A., M.Sc.	Soil chemistry and classification
W. MICHALYNA, B.S.A., M.Sc.	Soil genesis, classification, and chemistry
C. TARNOCAI, B.S.F., M.S.	Soil genesis, classification, and ecology

VISITING SCIENTISTS

National Research Council postdoctorate fellow

R. A. SKIPP, Ph.D.	Plant pathology

Graduate students

P. A. BURNETT, B.Ag.Sci., M.Ag.Sci.	Entomology
F. G. KOSMOLAK, B.Sc.	Plant biochemistry
M. QUINONES, B.Sc., M.Sc.	Plant pathology
G. ROWLAND, B.Sc.	Cytogenetics

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[1]On transfer of work to the University of Birmingham, Birmingham, England, August 1971 to August 1972.
[2]On transfer of work to the University of Sydney, Sydney, Australia, August 1971 to June 1972.
[3]On leave of absence to Plant Breeding Station, Njoro, Kenya, East Africa, September 1, 1971, to May 15, 1972.

INTRODUCTION

Progress continued toward the goals of the Station, which include the development of high-yielding, disease-resistant varieties of common and durum wheat, barley, and oats that meet the quality requirements of millers, maltsters, and animal feed processors; the development of improved methods of protecting stored grain, oilseeds, and other food products; and the classification of the soils of Manitoba for agricultural and other uses.

New sources of wheat stem rust resistance in *Triticum monococcum* L. and of oat crown rust in *Avena sterilis* L. were discovered in collections made by the Canadian expedition to the Middle East. Several hundred other collections of wild species of wheat, oats, and barley from the Middle East are being evaluated as sources of resistance to several diseases.

The embryo-infecting barley smut *Ustilago nuda* (Jens.) Rostr. was hybridized for the first time with the seedling-infecting species *U. nigra* Tapke. This accomplishment is the first step toward meeting the goal of this project to combine all genes for virulence in each species into one seedling-infecting strain.

The insects important in the deterioration of oilseeds in storage were shown to be different from those associated with stored cereals. Development of newer methods may be required to protect oilseeds in storage.

Cooperation with the University of Manitoba in staffing the Wheat Improvement Program at Njoro, Kenya, was continued with the secondment of Dr. J. W. Martens until May 1972.

The mailing address of this establishment is: Research Station, Research Branch, Canada Department of Agriculture, 25 Dafoe Road, Winnipeg, Man. R3J 2M9.

W. C. McDonald
Director

BREEDING, GENETICS, AND CYTOGENETICS

Plant Breeding Methods

A simple method of calculating standard errors of heritability estimates was developed. The method was used to compare predicted and observed responses to selection for yield in five different populations of common wheat. The study showed that the observed response agreed with the response predicted by multiplying estimates of heritability by the selection differential.

The theoretical variance of response to modified pedigree selection was developed. Response is expected to be more variable with higher selection intensity or greater genetic variance, and less variable with larger population size or decreased environmental variance.

Two analytical assessments of the effects of infection with stem and leaf rust on the estimation of genotype–environment interaction for yield in wheat showed that rust infection was an important consideration. The results suggested that much of the genotype–environment interaction in qualitative traits may be due to simply inherited traits.

Barley Breeding and Genetics

Significant progress was made toward the development of disease-resistant two-rowed varieties with improved malting characteristics. One line, from cross no. 6916, was selected that possesses resistance to stem rust and net blotch, and a modifying enzyme system similar to the six-rowed malting variety Conquest. Crosses between this line and two-rowed varieties of superior agronomic type and high yield potential are being processed.

A gene for hulless kernels was backcrossed into Keystone and Conquest to produce high-energy feed barleys. Several of the backcross lines yielded as well as the hulled recurrent parent and had hectoliter weights of over 75 kg (i.e., over 60 lb/bu).

A gene for high lysine from C.I. 3947 is being transferred to adapted varieties. Higher lysine would be of nutritional value in feed barleys.

Oat Breeding and Genetics

Several strains combining better straw strength and yield with moderate resistance to stem and crown rust have done well for the second year in the cooperative oat trials, but the appearance of the grain sample of the highest yielding strains is less satisfactory than that of three strains from the same cross with slightly lower yields.

A preliminary evaluation of material with a complex of rust resistance genes derived from *A. sterilis* revealed that, although the rust resistance was outstanding, the agronomic performance was mediocre. Larger populations will be evaluated in 1972 and 1973 in an attempt to locate strains with superior productivity.

A number of strains from the hulless oat breeding program look very promising and they may be better than Vicar.

Genetic studies indicated that the fat content of oats is inherited relatively simply and that oats with 8–10% fat could be produced if feeding trials indicate that this level is desirable.

Common Wheat Breeding

In 1971, Neepawa, which was released in 1969, occupied about 10% of the acreage of common wheat in Manitoba and eastern Saskatchewan. Because Neepawa is higher yielding and more resistant to lodging than Manitou, its acreage should continue to expand. Both varieties are attacked by races of leaf rust that are increasing in prevalence. One of our projects is to incorporate four genes for leaf rust resistance into Neepawa by the backcross method of breeding. Some longer-term projects are to improve Neepawa's level of postharvest dormancy and physical dough characteristics, to add awns, and to shorten the straw.

Complementing the program on high-quality hard red spring wheat is a new program on white spring wheats. High yield is the major breeding objective along with associated attributes such as reasonable maturity, lodging resistance, and disease resistance. It is hoped that a white wheat class may lead to new export markets for Canada.

Durum Wheat Breeding

The cultivar Hercules, released in 1969, occupied approximately one-third of the durum wheat acreage in 1971. Tests on its improved pigment content and gluten strength showed it to be acceptable commercially.

The selection of entries for advanced comparative trials is directed toward producing lines with quality equal to Hercules, greater yield stability, and maturity and height equal to that of Hercules and the new cultivar Wascana. One line with promise has been tested for 2 years in the Cooperative Durum Wheat Test. For the Black soil zone, semidwarf durums are considered to be of value, and 14 lines were tested at two locations in 1971. Some of these lines have excellent yield potential, but problems of late maturity and starchy kernels have to be resolved. A large number of semidwarf lines were selected in earlier phases of the program.

Three recently initiated aspects of the breeding program on which work continued are solid-stem character for sawfly resistance, pubescent-leaf character for cereal leaf beetle resistance, and increased root rot resistance. Studies were initiated on the postharvest dormancy of durum wheats, and on the relationship of head size to yield potential.

Cytogenetics of Wheat

All but one of the seven monosomics for the D genome of the variety Canthatch have been produced. The remaining monosomic (5D) may be present in several remaining unidentified D-genome monosomics. These D-genome monosomics will be used in the cytogenetic analysis of characteristics such as stem and leaf rust resistance, and milling and baking properties known to be determined or influenced by the D-genome.

To obtain evidence for the hypothesis that *Triticum carthlicum* Nevski could be the tetraploid ancestral parent of common bread wheat, the milling and baking properties of five varieties of *T. carthlicum* were determined and compared with those of the tetraploids Stewart durum wheat and Tetra Canthatch (AABB component of Canthatch), two synthetic hexaploids, and the natural hexaploid Canthatch. One of the synthetic hexaploids was produced by combining Tetra Canthatch with *Aegilops squarrosa* L., R.L. 5271, and the other by combining one of the *T. carthlicum* varieties with the same *A. squarrosa* parent. Three of the *T. carthlicum* varieties were somewhat superior to Tetra Canthatch but much inferior to Canthatch in all quality characteristics. Both the

synthetic hexaploids were much improved over their respective tetraploid parents but considerably inferior to Canthatch. Of significance, however, was the better performance of the synthetic *T. carthlicum* × *A. squarrosa* over that of Tetra Canthatch × *A. squarrosa*. This is rather unexpected because Tetra Canthatch is the AABB component of Canthatch, a variety with excellent milling and baking characteristics. Based on quality, the results support *T. carthlicum* as a possible source of the AABB component of common bread wheat.

Several additional varieties of *T. monococcum* L., including six from the Canadian collection made in the Middle East, have good field resistance to stem rust. Two of these have genes different from *T. monococcum*, R.L. 5244, which has already been transferred to tetraploid and hexaploid wheats.

Several hexaploid or near-hexaploid lines were developed with good resistance to either stem or leaf rust; resistance was derived from the synthetic tetraploids *A. speltoides* Tausch × *T. monococcum* and *A. speltoides* × *T. aegilopoides* (Link) Bal.

Genetics of Wheat

A number of single genes for rust resistance were isolated by backcrossing to a susceptible parent. Lines with genes for leaf rust resistance from the varieties Terenzio, Rafaela, and E.A.P. 2612751 and a gene for stem rust resistance from a wheat–rye translocation, WRT × T^5, were obtained. The genetic relationships of these genes with other known genes must still be studied.

Two additional genes for leaf rust resistance were backcrossed into Thatcher, but they are still linked with characteristics that may be undesirable. One of the genes is linked with a gene for hard threshability and the other with a gene for brown chaff.

Genetic studies are in progress on five stem rust resistant varieties from Kenya and four leaf rust resistant varieties, of which two are from China, one from Afghanistan, and one from Ethiopia.

CEREAL RUSTS

Stem Rust of Wheat

Stem rust of wheat developed late in 1971. Appreciable amounts of stem rust were not present on wild barley until the middle of August and no susceptible-type pustules were found in farm fields of Manitou and Neepawa. Race C18 (15B-1L), the predominant race in 1970, declined drastically and only one isolate was obtained in 1971. Races C33 (15B-1L) and C35 (32-113), which predominated, comprised 53% and 26% of the isolates respectively. Five isolates of race C41 were obtained from Manitoba. This race is similar to race C35 but has additional virulence on gene *Sr11*. Races C35 and C41 have moderate virulence on seedling plants of Manitou and Neepawa and may be threats to these varieties.

Leaf Rust of Wheat

Development of leaf rust was later than normal and appreciable amounts of leaf rust were generally not present until the early-dough stage. Consequently, yield reductions were light. Races of leaf rust were similar to those isolated in 1970, and the trend continued toward avirulence on gene *Lr10* and virulence on Manitou and Neepawa.

Crown Rust of Oats

Crown rust damage to commercial oats was much less severe than in the 2 previous years, but the annual race survey showed an increased virulence in the pathogen population. Most of the isolates identified from Manitoba and Saskatchewan were of the virulent races 264, 295, and 326.

A new set of crown rust differentials, comprised of 10 near-isogenic lines of the common oat variety Pendek, was developed. Each line contained a single, different, crown rust resistance gene transferred from *A. sterilis*. The crown rust isolates collected in 1971 were also run to this new set, and a number of the *Pc* genes showed a very high level of resistance.

More than half of the 2,000 *Avena* collections obtained from the Middle East in 1970 were screened to key races of crown rust in seedling and adult plant tests. This screening revealed 11 collections of *A. sterilis* resistant to both cultures 305 and 326, suggesting the presence of new crown rust resistance genes even more effective than *Pc38* and *Pc39*.

Physiology of Parasitism

Shikimate-derived aromatic compounds in the host–parasite complex. An unknown ferulate-containing wheat metabolite consists of four isomers that are interconvertible photochemically. Nuclear magnetic resonance spectra of the mixture were too complex to yield information on structure. A chromatographic system was developed with which these isomers can be separated on a preparative scale and milligram amounts of one of them will be available shortly for structural studies. It is still uncertain whether this compound is biogenetically related to *N*-(feruloyl)-2-hydroxyputrescine and its congeners occurring in rust-infected wheat leaves.

Sterols. Wheat leaves of susceptible and resistant lines contained cholesterol, campesterol, stigmasterol, beta-sitosterol, and an unknown sterol that accounted for 75% to 80% of the total sterol content. Another sterol, stigmast-7-enol, occurred in all rust-infected leaves and in one of 11 samples of noninoculated leaves. Sterol levels were not related to susceptibility or resistance. The level of stigmast-7-enol in infected leaves appeared to be correlated with the amount of fungal mass in the host. Uredospores of stem rust contained trace amounts of an unknown sterol, cholesterol, and either ergost-7-enol or stigmasterol; and larger amounts of stigmast-7-enol. After germination the level of cholesterol increased, especially in differentiating uredosporelings. The level of stigmast-7-enol tended to decrease after germination. Sterol fractions from wheat leaves (healthy and rust-infected) and from stem rust uredospores (nongerminated and germinated) were not phytotoxic. They did not inhibit rust development in susceptible leaves nor did they promote it in resistant leaves.

Glycoproteins and buffer-soluble proteins from uredosporelings. TCA-extractable glycoproteins contained mannose, glucose, and several unidentified components. Those of undifferentiated uredosporelings differ in their composition from those of differentiated uredosporelings. Initial tests gave no indication that rust glycoproteins are capable of eliciting a hypersensitive reaction when injected into susceptible reacting leaves. Buffer-soluble proteins of uredosporelings were separated by thin-layer isoelectric focussing and will be tested for biological activity in the host–parasite complex.

Polyribonucleotides of host and parasite. Gel electrophoresis yielded six major fractions of wheat leaf RNA, and four major fractions of rust RNA. With sucrose density gradient centrifugation, rust RNA was fractionated into high-molecular-weight ribosomal RNA (16 *S* to 25 *S*), low-molecular-weight ribosomal RNA (5 *S*) and tRNA (4 *S*), and a fraction containing RNA of intermediate molecular size. Temperature shock of spores to restore germinability after storage in liquid N_2 and treatment with the detergent Triton X-100 to facilitate suspension and remove germination self-inhibitor did not affect the profile of RNA species. A method was developed to prepare spores for germination en masse on millipore filters without the use of Triton X-100.

Chemical Control

Ten antibiotics, candicidin, chloramphenicol, cycloserine, epidermidin, filipin, gramicidin, hikizimycin, mitomycin, mycostatin, and usnic acid, were screened in a bioassay. They were found to be inactive or too low in systemic activity to be suitable as fungicides for the control of rust diseases of cereals.

Plantvax emulsifiable concentrate and a new carboxanilido systemic chemical, 2-iodobenzanilide, were found to be more effective in controlling rust under field conditions than Plantvax 75.

A new systemic chemical, R.H. 124, controlled leaf rust of wheat after a single application at 0.45 kg/ha (0.4 lb/acre). This material may be economical for leaf rust control under present conditions of leaf rust attack in Canada.

OTHER CEREAL DISEASES

Smuts

In Manitoba and Saskatchewan collections of *Ustilago avenae* (Pers.) Rostr. were found that are virulent on varieties such as Harmon, Kelsey, and Rodney, which derived their resistance from Victoria.

A race of *U. tritici* (Pers.) Rostr. that carries a gene for virulence new for Canada was introduced to the Maritimes in seed of the European variety Opal. The standard set of differential varieties cannot detect this gene. The South African variety SONOP, P.I. 227060, was therefore added as differential

no. 14. Selkirk, Pembina, Manitou, Neepawa, and related varieties are resistant to this race.

The embryo-infecting smut *U. nuda* (Jens.) Rostr. was hybridized experimentally with the seedling-infecting species *U. nigra* Tapke. The F_1-spores were intermediate in color and germinated at 92%. Lysis of promycelia or later stages of development occurred in about 90% of the germinated spores. The surviving monokaryons have growth types that range from purely mycelial, similar to *U. nuda*, to purely sporidial, similar to *U. nigra,* but with intermediate types predominating. Sporidial cultures with the proline-requiring mating-type *a* of the *U. nuda* parent were isolated and gave final proof for interspecific hybridization.

Barley Yellow Dwarf

In 1971, aphid migrants moved into cereal crops in Manitoba later than usual and populations were generally low. The incidence of barley yellow dwarf virus (BYDV) on cereals was minimal. Virus strains isolated from infected plants were characterized as belonging either to the nonspecific or to strains transmitted specifically by *Schizaphis graminum* (Rondani). At least one of the latter isolated caused very severe stunting of Coast Black oats.

Nine isolates of BYDV, collected in farm fields in 1970, were transmitted more efficiently by nymphs of *Rhopalosiphum maidis* (Fitch) than by adults. Transmission of these isolates by nymphs of four other species of aphids was low or zero and was similar to the patterns obtained by adults. With one of the isolates, there was no difference between the number of *R. maidis* aphids in age groups 0–1 days and 3–4 days that transmitted virus, but progressively fewer aphids transmitted virus in age groups 6–7 days and 9–10 days. Only the aphids in the latter group were adults.

Tests in growth cabinets showed that the factor for tolerance to BYDV in the barley cultivar C.I. 5791 had carried over to some of the hybrids between this line and certain commercial varieties. The hybrids varied in their reaction to four different strains of the virus. Hybrid 62-528 was the most promising of those tested. Tolerance was higher when plants were inoculated at the four-leaf stage than at the one- and two-leaf stage.

Aster Yellows and Blue Dwarf of Oats

There was a very high potential for an epiphytotic of aster yellows (AY) and blue dwarf of oats (OBDV) in the Great Plains area of North America in 1971, because there was a large population of the leafhopper vector of the causal agents of the diseases and a high percentage of the population was infective. Of more than 1,000 migrant leafhoppers tested in the spring, 9.4% and 16.5% were infective for AY and OBDV respectively. Although the diseases were prevalent on susceptible crops, an outbreak did not occur. It is thought that the cool, wet weather in July and the mean temperature of 3 C below normal retarded development of both the vector and the diseases sufficiently to minimize the disease intensity and consequently the crop loss. A similar high potential for an outbreak of the diseases prevailed in 1970, but an outbreak did not occur. Apparently, persistent high temperatures retarded disease development and masked symptoms.

Tests were made to determine the influence of temperatures and stage of plant growth at inoculation time on the incidence of AY and yield of AY-infected barley. The results confirmed the field observations of reduced incidence of infection and reduced yield loss when temperatures varied significantly from the optimum for the aster yellows causal agent (AYCA). This was particularly marked when plants were beyond the seedling stage when inoculated. At 25 C, the optimum temperature for the AYCA, the mean incidence of infection for a number of trials was 60%, whereas at 20 C it was 45.6%. When growth cabinets were programmed to simulate daily temperatures of 20–35 C, the incidence of infection was 25.9%. Yields, after adjustment for the effect of temperature per se, were highest at the variable temperature, lowest at 25 C, and intermediate at 20 C.

At all three temperatures the incidence of infection and yield loss were reduced with advancing age of the plant at the time of inoculation. This finding suggests some degree of resistance or tolerance in mature plants.

Strains of AYCA. Tests on a large series of AYCA isolates collected in 1970 and 1971 showed that strains of the more virulent "western" type predominated to a marked degree over those of the "eastern" type to

which common wheat and oats are susceptible. Similar tests, carried out when wheat and oats were first found to be susceptible to AY, showed that the two types of strains were present in roughly equal proportions. The relative abundance of the different strains in Manitoba is a reflection of the vector–host–strain complex in the areas from which the leafhoppers migrate into Manitoba. Wheat and oats appear to play a minor role in the epidemiology of the disease.

Screening of barley varieties for resistance to AY. Approximately 3,000 varieties of barley have been screened for resistance or tolerance to AY. Although no resistant material has been located, there is evidence of some degree of tolerance in some varieties. Tests will continue in an attempt to screen most of the world collection of barley varieties by 1972.

Barley Stripe Mosaic

Barley stripe mosaic virus (BSMV) was detected by infectivity and serological assays in 34.0% of 144 fields of two-row barley and in 4.5% of 44 fields of six-row barley surveyed in southeastern Manitoba. In most of these fields the incidence of plants with BSM symptoms varied from a trace to 5%. Herta was the barley variety most commonly infected with BSMV.

A study was made of symptomless BSMV infection as detected serologically in Herta barley under natural field conditions. In two fields of generally vigorous plants containing diseased plants scattered evenly throughout each field, the incidence of symptomless plants infected with BSMV was approximately equal to the incidence of plants with symptoms. In two other fields with predominantly unthrifty plants, most plants with BSM symptoms occurred in small patches of vigorous plants. Although the incidence of plants with symptoms in these patches was sometimes very high, no symptomless BSMV-infected plants were detected in unthrifty parts of these fields.

Differences in symptom severity induced in Black Hulless barley by different BSMV strains were not consistently correlated with the level of infectious virus in this host or with the concentration of virus used for inoculation. Strains that induced milder symptoms protected this barley from infection by strains that induced more severe symptoms.

Seed Treatment

The microfaunal components on 37 lots of buckwheat seed, harvested in Manitoba, were determined after 7 days' incubation. Field fungi predominated, with a high incidence of *Botrytis* sp. Storage of 11 tough and damp lots of buckwheat for 390 days in sealed jars in an unheated storage shed resulted in decreased germination, decreased infection with field fungi including *Botrytis*, increased infection with storage molds, and increased moisture content. In contrast, a dry sample in storage for the same period showed increased germination, reduced *Botrytis*, increased *Cladosporium*, no storage molds, and decreased moisture content. Emergence was significantly decreased from seed with high *Botrytis* levels at Brandon, Man., and was not improved with seed treatment. No phytotoxic symptoms were observed with 14 seed-treatment chemicals in field trials in 1970 and, with the possible exception of Manzate 200 (Du Pont of Canada Ltd.) at 2.60 g/kg and 5.20 g/kg, emergence was not reduced by any of the 10 treatments used in 1971.

The effects of 10 fungicide formulations on the microflora of wheat, barley, buckwheat, flax, rape, sunflower, and crambe seeds incubated for 7 days were investigated. The decreasing order of effectiveness of fungicides against fungi on the crops was Manzate D (Du Pont of Canada Ltd.), Benlate T (Du Pont of Canada Ltd.), Panogen Px (NOR-AM Agricultural Products Ltd.), Vitaflo (UniRoyal Ltd.), Arasan 75 (Du Pont of Canada Ltd.), TCMTB (Buckman Laboratories Ltd.), Polyram (Niagara Chemicals), Benlate (Du Pont of Canada Ltd.), Vitavax S1 (UniRoyal Ltd.), and Afugan (Canada Hoechst Ltd.). Synergistic effects were noted with Benlate T and Vitaflo. Benlate T was as effective as Manzate D in controlling *Alternaria* spp., *Botrytis* sp., *Cladosporium* spp., *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, *Penicillium* spp., *Rhizopus* sp., and *Streptomyces* spp., whereas the individual components Benlate and Arasan 75 were usually less effective. Because many fungicides used at similar dosages gave less control of subhull inoculum in special and oilseed crops than in cereals, it is apparent that this inoculum is hard to control.

The maximum adherence of five seed-treatment fungicides onto seven different oilseed, buckwheat, and cereal seeds was determined and related to physical and chemical characteristics of the seed of the crops. Adherence was related to the amount of surface area per 36 liters (bu) and to surface features of seed of the crops and not to the number of seeds per 36 liters (bu). The fungicides adhered most to rapeseed, which had a high surface area per 36 liters (bu) and a very rough surface. The fungicides, arranged in increasing order of adherence to seeds of crambe, sunflower, barley, buckwheat, wheat, flax, and rape are Panogen Px, Vitaflo DB, Arasan 75, Manzate D, and Benlate T. Manzate D and Benlate T had much greater adherence and smaller, more friable particles than the other fungicides. Panogen Px depends for effectiveness on its volatility, thus less adherence and larger aggregated particles are not factors limiting its use.

FIELD CROP INSECTS

Soil Ecology

A technique for examining soil fauna and flora was developed. Autoclavable, perforated drinking straws were sealed at both ends and filled with pearl barley pellets coated with limestone and molasses, with and without pesticides. The straws were moistened and placed vertically in field soil 5 cm from durum wheat plants. After 1, 3, 6, and 10 weeks microfaunal components adhering to and inside the straws were counted. The straws were inhabited by fast-moving Collembola, slower-moving mites, and nematodes. Mites and nematodes bred and then decreased in numbers because of overpopulation or staling of the medium. Mites were able to thrive better than Collembola within the straws. Nematodes increased in numbers when mites were reduced by the acaricide, propargite. The drinking straws are cheap and inconspicuous, and can be used to determine the mobility, vertical distribution, and antagonisms of the dominant microfaunal components. They permit the measurement of the efficacy of soil treatments against these components with time. But they have the disadvantages that some microfaunal genera are not isolated, pellet debris makes organism counts difficult, and variations in soil texture can alter movement of organisms into the straws.

Insecticides

Ten insecticides, four of which had not been tested before, were evaluated for sugarbeet root maggot control. Aldicarb, as in 1969 and 1970, reduced maggot infestations and increased beet yields most effectively. Aldicarb is expensive and registered for use in North Dakota, whereas carbofuran is cheaper and is registered in Canada but not in the USA; a cost calculation based on experimental plots was therefore of interest. Carbofuran had a greater cost benefit than aldicarb in both Manitoba and North Dakota.

Fensulfothion performed better as surface bands than as a furrow treatment. It was not phytotoxic to either seedling stands or stands after thinning. Although reductions in root maggot numbers were not different on the treated plots, the 4- to 5-inch bands increased the number of beets harvested and beet weight. Root maggots reduced the stand 11% on untreated plots. Improved performance was related to the increased dosage required to apply satisfactory bands.

In tests for the control of the red-backed cutworm in sugar beets, sprays of leptophos and Dursban (Dow Chemical Canada Ltd.) at 560.5 g/ha (8 oz/acre) gave as good seedling protection as endrin at 280.3 g/ha (4 oz/acre). Trichlorfon bait was as effective as these insecticides at 1,681.5 g/ha (24 oz/acre). Although trichlorfon appeared attractive to cutworms, application methods may limit its use.

The persistence of the insecticides trichloronat, fonofos, fensulfothion, and carbofuran in topsoils and subsoils from Morden (loamy sand), Plum Coulee (sandy loam), and Glenlea (clay) was examined over a period of 8 weeks. The soils were stored at 30 C and at a soil moisture equal to 90% of field capacity. Using the onion maggot assay, trichloronat was the most toxic insecticide in all soils. Bioactivity decreased rapidly in subsoil from Morden, in both soil fractions from Plum Coulee, and in Glenlea topsoil. All insecticides lost activity rapidly in Plum Coulee soil, whereas fensulfothion persisted longer in Morden and Glenlea soils, which required relatively high concentrations for initial mortalities.

Grasshopper Surveys

Surveys carried out during the summer indicated the beginning of another grasshopper outbreak, because population densities and the size of the areas infested had increased. In 1971 the survey of adults showed an infestation of 8,096 km^2 (3,126 sq miles): light infestation, 5,164 km^2 (1,994 sq miles); moderate, 2,797 km^2 (1,080 sq miles); severe, 135 km^2 (52 sq miles). In 1970 the survey showed an infestation of 1,189 km^2 (459 sq miles): light infestation, 1,000 km^2 (386 sq miles); moderate, 189 km^2 (73 sq miles). Approximately 2,146 ha (5,300 acres) were sprayed in 1971 for the control of grasshoppers. The forecast of grasshopper infestations for Manitoba in 1972 shows 10,287 km^2 (3,972 sq miles) infested of which 5,206 km^2 (2,010 sq miles) are light, 4,874 km^2 (1,882 sq miles) moderate, and 207 km^2 (80 sq miles) severe.

INSECTS AND MITES IN STORED PRODUCTS

Surveys

A survey of grain stored in open piles or temporary structures was conducted in May 1971. About 28% of 2,473 kl (68,000 bu) of the grain examined was spoiled by insects, or microorganisms, or both.

One hundred and forty-two samples of barley, wheat, oats, and corn were collected in the three Maritime Provinces during a 2-week exploratory trip early in September 1971. Heavy infestation of all commodities was found in all provinces.

Ecology

Cultivar reaction of oilseed, clover, and millet to infestation by stored-grain insects. Infestation potential of 16 cultivars of flax, mustard, rape, sunflower, millet, and clover seeds to five common species of stored-product insects was determined by studying the development and the rate of multiplication of the insects on whole and crushed seeds. When multiplication was used as a criterion, whole seeds were resistant to insect attack, although minor infestation occurred on certain cultivars. Neither whole nor crushed seeds of three clover cultivars were infested by the insects. The mustard cultivar Gisilba was also uninfested, although 2% of *Tribolium castaneum* (Herbst) and 4% of *Oryzaephilus mercator* (Fauvel) eggs developed on this seed. The effect of cultivars on the insects was more pronounced among millet and rape cultivars than among those of sunflower and flax. Oilseeds were more susceptible to *O. mercator* than to any other insect species. *Cryptolestes ferrugineus* (Stephens), which thrived on the millet cultivars Crown and Siberian, neither reproduced nor completed development on any of the oilseed or forage cultivars. All the cultivars of crushed flax, Noralta, Raja, and Redwood, were susceptible to *O. mercator, O. surinamensis* (L.), and *T. castaneum*; the rape cultivars Echo and Target only to *O. mercator*; the sunflower cultivars Armavirec, Krasnodarets, Mennonite, and Peredovik to all insects except *C. ferrugineus*; and the millet cultivars Crown and Siberian to all insects. *Tribolium confusum* Jacquelin du Val. reproduced only on sunflower and millet cultivars. The potential danger to stored oilseeds in Western Canada from a new pest, *O. mercator*, was also evaluated.

Insect–fungus interaction—a laboratory study. Nine species of stored-product insects representing eight genera in six families of Coleoptera and one genus of Psocoptera were exposed to 23 species of seed-borne fungi and one actinomycete cultured on potato-sucrose agar in the laboratory. Some feeding by all nine species was observed on *Cladosporium cladosporioides* (Fres.) De Vries, *Nigrospora sphaerica* (Sacc.) Mason, and *Alternaria alternata* (Fr.) Keissl. Most insects rejected *Streptomyces griseus* (Krainsky) Waks. & Henrici, *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur., and *Aspergillus* spp. *Sitophilus granarius* (L.) and *Rhyzopertha dominica* (F.) fed lightly on a few but failed to reproduce on any microorganism. The psocid *Lepinotus reticulatus* (Enderlein) and the beetles *Lathridius minutus* (L.) and *Microgramme argus* (Reitter) were the most successful fungivores.

A multivariate study of temporary outdoor grain bulks. To determine the usefulness of plastic covers on temporary grain piles, 901 samples were collected from 16 grain bulks in Manitobá in 1970. Thirteen variables, abiotic, microbial, and entomological, were measured and subjected to discriminant

function analysis. Preliminary results indicated that germination is not affected by covering, but there is an effect of covering that differs between cereals on the number of mites present and also on the amount of *Helminthosporium, Fusarium*, and *Actinomycetes* present. It seems that there is some advantage in covering bulks with plastic sheets provided there is room for ventilation at the top.

PEDOLOGY

Classification and Mapping

The Pedology Section, working cooperatively with provincial pedologists through the Manitoba Soil Survey, investigated in a broad reconnaissance survey approximately 843,181 ha in the Pointe du Bois (N.T.S. 52L) map sheet area in the southeastern sector of the province. Cooperative soil capability for agriculture studies with the Manitoba Canada Land Inventory group, Manitoba Department of Mines and Natural Resources, were completed on approximately 4,330,000 ha. This project within the designated ARDA area in Manitoba is finished.

A cooperative program, between the Canada Remote Sensing Center and the Pedology Section, to evaluate photographic imagery and infrared (IR) thermal scanning was undertaken at a number of test sites in various parts of the province. An evaluation of imagery produced in 1971 indicated that dependable differences in multispectral response patterns of various kinds of landforms were obtained from near infrared color, panchromatic black and white, and color photographs. IR imagery is useful in providing information about soil drainage, soil salinity, and subsurface changes in texture when scanning conditions are favorable. Generally, IR can readily distinguish open water and areas with moist surfaces from those that are dry. Use of multispectral data could well improve the accuracy of soil resource mapping. The effects of management practices in agricultural regions tend to complicate interpretation of data for terrain analysis. The gap between interpretive technology and systematic soil survey is still too wide to make full use of available multispectral data.

Soil Characterization

Chemical and mineralogical characteristics of cutans from B horizons of three Manitoba soils. Cutans from Orthic Black, Orthic Dark Gray, and Orthic Gray Luvisol soils contained higher amounts of total N and dithionite-extractable Fe than their respective horizon samples. Cutans from the Orthic Gray Luvisol contained, in addition, more organic matter and fine clay and had a slightly different distribution of clay minerals than its Bt horizon sample. Differences between the characteristics of the cutans examined and their corresponding horizon samples were small. These slight differences were attributed to sampling and the methods used.

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Experimental Farm
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INTRODUCTION

This report outlines the significant results of the research program at the Experimental Farm at Indian Head for 1971. None of the research is reported in detail. Significant results on long-term projects are mentioned. Results of our testing program are incorporated in the information on which practical recommendations are made to guide farmers in Saskatchewan concerning cereal crops, forage crops, fertilizer use, weed control, and rotations.

We increase and distribute Breeder, Select, and Foundation seed of cereals, oilseeds, and forage crops in cooperation with the Research Station at Regina.

Our program also includes a project for the testing and development of several lines of oats that show excellent promise, specifically as a forage oat for feeding cattle. Correspondence should be addressed: Director, Experimental Farm, Research Branch, Canada Department of Agriculture, Box 760, Indian Head, Sask., S0G 2K0.

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FIELD HUSBANDRY

Rotations and Soil Fertility

For 14 years plots have been sown continuously to wheat. When N at 18 kg/ha and P at 8 kg/ha were applied, this crop outyielded wheat in a 2-year rotation by 6.4 q/ha, based on the total acreage under cultivation. Canada thistle is increasing in these plots, but annual weeds were controlled effectively with herbicides. In another continuous crop sequence wheat, barley, and flax were rotated for 4 years. When P at 12 kg/ha and N at 67 kg/ha were applied, wheat averaged 38 q/ha, barley 27 q/ha, and flax 11.8 q/ha. In another rotation a bromegrass–alfalfa mixture was grown for 3 years, then the plots were broken and summerfallowed. The wheat averaged 35.4 q/ha on summerfallow and 17.5 q/ha on stubble. These yields equal those in a grain rotation where recommended rates of N and P were applied. Crops have been sown in a 9-year rotation for 60 years in fields where the soil is classed as Indian Head heavy clay. Yields have been maintained by the use of legumes and barnyard manure without commercial fertilizers. Wheat on summerfallow in 1971 yielded 38.6 q/ha, and oats as the second crop yielded 42.8 q/ha. Over 60 years these crops averaged 24.7 q/ha and 18.8 q/ha. For 15 years, wheat, oats, barley, and flax have been sown after both wheat and flax. In 1971, the yields of the cereal crops after flax were higher than after wheat, but over the 15-year period yields did not differ.

Rates of Seeding

Rates of seeding wheat on summerfallow were compared for 3 years at eight locations in southeastern Saskatchewan. These rates ranged from 34 to 202 kg/ha, and P at 9 kg/ha was applied at each rate. The optimum rate of seeding was 67 kg/ha at Arcola, Aylesbury, and Viceroy; 101 kg/ha at Kelliher and Langenburg; and 168 kg/ha at Fleming and Yorkton. The crops matured faster as the rate of seeding increased. More weeds grew in the plots sown at the light rates, but they were well controlled with herbicides. On the Experimental Farm, wheat was seeded at 34 to 134 kg/ha. Five levels of P were applied at each rate. Although the plant count was much lower at the light rate of seeding, each plant produced more heads, which resulted in little difference in yield. The light rate of seeding delayed maturity. The response to fertilizer was the same at all rates.

Fertilizers

Several rates of N were applied with P to stubble wheat at 20 sites in southeastern Saskatchewan. The NO_3-N in the 0–60 cm depth of soil ranged from 22 to 66 kg/ha. The response to additional N was well above average. The increase in yield ranged from 12 kg/ha with N at 22.4 kg/ha to 30 kg/ha with N at 90 kg/ha. In another group of tests at the same locations, wheat on summerfallow responded to additional N, even though the soil contained a high level of N.

For 27 years P at 4.7 to 23.7 kg/ha was applied to wheat sown on summerfallow on the Experimental Farm. In 1971, the 0–15

cm depth of soil in the check plots contained 9.9 kg of P/ha, and the plots that received 23.7 kg/ha every third year had 17.7 kg/ha, indicating a marked increase in available P. The response to fertilizer in 1971 was about the same as at the start of the experiment. For the past 4 years in this project, P at 9.4 kg/ha and N at 22.4 kg/ha were applied to all stubble plots except the checks. The yield of the fertilized plots averaged 19.3 kg/ha and the checks 9.7 kg/ha. All fertilized plots yielded about the same, irrespective of the available P in the soil.

Manure has been applied at 13, 20, and 26 metric tons/ha, once every third year, over a 25-year period to Indian Head heavy clay soil. Available N and P have increased in all plots. Yield increases are much greater now than in the early years of the experiment. In 1971, wheat on summerfallow on the plots that received 20 metric tons of manure/ha yielded 43.6 q/ha compared with 35.5 q/ha for the checks. In the stubble plots the same treatment increased the yield by 7.2 q/ha. For maximum production on the stubble plots additional N would be required.

In a soil with a medium rating for available N and P, stubble barley yields were greatly increased by the use of N at 45 kg/ha. The application of N was just as satisfactory in the fall as in the spring. Urea applied to the surface produced increases comparable to ammonium nitrate.

For 15 years all stubble was burned off some plots, and all combine residue was incorporated in the soil in others. The NO_3-N in these plots and the yield of wheat varied little over this period.

All the growth on some of the plots on summerfallow was controlled with chemicals. The yield of wheat on these plots was compared with the yield on plots cultivated at least five times during the summerfallow period. The yields were comparable, but the use of chemicals is not practical because they are expensive.

Twelve rates of N and six rates of P were applied to established stands of bromegrass–alfalfa mixtures for 3 consecutive years. Although significant increases in yield resulted from these treatments, few of them were profitable. At one location in the first year the alfalfa decreased from 54% to 24% as the rate of N was increased from 11 to 124 kg/ha. After another 2 years of treatments, the alfalfa had decreased a further 13% in all plots. At another location N did not affect the percentage of alfalfa the first year, but after the next 2 years, N at rates greater than 34 kg/ha decreased the alfalfa in the mixture by 9%.

Weed Control

The yields of wheat and barley approached normal in plots where picloram had been applied at rates up to 1 kg/ha 3 years previously. For complete eradication of Canada thistle from these plots, herbicides had to be applied again.

Mecoprop at over 1 kg/ha, and a mixture of dicamba, 2,4-D, and mecoprop at a minimum rate of 0.5 kg/ha controlled cow cockle without injuring wheat. Alachlor at 2.5 kg/ha appeared to control green foxtail growing in wheat and barley. Trifluralin at 1 kg/ha used as a preemergence herbicide gave excellent results. Small bugloss was severely retarded by an ester of 2,4-D at 0.6 kg/ha and by 1:1 combination of mecoprop and MCPA at 1.2 kg/ha. Early application of these herbicides was essential for control.

The weed population has been reduced in plots where 2,4-D and MCPA have been applied at a light and heavy rate once each year since 1948. In 1971, the weeds averaged 2.7/m^2 in the plots where the light rate was used, 2.3/m^2 where the heavy rate was used, and 32.6/m^2 in the checks.

PLANT SCIENCE

Cereals

The growing season was excellent for cereals. Adequate reserve moisture was available to assure even emergence and to maintain growth. The month of May was one of the driest on record; June and the first half of July were wet. No effective rain fell between July 6 and October 18. Maturity was hastened by a lack of soil moisture during the critical ripening period. This narrowed maturity variations and caused a reduction in kernel size and plumpness. Rust was not a factor this year. Regional tests were made at seven locations in addition to the Experimental Farm. Yields were the second highest on record. Neepawa yielded 31 q/ha (46 bu/acre) and averaged 0.67 q/ha (1 bu/acre) more than Manitou. Canthatch yielded the same as Neepawa; the yields of Cypress,

Chinook, and Selkirk were all lower. Pitic 62 yielded only 10% more than Neepawa, matured late, and produced shrunken kernels with a low weight per measured unit of volume. Wascana and Hercules durum wheats yielded 30 q/ha (44 bu/acre), which was 0.7 q/ha (1 bu/acre) higher than Stewart 63. Apparently the year was favorable for Hercules and Wascana. Random, Kelsey, and Sioux oats produced the highest yield, 37 q/ha (96 bu/acre); Fraser yielded 0.4 q/ha (1 bu/acre) less. Galt, a feed barley of the six-rowed type, had the highest yield, 39 q/ha (73 bu/acre); Bonanza, a malting variety, was next with a yield of 39 q/ha (72 bu/acre). Of the two-rowed barleys Centennial had the highest yield 39 q/ha (72 bu/acre); Conquest yielded 34 q/ha (63 bu/acre). Redwood 65, the highest yielding flax, produced 16 q/ha (26 bu/acre). Noralta yielded 15 q/ha (24 bu/acre). Linott produced the lowest yield.

Cooperative evaluations of Breeders material, varieties, and lines of common spring wheat, durum wheat, barley, oats, and flax continued. Members of the staff at Indian Head and Swift Current sent several hundred promising selections from early-generation common and durum lines to California to be increased.

Forage Crops

There was a good moisture reserve in sod crops in the spring of 1971; the weather in May was the driest on record for this month. Perennial hay crops produced only an average crop, although June and the early part of July were wet. No effective rain fell between July 6 and October 18. Most perennials could only be cut once. Annual hays yielded very well, and the amount of dry matter was above average. Evaluation of Breeders lines, varieties, and introductions continued in cooperative and uniform tests.

A successful stand of new seedings was obtained on a new test area on the Experimental Farm. The new area is more productive than the old area, which has been subject to soil erosion in past years and now has some nonproductive sections. The dry weather in May caused poor establishment in tests of small-seeded species (i.e., crested wheatgrass progeny tests).

Management practices. Rambler and Beaver alfalfas that were cut for hay at the 10% bloom stage produced higher yields than when cut at the 25% bloom or full bloom stage. Usually cutting at the 25% bloom stage produces slightly higher yields. Chipping the aftermath in the fall had no effect on winter survival. The yields of alfalfa and grass in the same row were the same as when the grass and alfalfa were in alternate rows.

After 6 years, the use of alfalfa in the rotation significantly increased the yield of wheat on both summerfallow and stubble in 1971. The fertilizers N and P accentuated the increase. Grass alone had no effect on yields. The average increase for 4 years on stubble without fertilizer, where alfalfa had been grown, was 6.5 q/ha (9.6 bu/acre); where fertilizer and alfalfa were used it was 11.6 q/ha (17.2 bu/acre). Fertilizers (11-48-0 at 67.3 kg/ha (60 lb/acre) plus 34-0-0 at 112 kg/ha (100 lb/acre)) on the stubble, where grass alone with no alfalfa had been grown, increased the yield by 7.4 q/ha (11.0 bu/acre). In no year has the species × rate of fertilizer interaction been significant. During 1966–71 the fertilizer 11-48-0 applied at 56 kg/ha (50 lb/acre) in direct contact with the seed of Echo rape increased the yield by 3.4 q/ha (6.1 bu/acre). In 1971, the increase was 7.3 q/ha (13 bu/acre). Seedling growth was very markedly increased where fertilizer was used, providing better establishment and weed competition. The fertilizer 11-48-0 applied at 90 kg/ha (80 lb/acre) in direct contact with the seed did not affect germination of Echo rape. Several lines have been isolated out of Echo oilseed rape that are higher in yield and oil content and have improved seed size. Some 130 plants selected out of a bulk-screened lot of large-seeded SPAN (XL SPAN) oilseed rape appeared to have maintained their improved seed size. The content of erucic acid will be established. Fifty quintals (110 cwt) of a yellow-seeded rape were grown for later feeding trials. A cooperative forage oat test at 11 locations across Canada has been coordinated for the last 2 years from Indian Head. Two lines developed at Indian Head (1863-4 and 1863-44) have averaged 11% more dry matter than the standard Fraser. There appears to be satisfactory segregation in the early-generation oat crosses that are being worked on.

SOILS–HORTICULTURAL CROPS

Effect of crop rotation on some soil-borne pathogens of potato. Rotations had a marked effect on the incidence and severity of wilt disease and consequently on potato crop yields. The primary cause of the disease appeared to be *Verticillium albo-atrum* Reinke & Berth. *Colletotrichum coccodes* (Wallr.) Hughes was also isolated and a few pink fusaria were noted. The highest level of wilt occurred with continuous potatoes and in the second potato crop of a 6-year rotation; the lowest level occurred in a 3-year rotation. The first potato crop of a 6-year rotation had an intermediate degree of wilt. Black dot, caused by *C. coccodes*, occurred at a higher level than expected and at much the same level in all rotations.

Effect of fertilizer placement on potato yields. Split applications of ammonium phosphate and ammonium nitrate fertilizers produced higher potato yields than combined applications, provided the ammonium nitrate was applied at the early-bud stage of the potato plant. The applications of ammonium nitrate at the full-flower stage failed to produce significantly higher yields than the single applications of ammonium phosphate and ammonium nitrate. Considerably higher yields and a larger percentage of marketable tubers were obtained by surface placement of ammonium nitrate at the bud stage than by the side-band placement of ammonium nitrate at the bud stage. All plants were hilled and irrigated after the fertilizer treatments and at the bud and flower stages.

Effect of N and P fertilizers on yield and specific gravity of potatoes. Data collected for 7 years indicated that N at 56 kg/ha with P at 50 kg/ha produced a significant increase in total yield over that produced by the check. Slightly higher yields were obtained by increasing the rates of N and P.

The specific gravity of tubers increased with higher rates of P up to 50 kg/ha. At each rate of P (0, 25, 50, 75, and 100 kg/ha) increasing the rate of N from 0 to 56, 112, 168, and 224 kg/ha consistently decreased the specific gravity of the tubers.

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INTRODUCTION

The Research Station, Melfort, Sask., serves one of the largest and potentially most productive and diversified agricultural areas in Canada. The Station specializes in developing better methods for producing, harvesting, and utilizing forage crops. It also has an important research program on the production and utilization of cereal and oilseed crops, particularly rapeseed, because 85% of Saskatchewan's rapeseed crop is grown in the northern park belt.

The 1971 growing season from April to August inclusive was better than average, with a rainfall of 28 cm (+4 cm), an average daily temperature of 12 C (+0.2), and a killing-frost-free period above -2 C of 133 days (+11). These growing conditions favored a buildup of plant pests, most notably the bertha armyworm, which caused considerable losses to the rapeseed crop; thousands of hectares had to be sprayed from the air with methomyl (Lannate) in an all-out battle against this pest.

During the summer good progress was made in the forage harvesting research being conducted in cooperation with the Engineering Research Service at Ottawa. A hay-drying tower was built and a stacking wagon was used to evaluate and compare two new haying systems.

During the year a booklet entitled: *Forage Production and Utilization in the Aspen Parklands of Western Canada* was published. This, as well as our annual Research Highlights, is available on request. Enquiries for this and other information should be addressed to the Director or to the research scientist concerned, Research Station, Research Branch, Canada Agriculture, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Breeding and Evaluation

Sainfoin. Selected plants from a cross between *Onobrychis viciaefolia* (Scop.) and *O. vassilczenkoi* Grossheim were backcrossed to *O. viciaefolia* cv. Melrose. The resulting progeny were grown in an open-pollinated nursery. The open-pollinated progeny produced an average of 16% more dry matter and 39% less seed than Melrose.

The variety Melrose, licensed in 1969, produced dry matter and seed yields that have averaged 5,712 and 732 kg/ha for the past 3 years; for the variety Eski they averaged 4,749 and 348 kg/ha.

Alfalfa. For the past 4 years, seed yields of the varieties Rambler, Beaver, and Roamer have averaged 411, 343, and 296 kg/ha when the alfalfa leafcutter bee, *Megachile rotundata* (Fabr.), was used as a pollinator. Dry matter yields for the same period and varieties were 3,203, 3,382, and 3,536 kg/ha, respectively.

Sweetclover. For Yukon, Arctic, Polara, and Erector sweetclovers, 4-year average dry matter yields were 6,115, 5,589, 6,114, and 5,690 kg/ha and the 4-year average seed yields were 773, 748, 620, and 568 kg/ha.

Pollination Studies

Alfalfa leafcutter bee. The use of *M. rotundata* to pollinate alfalfa was successful in 1971, despite a short pollination period because of adverse weather in July. A field of Beaver alfalfa populated with 50,000 bees/ha yielded 404 kg seed/ha.

A new incubation system was perfected in 1970 and has been tested for the past 2 years by incubating over 0.5 million cocoons each year. As the bees emerge from the cocoons they are attracted to brightly illuminated collection trays located on the outside wall of the incubator. Collection trays are replaced as necessary to prevent overcrowding. Under this system incubation can continue without interruption; also, the percentage of bees that emerge is higher and the incubation period is shorter than under the conventional system, where incubation is completed under field conditions.

Production Management

Precision in estimating pasture production. The accuracy and reliability of sampling for pasture productivity estimates were investigated using 0.84- and 2.51-m^2 exclosures. Yield estimates based on the larger exclosures averaged 8% lower than those based on the smaller exclosures. For estimates of pasture production and its consumption by livestock to be within 90% confidence intervals around the mean, four exclosures were needed on each pasture when four replicates were used, 10 exclosures/pasture with three replicates, and 19 exclosures/pasture with two replicates. The size of the pasture, 2.43 or 0.61 ha, did not affect the sampling requirements.

Response to fertilizer applications in the Saskatchewan River delta. A timothy - alsike clover mixture was seeded in early June and harvested in early October 1971. Fertilizers at rates of 0 to 168 kg N and P/ha and 0 to 84 kg K/ha were applied at seeding time in a factorial design.

Dry matter yields ranged from 500 kg/ha from the control plots to 5,000 kg/ha from areas receiving P and N at 56 and 84 kg/ha. Applications of 84 kg N doubled dry matter yields at each rate of P, but additional N had no effect. Applications of 56 kg P quadrupled dry matter production at each rate of N, but higher rates of P did not further increase production. Dry matter production was not changed by adding K.

Forage Harvesting

Evaluation of hay harvesting and storage methods. In the summer of 1970, brome-alfalfa hay at the early-bloom stage was harvested by four methods: mower and rake; mower-conditioner-swather; mower-conditioner, windrow, and rake; and self-propelled swather-conditioner. Hay harvested by each of these methods was baled at 40% moisture, artificially dried, and stored under a roof; or baled at 20% moisture and stored under a roof; or baled at 20% moisture, stooked in the field for 3 weeks, then stacked outside.

The hays were fed to lambs as the sole diet. When artificially dried and immediately stored, hays harvested with machines equipped with crushers or crimpers had a higher feeding value than unconditioned hays. When they were stored (weathered) outside, they had a lower feeding value than the unconditioned hays.

When the hays formed 70% of ground complete rations for growing-finishing lambs, methods of harvesting, or baling and storing the hays, or both, had a significant effect on animal performance. In general, hay that was conditioned, left in a windrow, then baled without raking had a better feeding value than hay that was swathed and raked. Also, hay that was stooked in the field and weathered before being stacked outdoors had a lower feeding value than hay that was field-dried and promptly stacked under a roof. There was a range in value of about $20 per ton among the 12 hays involved in the test.

Utilizing Pastures

Management of steers on pasture. Four systems of managing steers on pastures of bromegrass, *Bromus inermis* Leyss., and alfalfa, *Medicago sativa* L., were compared for the 5th consecutive year. The four systems were: maintaining a low stocking rate and feeding back surplus pasture preserved as silage (control); maintaining a high stocking rate throughout the season and supplementing pasture herbage with oat soilage; maintaining the same high stocking rate but supplementing pasture with rolled barley; and "put-and-take" stocking. Fertilizer was applied at a rate of 90 kg N/ha for the 2nd consecutive year.

In 1971, the overall production of dry matter slightly exceeded the 5-year average (4,111 vs. 3,961 kg/ha). Herbage production under the put-and-take system continued to be lower than under the other systems.

Steers consistently gained an average of approximately 1.08 kg/day on all treatments except pasture with supplementary barley, on which gains averaged 1.26 kg/day. When pasture was supplemented with oat soilage, 396 kg of beef/ha were produced, whereas gains of about 285 kg/ha were obtained from the control and put-and-take systems. Steers fed supplementary barley produced an average gain of approximately 470 kg/ha.

Supplementary barley in the diet also increased losses from bloat. During the past 5 years, out of the 642 steers in this experiment six died from bloat; five of these were being fed supplementary barley. The losses occurred mainly during August when the ratio of

grain to pasture consumed was approximately 1:1. Therefore, although the potential net profit on pasture is increased by feeding supplementary barley, the degree of managerial skill required is also greater than for any of the other three systems.

Crested wheatgrass vs. Russian wild ryegrass for pasture. During the first 4 to 6 weeks of the grazing season, steers pastured on crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., consistently produced higher rates of gain and gain/ha than those on Russian wild ryegrass, *Elymus junceus* Fisch. However, crested wheatgrass tended to become dormant in midsummer and to lose nutritive value rapidly once it had headed. Thus, steers grazing Russian wild ryegrass could catch up in terms of gain per hectare and, in 2 of the past 5 years, in average daily gain, by the end of the grazing season.

Oat varieties compared as pasture. Two 0.1-ha plots of each of four oat varieties were grazed in rotation by growing lambs given free access to a creep feed. Average daily gain (g), lamb days/ha, dry matter production (kg/ha), dry matter consumption (kg/ha), creep feed consumption (kg/ha), and lamb gain (kg/ha) by variety were: Fraser, 304, 2,629, 6,209, 4,319, 1,383, 795; Harmon 272, 2,291, 5,918, 4,385, 930, 622; Kelsey, 268, 2,518, 6,409, 4,635, 1,474, 677; and OA-12301, 286, 2,291, 5,208, 3,541, 1,327, 652. Wastage of pasture dry matter ranged from 23% to 30%. In 1970, when no creep feed was fed, average daily gain across all varieties was only 163 g/head.

Utilization of Harvested Forages

Processing hay for wintering calves. Long, chopped, ground (5.08-cm screen), or finely ground (1.27-cm screen) hay was self-fed to groups of 13 Charolais × Angus steer calves. The hay used was from sweetclover, *Melilotus officinalis* (L.) Lam., and contained 12.6% crude protein. It was fed for 62 days from February to April, 1971. Records were kept of the labor, time, and fuel required to process the hay. Average daily gains by the four groups were 0.34, 0.45, 0.64, and 0.71 kg, and dry matter intakes were 6.71, 5.94, 7.44, and 7.48 kg. The improvement in efficiency of feed conversion more than compensated for the additional cost of processing.

Dehydrated alfalfa vs. dehydrated alfalfa silage. Six groups of four lambs were individually fed growing rations of crested wheatgrass hay and 10% or 20% dehydrated alfalfa; or the hay and 10% or 20% dehydrated alfalfa silage; or isonitrogenous basal rations containing hay and 4% or 8% rapeseed meal. When the alfalfa or alfalfa silage was included at the 10% level, voluntary intake and digestible dry matter intake were highest for lambs fed the silage form. However, at the 20% level, intake of the silage ration was lower than intake of either the alfalfa or the basal ration.

When 10% or 20% alfalfa or alfalfa silage was added to finishing rations containing 46% barley and oats (3:1), voluntary intake of the silage ration was lower than intake of the alfalfa ration at either level of inclusion.

Utilizing ground hay in starting rations and comparison of three anabolic implants for feedlot steers. Under self-feeding conditions, 282-kg Charolais × Angus steers placed on 90% grain rations at 9, 35, 71, and 109 days after the start of the feeding period showed no statistically significant differences in rates of gain, dressing percentages, or carcass grades. Steers in the four groups each consumed 22, 197, 394, and 591 kg respectively of ground brome–alfalfa hay as part of their ration, and their rate of gain varied from 1.36 to 1.45 kg/head daily. There was no indication that any liver or rumen damage occurred during the time taken to adjust to the high-grain ration, probably because the grain portion of all rations gradually changed from an oat–barley mixture to a barley–wheat mixture as the 166-day test progressed.

Within each of the four groups of 12 steers, three steers selected at random received no implant, three were implanted with 36 mg of diethylstilbestrol (Stimplants; Pfizer & Co.), three with 36 mg of Ralgro (Zeranol; Commercial Solvents Corporation), and three with progesterone - estradiol benzoate (Synovex S; E.R. Squibb & Sons). All implant treatments caused a highly significant increase in daily gains, which averaged 1.23, 1.55, 1.45, and 1.41 kg for steers on the four treatments. Dressing percentages and carcass grades were unaffected by implant treatment. The greatest growth response to the implant treatment occurred during the first 9 weeks, and ended by the 15th week with Synovex S and the 18th week with diethylstilbestrol and

Ralgro. (Note: Ralgro is not licensed for use in Canada.)

Packed vs. unpacked sweetclover silage. Sweetclover containing 74% moisture was ensiled, with or without packing, in uninsulated bunker silos. Wastage was 10.9% in the packed silo, caused mainly by freezing, and 29.4% in the unpacked silo, caused mainly by spoilage. The silages were fed to groups of calves, yearlings, and bred cows, with or without 1.8 kg of oats/head per day. Average daily gains for the calves, yearlings, and cows fed packed or unpacked silage without supplementary grain were 0.34 vs. 0.15, 0.26 vs. 0.31, and 0.34 vs. 0.48 kg, respectively. The corresponding values for daily dry matter intake were 4.4 vs. 4.3, 5.9 vs. 5.7, and 5.8 vs. 6.9 kg. When 1.8 kg of oats were added to the ration, the rate of gain increased by approximately 0.45 kg daily. Intake of silage was generally not decreased when oats were fed, and in some cases it was increased.

CEREAL AND OILSEED PRODUCTION AND UTILIZATION

Crop Breeding and Variety Testing

Oats. Considerable success has been achieved in developing strains with large kernels and a relatively low percentage of hull. Their straw strength is equivalent to that of Fraser and Random. Thus, the strains will be satisfactory for production in northern Saskatchewan under heavy applications of fertilizer.

One promising hybrid line was advanced to the Western Co-operative Oat Test in 1971. Forty-five lines from two crosses were placed in preliminary yield tests in Manitoba and Saskatchewan, and several show outstanding yielding ability and will be placed in advanced trials in 1972.

Rapeseed. Yields of low erucic acid rapeseed varieties (Span, Oro, Zephyr) were 93% as high as those of the standard varieties (Echo and Target) on the basis of a six-station-year average. Oil content averaged 41.6% for the low erucic acid varieties and 42.7% for the standards. Varieties of *Brassica campestris* (Span and Echo) required a growing season of 88 days, whereas the *B. napus* varieties (Zephyr, Oro, Target) matured in 97 days.

Corn. Field corn planted at Melfort on May 10 on summerfallow land and fertilized with 112 kg N/ha, 56 kg P_2O_5/ha, and 56 kg K/ha yielded from 11 to 15 metric tons of dry matter/ha, when harvested for silage on September 15, 1971. Some hybrids tested, such as C.D.1 and D × F, matured very little grain, but the hybrids 3 × F and Pioneer × 8145 yielded 75 and 80 hl of matured grain/ha, respectively, in 1971. The 2-year average dry matter yields of Morden 67 and Morden 88 were 14.5 and 17 metric tons/ha, when harvested for silage. In both seasons the growing conditions were good and the frost-free period was somewhat longer than normal.

Horse beans. Fifteen varieties of horse beans, *Vicia faba* L., were sown on May 4, but dry soil caused patchy germination and emergence was not complete until the beginning of June. As the beans required 115 to 125 days to mature, harvesting was not completed until October. The best varieties and their yields were: Fribo, 2,820 kg/ha; Ascott, 2,726 kg/ha; Herz Freya, 2,658 kg/ha; and Erfordia, 2,630 kg/ha. There were no adverse effects due to insects or diseases.

Crop Management

Crop rotation. Long-term crop rotation studies on several soils in northeastern Saskatchewan showed that inclusion of grass and legume crops in a rotation increases the yield of subsequent crops by over 10% and reduces the amount of summerfallowing required. This results in increased production and better control of soil erosion. One of the most productive rotations for many farms in the park belt of Saskatchewan consists of one-half of the land in cereal or oilseed crops, one-third in hay, and one-sixth in black summerfallow, on a regular basis each year.

Coated seed. Spring wheat and rapeseed coated with various plastic compounds were seeded on September 22 and October 13, 1970. Space was reserved in the test for spring seeding of uncoated seed.

A count taken in June 1971 showed 100% stand from spring seedings but only a few scattered plants from fall seedings of treated seed. In a cooperative trial with the Plant Science Department, University of Manitoba, the test was repeated in the fall of 1971 using improved seed-coating ingredients.

Effects of soil moisture and amendments on yield and quality of rapeseed. Soil moisture and amendment treatments on three Gray Wooded and one Dark Gray Wooded soil significantly affected yield, oil, and protein content of Target rape, *B. napus.* Low soil moisture tension resulted in the highest yields compared with high soil moisture tension. Under low moisture tension, amendments consisting of ammonium nitrate at 70 μg N/g soil or manure at 2.5% of soil weight gave the highest yields. The Dark Gray Wooded Nipawin loam soil with added ammonium nitrate under high moisture tension produced rapeseed with the highest protein content (43.3%). The lowest protein content (28.2%) occurred in rapeseed grown on control plots or with straw amendments on Waitville and Garrick loam Gray Wooded soils. Oil content ranged from 38.9% to 50.0%. Protein and oil contents were found to be inversely related (R^2 = 69.1%). The lowest fiber content, or highest protein plus oil, was found in rape grown on Dark Gray Wooded Nipawin loam soil.

Legumes for green manure. A 5-year study was conducted to determine the benefits of growing legumes as green manure crops on Black (Msic) and Gray Wooded (Gal) soils. Legume crops of alfalfa, *Medicago sativa* L., red clover, *Trifolium pratense* L., or sweetclover, *Melilotus officinalis* (L.) Lam., were tilled into either type of soil as green manure, before the bud stage of growth. This treatment produced a yield increase comparable with that produced with 76 kg N/ha as chemical fertilizer applied at the start of the summerfallow period. Tilling down the seedling stand of legumes for green manure in the fall of the first year's growth or in the following spring produced yield increases over yields of untreated control plots that approached significance (P = 0.05). Yields of wheat grown after legume hay or seed crops were similar to those produced on wheat stubble that received 76 kg of fertilizer N/ha in the spring. The beneficial effect of the legume crop on the second test crop of wheat was greater than that from the chemical fertilizer, especially on the Gray Wooded soil (Gal).

When the legumes were tilled down in the fall of the seeding year, the subsequent wheat crop produced better yields after sweetclover than after alfalfa or red clover, on both soil types. Sweetclover was also superior on the average to the other legumes in increasing the yield of wheat when the legumes were plowed down at the bud stage or later.

When the legumes were grown to the bud stage or later, the green manure generally increased the NO_3-N content of the surface soil, especially that of the Gray Wooded soil.

Yield response of barley as affected by fertilizer rates and available soil nitrogen. Yield response of Conquest barley to N fertilizer applied at 22, 45, 67, and 134 kg/ha with or without 20 kg P/ha was related by regression analyses to NH_4- plus NO_3-N and to NO_3-N alone, in soils of northeastern Saskatchewan. Both linear and quadratic equations obtained from the regression analyses were used to develop tables for estimating yield response of barley according to N fertilizer rates and soil tests for NH_4- plus NO_3-N and for NO_3-N alone.

A greater response to N fertilizer occurred with a given amount of NH_4- plus NO_3-N than with the same amount of NO_3-N alone. The difference in response supports the conclusion that NH_4-N in the soil has a significant effect on barley yields in northeastern Saskatchewan. Also, yield response to N fertilizer was greater when P was applied.

Confidence intervals showed that wide variation could be expected in yield response to N fertilizers. The variation was attributed to differences in soil type, soil moisture, and climatic factors among experimental sites.

Chemical summerfallow. The results of a 6-year study showed that, when up to 100% of the tillage normally required for summerfallowing was replaced by applications of herbicides, there was no significant reduction in the moisture or nutrient buildup in the soil or in the yield of the subsequent crop of wheat. The highest yields occurred when all but one tillage operation, on June 15, were replaced by treatments with herbicides. Substitution of herbicide applications for tillage to control weeds is often more effective and conserves a greater amount of trash for soil-erosion control. Because herbicides for the control of broad-leaved weeds are economical, whereas those for the control of grassy weeds are expensive, a combination of tillage to control grassy weeds and use of herbicides to control broad-leaved weeds is currently the most economical and efficient method of summerfallowing.

Weed control in field crops. Cleavers, *Galium* sp., is becoming a serious problem in rapeseed-growing areas because it is difficult to separate its seed from rapeseed. At Arborfield in 1971, this weed was controlled in barley with mixtures of dicamba, 2,4-D, and mecoprop (0.56 kg/ha); bromoxynil and MCPA (0.84 kg/ha); linuron and 2,4-D (0.35 + 0.35 kg/ha); or mecoprop alone (1.68 kg/ha). The herbicides were applied with water at 75 liters/ha when the cleavers were in the seedling stage of growth.

Wild oats, *Avena fatua* L., were effectively controlled in a 1971 crop of rapeseed by trifluralin at 1.12 kg/ha incorporated into the soil with a power rotovator in the fall of 1970. The fall application was superior to a spring application for wild oat control, but fall and spring applications were equally effective for the control of certain broadleaved weeds.

Crop Utilization and Animal Nutrition

Rapeseed screenings in rations for finishing steers. Rapeseed (refuse) screenings were incorporated at levels of 0%, 20%, 40%, and 60% of rations for finishing beef steers. Average daily gain, dry matter intake, efficiency of feed conversion, and dressing percentages were similar for groups fed 0% or 20% screenings. Increasing the proportion of screenings to 40% or 60% reduced average daily gain, efficiency of feed conversion, and dressing percentage. Carcass quality as measured by carcass grade decreased with each increase in the proportion of screenings in the ration.

Rapeseed meal in rations for market pigs. Rapeseed, *B. napus* cv. Target, meal was included at 0%, 5%, 10%, or 15% in a 16% crude protein, barley - soybean meal ration for growing–finishing pigs. As the amount of rapeseed meal increased, the rate of gain, feed efficiency, and dressing percentage were progressively reduced, but carcass grade improved slightly. The relative price advantage of rapeseed meal (7.7 ¢/kg) over soybean meal (13.2 ¢/kg) was not sufficient to justify its use as the sole source of supplementary protein, and there was no economic advantage in increasing the level of rapeseed meal above 5% of the ration.

Supplementary copper for growing–finishing pigs. Supplementary copper at 200 ppm added to a standard Record of Performance ration containing 18.7% crude protein improved the rate of gain by 2% and feed efficiency by 3.5%. When copper was added to a ration containing 18.1% crude protein, none of which was animal protein, the rate of gain was increased by 3% but feed efficiency was reduced by 2%. The addition of copper at 125 ppm to both rations had no effect on rate of gain or feed efficiency.

Adding 200 ppm of copper increased the amount of copper in the liver from 46 to 136 ppm (dry matter basis), which is still below the tolerance level set by the Food and Drug Directorate. Copper level in the loin eye muscle was less than 6 ppm (dry matter basis), regardless of the ration fed.

Response of barrows and gilts to changes in protein levels during growth. High (H) (17.2% crude protein) and low (L) (15.3% crude protein) protein rations were fed in various sequences to barrows and gilts during three growth periods (23 to 45 kg, 45 to 68 kg, and 68 to 91 kg). Barrows grew faster than gilts, but differences depended on the protein level of the ration. The difference was least in animals on the HHL treatment (barrows 0.78, gilts 0.74 kg/day) and greatest in those on the LHH treatment (barrows 0.75, gilts 0.62 kg/day). Feed-to-gain ratios ranged from 2.89 for barrows and 3.01 for gilts on the LLL treatment to 3.02 and 2.87, respectively, on the HLL treatment. Carcass grades were similar for barrows and gilts on treatment LLH (hog value index of 100.4 vs. 100.6) and quite different on treatment HLL (96.4 vs. 100.9). Ration quality (protein level) during the initial growth period was more important for gilts (reflecting a higher protein requirement, or lower feed capacity) than for barrows.

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Seed Section

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[1] On postdoctoral transfer of work at Weed Research Organization, Kidlington, England, September 1971 to August 1972.

INTRODUCTION

This is a report of the work done in 1971 at the Research Station, Regina. The Station continues to develop as the main center for weed research in Western Canada.

The new office–laboratory building was completed and the staff members who had been working in downtown Regina were moved to the main site. Three research scientists were added to the staff. Dr. J. H. Hunter started a program on weed control in field crops. Dr. S. U. Khan was transferred from the Research Station at Lacombe to undertake work on the interaction of herbicides with soil organic matter. Mr. G. S. Emmond came from the Experimental Farm at Indian Head to work on herbicide residues in soil. Mr. G. G. Bowes completed his educational leave and resumed his program on the control of weeds on rangeland.

Wascana durum wheat, which was developed here by Dr. E. A. Hurd before his transfer to Swift Current, was released to the public in 1971. We expect that it will replace other durum varieties in the Brown and Dark Brown soil zones.

The winter increase of plant breeders' material in California was expanded by 50% in 1971.

The mailing address of this establishment is Research Station, Research Branch, Canada Department of Agriculture, Box 440, Regina, Sask.

J. R. Hay
Director

WEED SCIENCE

Green foxtail. In 1971, green foxtail first emerged on May 31, at the same time as the wheat. These observations were typical of those made over a 6-year period. With a weed that germinates late in the spring, such as green foxtail, it is not possible to kill out a flush of growth by cultivation before seeding cereal crops. For optimum yields at the Station, these crops must be sown before the first week in June.

Over the 6-year period, there was further germination of green foxtail throughout the summer. Although the number of plants that germinated during each 2-week period was erratic, the average figures for the 6 years showed a smooth trailing off from the peak period in June.

The impression of farmers that green foxtail is worse in stubble crops than in summerfallow crops was confirmed. Over a 5-year period after the rotations were established, the number of green foxtail plants averaged 1,205/m^2 in wheat on fallow and 2,277/m^2 in wheat on stubble. These are the total emergence figures for the whole growing season.

In its first year of testing, C-20482 (CIBA-Geigy Canada Ltd.) at 2.24 kg/ha gave good control of green foxtail in wheat.

Crop tolerance to new herbicides. Postemergence application of C-20482 at 4.48 kg/ha, BAS 3510 (BASF Canada Ltd.) at 2.24 kg/ha, TO 2 (Mitsui Toatsu, Japan) at 3.92 kg/ha, and AC 50191 (Cyanamid of Canada Ltd.) at 2.24 kg/ha did not injure wheat under weedless conditions. Flax tolerated preplanting soil-incorporated applications of A 820 (Allied Chemical Co.) at 3.36 kg/ha and postemergence applications of alachlor at 2.24 kg/ha and asulam at 3.36 kg/ha. In later tests these herbicides for which crops have shown good tolerance in preliminary testing will be evaluated for their ability to control weeds.

Wild oats. WL 17731 (Shell Oil Co.) significantly reduced the growth of wild oats without killing the plants. Wheat was very resistant to WL 17731, but barley was injured by this herbicide. It was most effective if applied when wild oats were at the four-to-six-leaf stage. Control at this stage was not quite as good as that obtained with barban applied at the two-leaf stage. Two emulsifiable concentrate formulations were tested and found to be comparable with the wettable-powder form that was tested earlier.

New weeds. A number of requests for methods to control absinth, nodding thistle, and bladder campion have been received in recent years. Therefore, tests were made

around the province on control of these weeds. Absinth growing in native grassland was satisfactorily controlled with dicamba at 0.56 kg/ha. Control with 2,4-D or 2,4-DB was unsatisfactory at rates up to 1.12 kg/ha. Nodding thistle, a biennial, was best controlled with 2,4-D applied at 1.12 kg/ha in June and again in September. Single applications in the spring or fall were somewhat less effective. Fenoprop at 2.24 kg/ha gave excellent control of bladder campion on fallow land. At 2.24 kg/ha, 2,4-D was not effective on bladder campion.

Esters vs. amines. The butyl esters of 2,4-D and the dimethyl amine salts of 2,4-D were compared as to their ability to kill Russian thistle, flixweed, and stinkweed. When Russian thistle was 2.5 to 5 cm high, good control was obtained with both formulations. Stinkweed and flixweed were controlled by both forms when they were applied in the fall at 0.42 kg/ha. These plants are more resistant in the spring, at which time 0.70 kg/ha of the amine salts of 2,4-D was required to give control comparable with 0.56 kg/ha of the butyl ester form.

2,4-D drift. Four more trials were conducted at the Defense Research Establishment, Suffield, Alta. 2,4-D-C^{14} was trapped in silica gel samplers downwind from the target area. The results of these trials confirmed those obtained last year. About 4% of the mass of 2,4-D was collected downwind from the spray swath 0 to 3 min. after spraying. This was assumed to be droplets and to be the same for the amine and ester forms. About 35% of the butyl ester of 2,4-D moved out of the target area in the 3- to 90-min period after spraying. Because recovery of droplets during this period was not expected, this was thought to be the vapor loss. No dimethyl amine salt of 2,4-D was recovered during this period. Therefore, the hazard from the vapors was considerably greater than from the droplets in these tests. The materials were applied in water at 112 liters/ha.

Herbicide residues. When triallate was applied in the fall at 2.5 kg/ha, 74% was still present on May 3 of the following year. By June 14, this had decreased to 64%. Negligible amounts were found below a depth of 5 cm.

The persistence of trifluralin in the soil after application at 1.4 kg/ha was measured here and at the Research Station at Melfort. At the end of a 5-month growing season, 11% was still present in the top 5 cm here and 21% at Melfort. Less than 2% was detected at the 5- to 10-cm level in both tests.

The amount of TCA in wheat, oats, barley, and flax after postemergence application at 1.1 to 8.8 kg/ha was also determined. Because cereal crops are sometimes fed to livestock for forage, residues were determined at 45 days after application, as well as at maturity. In the grain, the TCA residues ranged from 0.2 to 1.2 ppm. Much higher levels, ranging from 6 to 65 ppm, were found in the forage.

No dinoseb was found in oil expressed from rapeseed that had been treated with this chemical as a desiccant just before harvest.

Isopropyl, *n*-butyl, and isooctyl esters of 2,4-D were rapidly hydrolyzed to the acid form in the soil. Hydrolysis occurred even in cool, relatively dry soils. The isooctyl ester was more stable than the two short-chain esters.

Sprayer mounted on a disc-seeder. A method for applying and incorporating triallate and seeding wheat in one operation was developed by W. Normand on his farm near Regina. A spray boom is mounted on a disc-seeder; the spray from fan-jet nozzles is directed into the soil as it is thrown up behind the discs. The spray angle is carefully adjusted to avoid injury to the wheat. In tests run from 1969 to 1971 at the Station, this method controlled wild oats as well as or slightly better than when, after seeding, triallate was applied with a conventional sprayer and incorporated into the soil with a double harrowing. The latter method requires three to four trips over the field.

Ground cover at spraying time. The amount of ground covered by wheat, barley, and flax at spraying time was determined by using a point sampler. We were interested in the amount of the herbicide spray solution that might be intercepted by the crop plants. Wheat seeded with a disc-seeder covered about 45% of the surface area at the four-leaf stage and 65% at the tillering stage. Barley sown with a disc-seeder covered about 35% of the area at the four-leaf stage. Crops sown with a double-disc drill covered less area than those seeded with a disc-seeder.

When flax that was seeded with a double-disc drill was 8 and 18 cm high, the ground cover was 13% and 27% respectively.

Apical dominance. Apical dominance in plants is being studied because of the implications it has had on the ability of weeds to resume growth after mowing or cultivation. In tests conducted in 1971, seed size and water stress affected the ability of the lateral buds on stems to develop. Pea plants grown from small seeds showed less apical dominance (more lateral bud development) than plants grown from large seeds of the same population. The apical dominance in peas, beans, and sunflowers was less when the relative humidity was high.

Photoperiodism in stinkweed. In a growth chamber stinkweed was found to be a quantitative long-day plant: it produces flowers sooner under long days than under short days. The number of leaves produced prior to flower initiation was halved by increasing the length of day from 8 to 16 hr. Increasing N in the nutrient solution fed to these plants caused an increase in the number of leaves produced before flowering on both long and short days.

Under long days, temperature did not significantly hasten or delay flowering. Under short days, a raise in temperature from 15 to 21 C increased the number of days to flowering.

SEED SECTION

Seed increase. Seed of seven new varieties that were developed by the Research Branch was distributed to seed growers. These were Wascana durum wheat, Random oats, Tempest buckwheat, Zephyr rapeseed, Span rapeseed, Sundance winter wheat, and Yukon sweetclover.

Wascana durum wheat matures earlier, has shorter and stronger straw, and yields more than Stewart 63 or Pelissier. It matures 2.5 days later than Hercules and has slightly taller and weaker straw. Wascana yields 13% more than Hercules in the Brown soil zone. It has as high quality as Hercules.

Breeder seed of the Branch's varieties was sent to 450 seed growers. They received 5,268 kg (11,603 lb) of 31 varieties from 12 different crops. At the Station 52 varieties of 15 crops are maintained.

During the winter of 1970–71 the Seed Section again increased material for plant breeders of the Branch at Brawley, Calif. There is a strong demand for this service, which speeds up the breeding programs. Twenty-two breeders submitted material for increase in the winter of 1971–72. Slightly more than 4 ha of irrigated land were used.

Variety verification. In 1971, 2,991 samples collected by the Plant Products Division and by the Canadian Seed Growers Association were grown for verification of purity. Six of the 697 barley samples and 3 of the 147 oat samples showed significant levels of admixture. Twenty-five of the 287 flax samples but only 4 out of the 957 samples of bread wheat were not pure. Several samples of Hercules durum wheat contained other varieties.

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Saskatoon, Saskatchewan

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R. J. LEDINGHAM, B.Sc., M.Sc.	Cereal root diseases
G. A. PETRIE, B.A., M.A., Ph.D.	Oilseed crop diseases
J. D. SMITH, B.Sc., M.Sc.	Grass diseases

[1]On transfer of work at Wadenswil, Switzerland, September 1970 to August 1971.
[2]On transfer of work at London, England, October 1971 to September 1972.

Departure

R. W. L. KAUL, Dipl. Agr., Ph.D. Resigned September 28, 1971	Drought physiology

VISITING SCIENTISTS

National Research Council postdoctorate fellows

I. J. ANAND, B.Sc., M.Sc., Ph.D., 1969–71	Oilseed crops
M. H. BALBA, B.Sc., Ph.D., 1971–72	Pesticide chemistry
J. C. KARAPALLY, B.Sc., M.Sc., Ph.D., 1969–71	Pesticide chemistry

Colombo Plan graduate student

M. A. SALAM, M.Sc., 1969–72	Oilseed crops

INTRODUCTION

The Research Station at Saskatoon conducts a broad research program on crop and animal production. Included are the breeding of rapeseed, mustard, sunflowers, wheat, barley, alfalfa, sweetclover, sainfoin, trefoil, bromegrass, crested wheatgrass, intermediate wheatgrass, slender wheatgrass, reed canarygrass, and a number of miscellaneous crops; ecology and control of some of the most important plant diseases and weeds, and insect pests affecting plants, animals, and man; the histophysiology of insects; the characterization and fertility of soils; and pesticide application and residues in crops and soils. The accomplishments during 1971, for selected subjects, are summarized in this report.

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J. E. R. Greenshields
Director

CROPS

Oilseeds

Rapeseed breeding. The low erucic acid rapeseed (LEAR) varieties, Oro, Zephyr, and Span, developed at the Station accounted for some 10% of Canada's 1971 record crop of 2.27 million metric tons (100 million bu). This quantity was more than sufficient to meet the requirements for evaluation of LEAR varieties, in preparation for a complete changeover in 1972. The successful winter multiplication and distribution of 453.6 metric tons (1 million lb) of Span was a significant factor in meeting the 1971 seeding requirements for LEAR seed. Span accounted for 88,500 metric tons (3.9 million bu) of the 227,000 metric tons (10 million bu) of these varieties produced in 1971.

The commercial performance of the LEAR varieties was essentially as predicted on the basis of the Cooperative Rapeseed Tests coordinated here and conducted at 20 locations throughout Western Canada.

The low oil and protein contents of LEAR varieties have been of particular concern to growers and processors. However, an intensive breeding program to improve these qualities, as well as seed yield, resulted in the identification of one line of *Brassica napus* L., SZ69-687, and a sister selection of Span, which were equal or superior in oil, maturity, height, and seed yield to the standard varieties Target and Echo in the 1971 trials. These improved strains will probably begin to commercially replace the present LEAR varieties in 1973.

In 1971, most of the growers were able to produce commercial seed of LEAR varieties with a minimum of contamination. In commercial seed the average content of erucic acid was 0.9% in Oro and 3.0% in Span. The first seed of Span released to growers contained 2.5% to 2.8% erucic acid. To reduce the erucic acid in Span to less than 0.5%, an intensive breeding program was successfully undertaken in cooperation with the Branch establishments at Winnipeg, Regina, Indian Head, and Swift Current. As a result 2,200 kg (4,900 lb) of reselected Span were obtained in the fall of 1971. Because the experience of 1971 suggests that an erucic acid level of 3% can be commercially maintained in 1972, the reselected seed stock will not be introduced until it has been evaluated in the field alongside other LEAR breeding material. This will include SC69-818 and other lines that are the result of one and two additional backcrosses to normal varieties and strains with outstanding yield and quality characteristics.

The rapeseed industry is impatiently waiting for the development of agronomically acceptable strains of the Argentine type that yield seed essentially free of glucosinolates in the meal and an oil with little or no erucic acid. In extensive tests in the laboratory and in the field in California and at the Station, some 125 lines have been identified that combine these two characteristics. This material was evaluated again in California in the winter of 1971–72 and it is anticipated that field tests will take place in 1974.

Yellow-seeded strains. In cooperation with the Experimental Farm at Indian Head a field-scale increase of one yellow-seeded line

of *B. campestris* L. was made to provide meal for nutritional experiments and to observe its agronomic performance. No weaknesses, such as might be expected from a lower fiber content in stems, pods, and branches, were observed. This and other tests suggested that the program to transfer the yellow seed coat characteristics into the LEAR (*B. campestris*) varieties should be given a high priority. In addition, two new sources of yellow seed in *B. napus* species were identified.

Morphological studies on seed size from yellow- and brown-seeded plants of *B. campestris* indicated that the sizes of the seeds from both types follow a normal curve, irrespective of the portion of the plant on which they are borne. Yellow seed coats usually weigh about 3% less than brown seed coats. Brown seed coats normally make up 10% to 16% of the total seed weight. Yellow-seeded selections continue to show 3% to 4% higher protein and 2% to 3% higher oil content than brown-seeded plants. The use of yellow-seeded character in future rapeseed varieties appears promising.

Haploids. Studies on the occurrence of haploids in Canadian and European varieties of *B. napus* confirmed an earlier report that frequency differences between strains are genetically controlled. In Canadian varieties haploids occur more often than in European varieties. The inheritance of this character and its implications for varietal uniformity are being studied.

Insect bioassay of oilseed proteins. Larvae of the yellow mealworm, *Tenebrio molitor* L., apparently can be used to determine the nutritive values of proteins. Preliminary investigations showed that this insect classifies nutritional values of proteins in defatted oilseed meals in much the same way as the mouse; however, the mouse apparently uses flaxseed meal more efficiently than *T. molitor*. Ranking of the oilseeds by larvae of *T. molitor* was as follows: soybean = sunflower = Polish rape > safflower = Argentine rape > flax. Positive but not significant correlation was found between gains in fresh weight of larvae and ash content of the meals. Positive and significant correlation existed between the gains in fresh weight and protein efficiency ratio as determined with weanling mice.

Grasses

Stability of varieties. The stability of four varieties of bromegrass was tested through three generations of seed production. Three of the varieties originated in the USA, but are grown for seed in Western Canada for use in Eastern Canada and the USA. Production tests were conducted for farmer seed lots by trials at the Station, representing the seed-production area, and at Guelph, Ont., representing the consuming area, in cooperation with Dr. B. R. Christie.

The southern varieties Lincoln, Fischer, and Saratoga showed no significant differences in forage production between original seed from the USA and Certified seed grown in Western Canada. There were no detectable changes in height, weight of seed per measured volume, or flowering time. Tests of in vitro digestibility of forage material showed good maintenance of type within variety. The only differences noted between Lincoln and Saratoga were in seed yields. There was as much variation between Certified seed lots as between original Breeder and Certified seed. Carlton, a northern type variety, showed no measurable differences between Breeder and Certified seed lots produced in Manitoba and Saskatchewan.

It was concluded that bromegrass varieties have good stability even when seed is grown well outside the area of origin.

Bromegrass-alfalfa mixtures. Five bromegrass strains and three alfalfa varieties, when grown in various mixtures of grass and legume, showed no significant differences in yield in 5 years, 1966–70. However, Lincoln bromegrass caused stunting of alfalfa and reduced the legume balance. Two strains of reduced-creeping bromegrass allowed more alfalfa in mixtures but did not alter total yields. Roamer, Beaver, and Grimm gave nearly identical yields in mixtures with grasses.

When the test area was broken and seeded to wheat in 1971, there were fairly marked differences in grain yields from various bromegrass sods. Wheat yielded 1,960 kg/ha (29.2 bu/acre) after mixtures of Lincoln bromegrass with alfalfa and 2,540 kg/ha (37.7 bu/acre) and 2,850 kg/ha (42.4 bu/acre) after the two reduced-creeping bromegrasses with alfalfa. Where bromegrass had been grown without alfalfa, wheat yielded 1,310 kg/ha (19.5 bu/acre) on Lincoln sod and 2,334 kg/ha (34.7 bu/acre) and 2,603 kg/ha

(38.7 bu/acre) on the sod of the two reduced-creeping bromegrasses.

More study is warranted on the varietal differences in bromegrasses in their adverse effects on companion legume and subsequent cereal crops in rotation.

Cereals

Wheat breeding for yield. Initial crosses made in 1967-68 have advanced to F_4 and F_8 generations through the use of increase facilities in California. The more important crosses included Gaines × Manitou, Gaines × Pitic 62, and Manitou × Pitic 62. The main objectives in making these crosses were to combine high yield with other suitable agronomic characters, as well as varietal markers. Gaines winter wheat proved to be a very satisfactory parent for producing high-yielding spring wheats with suitable maturity. Progeny lines from crosses involving Gaines were tested in various replicated trials in 1971; several outyielded Pitic 62. Because of the white-seeded character of Gaines, many lines are almost white-seeded and readily identifiable.

Wheat management for yield. A Uniform High-yielding Wheat Trial has been coordinated from the Station since 1969, and data for 40 station-years are available. The tests took place at 15 locations across Canada and included up to eight varieties or strains of wheat and two varieties of barley. Up to three levels of fertility were involved. It was found that (i) wheat varieties, such as Pitic 62, can yield as well as barley, such as Galt, in kilograms of grain per hectare (bushels per acre) and substantially outyield barley in kilograms of protein per hectare (pounds per acre); (ii) with good management, dryland yields of feed wheat over 6,700 kg/ha (100 bu/acre) can be attained; (iii) varieties respond differently to fertilizer; (iv) only large amounts of N significantly affect protein level; and (v) Pitic 62 is always 2% to 3% lower in protein than Neepawa at specific levels of management.

A study of forage yields, including Manitou wheat, five foreign wheats, two varieties of barley, and three varieties of oats harvested at four growth stages, was conducted in 1970 and 1971. Although oats is considered to be one of the most suitable annual forages for Saskatchewan, some foreign wheats produced more forage than the other cereals at comparable growth stages, and particularly in terms of digestible organic matter. The evaluation of grain and forage quality is being done in cooperation with the Animal Science Department, University of Saskatchewan.

Irrigated Crops

Adaptation of hybrid field corn. During the past 7 years more than 100 short- and medium-season corn hybrids were tested for their ability to produce high yields of total plant material and grain, combined with maximum grain maturity, for use as an alternative silage crop in the developing irrigation region of south central Saskatchewan between Saskatoon and Outlook. In plot trials conducted at the Station in 1971 on medium-textured sandy loam soil, the yield potential ranged from 13.4 to 15.7 metric tons/ha (6 to 7 tons/acre) of the most suitable hybrids. The grain component of this group contributed about 6,270 kg/ha (100 bu/acre) and the moisture content was 30% to 40% at harvest.

None of the hybrids tested could be considered useful for grain corn production. Although many varieties produced physiologically mature, well-filled kernels in the hard-dough or dent stage, the moisture content of the grain was usually from 40% to 60% at the time of first frost (usually mid-September). The possibility of obtaining more mature grain by delaying harvest 3 to 4 weeks to mid-October or later was favorable for only a very few hybrids, but even these seldom dried to below 20% to 30% kernel moisture. Artificial drying to 15% moisture would be required every year unless the grain was preserved for use as high-moisture feed.

Some of the more promising hybrids adapted for use as an irrigated silage crop for this area include Stewart's 2300, Stewart's 2301, Stewart's 2605, Stewart's 2607, Stewart's 3509, Warwick SL209, Warwick Exp 67-394, United 106, Weathermaster 3XF, Weathermaster CD4, Ox 401, Ox 402, Dekalb 22, Trojan TX68, and Northrup King KE410. The Morden 67 and Morden 88 hybrids are equal in grain content and maturity, but total yield for silage is about 2.24 metric tons/ha (1 ton/acre) less.

Weed Control

Residues of picloram to control weeds. In experiments conducted over a 6-year period, picloram was applied once in each

3-year crop cycle of either fallow, wheat, wheat or fallow, oats, oats, at rates from 0.0175 to 0.140 kg/ha (0.25 to 2.0 oz/acre). The herbicide gave effective weed control in the first year at 0.035 kg/ha or higher and in the second year at 0.053 kg/ha or higher. In the year of application, wheat was slightly injured at rates of 0.0525 kg/ha or higher. There was no crop injury in either of the 2 years after application. There was no injury to oats in any year. The residue of picloram in the fall of the year after application was approximately 10% of the applied amount.

Picloram with 2,4-D in a 1:2 ratio, applied on a biennial basis at up to 0.105 kg of picloram/ha in the crop year or 0.140 kg/ha in the fallow year, gave good weed control. When the mixture was applied in the crop year some injury occurred. However, when the herbicides were applied in the fallow year, the residue was sufficient to control weeds without injury to the subsequent wheat crop. Application in the fallow year also resulted in 15% to 20% less residue in the soil, when sampled 3 months after application, than application in the crop year.

Annual applications of picloram at 0.0175, 0.0350, and 0.070 kg/ha either alone or in combination with 2,4-D or MCPA in a 1:16 ratio resulted in excellent weed control at the two highest rates with slight crop (wheat) injury at the highest rate. At the 0.035 kg/ha level combined with MCPA or 2,4-D, weed control and crop response was the same as to bromoxynil + MCPA at 0.560 kg/ha.

ENTOMOLOGY

Grasshoppers

Ovicidal properties of juvenile hormone analogues. The ovicidal properties of several synthetic analogues of insect juvenile hormones were tested by topical application to both male and female grasshopper adults and eggs. Topical applications to adult females had little effect on the rate of egg production, but the hatch of the eggs produced was reduced from a normal 70+% to 12% - 25%. The active analogues were most effective when applied during the first 3 to 4 days of adult life. Some affected not only the first batch of eggs but also subsequent batches and eggs produced by the next generation. The ovicidal properties of these materials were reduced when adult males were treated and then mated with normal females, but the effects were the same. The eggs hatched at only 35% to 50% of the normal rate. Thus, the analogues must be passed from the male to the female during mating, either as a component of the sperm or, more likely, as a component of the accessory gland secretions. The analogues were more effective when they were applied directly to the eggs and were most effective when applied before the seventh day of embryogenesis. The application of 0.1 μg of some analogues to eggs weighing about 4 to 5 mg prevented the embryos from completing blastokinesis and thus averted any hatch.

Wireworms

Orientation behavior of Agriotes obscurus *(L.) larvae.* Temperature gradients produced in soil by germinating wheat kernels were measured and then artificial pointlike heat sources were used to produce microgradients of the same magnitude. The larvae showed no reaction to such heat sources. Apparently wireworms do not possess specific thermoreceptors for detecting and following temperature gradients to food sources. These and related experiments showed, however, that the larvae orientated to germinating grain seed and did not find the seed by random wandering. An apparatus was devised to test the volatile components issuing from germinating seed. The wireworms moved directly to the end of a capillary emitting grain-gas from as far away as 20 cm (7.8 inches). When this grain-gas from wheat seed was passed through a KOH trap no orientation occurred. The larvae also moved along a weak CO_2 gradient to its source. The results suggested that the CO_2 produced by the germinating seed was the main attractant, but other volatile components may also be involved. Various head appendages were amputated to try to locate the CO_2 receptors. The results showed that the receptors apparently were not allocated on any one set of head appendages.

Rapeseed Insects

Bertha armyworm. An unprecidented outbreak of the bertha armyworm, *Mamestra configurata* Wlk., occurred on rapeseed crops in an area extending from Dauphin and Swan Lake, Man., across northern Saskatchewan to Edmonton, Alta. In Saskatchewan the damage was estimated to be less than 10% of the overall acreage but up to 30% in some heavily infested districts where populations of 360 to 480 larvae/m^2 (300 to 400/sq yd) were common.

Although larval infestations in 1970 were generally low, the captures of emerged moths in 1971 in a single light trap in northeastern Saskatchewan were the highest recorded in 10 years. The use of light traps may be an important surveillance method to determine the outbreak potential.

The insecticide methomyl, registered for use against some lepidopterous pests in the USA, gave excellent control of the bertha armyworm in the only field infestation found in Saskatchewan in 1970. In 1971, aircraft application of methomyl to experimental plots at 0.07, 0.14, 0.28, and 0.56 kg/ha (1, 2, 4, and 8 oz/acre) in three infested rapeseed fields confirmed its effectiveness at 0.21 to 0.28 kg/ha (3 to 4 oz/acre). Consequently about 303,750 ha (750,000 acres) were sprayed, mostly by aircraft, in an effective control program. No detectable residue (less than 0.05 ppm) was found in seeds harvested 17 days after treatment, even though the highest rate had been used.

Alfalfa Leafcutter Bee

Management. Honey provided on fine screening or on toweling in rearing trays or cages made possible almost complete survival, for at least 5 days, of bees that emerged during weather unfavorable for field foraging. This feeding appeared to delay the start of foraging for 1 or 2 days, when the bees were released in the field.

Only 0.2% parasitism by *Monodontomerus obscurus* Westwood appeared in 1971 in the 1970 progeny of three imported stocks of the 1969 brood of *Megachile rotundata* (Fabr.) that were parasitized 3.4%, 9.0%, and 14.4% respectively. Natural light through windows appeared to be more effective in drawing the parasites from the rearing tray than either 60-watt incandescent or 6-watt black light bulbs.

Mosquitoes

Abundance. In southern Saskatchewan, mosquitoes were more abundant in 1971 than in 1970. This was caused in large part by the increased abundance of *Aedes vexans* (Mg.), which ranged from twice as abundant at Outlook to 31 times more abundant at Weyburn, and of *Culiseta inornata* (Will.), which was slightly more abundant at Saskatoon and two to three times more abundant at Outlook and Weyburn. *Culex tarsalis* Coq., the principal vector of western encephalitis (WE) virus, was slightly more abundant at Weyburn (southwestern Saskatchewan) than in 1970, and four times more abundant at Saskatoon, but at Outlook, in the area under irrigation, the population was only about one-third that of 1970. Compared with the long-term (1963–70) averages, in 1971 mosquitoes were 84% and 95% more abundant at Saskatoon and Weyburn respectively, and 29% less abundant at Outlook. The population of *C. tarsalis* was 33% above the long-term average at Saskatoon, but 49% below the long-term average at Outlook, and 8% below at Weyburn. Irrigation apparently was of little importance in contributing to the mosquito populations, including *C. tarsalis*, in the Outlook district in 1971. However, two of 10 breeding sites of *C. tarsalis* discovered in the Outlook district were associated with the irrigation system.

Arbovirus activity. In 1968, the *C. tarsalis* populations in Saskatchewan reached their lowest levels since the study began in 1962. This was accompanied by a general lowering of WE virus activity that had been in progress since 1965, as indicated by only three confirmed cases of WE in horses. Since 1968, *C. tarsalis* populations and WE virus activity have been increasing. In 1969, of the 40 WE clinical cases in horses that were reported four were confirmed, and 15% of the 125 indicator chickens distributed in five flocks acquired WE infections. These were the first infections in the indicator flocks since 1966. In 1970, of the 17 clinical horse cases reported two were confirmed, and 19% of 100 indicator chickens in four flocks acquired WE infections; the highest since 1965. Seven isolations of the WE virus were made from *C. tarsalis*, to give a minimum infection rate of 1.9/1,000. This rate is low but the highest since 1966. Examination of all the specimens collected in 1971 has not yet been completed, but there appears to have been a decrease in

the level of WE virus activity from that of 1970. A feature of the mosquito-arbovirus study, the significance of which is not yet apparent, has been the isolation from mosquitoes during the past few years of arboviruses other than WE. These have included virus strains of the Hart Park – Flanders complex, Turlock virus, and some still not identified. Increase in the incidence of these isolations accompanied the use of suckling mice for primary isolations. As far as is known, the Hart Park – Flanders and Turlock viruses are exclusively parasites of birds. The Hart Park – Flanders virus has also been isolated from wild birds in Saskatchewan and is widespread in the province.

Pesticide Application

To reduce environmental pollution it is necessary to confine pesticides to the area being treated and to use them in minimal quantities. During the last 2 years, considerable progress has been made in this direction. Laboratory and field sprayers have been developed that will produce homogeneous sprays of uniform droplets of any chosen size. With this equipment, the relationships between droplet size, pesticide dosage, and spray volume for any crop–pest combination can be investigated.

Preliminary studies in the laboratory suggested that generally small droplets of herbicides are more effective than large ones. Under field conditions other factors, such as wind and target impaction, affect the result so that droplet size is of lesser importance. But spray volume may be the critical factor with considerable loss of effect when the rate is 11.2 liters/ha (1.0 gal/acre) or less.

Many studies will have to be made before one can specify the optimal treatment for any given crop and pest. In general, it appears that a practical answer will be found in sprays having mixed droplet sizes, providing they are from 150 μ to 300 μ. Such sprays would have no droplets small enough to cause a drift problem and none so large that coverage would be reduced.

Preliminary studies indicated that it may be possible to produce such sprays with ordinary hydraulic nozzles by winnowing the mixed drop spectra. This work is in progress.

PLANT DISEASES AND PLANT PHYSIOLOGY

Common Root Rot

Resistance. Losses caused by common root rot in cereal varieties were compared in field tests. The loss in a variety was calculated as a percentage of the potential yield determined from the productivity of clean plants. Susceptible varieties incurred much greater reductions in yield than resistant ones. This difference was attributed primarily to the incidence of disease. In common wheat, diseased plants of a resistant variety were damaged as severely as comparably diseased plants of a susceptible variety.

Lines of wheat and barley that exhibited good resistance in field tests were selected from various crosses. Resistance in *Triticum* sp. generally appears to decrease with increasing ploidy level, although there is a wide range of reaction in hexaploids. Red Fife and Garnet, varieties of *T. aestivum* L., appear to be as resistant as Manitou.

Culture filtrates. Toxin production by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur varied with the source of N provided the cultures. DL-Serine and DL-alpha-alanine produced high levels of toxin, whereas glycine and beta-alanine supported little production.

Biological control. In greenhouse tests, the addition of several fungi to the soil protected seedlings from common root rot and increased their productivity about 50%. The average disease rating was 6 in the treated series and 22 in the check. The fungi were recovered from many seedlings in treated soil and cross-protection is being investigated as a control mechanism.

Diseases of Grasses

Leaf and stem spots. Native fescues are probably the main reservoirs of infection for *Phleospora idahoensis* Sprague in western North America as far east as the Saskatchewan–Manitoba border. The perfect stage of this fungus corresponds with *Didymella festucae* (Weg.) Holm, which also has an alpine-arctic distribution in Europe. In a field test, N reduced the incidence and severity of stem lesions on creeping red fescue.

Snow mold of lawn grasses. Fusarium nivale (Fr.) Ces. was the pathogen most frequently isolated from affected bluegrass turf in the province. *Sclerotinia borealis* Bub. & Vleug. caused severe damage on golf greens of *Agrostis* spp., from Prince Albert in the north to Swift Current in the south. Apparently these findings constitute new records for Saskatchewan.

Diseases of Alfalfa

Yellow leaf blotch developed rapidly from natural infection in a newly established disease nursery of 10 standard varieties. Black stem did not occur. Culture filtrates of isolates of *Phoma medicaginis* Malbr. & Roum. did not inhibit germination of alfalfa, flax, rape, or wheat.

Diseases of Oilseeds

In 1971, the estimated loss in yield of the rapeseed crop in Saskatchewan due to sclerotinia stem rot was less than 1%. Fusarium stem rot increased in prevalence and was particularly noticeable on brown mustard.

In pathogenicity tests, *Fusarium* spp. from rape were highly virulent on rape, cultivated mustards, crambe, flax, and safflower; they were moderately pathogenic on sunflower but caused little damage on wheat. A *Fusarium* isolate from wheat attacked flax but not rape, whereas some isolates from flax attacked brown mustard, flax, and rape. *Fusarium* spp. were isolated frequently from seed samples from northern districts of the Prairie Provinces.

Pythium spp., which cause damping-off and seedling blight of crucifers and flax, were prevalent in many soil samples collected in Saskatchewan. At least three species of *Phythium* were implicated in the disease.

Drought Resistance in Wheat

Stomatal aperture and oxygen evolution, as indices of gas exchange and potential net photosynthesis respectively, were measured in addition to water status in wheat varieties. A rapid method was developed for measuring oxygen evolution. Although the 1971 field season was relatively moist and stress levels in plants rarely dropped below −15 bars, the indices appeared to be related to the productivity of the varieties.

SOILS

Pedology

Classification and mapping. Since 1968, the Pedology Section in conjunction with the Saskatchewan Institute of Pedology has been conducting a broad reconnaissance survey of the soils in the northern provincial forests lying south of 55° N lat. During the past summer, the field program was almost completed within this area with the mapping of approximately 4.5 million ha (11 million acres). Analysis of a broad representation of soils throughout this area is well under way. Appraisal of the soils of much of this area has been completed. In addition, the detailed reconnaissance mapping of over 404,700 ha (1 million acres) was completed in the Swift Current map sheet area during the past year. A program to evaluate the productivity of some of the main soils in this area has been started in conjunction with this mapping program.

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INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on a variety of soils, and cattle are raised in large numbers on natural grasslands and on grass–alfalfa mixtures. Some small areas are irrigated. Research is focused on improving the economy and stability of this production.

Crop production was average despite the fact that 1971 was the second driest of the 86 years for which precipitation records are available. The total annual precipitation was 22 cm, compared with 18 cm in 1937, the driest year on record. In the spring of 1971 moisture reserves were good, and during June and early July precipitation was near normal. Very little precipitation and warm, sunny weather during August and September provided ideal conditions for harvesting.

Research was highlighted by the licensing of Wascana durum wheat, Drylander alfalfa, and Mayak Russian wild ryegrass. Wascana was developed by Dr. E. A. Hurd at Regina before his transfer to Swift Current; it is a high-yielding, high-quality, drought-resistant variety for the southern prairies. Drylander was developed by Dr. D. H. Heinrichs; it is an improved creeping-rooted variety for the production of pasture and hay in the open plains region of Western Canada. Mayak was developed by Dr. T. Lawrence; it is a replacement for Sawki and yields more forage and seed.

During the year M. R. Kilcher completed 5 years of research that showed that the best yield, stability of production, and quality of grass–alfalfa mixtures grown for hay in southwestern Saskatchewan can be obtained by seeding the alfalfa and the grass separately, in parallel or crossed rows, spaced 60 cm apart. Dr. R. W. Lodge also showed that Russian wild ryegrass provides the most grazing in late fall and winter when it is grown in rows spaced 60 cm apart.

These and other research accomplishments during 1971 are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report or from the individual research scientists. Correspondence should be addressed: Research Station, Research Branch, Canada Department of Agriculture, Box 1030, Swift Current, Sask. S9H 3X2.

A. A. Guitard
Director

CEREAL CROPS

Breeding

Spring wheat. Programs have been designed to develop drought-resistant bread-quality and lower-grade milling and feed wheats. Several lines of lower-quality wheat have been developed that yield 10% to 15% more than Neepawa and that have more resistance to rust and have heavier kernels. All are earlier maturing than Pitic. It is anticipated that at least one of these lines will be suitable for licensing as the first variety of this new class of wheat suitable for production in southern Saskatchewan.

Durum wheat. Wascana (D.T. 317) was licensed and 27,000 kg of seed distributed. It was selected from Lakota[2] × Pelissier. Wascana outyielded Stewart 63 by 15% and Hercules by 9% in the Brown soil zones of Saskatchewan, and in 1971, when moisture was below normal, it was equal to Pelissier in yield. Wascana is intermediate between Stewart 63 and Hercules in number of days to maturity, resistance to lodging, height, and kernel size; it is lower in bushel weight but resistant to stem and leaf rust, loose smut, and bunt. Wascana has stronger gluten and higher pigment content than Stewart 63.

Studies of the rooting characteristics of several varieties of durum wheat have shown high positive associations of the number of seminal roots and total root length of seedlings and mature plants with the ability to produce seed under dry growing conditions. As a result of these studies, seedling root

characteristics may be useful in selecting for drought resistance.

Rye. A vernalization technique was developed that induced faster heading of fall rye in the greenhouse. The procedure consists of vernalization of the seedlings at 7.2 C with an 8-hr photoperiod. This method induces heading 2 weeks earlier than when kernels are germinated at 0 C in continuous darkness.

Harvesting Losses in Barley

In a 4-year study, losses associated with the windrowing and combining of Vantage barley have been identified. Although there were large variations among years, natural losses in the standing crop and those associated with windrowing usually increased as the crop was windrowed at successively later stages of maturity from 50% to 14% kernel moisture. Average losses ranged from 43 kg/ha at 50% moisture to 107 kg/ha at 14% moisture. Yearly variations in losses occurred that were associated with picking up the barley from the swath and combining it. When picked up and combined at 14% kernel moisture, average losses ranged from 150 kg/ha for the barley that was windrowed at 50% kernel moisture to 70 kg/ha for the barley that was windrowed at 14% kernel moisture. Pick-up and combining losses were not influenced by kernel moisture at the time of windrowing, but the losses appeared to be influenced by the length of time that the barley was left in the swath before it was combined. Presumably, the longer the barley remained in the swath, the greater the settling of the swath and the weathering of the kernels. These results show that harvesting losses with barley can be minimized by windrowing at the 35% kernel moisture content (previously identified as the maximum allowable moisture content for windrowing), and by picking up from the swath and combining as soon as the moisture content of the kernel is reduced to 14%, which is safe for storage.

TURKEY NUTRITION

Dietary Fat

Calorie-to-protein ratio. Studies with broiler-type turkeys showed that similar dietary calorie-to-protein ratios gave the best early growth performance whether the diets contained 3% or 9% added fat, and that finishing diets that produced the best growth also gave the best finish. Males and females responded similarly to starter diets, but females tolerated a wider range of calorie-to-protein ratios in the finishing diets.

Source of fat. Diets with equal calorie-to-protein ratios that contained 0%, 2%, and 11.4% palm oil or rapeseed oil were fed to male Silver Auburn × Bronze turkeys from 1 day to 24 weeks old. Body growth was depressed by 11.4% rapeseed oil, but was stimulated by 11.4% palm oil. Feed conversion was inversely proportional to the level of added fat. When the dietary fat level was increased, the carcass fat score improved and an increase was shown in the yield of skin, the fat content of breast and thigh meat, and the drip loss in cooking, but the yield of breast meat, thigh meat, and drumsticks and the volatile cooking losses were decreased. The initial addition of 2% fat to the diet influenced the characteristics of the carcass more than the increase from 2% to 11.4% fat; the source of dietary fat also influenced the carcass fat score, the carcass composition, and the cooking losses.

Storage characteristics of broilers. When broilers that had been fed 10% rapeseed or soybean oil or animal tallow were stored for 7 months at -12 C, greater losses in tenderness and juiciness were found than when birds were stored for this period at -23 C.

Pelleting diets containing fat. Steam pelleting of diets containing 0% or 3% added fat improved the performance of turkeys, but no effect was shown from pelleting diets containing 9% added fat. Steam pelleting of the low-fat diets improved carcass scores and increased the proportion of skin and edible meat.

Nutrient Density

Four strains of turkeys utilized dietary nutrients at approximately the same efficiency at each of three nutrient density levels. Two of the strains, which had higher feed intake levels, produced heavier birds at all nutrient density levels. Broad Breasted Bronze males (strain B) fed the intermediate level of nutrient density averaged 15.0 kg at 22 weeks of age in comparison with 14.7 kg at 24 weeks of age in 1968, when the birds were fed the same nutrient density level without considering weekly body weight gain and feed intake adjustments. A difference of 2.27 kg/bird in feed intake was observed in both male and female Broad Breasted Bronze turkeys but not in Broad Whites.

FORAGE CROPS

Breeding

Alfalfa. Drylander (Sc. Syn. 3651) was licensed. It is an improved creeping-rooted variety that is well adapted for the production of pasture and hay in the open plains region of Western Canada. Drylander is a 15-clone synthetic with *Medicago sativa* L., *M. media* Pers., and *M. falcata* L. ancestry. The clones were the best among a large number selected out of old breeding nurseries that had been overseeded with bromegrass. The plants were selected for longevity, strong creeping-rooted habit of growth, excellent competitive ability with bromegrass, good seed set, and nonshattering seedpods. Individual plants of the selected clones were evaluated for seed yield and disease resistance in growth rooms, and their progenies were checked for degree of creeping-rootedness and winterhardiness in the field.

Approximately 70% of the plants in Drylander are creeping-rooted compared with 60% in Rambler and Roamer. The flowers are yellow and cream, with only an occasional white and blue flower. Drylander is as tall as Rambler but shorter than Roamer. It is similar to Roamer in resistance to bacterial wilt. Drylander yields as well as Rambler and Roamer at the first cutting, but at subsequent cuts it yields less than Roamer, thereby showing slow recovery, which is usually associated with winterhardiness. This lower yield at the second and third cutting is not considered a disadvantage in the Brown and Dark Brown soil zones, where alfalfa is usually cut only once each season.

Russian wild ryegrass. Mayak was licensed as a replacement for Sawki, which was released by the Station in 1967. The name Mayak is derived from the Blackfoot Indian word for grass. Mayak is a synthetic of 20 clones selected from the breeding program here and from strains obtained from Dr. G. Rogler, North Great Plains Research Station, Mandan, North Dakota. The clones were selected for high forage and seed yield and resistance to leaf spot disease. Open-pollinated and polycross progeny tests were used to evaluate selected plants.

Mayak is morphologically indistinguishable from Sawki and Vinall. It is more resistant to leaf spot than either Sawki or Vinall. At nine locations in Western Canada and at Mandan, North Dakota, Mayak produced an average of 6% more forage and 16% more seed than Sawki.

Altai wild ryegrass. Mass selection is being used to develop a variety with sufficiently high seed yield for commercial production. Populations with blue, green, and blue-green foliage have been established to obtain more uniform cultivars with higher seed yield. Single plants have been selected for high seed yield, improved seed quality, freedom from ergot, freedom from aphid-transmitted virus attack, and desirable plant type within each of the foliage colors. A simulated synthetic was developed for each foliage type to obtain a rapid assessment of its value.

Intermediate wheatgrass. Approximately 1,500 single plants were selected from a breeding nursery established in 1968. Screening for seed quality in the laboratory and seedling vigor in the greenhouse reduced the number of selections to 200 plants. Open-pollinated seed from these plants was used to establish a new breeding nursery, which will be used to make a final selection within this material before formation of synthetics. Open-pollinated seed from selected plants in the breeding nursery was also used to form seven simulated synthetics for evaluation of the selected populations.

Establishment

Depth of seeding. Increasing the depth of seeding delayed emergence more in Russian wild ryegrass and crested wheatgrass than in Altai wild ryegrass. When seeded 2.5 cm

deep, only 24% of the carbohydrate in the seed of Altai wild ryegrass was used at emergence compared with 42% for crested wheatgrass and 44% for Russian wild ryegrass. When seeded 5 cm deep, 56%, 60%, and 85% of the carbohydrates were used by Altai wild ryegrass, crested wheatgrass, and Russian wild ryegrass, respectively. When the three species were seeded 8.9 cm deep, they required 7 to 14 days longer to emerge than when seeded 1.3 cm deep, but the delay in emergence did not result in an increase in root length.

Rate of spreading of creeping-rooted alfalfa. Fifteen plants with strong creeping-rooted characteristics were selected from among populations of alfalfa that were more than 5 years old and studied for rate of spreading when planted 1.8 m apart. One year after planting, only three of the 15 lines displayed shoot formation in all five replicates. In the second year, all clones had developed aboveground shoots and the range of spread was from 101 cm for the least spreading to 176 cm for the strongest spreading plant. During the third year the spread increased 27% more. The stand density decreased as distance from the center of the plant increased. By the third year, most plants had spread to within each other's peripheries.

Forage Yield

Row spacing. Carlton bromegrass, Chief intermediate wheatgrass, and Fairway and Summit crested wheatgrass were each grown with Rambler alfalfa as mixtures and separately in alternate and crossed rows with rows spaced 30, 60, and 90 cm apart. Arrangement and spacing of rows did not influence hay yield the year after seeding, but, for the next 4 years, the yields from cross or alternate rows seeded 60 and 90 cm apart were 25% to 35% higher than from rows seeded in the same patterns but only 30 cm apart. The 60-cm cross or alternate row seeding gave the most consistent yield increases and the highest production over 5 years. Seeding the alfalfa and the grass in alternate parallel rows or crossed rows improved the quality by increasing the proportion of alfalfa in the hay. The response was similar for all grass species.

In the fifth year of a study on late fall and winter grazing on Russian wild ryegrass, 51.1 animal unit (AU) days/ha of grazing were provided when rows were spaced 20 cm apart, 70.7 AU days when rows were spaced 40 cm apart, and 97.7 AU days with 60-cm row spacing. Wide row spacing of Russian wild ryegrass increased the basal area of individual plants, but not enough to compensate for the reduced plant density. With the 40- and 60-cm row spacings the basal area was less than 10%. Less than 10% ground cover is considered to give the best balance between plant growth and available moisture.

Comparison of legumes for dryland pasture. In the second production year, Drylander and Kane alfalfa seeded with both Russian and Altai wild ryegrass in alternate rows spaced 30 cm apart produced higher yields of forage than Rambler, Roamer, or Beaver. In the same tests, Krasnodar persisted better than Eski sainfoin, but both provided much less pasture than the alfalfa varieties. After 2 years of heavy grazing by beef cattle, cicer milkvetch and crownvetch had practically disappeared from the stand. As in the first year, the animals showed a greater preference for alfalfa and sainfoin than for milkvetch and crownvetch. The grasses produced about twice as much forage as the best legumes grown in alternate rows with them.

Grasses and legumes for irrigated pasture. Ten grass–legume mixtures were evaluated over 4 years for pasture production and distribution of growth on irrigated land under high levels of fertility. The pastures were grazed by yearling heifers weighing approximately 325 kg. A mixture of Troy Kentucky bluegrass and Rambler alfalfa produced an average of 12,588 kg of dry matter /ha during four summers of grazing. A mixture of reed canarygrass, creeping red fescue, and Rambler alfalfa performed nearly as well. Birdsfoot trefoil and White Dutch clover were inferior to alfalfa in the mixtures, because they failed to persist beyond the third year. Carlton bromegrass, Chief intermediate wheatgrass, and Climax timothy displayed poor growth distribution patterns, and the latter two tended to disappear from the stand in the fourth year.

Forage Quality

Prediction of voluntary consumption of digestible energy. The procedure developed in 1970 for determining the in vitro digestible energy in forage was used to establish bench

mark values that can be used by the feed-testing services to predict the voluntary consumption of digestible energy by ruminants. Based on in vitro and in vivo analyses of 102 different lots of hay, made from pure stands of Ladak and Rambler alfalfa, crested wheatgrass, bromegrass, reed canarygrass, and Russian wild ryegrass, the voluntary consumption of digestible energy by sheep was highly associated with the in vitro digestible energy content of the hay, as measured in the laboratory. Correlation coefficients for each of the six individual grass species ranged from 0.75 to 0.90. The two pooled prediction equations for legumes and grasses were highly significant; their coefficients of variation from regression were similar in magnitude to those commonly observed between individual animals.

Concentration of crude fiber and cell wall constituents of the forage were negatively associated with voluntary consumption of digestible energy by sheep. Correlation coefficients for the association of concentration of crude fiber with the voluntary consumption of digestible energy from hay ranged from 0.65 to 0.89 for the six species. For cell wall constituents the coefficients ranged from 0.52 to 0.89. Neither measurement was as accurate as in vitro digestible energy for the prediction of the nutritive energy value of hay. The standard deviation from regression in the prediction equation for digestible energy consumption was reduced only slightly by considering crude fiber and cell wall constituents as secondary variables.

Artificial mastication of forage. An artificial mastication procedure was developed and tested on 24 lots of hay. The procedure includes an initial 24-hr artificial rumen digestion of coarsely chopped forage, followed by controlled mastication in an aggregate of helical gears. The rate of physical breakdown was measured by the percentage of masticated roughage fine enough to pass through a 0.5-mm mesh during wet sieving. Average length and width of artificially masticated particles were used to establish the mode of breakdown.

It was established that the reticulo-omasal opening of the animal functions as a sieving mechanism to retain feed particles in the rumen until they are reduced to a threshold size that can be readily passed. The average mass of each particle passed was greater for forage that tended to break into short cubical or spherical shapes than for forage that broke into long, threadlike particles. Both rate and mode of physical breakdown were related to voluntary consumption of coarse roughage by sheep. However, the rate of physical breakdown during the mastication of coarse roughage appeared to be an inherent characteristic of the roughage and, because the measurements of the rate of physical breakdown by artificial mastication are time consuming and empirical, the procedure probably would not be useful for routine assessment of forage quality.

Oat hay. Three varieties of oats that were harvested at weekly intervals in 1970 and found to range from 90% leaf in the vegetative stage to 12% to 15% leaf at maturity were analyzed for protein content and digestible organic matter energy. The protein content of the whole plant declined from 30% in the early leaf stage to 7% at maturity, and the digestible organic matter declined from 65% to 50%.

Fraction 1 protein. There was a significant difference among 100 clonal lines of alfalfa for Fraction 1 protein content. The low line contained 3.28% Fraction 1 protein and the high line 5.52%. None of the lines contained less than 2.0% Fraction 1 protein, which is considered to be the threshold below which bloat will not occur.

Collection and Classification of Native Species

Studies of plant communities and the geographic distribution of plant species were continued in the parkland of eastern Alberta and west central Saskatchewan. A total of 145 sites were studied, including 65 wooded and muskeg sites, 45 grassland, and 35 weed communities. Approximately 1,250 plant specimens were collected for the Station herbarium, and 31 mass collections were made for the *Plantae Exsiccatae Canadensis*, which will be issued by the Plant Research Institute. Approximately 500 specimens were acquired in exchange with older herbaria, mostly in Western and Central Europe. These specimens are used to establish relationships between plant communties in Western Canada and those in Europe, and to identify any weedy species that may be introduced.

ENVIRONMENT

Soil Nitrogen

Spring to fall changes in a summerfallow–wheat rotation. From 1967 to 1971, NO_3-N, exchangeable NH_4-N, and soil moisture were measured to 60 cm deep at weekly intervals from spring thaw to freeze-up in a field where spring wheat was grown in rotation with summerfallow. There was an overall increase in the NO_3-N content during the summerfallow years; however, in the years that the field was cropped to wheat or when the summerfallow was weedy, there was usually a reduction in the NO_3-N content of the soil. The effects of rainfall, sudden transient cold spells, and overwinter freezing were superimposed on these general trends. If the soil was near field moisture capacity when rain fell or if a rainfall was heavy, there was an immediate reduction in NO_3-N due to leaching, but later, as the soil dried, a large flush of NO_3-N was produced. If the soil was near the wilting point when rain fell, or if the rainfall was light, there was no apparent leaching from the top 60 cm of soil, but only a small flush of NO_3-N was produced. Rainfall was the main cause of changes in NO_3-N content, but flushes of NO_3-N production were also caused by late spring and early fall frosts. In three of the four winters under observation, NO_3-N increased about 20 kg/ha between fall freeze-up and spring thaw. There were a few mysterious NO_3-N peaks and large variations in the NO_3-N content of the soil between harvest and freeze-up that could not be explained. No relationships could be established between changes in exchangeable NH_4-N in the soil and the environmental variables that influenced the NO_3-N content.

Effect of temperature, soil moisture, and precipitation. The influences of temperature, soil moisture, and rainfall on NO_3-N and total N in the soil were determined on a summerfallowed Chernozemic Brown soil during 1967, when precipitation was very low, and during 1971, when precipitation was moderately low. Changes in the NO_3-N content of the top 30 cm of the soil profile were directly related to temperature. When the temperature rose, the increase in NO_3-N was greatest in the top 10 cm of soil, somewhat less between 10 and 20 cm, and still less at 20 to 30 cm. In 1971 the rate of increase in NO_3-N in the top 20 cm of soil was 1.40 kg/ha per degree C, but in 1967 when less precipitation was received only 0.76 kg/ha per degree C. In 1971 there was an inverse relationship between temperature and change in NO_3-N at the 30- to 60-cm depth. This relationship is thought to be due to upward movement of NO_3-N in evaporating soil water.

During both years there was a positive relationship between soil moisture and changes in the NO_3-N content of the top 60 cm of soil. However, in 1971, there was a negative relationship between soil moisture and changes in NO_3-N in the top 20 cm of soil, and a positive relationship between moisture and change in NO_3-N in the 20- to 60-cm segment. The rainfall curves for the various depths showed at least two opposing processes: one process predominated with rainfalls of less than 1 cm and caused NO_3-N losses near the surface; the other process, which caused increases in NO_3-N, was most active at the surface, but also occurred deeper in the soil when rainfalls were over 1.25 cm.

Effect of temperature, soil moisture, and level of N. A Wood Mountain loam held at 22%, 14%, and 10% moisture was incubated at temperatures similar to averages in the top 15 cm of soil during May, June, July, and August. Nitrification and mineralization were directly proportional to temperature. During the first 14 days of incubation, the Q_{10} coefficient for nitrification was 1.7. The influence of moisture was not as precise as that of temperature, but generally nitrification and mineralization were directly proportional to soil moisture content. Nitrification was highest when ammonium was added, and mineralization was greatest when peptone was added to the soil. It appears that the addition of ammonium primed the mineralization of the indigenous organic N. Based on this study, it was estimated that summerfallowed Wood Mountain loam at 22%, 14%, and 10% moisture would produce NO_3-N at 91, 58, and 48 ppm between the beginning of May and mid-September. Field sites with average moisture contents, of 24.5% and 15.5% produced NO_3-N at over 104 and 41 ppm during this period.

Soil Phosphorus

In 1967, P at 0, 100, 200, and 400 kg/ha was applied to a Wood Mountain loam and a Sceptre heavy clay cropped in a wheat-summerfallow rotation. A 500-g sample from each of the four treatments was potted in the greenhouse and cropped continuously with five plants per pot to alternate crops of Conquest barley and Garry oats. After 19 successive crops, the available P in the soil to which P at 400 kg/ha was added continued to be significantly higher than with the other rates of supplementation. The available P in soils to which P at 200 and 100 kg/ha was added had been decreased until it was similar to that of the unamended soil before cropping. Recovery of the applied P by the plants ranged from 60%, where 400 kg/ha of P had been applied, to 100%, where only 100 kg was applied. There was no apparent permanent fixation of P in any of the four soils studied in the greenhouse.

Influence of Polarity of Liquid and Manipulation Stress on Soil Structure

When moisture is removed from frozen soil by sublimation, a breakdown of aggregates occurs. When water was added to this soil, clods formed again and the extent of clod formation was related to the degree of manipulation. However, when the soil was wetted with a nonpolar liquid such as carbon tetrachloride, no clod formation occurred, even with extensive manipulation. It was also found that removal of organic matter from the soil with hydrogen peroxide did not prevent the formation of aggregates or massive clod structures by manipulation. The removal of organic matter from the soil, followed by leaching, and then freezing and drying caused the formation of small aggregates.

Characterization of Actinomycetes in the Brown Soil Zone

Soil samples were collected monthly during the growing season from grassland and cultivated sites on Sceptre heavy clay and Hatton fine sandy loam. Quantitative analyses of these samples showed that actinomycetes make up from 20% to 50% of the total viable soil microorganisms in the surface 10 cm of both grassland and cultivated soils, that the proportion of actinomycetes within the total microflora increases sharply with increased depth in the soil profile, and that the populations of actinomycetes in summerfallow are always considerably lower than in native grassland. Seven genera of actinomycetes were identified in dryland soils, but the populations were always dominated by *Streptomyces* sp. The grassland soil supported a much more heterogeneous population of actinomycetes than the cultivated soils, and there were large differences in species composition.

Precipitation

Low precipitation. 1971 was the second driest of the 86 years for which precipitation records are available. Precipitation totaled 22 cm compared with 28 cm in 1937, the driest year on record. However, because of good moisture reserves in the spring of 1971 and suitable distribution of moisture during the summer, this apparent drought did not cause below average yields of cereals. Precipitation during 1970 was 45 cm, whereas it was 25 cm in 1936. During 1971, precipitation was near normal during June and early July and a very timely 1.4 cm of rainfall was received during the third week of July, when the grain was at a critical stage of kernel development. Much below normal rainfall in August and below normal rainfall in September combined with warm sunny weather to provide ideal harvesting conditions.

Moisture reserves in summerfallow were not increased during the summer, fall, or winter of 1971. Soil-water reserves under stubble were negligible at the end of the year.

Precipitation sequences. Using the Markov chain theory, a study was made of the persistence of months with low precipitation. The theory assumes equal probability of the monthly rainfall being above (wet) or below (dry) the median rainfall. The study, based on 85 years of monthly precipitation records at Swift Current, showed that there is a slightly higher probability of a dry month being followed by a dry month or a wet month by a wet month than there is of a change from dry to wet or wet to dry. There was also evidence of weak persistence of dry periods of up to 5 months in length with longer runs occurring at random. Conversely, there appeared to be a weak persistence of wet periods of 9 months or longer with shorter sequences appearing at random.

RESEARCH EQUIPMENT

Plot Seeders

Swift Current cereal seeder, Model SC 701. A number of auxiliary systems were designed for this seeder. A cab was developed to house the operator and the seeding cones. Two conventional fertilizer applicators were modified and attached for application of fertilizer with the seed, in sideband or by broadcast, and a side-banding attachment was designed to place the fertilizer below the seed, to the side, or both below and to the side of the seed. A four-row hoe opener was developed for direct seeding into untilled stubble, and a conventional seedbox was added for continuous seeding when the cones are used for the application of measured amounts of fertilizer. Also, the frame was redesigned so that the seeding equipment can be rapidly removed and a utility trailer attached. A magazine system that can be preloaded to feed the seed automatically to the cones is now being developed.

Forage seeder, Model SC 714. The cereal seeder (Model SC 701) was redesigned to make it suitable for forages. With this seeder, six rows spaced 30 cm apart can be seeded simultaneously, and the soil packed both in front of and behind each opener. Seed is dispensed to each opener through a 17.8-cm cone. A two-row attachment with hoe openers was designed for seeding at very precisely specified depths or at linearly increasing depths from 0 to 12.4 cm as the plot is traversed.

Plot Harvesters

Forage harvester, Model IV. The forage harvester, Model II, which is now used extensively in many countries, was redesigned to reduce the cost of its production and to reduce the possibility of failure of the drive mechanism. The original drive mechanism was replaced with a Peerless series 1200 transaxle, which provides forward speeds of 1.78, 1.93, and 2.89 km/hr and a reverse speed of 1.48 km/hr at an engine speed of 3,200 rpm. The selection of forward speeds is very useful for cutting forage of various densities. A starter-generator was also added to the motor. The addition of a self-starter to the motor makes it possible to stop the motor when the harvester is not being used for cutting, thereby reducing the engine wear that usually occurs when motors are idled for extended periods. The modifications, particularly the substitution of the transaxle, reduce the cost of manufacture by 33%.

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Departures

A. G. KUSCH, B.Sc., B.S.A., M.Sc. Retired August 20, 1971	Oilseed breeding
J. S. HORRICKS, B.Sc., M.Sc., Ph.D. Resigned November 8, 1971	Plant pathology

VISITING SCIENTIST

J. M. CLARKE, B.S.A. University of British Columbia postgraduate student	Grass seed physiology

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[1] Postgraduate leave to University of Minnesota, St. Paul, Minn., September 1971 to September 1972.

INTRODUCTION

The Research Station at Beaverlodge and its associated experimental farms at Fort Vermilion, Alta., and Prince George, B.C., comprise the Northern Research Group. Research is aimed at agricultural problems of the areas north of latitude 53° N in British Columbia, north of 50° N in Alberta, and west of longitude 110° W in the Northwest Territories.

The greatest agricultural problem in the more northerly parts of the vast region served by the Group is lack of moisture. Annual precipitation at Fort Vermilion is only 36.83 cm (14.5 inches), and about one-third of this occurs in winter. Annual precipitation at Beaverlodge is 45.47 cm (17.9 inches) and at Prince George 62.74 cm (24.7 inches). The limited precipitation, long summer photoperiod, and Gray Wooded soils are important factors affecting the crop-environment relationship. Long-term research is directed toward a better understanding of these factors.

At Beaverlodge, research is conducted on soils, apiculture, and cereal, forage, horticulture, and oilseed crops. Forage crop management research is the major activity at Fort Vermilion, and forage crop production, management, and utilization are the main areas of research at Prince George.

This report summarizes the research that was carried on in 1971. This report and reprints of the publications are available on request. Correspondence to individual research scientists should be addressed to: Research Station, Research Branch, Canada Agriculture, Box 29, Beaverlodge, Alta. T0H 0C0; Experimental Farm, Research Branch, Canada Agriculture, Fort Vermilion, Alta. T0H 1N0; or Experimental Farm, Research Branch, Canada Agriculture, Prince George, B.C.

L. P. S. Spangelo
Director

APICULTURE

Breeding

Evaluation of hybrids of New Zealand × California honeybee stocks for honey production. Hybrid offspring of New Zealand × California drones significantly outyielded the parental stock. The honey production was 117 kg (258 lb), 108 kg (239 lb), and 105 kg (230 lb)/colony for the hybrids, California, and New Zealand stock respectively.

FORAGE CROPS

Breeding

Reed canarygrass. A new low-shattering reed canarygrass variety is being released. Designated BL 661 until approval of a proper name, this variety yielded twice as much seed and equaled the forage yield of Frontier. It is adapted to all areas of Canada where reed canarygrass can normally be grown. Economic seed production will now be consistently possible, and could provide adequate Canadian supplies of reed canarygrass seed. This should stimulate use of reed canarygrass as a highly productive forage, especially under irrigation. Seed of the new variety is to be increased and distributed by the Canadian Forage Seeds Project.

Seed Production

Alfalfa leafcutter bees and pollination. Populations of the alfalfa leafcutter bee, *Megachile rotundata*, increased 2.5-fold in 2 consecutive years when polyethylene cages were used to protect their domiciles at Fort Vermilion, which is outside the area of adaptation of this insect. Yields of 285 kg/ha (250 lb/acre) of alfalfa seed were obtained with a stocking rate of 25,000 cells/ha. Because of the flight range of these bees is limited (40 m), the domiciles may need to be moved for more effective pollination.

Grasses for sulfur-deficient soils. The 3-year average seed yield for creeping red fescue in an S-deficient soil was 518 kg/ha when an NPK fertilizer was applied annually. The addition of S to the fertilizer failed to influence seed yields. Creeping red fescue may therefore be considered as an alternate

crop for those soils low in water-soluble SO_4-S (5 ppm or less) where cereal grains suffer from S deficiency.

Cereal companion crops for seed grasses. The differences in response of grass species to companion crops were demonstrated in a study involving eight species and seven companion crops established in 1969. Seed yields obtained the year after seeding showed that grasses tended to fall into two distinct groups; some required an uninterrupted growth period in the seedling stage, and others could tolerate some restraint during their first year. Russian wild ryegrass, meadow fescue, and creeping red fescue grew best if seeded alone relatively early in the spring; this provided a full season for development in the year of seeding. Crested and intermediate wheatgrass and bromegrass all tolerated the companion crops in the year of seeding and still produced satisfactory seed yields the following year.

Rapeseed proved to be the companion crop most generally tolerated by perennial seed grasses, except for Russian wild ryegrass, which was suppressed by all companion crops. Flax proved equally acceptable to crested and intermediate wheatgrass, bromegrass, and meadow fescue. Wheat and early-maturing varieties of barley were satisfactory companions for crested and intermediate wheatgrass and bromegrass. Oats can be considered a companion only for intermediate wheatgrass.

The late-maturing variety of barley proved unsatisfactory as a companion seeding for any grass.

Disease. Severe infections of stem eyespot caused by *Phleospora idahoensis* on creeping red fescue were more prevalent in 1971 than in previous years. Seed losses attributed to this disease occasionally approached 60%. Research into techniques of removing contaminated debris by various mechanical means failed to reduce infection. Differences in the incidence and severity of stem eyespot were observed in a field test of fertilizers in which N, P, and S were applied in different combinations to creeping fescue grown for seed. All fertilizer treatments tended to lower the eyespot index, but only N greatly reduced the disease.

Herbage Production

Fertilizing cultivated pastures. The 3-year average net return from beef raised on pastures fertilized annually with N at 55 kg/ha and P at 32 kg/ha was 30% higher than that from beef raised on nonfertilized pastures. Comparative data for the control and fertilizer treatments were: carrying capacity, 0.44 and 0.38 ha/animal unit per month; daily gains for yearling steers, 2.39 and 2.54 kg; herbage production, 1,749 and 3,221 kg/ha.

Effect of fertilizer and harvest date on mature hay stands. At Beaverlodge, application of N at 0, 100, and 200 kg/ha increased the 3-year average dry weight yield of mature (4th-year) creeping red fescue from 232 to 1,382 and 1,760 kg/ha respectively. Comparable yields for Russian wild ryegrass were 398, 998 and 1,489 kg/ha. The crude protein content of creeping red fescue was not influenced by the addition of N, but with the same rates of N, the crude protein content of Russian wild ryegrass was increased if the forage was harvested early (June) or late (August). Protein levels in midseason (July) were similar for all rates of N.

In a similar trial with a mixed stand of bromegrass, alfalfa, and fescue, herbage yield and quality were not affected by fertilizers or harvest dates. However, multiple cuttings diminished alfalfa and increased growth of grasses and dandelions.

Cereal regrowth for pasture after a silage cut. Eleven cereal varieties were harvested for silage at the soft-dough stage and the regrowth was measured in early October for 2 years at Prince George. Jubilee barley produced an average of 726 kg/ha of dry matter, compared with 181 kg for Glen, Sioux, and Pendek oats. Average digestibility of the regrowth ranged from 58% to 67% and average protein levels were 14% to 19%. The mineral composition was adequate for optimum livestock production, with higher levels of Ca, P, K, and Cu than at the silage stage.

Timothy and reed canarygrass for pasture. In 84 grazing days at Prince George in 1971, timothy pasture supported production of 578.4 kg of steer beef/ha and reed canarygrass pasture, 522.4 kg of beef/ha. With a barley supplement at 1 kg/100 kg liveweight per day, the steers raised on reed canarygrass produced 692.8 kg of beef/ha. This was the first year of grazing after establishment of the stand in 1970.

For five steers raised on each of the various types of pasture, the mean Cu contents of liver tissue at time of slaughter were: on reed canarygrass plus grain (grazed), 8.9 ppm; on reed canarygrass (grazed), 10.5 ppm; on reed canarygrass plus grain supplement (zero grazed), 13.2 ppm; on reed canarygrass (zero grazed), 14.2 ppm; and on timothy (grazed), 28.5 ppm.

Copper and zinc supplements for beef rations. Forage and grain from the Peace River region and central British Columbia were analyzed. In most instances they contained less than 50 ppm Zn and less than 4 ppm Cu, the minimum dietary requirements for beef cattle according to the National Academy of Sciences (1970). However, when supplements of Zn and Cu were added singly to a normal forage–grain ration for beef heifers, change in shank circumference was the only response detected out of 27 variables measured. The entire group of heifers averaged 8.40 kg of feed/kg of gain during the 5-month feeding period and their carcasses dressed out at 60%.

SOILS

Soil Fertility

Fertilizing barley on broken grass sod. At Beaverlodge, increased yields of Galt barley were obtained on Black soil with increasing rates of N fertilizer on fescue sod broken in July, August, and September before the harvest year, and in the spring of the cropping year. With P at 22.4 kg/ha and K at 28.0 kg/ha, 3-year average yields were 23.4, 20.0, 14.5, and 0.1 q/ha for the four breaking times. When N was applied at 90 kg/ha, the yields for each breaking treatment were 41.7, 39.0, 31.1, and 25.9 q/ha. For the July breaking, responses to N at 45 kg/ha were similar to responses to N at 90 kg/ha. A higher average yield was produced on the sod broken in July with no N treatment than the sod broken in spring and treated with the highest rate of N. The higher barley yield on the briefly fallowed July breaking was mainly due to the greater available soil NO_3-N, available soil water, and the better seedbed, which resulted in better emergence and germination.

Extraction of plant-available Al and Mn from acid soils. In a greenhouse liming experiment, yields of barley, turnip rape, and alfalfa grown on 40 acid surface soils were compared with soil Al extracted by seven methods. The yield responses to liming were closely correlated with the exchangeable Al and 0.01 M $CaCl_2$-soluble Al of the soils. Simple extraction methods developed at Beaverlodge proved equal to standard complex methods. The simplified Beaverlodge extraction method and the seven other methods were used to extract Mn from the same 40 soils and the amounts extracted were compared with the concentration of Mn in barley, rape, and alfalfa. Of all the methods, the Beaverlodge 0.01 M $CaCl_2$ method gave the best estimate of plant-available Mn, proving that this method can be used for the simultaneous extraction of plant-available Al and Mn. This method has been further simplified to make it more suitable for routine diagnostic purposes. It now consists of shaking soil at a 1:2 ratio with 0.02 M $CaCl_2$ for 1 hr.

Rotations

Effect of alfalfa and grasses on yield of subsequent wheat crops. On Gray Wooded soil at McLennan, Alta., the 4-year average yield of wheat was 76% greater succeeding alfalfa than succeeding fallow. The yields after bromegrass + alfalfa were almost equal to those after alfalfa, and the yields after pure grass stands were about as poor as those after fallow. The number of years that the forage stands had been in production did not affect their benefit to wheat.

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Research Station
Lacombe, Alberta

PROFESSIONAL STAFF

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L. C. GODFREY, B.Sc.	Administrative Officer

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J. A. NEWMAN, B.Sc., Dip. An. Gen., Ph.D.	Population genetics
E. H. REIMER (Mrs.)	Systems and programming
G. M. WEISS, B.S.A., M.Sc.	Biostatistics

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D. R. WALKER, B.Sc., M.Sc.	Soil chemistry

Solonetzic Soil Substation, Vegreville

R. R. CAIRNS, B.S.A., M.Sc., Ph.D.	Officer in Charge; Soil physics and chemistry

Departures

S. U. KHAN, B.Sc., M.Sc., Ph.D. Transferred to Research Station, Regina, Sask., August 1, 1971	Soil chemistry
A. D. MCFADDEN, B.Sc., M.Sc. Retired November 30, 1971	Head, Plant Breeding Section

INTRODUCTION

This report summarizes our principal findings of 1971 in beef cattle and swine breeding and carcass research; cereal and forage breeding and pathology; soil chemistry and management; and weed control and crop management. Further details are given in the listed publications.

Interest continues to be extremely high in our results with crossbreeding beef cattle.

Because of the increased interest in the production of rapeseed in central Alberta, some changes of emphasis have been made in our program with this crop, particularly toward the diseases affecting it.

Dr. D. K. McBeath of the Crop Management and Soils Section was seconded for 2 years to a soil research program in India.

A. D. McFadden, Head of the Plant Breeding Section, retired in December after many years of very faithful work and many valuable contributions to cereal production. He has accepted an assignment with CIDA in Tanzania.

On invitation, Dr. H. T. Fredeen, Head of the Animal Science Section, presented seminars in England, Denmark, and Sweden.

Address all correspondence to: Research Station, Research Branch, Canada Department of Agriculture, Lacombe, Alta. T0C 0C0.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Selection for yearling weight. Ten years of selection for yearling weight in a breeding herd of 500 head of Shorthorn cattle at the research stations at Brandon and Lacombe has resulted in a net genetic gain of approximately 40 kg in the selected trait. The realized heritability has been 0.47 ± 0.13 for males and 0.31 ± 0.09 for females at Brandon, and 0.39 ± 0.17 for males and 0.25 ± 0.09 for females at Lacombe. The combined estimate for both sexes at both stations was 0.40 ± 0.06.

Carcass performance of Simmental crossbreds. Contemporary male progeny from Simmental (92 animals) and Charolais (98 animals) sires were equivalent in percentage yield of trimmed lean product and in several other quantity and quality measurements made on the carcasses. The only statistically significant breed difference was shown by Charolais with a superior dressing percentage ($P < 0.05$). This difference was identified as a difference in hide weight; the Simmental-cross bulls produced 1.4% and steers 0.9% more hide. Crosses out of Hereford dams had 0.5% more hide than those out of Angus dams ($P < 0.05$). Steers were fatter and yielded approximately 3% less trimmed retail product than contemporary bulls.

Feedlot and carcass performance of several breeds and crosses. Feedlot performance of 174 hybrid bulls produced at the Research Station, Lethbridge, in matings of Angus, Hereford, and Holstein dams with Angus, Hereford, Shorthorn, Charolais, and Brown Swiss sires showed the progeny of Holstein dams superior ($P < 0.01$) in pre- and post-weaning growth rate. Progeny of Holstein dams or by Charolais or Brown Swiss sires had the least external fat cover ($P < 0.01$) and the greatest percentage yield of deboned-defatted lean ($P < 0.01$). Hide weight was least for progeny of Holstein dams and greatest for progeny of Hereford sires or dams ($P < 0.01$). British breed crosses had the greatest degree of marbling, but there were no breed differences in percentage of ether-extractable fat of the *longissimus dorsi* or in measurements of tenderness. Progeny of Hereford dams were more efficient than Holstein progeny in converting feed to liveweight gain ($P < 0.01$). This tended to negate the Holstein-cross advantage in growth rate and lean content, and there were no breed-of-dam differences in energy requirements per unit of lean produced. Progeny of British breed sires required the greatest energy intake per unit of lean product produced ($P < 0.05$).

Swine

Selection for growth and carcass lean. Eight generations of index selection for minimum backfat and maximum growth rate in a replicated experiment was superior to single-trait selection for the index components. Comparisons with 150 control line pigs in the eighth generation showed that the index line had 3% faster growth and 11% less backfat. The line selected for maximum growth rate was 4% faster in growth with 3% less fat, whereas the minimum fat line was 6% slower in growth with 12% less fat. In percentage dissected lean of the entire loin, the three lines expressed as a percentage of contemporary controls were maximum growth line 98% (95 pigs); minimum fat line 111% (93 pigs); and index line 111% (131 pigs). For all lines, boars were significantly superior and barrows significantly inferior to gilts in backfat thickness, proportion of lean in the ham, and percentage dissectible lean of the loin.

The selected lines did not differ significantly from the control in marbling score, muscle pH, or transmission value (water-binding capacity of muscle protein). Muscle color was positively correlated ($P < 0.05$) with leanness of carcass ($r = 0.25$) and slaughter age ($r = 0.32$), but no other meaningful associations between quantity and quality traits were detected.

Carcass Research

Characteristics of beef carcasses in relation to commercial grade. In studies with 168 steers, 145 heifers, and 259 bulls, higher carcass grades were associated with heavier carcass weights, higher marbling scores, higher ether extract of *l. dorsi*, and greater external fat cover. Grades did not differ in area of *l. dorsi* after adjustment for differences in carcass weight. There were no measurable relationships between grade and palatability factors (tenderness, flavor, juiciness). External fat cover was positively related to intramuscular fat, with correlations of 0.34 (bulls), 0.23 (steers), and 0.12 (heifers). Marbling score was not associated with tenderness, juiciness, or flavor, as evaluated by a taste panel.

Quality of beef carcasses in relation to cooler aging. Tenderness of meat samples from 570 youthful beef carcasses improved quite consistently with length of aging period, regardless of carcass fatness, sex, or origin. Most of the improvement occurred in the first 3 to 6 days of aging, and only a relatively small increase in tenderness took place from 6 to 13 days. Steaks from the anterior portion of the *l. dorsi* were more tender ($P < 0.01$) than those from the posterior portion. Excision of the muscle from the carcass 24 hr post-mortem did not adversely affect tenderness. This discovery disagrees with reports that "cold shortening" of muscle (that is, the shortening of muscle fibers during rigor mortis, which has an adverse effect on tenderness) is most pronounced in muscles that are not supported by the skeleton.

Quality of beef carcasses in relation to sex. In a comparison of the carcasses of 168 steers, 147 heifers, and 259 bulls, heifers were found to be superior to bulls and inferior to steers in objective measurements of tenderness (Warner-Bratzler shear) after 72 hr post-mortem aging, but no sex differences were evident after 13 days of aging. The *l. dorsi* of heifers had more marbling ($P < 0.05$) than in steers, but when the fat content of this muscle was determined chemically, the two sexes gave similar results. The sexes did not differ in meat color, except that bulls exposed to preslaughter stress had higher pH values, darker color ($P < 0.05$) of the *l. dorsi* muscle, and improved scores ($P < 0.05$) for tenderness, juiciness, and flavor.

Distribution and composition of carcass fat in swine. A direct relationship between degree of fatness and saturation of the constituent fatty acids was established by a study of 616 hog carcasses of barrows, gilts, and boars from several lines of breeding. Fatter carcasses had higher percentages of myristic and palmitic acids ($P < 0.05$) and lower values for linoleic acid ($P < 0.05$). Boars and barrows had a higher percentage of linoleic acid than gilts, whereas barrows had greater percentages of the saturated myristic and palmitic acids than gilts or boars ($P < 0.05$). There were no sex–line interactions.

Based on subcutaneous, body cavity, intermuscular, and intramuscular fat, boars were leaner and barrows fatter than gilts. Backfat measurements provided a reliable measure of total fat trim, but the interrelationships of subcutaneous fat with intermuscular or intramuscular fat, though generally positive, were quite low. The chemical analyses were completed by the Analytical Chemistry Research Service, Canada Department of Agriculture, Ottawa.

Physiology

Growth patterns and composition of pigs. Growth patterns for protein and fat were studied in 90 Lacombe breed pigs weighing from 10 to 132 kg. The average daily gain of protein and fat in the body and in the carcass increased almost linearly with an increase in liveweight. These observations vary markedly from the long-accepted theory that lean tissue growth in pigs reaches a maximum at 65–75 kg liveweight and fat at 90–100 kg.

The rate of increase in daily gain of fat was only slightly higher than that of protein; the result was a slow and gradual change in the relative proportions of these tissues as carcass weight increased. The protein in the carcass declined from 14.1% in animals of 90 kg (200 lb) liveweight to 14.0% in animals of 120 kg (265 lb), whereas the percentage of fat increased from 36.6% to 37.8%. Above a liveweight of 120 kg, the percentage of protein decreased and the percentage of fat increased faster.

These results suggest that meat-type hogs can be grown to heavier weights without substantially changing the relative proportions of lean and fatty tissue.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Depth of seeding barley. In field trials, Conquest, Galt, and two short-strawed selections were sown 2.5, 5.0, and 7.5 cm deep. Emergence and yields decreased with increasing depth of seeding. The effect was greater with the two short-strawed selections, which also had shorter coleoptiles. The depth × variety interaction was nevertheless not significant for either seedling stand or yield. The correlation coefficient for seedling stand and yield ($n = 46$) was +0.696.

Net blotch of barley. High in vitro activity of enzymes commonly involved in tissue maceration was not detected in virulent isolates of *Helminthosporium teres* Sacc., so virulence may not be associated with pectin methylesterase, pectin trans-eliminase, cellulase, or proteolytic activity. Polygalacturonase and polygalacturonate trans-eliminase activity, however, was higher in the virulent than in the avirulent isolates. The high cellulolytic, pectic, and proteolytic enzyme activity in the avirulent isolates are probably associated with a successful saprophytic existence.

Disease survey. A disease survey of cereal fields in central Alberta showed that leaf diseases and smuts reduced yields by 6% in 1971. Root rot was found in about 90% of the barley fields surveyed, and yield reduction due to root rot was 10%.

Forage Crops

Spot blotch on grasses. Five isolates of *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem., a pathogen known to cause root rot and spot blotch of cereals, were collected in central Alberta and tested for pathogenicity on the foliage and roots of 5 cereal species and on the foliage of 24 grass species. In both cereals and grasses, there was a significant difference in resistance between species. A significant difference in virulence of isolates was also found.

Effect of coumarin on pathogens of sweetclover. The susceptibility of sweetclover, *Melilotus alba* Desr. and *M. officinalis* (L.) Lam., to infection by bean yellow mosaic virus and *Ascochyta imperfecta* Pk. was not altered by the levels of coumarin. In the sweetclover plant, coumarin was mainly bound as a glucoside, which was not inhibitory to the fungi. However, in media that contained freshly ground sweetclover, the inherent glucosidase released coumarin, which inhibited fungal growth as did media containing similar levels of pure coumarin.

Protein content of forage components of oats. Samples of six varieties of oats were taken at the early dough stage. The protein content of the seed, leaf blade, leaf sheath, and stem averaged 12.7%, 10.5%, 7.1%, and 4.2% respectively. There were varietal differences in the protein content of leaf blades and seed, but the ranking of varieties was not the same for the two components. Varieties did not differ in protein content of leaf sheaths and stems.

Disease survey. An extensive survey of foliar diseases of five species of legumes and three species of grasses was carried out in 1971. Methods based on the infested area of leaves and stems were devised to measure the intensity of each of 30 diseases. The prevalence and distribution of the various species of forage crops were estimated, and the

losses caused by the various diseases calculated. In central and northern Alberta, the total loss was about $4.7 million, or an overall average loss of 5.65%.

Other Crops

Bacterial leaf spot of sunflowers. Bacterial leaf spot was prevalent on sunflowers in Alberta in 1971. The causal agent is a species of *Pseudomonas* that is both soil- and seedborne. Leaf lesions may develop as a result of systemic infection or from externally applied inoculum. There are no known commercial varieties of sunflowers that are resistant to the disease, which has also been found on wild sunflowers.

Horticultural Crops

Effect of plastic mulch on strawberries. In the first crop year, the yield of strawberries mulched with black plastic was inferior to that obtained from matted rows. Three cultivars in mulched plots produced a mean yield of 1,302 kg/ha, and in matted rows 5,062 kg/ha. Mulching did not affect maturity.

Effect of green sprouting on early potato yields. Holding potato tubers at 21 C for 20 days before planting, to initiate sprouting, resulted in greater yields 75 days after planting than from tubers held at 4.5 C. The same results were obtained with four cultivars, regardless of whether the potatoes were held under light or darkness.

Production of onion sets. The cultivar Yellow Ebenezer, seeded at 67 kg/ha in a row spacing of 30.5 cm, produced sets at 21,485 kg/ha that graded 78.9% marketable. The onion sets were large enough to be lifted for curing 87 days after seeding.

Garlic production. Garlic cloves, seeded at a spacing of 5.08 cm in a row spacing of 30.5 cm, produced a marketable yield of 14,893 kg/ha. This yield was superior to that obtained from cloves seeded at 7.62 cm and was more than double that obtained from a 10.16-cm spacing.

CROP MANAGEMENT AND SOILS

Weed Research

Economic appraisal of weed competition. Published results on yield losses in wheat and flax due to different population levels of wild oats were examined, and the effect of removing similar infestations of wild oats at various times after emergence was studied. Regression methods were used to develop mathematical models for predicting these losses.

Field plot tests were set out in 1971 to test these models and to provide data for deriving models to predict losses from wild oats, tartary buckwheat, and smartweed in barley and rape. Sufficient information was obtained to indicate that the mathematical approach for predicting direct losses due to weeds is practical. Other factors affecting competition of weeds with crops will be investigated for possible inclusion in the models, if relevant.

A new herbicide for wild oats. Three years of study in the field and the laboratory have shown that some formulations of WL-17731 (Shell) have great potential as postemergence herbicides for controlling wild oats. Formulations FX-2039 and FX-2182, both emulsifiable concentrates of WL-17731, applied at 1.4 kg/ha in 15 to 35 liters of water during the two- to five-leaf stage of the weed gave good to excellent control. In the field trials, the best control resulted when the herbicide was applied at the later stages of weed growth. However, the yield response of wheat was greatest from treatments applied during the two- to three-leaf stage, presumably because of the earlier removal of the wild oats. This compound inhibits growth rather than killing the wild oats, although the leaves become necrotic. Wheat has high tolerance, and preliminary studies suggest that rapeseed possesses similar tolerance. Barley was sensitive to all formulations tested.

These new formulations represent a big step forward, because the currently used postemergence herbicide barban must be applied during the two-leaf stage of the wild oats. Consequently, farmers often are unable to use the herbicide owing to bad weather

during the few days when effective spraying is possible. As with barban, these new formulations lose much of their phytotoxicity if they are mixed with other herbicides such as 2,4-D, MCPA, or dicamba.

Linuron–MCPA mixture, a selective herbicide for cereals. Linuron has been used successfully to control various weeds in several horticultural crops for a number of years. However, only in the past 4 years has it been found that mixtures of linuron and MCPA can be used at sufficiently low rates to avoid injury to cereals and yet effectively control weeds. Wheat and oats have demonstrated a high tolerance for this mixture, but more work is needed to establish the tolerance in barley.

This mixture is particularly useful because of its excellent control of green foxtail, corn spurry, chickweed, hemp-nettle, and stork's-bill. These species are all highly tolerant of our commonly used herbicides. Linuron is a wettable powder that presents some problems if it is applied by the kind of sprayer currently used on grain farms.

Soils

Response of Gateway barley to N and P fertilization. A barley yield equation has been developed from field results obtained over several seasons on Chernozemic and Luvisolic soils at six locations in central Alberta. This study was conducted in cooperation with the departments of Soil Science and Computing Science, University of Alberta, and the Alberta Department of Agriculture. Variables in the yield equation include fertilizer rates, soil nutrient status, and a site moisture-stress index. A daily soil-moisture budget was calculated for each site, and this budget was used to identify stress-days. Data external to this investigation were used to derive an equation relating the yield of barley to the moisture stress occurring within three stages of crop development: planting to emergence, emergence to onset of tillering, and jointing to heading. This moisture-stress equation was used to calculate the site moisture-stress index.

With nutrients nonlimiting, about 55% of the variation in yield of barley was explained by moisture stress occurring before heading of the crop. The site moisture-stress index entered the barley yield equation as an interaction with applied N fertilizer. The nature of this interaction suggests that if the soil-moisture conditions at time of seeding are poor, the optimal input of fertilizer N is reduced about 40% from that calculated for good soil-moisture conditions. It was shown that the ratio of N to P recommended at the optimal level of fertilizer input is often not the combination of N and P that would be recommended for fertilizer inputs below the optimal level.

Influence of S fertilization on Se content of forage species. The concentration of Se in alfalfa, red clover, and alsike clover was reduced where growth was increased as a result of S fertilization. No reduction in Se concentration occurred in these species, or in timothy and bromegrass, when growth was not increased by S fertilization. Evidently decreased Se concentration was a result of a fairly constant Se uptake regardless of plant yield rather than a direct inhibitory effect of sulfate ions on Se absorption by the plant.

Comparative response of rape and barley to fertilizers. Generally, a similar pattern of response to N, P, K, and S was obtained with Span rape and Galt barley grown on six Chernozemic and two Luvisolic soils in central Alberta. At one location a yield response to K application was obtained from barley, but not from rape. However, soil analyses indicated that this difference was due to local soil variation.

Distribution of N in fulvic acid fraction extracted from the Black Solonetzic and Black Chernozemic soils of Alberta. The proportions of N accounted for as amino acid-N, amino sugar-N, and ammonia-N in the acid hydrolysates of fulvic acids increased in the order: Solonetz > Solod > Chernozem. The composition and relative molar distribution of amino acids among the fulvic acids obtained from the three different soils were fairly similar. The amino acid composition was not greatly affected by the differences in salt regime.

Thermal stabilities of amino acid components of humic acids under oxidative conditions. The thermal stabilities of amino acid components of humic acids isolated from the Black Solonetzic and Black Chernozemic soils were determined by heating them in a

current of air for up to 600 hr at 170 C. Serine and threonine were the least stable; proline, arginine, and lysine intermediate in stability; and glutamic acid, aspartic acid, glycine, alanine, valine, isoleucine, leucine, tyrosine, phenylalanine, and histidine the most stable amino acids. The data did not follow first-order kinetics.

The permanganate oxidation of acids from Ah soil horizons. Humic acid, fulvic acid, and humin fractions extracted from a Black Chernozem, a Black Solod, and a Black Solonetz were methylated with diazomethane and oxidized with permanganate solution. The oxidation products were extracted into ethyl acetate, separated by preparative gas chromatography, and identified by comparing their mass and microinfrared spectra with those of authentic specimens.

The total yield of oxidation products followed the order: humic acids > humins > fulvic acids. The products resulting from the oxidation of humic and fulvic acids averaged 63% benzenecarboxylic, 32% phenolic, and 5% aliphatic carboxylic acids. The oxidation products from humins averaged 76% benzenecarboxylic, but only 20% phenolic and 4% aliphatic carboxylic acids, thereby showing some differences in the chemical structure of humins from those of humic and fulvic acids. The most prominent compounds produced by the oxidation of humic acids were hydroxy benzenepentacarboxylic and benzenetetracarboxylic acids.

In general, differences in the distribution of the major oxidation products among the three main fractions were greater than those within individual humic fractions. Therefore, the chemical structures of humic acids extracted from three different soils appeared to be more similar to each other than to those of fulvic acid and humin fractions from the same soil. The same results were found with fulvic acids and humins extracted from the three soils.

Between 79% and 95% of the oxidation products were identified. The oxidation products may have originated from: condensed lignin structures, complex structures of microbiological origin, or polymeric structures consisting of benzenecarboxylic and phenolic acids held together by hydrogen-bonding, or all three kinds of structures.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Coal products as fertilizers for Solonetz soil. In pot experiments, with the use of barley seedlings as an indicator crop, it was found that sulfomethylated and sulfonated coal products were less effective N fertilizers than ammonium nitrate for a Solonetz soil. Sulfonated coal suppressed the uptake of Na and K and was toxic to the plants. There was no evidence of any beneficial effect of the humic substances in coal on plant growth beyond that attributable to the nutrients they contained.

Long-term heavy fertilization of bromegrass on Solonetz soil. For 10 years beginning in the fall of 1960, 16-20-0 fertilizer at 4,300 kg/ha was applied annually to bromegrass, *Bromus inermis* Leyss., growing on a Solonetz soil known to be deficient in N in order to study the effects of the treatment on the chemical properties of the soil. The saturation percentage, pH, C percentage, soluble Na, and exchangeable Na and K contents of the Ap horizon were significantly lowered by the use of fertilizer. The soluble Ca, Mg, and K contents of this horizon were increased and the percentage N and the exchangeable C and Mg contents were unchanged by fertilization. In the Bnt horizon, the soluble Ca, Mg, and K levels were all increased by fertilization; the exchangeable Na content was decreased; the exchangeable Mg was increased; and the other properties were unchanged by fertilization. Below the Bnt horizon, the chemistry of the soil was extremely variable and no differences were discernible.

Effect of deep plowing on the fertility of Black Solonetz soils. Field studies were established to measure the relative effectiveness of deep plowing and fertilization on the productivity of four Solonetz soil types in the Black soil zone, under quite similar climatic conditions. On three of the Solonetz soil types, fertilization was essentially as effective as deep plowing in stimulating productivity, and the effects of both treatments on crop chemistry were somewhat similar. The soil that was least affected by fertilization and greatly affected by deep plowing had the most unproductive Bn horizon of any of the soils in the study.

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R. H. ROBERTSON, B.A., M.Sc.	Serology
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P. R. WILKINSON, B.A., M.A., Ph.D.	Ticks and economic entomology

Departures

R. W. PEAKE, B.Sc., M.Sc. Retired December 29, 1971	Assistant Director
B. M. PEHRSON (Miss), B.Comm., B.Ed., M.L.S. Deceased June 16, 1971	Librarian
L. A. JACOBSON, C.D., B.Sc., M.Sc. Retired March 31, 1971	Pale western cutworm
J. S. HORRICKS, B.Sc., M.Sc., Ph.D. Transferred to Beaverlodge, Alta., May 1, 1971	Cereal diseases
R. A. MILNE, B.S.A., M.Sc. Retired September 15, 1971	Salinity and drainage

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U. SOEHNGEN, B.Sc., M.S., Ph.D.	Forage-crop insect pollinators
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INTRODUCTION

This report reviews briefly the main research results obtained during 1971 at the Research Station, Lethbridge. Research at the Station is organized into 29 multidisciplinary programs related to Western Canadian agriculture. Emphasis during the year was placed on intensified research on assessing crop losses due to disease, use of foreign breeds in crossbreeding for beef production, sheep management, feedlot bloat, rapeseed management, grass breeding, control of soil salinity, nonpolluting methods for controlling diseases and insects, and breeding feed grains. The addition of an economist to the staff has enabled us to integrate economic and production research.

The Station continued its cooperation with grower and producer organizations and the departments of Agriculture of Alberta and other provinces in the application of its research results to agricultural production and protection. Significant progress was made toward the control of warble flies and aquatic weeds, the determination of principles of beef crossbreeding, and establishment of new crop enterprises.

This Station is responsible for a Canadian foreign aid program in India to establish research to improve crop production on dry land. Projects in soil physics and fertility, crop management, and agricultural engineering were established at 11 locations in India.

We regret to record the death on June 16, 1971, of Miss Bertha M. Pehrson, who had been our librarian since 1950.

Detailed information on research results can be obtained from the scientists or from the publications listed in this report. Correspondence should be addressed: Research Station, Research Branch, Canada Agriculture, Lethbridge, Alta. T1J 4B1.

J. E. Andrews
Director

ANIMAL SCIENCE

Sheep

Heritabilities and genetic correlations of baby teeth. High heritabilities were obtained for baby teeth of Rambouillet and Romnelet paternal half-sibs. These were width of the two central incisors measured at the top, 0.63; length of central pair of incisors, 0.58; length of next adjacent pair, 0.51; length of third pair from center, 0.41; angle of front teeth with upper gum, 0.24; and distance between canines, 0.38. Most of the genetic correlations between width of the central incisors and the other measurements were positive.

Meat flavor of male lambs. Samples weighing 1.36 kg, cut from the right hind leg of 32 ram lambs, 36 induced cryptorchids, and 32 wether lambs, were roasted and tested for flavor. All animals weighed 40 to 45 kg at slaughter. Eight taste panelists graded each roast as very poor, poor, normal, good, or very good. The roasts were judged to be poor, 2%; normal, 32%; and good or very good, 66%. Taste scores among the three sex types did not differ significantly.

Dairy Cattle

Dried molasses beet pulp. Feed intake and milk production by dairy cows tended to increase as the level of dried molasses beet pulp in the ration was increased from 0% to 15%. Solids-corrected-milk production increased from 25.7 to 27.0 kg/day in cows with a high breed-class-average index and from 21.0 to 21.9 kg/day in cows with a low index. As dried molasses beet pulp in the ration was increased, the efficiency of energy utilization of cows with a high index remained at about 2.6 Mcal/kg of solids-corrected milk produced, whereas that of cows with a low index increased from 2.80 to 3.15 Mcal/kg.

Body size and milk production. The influence of body weight during lactation on milk fat and solids-not-fat yield declined with successive pregnancies. The decline was more evident in Holsteins than in Ayrshires and Jerseys. Relationships were inverse between yield and liveweight at 180 days after calving, and between yield and wither height at first calving, when calving weight and age were constant.

Beef Cattle

Metabolic fecal nitrogen. Excretion of N by sheep and cattle was shown to be related to excretion, rather than intake, of dry matter. Extrapolation of N excretion to zero N intake gives a value for metabolic fecal N or loss of N independent of unabsorbed feed N. This information permits calculation of the true N digestibility of feeds from conventional digestibility data.

Subcutaneous fat in females. Subcutaneous fat, measured by ultrasonic scanning over the area between the 11th and 12th ribs, averaged 6 mm deeper on Angus and Hereford 2-year-old heifers that gained 0.6 kg/day over a 10-month period than on heifers that gained only 0.2 kg/day. Average fat depth on normally growing yearling crossbred heifers increased from 3.4 mm in June to 12.6 mm in November. Depth of subcutaneous fat could be useful in assessing the body condition of female beef cattle during growth.

Blood constituents in females. Packed cell volume of blood and levels of blood glucose, plasma nonesterified fatty acids, and plasma ketones increased significantly in nonpregnant 2-year-old Hereford and Angus heifers during a 48-hr fast. Neither body weight gain during the 140 days before fasting nor subcutaneous fat over the area between the 11th and 12th ribs was related to changes in levels of blood constituents that occurred during the fast.

Productivity of hybrid cows. During a lifetime productivity study begun in 1956, Brahman × Hereford hybrid cows produced 26% more calves and 52% more weight of beef to weaning than Hereford cows; they also produced calves with a heavier weaning weight and tended to remain productive about 3 years longer than Herefords.

Selection for postweaning gain. Calves from dams selected for postweaning performance on a low-plane ration tended to gain faster to weaning than calves from dams selected similarly on a high-plane ration. Ultrasonic measurements of 222 male calves at weaning in 1971 showed significant differences between the lines in fat cover but not in rib eye area. Calves from low-plane dams tended to have less fat cover than calves from high-plane dams. Hereford calves had less fat cover than Angus calves.

Crossbreeding. Hybrid bulls were used to evaluate postweaning growth and carcass characteristics of crosses between Hereford, Angus, and Holstein dams and Angus, Hereford, Brown Swiss, Charolais, and Shorthorn sires. Progeny of the Holstein dams surpassed those of other breeds in preweaning and postweaning traits. Differences due to breed of sire were generally not significant, except for growth rate in the feedlot. Progeny of Hereford dams were more efficient than those of Holstein dams in converting feed to liveweight gain. Calves sired by British breeds required the greatest energy intake per unit of lean meat.

Poultry

Mercury levels in chickens. Growth rate was depressed when broiler-type chickens were fed rations with 5.3, 10.6, and 21.2 ppm added mercury (Hg); however, Single Comb White Leghorn chickens were affected only by the highest Hg level. The addition of 2.6 ppm Hg did not affect the growth rate of either breed. Mercury levels in body tissues increased with increasing level of Hg in the diet, and were highest in the the kidney and liver, intermediate in the breast meat, and lowest in the heart.

Mercury levels in chickens, ducks, and pheasants. Chickens, ducks, and pheasants were fed from 5 days of age on diets containing 0.0, 0.33, 3.3, and 33 ppm added Hg from methyl mercury dicyandiamide. The life-span of pheasants, ducks, and chickens fed the 33-ppm diet averaged 14.4, 19.8, and 33.1 days. Tissue Hg levels of birds 35 days old were generally higher in ducks than in pheasants, and higher in pheasants than in chickens. After Hg had been withdrawn from their diets, ducks retained more Hg in their tissues than pheasants, and pheasants retained more than chickens.

Calcium and phosphorus levels in rations. Weight gains of Single Comb White Leghorn chickens were less affected by high or low calcium (Ca) levels or by added phosphorus (P) in the diet than were those of broiler-type chickens. Broilers receiving 0.18% P in their basal diets made lower gains when 0.2% or 1.2% Ca was added than when intermediate amounts of Ca were added. Growth of broilers receiving 0.36% P in the diet was not affected when 1.2% Ca was given, but when

0.18% P and 0.2% Ca were fed their growth was slower.

CROP ENTOMOLOGY

Cutworms

The pale western cutworm severely damaged some wheat fields in southern Alberta, and an increase in numbers is expected in 1972. Redbacked cutworms were more prevalent than in 1970.

Sprays of Dursban (Dow Chemical), leptophos (Phosvel; Velsicol), and N2596 (Stauffer) applied to microplots of sugar beets were as effective as endrin in controlling redbacked cutworms. AC47031 (Cyanamid) had to be applied at twice the dosage to give the same control.

Up to 70% pupation was achieved in rearing 1,000 redbacked cutworms/week in lots of 100 on an artificial diet supplemented with plant material. The larvae are handled only four times.

Three of 30 compounds obtained from the U.S. Department of Agriculture, Beltsville, Md., produced weak sexual responses in male redbacked cutworm moths, but 11 similar compounds synthesized locally failed to elicit any response.

Grasshoppers

A fourfold increase in grasshopper populations is predicted in Alberta in 1972. Moderate to light infestations are expected to cover almost 41,440 km^2 (16,000 sq miles).

Of three insecticides tested, only carbofuran was more effective than the insecticides registered for control of the twostriped grasshopper. Six grasshoppers/m^2 (five/sq yd) on wheat reduced yields by 26%.

Melanoplus gladstoni Scudder, *M. infantilis* Scudder, and *M. dawsoni* (Scudder) constituted 55% to 90% of the grasshoppers on seven range areas of Alberta.

Crowding increased the longevity and fecundity of the second generation of the migratory grasshopper. This may explain why grasshoppers multiply more rapidly than expected during outbreaks, and why levels of grasshopper populations cannot be correlated with weather conditions.

Eleven amino acids were shown to be essential in the diet of the twostriped grasshopper.

Aphids

Fourteen species of predators and parasites of the pea aphid, a major pest of alfalfa, have now been identified. One of these, a hymenopterous parasite *Aphidius smithii* Sharma & Rao, was recorded for the first time in Alberta.

Wheat Stem Sawfly

Quality rather than quantity of light evidently determines the level of sawfly resistance in Rescue wheat. Resistance was not correlated with hours of sunshine but was correlated with the number of rainy days in June. Shading and watering of plants in the field had little effect. Filtering sunlight over field-grown Rescue to simulate the radiation measured on rainy days produced hollower stems than occur under straight shading for an equal period.

Cabbage Maggot

One application of chlorfenvinphos granular at seeding followed by a drench 53 days later satisfactorily controlled the cabbage maggot in rutabagas, but it was not as effective as aldrin. Carbofuran is not effective for use in southern Alberta.

It is currently recommended that rutabagas be grown at least 8 km from previous infestations. Only one of 13,450 marked adults, however, was captured on trap crops over 1 km from the release point. This finding suggests that the recommended distance for isolation could be reduced.

Rape Insects

Insect pests found on rape plants in Alberta in 1971 were the bertha armyworm, alfalfa looper, clover cutworm, beet webworm, saltmarsh caterpillar, flea beetles, false chinch bug, and aphids.

Malathion, trichlorfon, and dimethoate effectively controlled the false chinch bug in the laboratory. Carbofuran gave excellent control of flea beetles and, when applied early, significantly increased plant weight and height.

Potato Insects

Fonofos and fensulfothion gave excellent to good control of wireworms and were superior to the two insecticides currently registered for this use. Supracide (Ciba-Geigy)

equaled endosulfan for controlling DDT-resistant Colorado potato beetles.

Sugarbeet Insects

Eighty-five percent of the sugar beets in southern Alberta as well as several thousand hectares of rape were sprayed to combat the beet webworm. Aldicarb, diazinon, carbofuran, fonofos, and carbophenothion applied in the furrow controlled the sugarbeet root maggot. Neither of the herbicides Roncet (Stauffer) or Avadex (Monsanto), commonly used on sugar beets, affected the action of the insecticides.

Pollinating Insects

Hives for the alfalfa leafcutter bee were further improved by applying combinations of red and black paint on the entry surface and by making tunnels at least 15.24 cm long, with holes 0.71 cm in diameter.

Insecticide Residues

Methods were developed for the analysis of leptophos, its oxygen analogue, and its phenol in wheat plants and kernels. Under field conditions, leptophos degraded slowly in the plants and soil and was not detected in the kernels.

Elemental sulfur, often present in soil samples, may interfere with residue analysis. A method for its detection at subnanogram levels was developed.

PLANT PATHOLOGY AND PHYSIOLOGY

Cereal Viruses

A simple, efficient technique for handling the wheat curl mite, vector of wheat streak mosaic virus (WSMV) and wheat spot mosaic virus (WSpMV), was developed. With this technique, the WSMV-immune *Triticum* × *Agropyron elongatum* hybrid described in the Research Report for 1970 under Plant Science was found to be resistant to the mite and, perhaps consequently, to WSpMV. In contrast, a WSMV-immune *Triticum* × *A. intermedium* line from South Dakota was found to be susceptible to both the mite and WSpMV.

Downy brome, a troublesome weed in winter wheat, is susceptible to WSMV but it has now been shown not to be an important overwintering host of the virus. Seventy-two seedlings of this winter annual were lifted in the fall from an area where, earlier in the year, the seed parents had harbored viruliferous wheat curl mites. When tested, none of the seedlings were found to be carrying the virus.

A nonspecific strain of barley yellow dwarf virus transmitted by moderate populations (initially one per plant) of the oat-bird-cherry aphid, *Rhopalosiphum padi* (L.), reduced the yield of dry matter and changed the quality of forage from Victory oats and Betzes barley. The virus and its aphid vector had a striking effect on levels of total nonstructural carbohydrates and cell-wall constituents. In Victory oats the percentage of total nonstructural carbohydrates decreased and the percentage of cell-wall constituents increased; in Betzes barley the effect was reversed. Neither crop showed a reduction in percentage of protein on a dry-weight basis, but yields of protein were lowered because dry matter yields were reduced by more than half.

Cold Hardening of Wheat

The properties of invertase in Kharkov 22 MC wheat leaves have been shown to change during cold hardening. Major quantitative changes in the proportions of the invertase isozymes present occurred during cold hardening, which supports the hypothesis that isozymic substitutions are involved in cold hardening.

Alfalfa and Turf Diseases

In greenhouse studies, low soil fertility, low pH, and large populations of the nematode *Paratylenchus projectus* Jenkins 1956 collectively contributed to alfalfa-sickness symptoms.

Winterkilling induced by stem nematodes reduced plant populations of Beaver and Vernal alfalfa by half in 3 years. Losses of yield for the same period averaged 14%.

Although none of the fungicides tested for controlling snow mold on turfgrass were as effective as the mercurials, quintozene (Terraclor; Olin Mathieson Company) and Daconil 2787 (Diamond Shamrock Canada Ltd.) were the best of many proposed replacement compounds under test.

Lethbridge dwarf *Poa* (B101), a strain of Kentucky bluegrass selected for use on lawns and athletic fields, has been under test for 2

years and appears to be well adapted to the Alberta climate. It is resistant to cold injury, snow mold, and matting.

Potato Diseases

Symptoms of bacterial ring rot developed earlier and were more severe in root-inoculated potato plants grown from stem cuttings treated with indole-3-butyric acid than in those grown from nontreated stem cuttings or from tuber seed pieces.

Ring-rot bacteria isolated from infected potatoes maintained their virulence in agar culture over 3 years, a longer period than has been reported in the literature.

Symptoms caused by the leaf roll virus were more severe in potato plants grown from tubers infected with the leaf roll virus and inoculated with ring-rot bacteria than in plants grown from tubers infected with the leaf roll virus only.

A formula was developed that relates the severity of virus leaf roll symptoms to potato yield.

Rape Diseases

A method developed and used for measuring the loss in yield from systemic infection (staghead) of rape incited by the white rust fungus, *Albugo cruciferarum* S. F. Gray, showed that the percentage yield loss approximated the percentage of systemically infected stems. Losses from the disease in Span rape were more severe in crops sown before mid-May (10–13%) than after (1–7%). Oro rape was not susceptible to the strain of the pathogen present on Span in southern Alberta.

PLANT SCIENCE

Cereals

Sundance winter wheat. After Sundance hard red winter wheat had been licensed in Canada, over 20 metric tons of Select seed were released for fall seeding in 1971. Sundance was developed at Lethbridge from a Cheyenne × Kharkov 22 MC cross. It is superior to Winalta and Kharkov 22 MC in yielding ability and to Kharkov 22 MC in resistance to shattering. Sundancé is equal or superior to Winalta in winterhardiness, but is slightly lower in baking quality.

Cytogenetics of common root rot in wheat. Substitution of chromosome 5B of Apex, a wheat moderately resistant to common root rot, for chromosome 5B of S-615, a highly susceptible line, is known to make S-615 as resistant as Apex under certain conditions. To determine whether more than one locus on chromosome 5B is involved in root-rot reaction, S-615 and the substitution line, S-A5B, were crossed. The F_1 was backcrossed to monosomic 5B of S-615. Disomics were extracted from each of 130 of these backcross lines.

Of 71 homozygous disomic S-A5B crossover lines rated for root-rot reaction, 32 were resistant and 39 susceptible. As there were no intermediates, the resistance conferred by chromosome 5B of Apex is probably due to a single gene, as postulated. Seedling blight affected three susceptible lines (15%, 18%, and 35% survival vs. 83% for S-615 and 87% for Apex), probably because of a crossover between the gene for susceptibility on chromosome 5B of S-615 and a gene modifying its action on chromosome 5B of Apex.

Inheritance of subcrown internode length. Studies of the inheritance of subcrown internode length in crosses between the spring wheats Thatcher, Cypress, Chinook, and Rescue showed that Thatcher and Rescue differ by two genes. Cypress and Chinook have essentially the same gene complement, and both differ from Thatcher and from Rescue by one gene.

Scald in barley. Resistance to scald caused by *Rhynchosporium secalis* (Oud.) Davis was transferred from the cultivar Rivale to Betzes by backcrossing. In a greenhouse experiment, inoculation of this line reduced its yield by 7%, whereas the yield of Betzes was reduced by 19%. In field trials in the absence of scald, the yields of the resistant backcross line were not significantly different from those of Betzes. The backcross line developed some lesions when inoculated with *R. secalis* but Rivale did not, which indicates that the effectiveness of the gene for resistance may be less in Betzes than in Rivale.

Forage Crops

Oxley cicer milkvetch. Oxley, the first Canadian cultivar of cicer milkvetch, was licensed on February 4, 1971. It is a rhizomatous, fine-stemmed perennial legume not known to induce bloating in livestock. It is

winter-hardy, but grows slowly in the seedling stage and recovers slowly after cutting or grazing. Oxley is similar to alfalfa in protein content and dry matter digestibility. It has potential as a hay crop, especially when grown with grasses, in the Black and Dark Brown soil zones. A unique area of use appears to be in the foothills of southwestern Alberta, where Oxley may be broadcast into existing stands of timothy to improve quality and to increase quantity of forage.

Sainfoin. Sainfoin, another legume that will not induce bloating in livestock, has been evaluated for several years as a hay, pasture, and seed crop. A 5-year study showed that a mixture of sainfoin and Russian wild ryegrass, *Elymus junceus* Fisch., was superior to other sainfoin-grass combinations on dry land, although its yield was 10% less than alfalfa and Russian wild ryegrass. Sainfoin-timothy was the highest yielding sainfoin-grass combination under irrigation over a 2-year period. Sainfoin has performed poorly in mixtures with rhizomatous grasses such as brome and pubescent wheatgrass. In a 4-year dry land grazing trial with ewes and lambs, sainfoin outyielded alfalfa by 8%. The animals consumed a higher proportion of the sainfoin than of the alfalfa. Melrose, the only Canadian variety of sainfoin, has consistently outyielded other sainfoin strains in forage and seed production on dry and irrigated land.

Timothy. Differences were detected in the competitive ability of seedlings of one variety and two strains of timothy. The timothy was grown in pure or in mixed culture at spacings of 1, 2, and 4 cm. The naturalized strain, obtained from Waterton, Alta., appeared to be the most aggressive of the three. At the high density it seemed best even without tillering, and at the low density it had the most tillers. The Waterton strain could offer plant breeders an opportunity to select for a strain of timothy that excels in seedling aggressiveness and is adapted to southwestern Alberta.

Irrigated pasture. Yearling Hereford steers, rotated among four irrigated pasture fields, made average daily gains of 0.95 kg/head on orchardgrass, 0.86 kg on creeping red fescue, and 0.84 kg on reed canarygrass during a 103-day grazing period. Orchardgrass and reed canarygrass provided a consistent supply of grazing for seven yearling steers/ha (three steers/acre), and yielded some hay. The creeping red fescue pasture was subjected to considerable fouling by the animals, was not well utilized, and was badly invaded by weeds, mainly dandelion. Frequent shifting of the animals among fields was required to provide a fresh forage.

Horticulture

Sweet corn. In a plant population study, the highest ear and kernel yields of sweet corn were obtained from plots of the cultivar Mello-Gold grown under irrigation at 87,500 plants/ha (33,000 plants/acre). Ear dimensions decreased with increasing population.

Plant spacing of Netted Gem potatoes. Single rows (30,000 plants/ha) and two-row bed plantings (56,000 and 85,100 plants/ha) of Netted Gem potatoes were harvested sequentially. Yields increased progressively through the harvest season, the densest plantings producing the highest yield. Tuber shape index, based on width to length, decreased as the season progressed. Dry weights and specific gravities of tubers increased from harvest to harvest, but did not appear to be affected by spacing treatment. Dry weights of foliage appeared to be affected more by irrigation schedules than by spacing, and average size of tubers decreased as plant populations increased.

Weeds

Herbicide trials with potatoes. Harrowed preemergence treatment with Sencor (Chemagro Corporation) at 0.56 or 0.84 kg/ha (½ or ¾ lb/acre) gave good control of annual broad-leaved weeds and fair control of green foxtail. Postemergence treatment with 0.84 or 1.12 kg/ha (¾ or 1 lb/acre) gave excellent control of broad-leaved weeds, poor control of green foxtail, and lower tuber yields. Even the lowest yield of tubers on plots treated with Sencor was double that from the untreated controls, which had been cultivated and hilled once. Other successful treatments were incorporated preplanting EPTC (Stauffer Chemical Company) at 6.72 kg/ha (6 lb/acre); EPTC at 4.48 kg (4 lb) followed by preemergence linuron at 1.12 kg (1 lb); and postemergence chlorbromuron at 1.68 kg (1½ lb), which did not control green foxtail.

Control of aquatic plants. Excellent control and a reduction of possible later infestations

of aquatic plants were obtained by the application of a 1:1 mixture of diquat and paraquat diluted 1:15 with water and injected 60 to 90 cm below the water surface. Richardson pondweed is resistant to the mixture at dosages recommended for other species but can be controlled with a 1:1 mixture of diquat and copper sulfate at 0.8 ppm.

Selective control of the yellow pond-lily, *Nuphar variegatum* Engelm., was obtained. Mixtures injected under water caused very little damage to the pond-lilies, whereas surface applications with a wetting agent added gave good control. The mixture of diquat and paraquat at 4.5 kg/ha (4 lb/acre) gave the best control of pond-lilies, and a mixture of endothall and fenoprop at 5.6 kg/ha (5 lb/acre) gave satisfactory control. As with all procedures to control emergent aquatic plants, large volumes (1,685 to 2,246 liters/ha or 150 to 200 gal/acre) of water and the addition of a wetting agent were necessary.

SOIL SCIENCE

Soil Fertility and Management

Fertilization of rape on irrigated land. Echo and Span responded equally well to fertilizer treatment at two locations. The maximum yield obtained was 3,580 kg/ha. The best fertilizer treatment at one location was 110 kg N and 50 kg P/ha, indicating that rape will respond to high rates of N fertilizer.

Irrigation and spacing practices for potatoes. Tuber yields (1969–71) were highest when irrigation was scheduled by the tensiometer method and second best when the irrigation-gauge method was used. Row spacing of 76 or 91 cm had no effect on yield in 1970 and 1971, but plants spaced 24 or 30 cm apart outyielded those spaced 38 cm apart.

Response of dryland cereals to applied N and P. A summary of data of fertilizer trials conducted for 15 years on dry land indicated that optimum N levels were highly dependent on availability of moisture, whereas P response was less moisture-dependent. The amount of P as determined by soil tests was a useful indicator of the response to added P, but the NO_3-N test gave little indication of optimum N fertilizer rates.

Minimum tillage on dry land. A 4-year study of summerfallowing with minimum tillage was carried out on clay loam soil. A blade cultivator or a one-way disc was used for tillage. Paraquat, occasionally combined with 2,4-D ester or bromoxynil + MCPA ester, was used when necessary for weed control. The indicator crop, Chinook spring wheat, yielded best on chemical fallow with a fall blading. In 1971 the yields and plant heights from the one-way treatment were significantly lower than from the other treatments. Before the blade and one-way treatment plots were seeded in 1971, the soil had significantly less moisture than the other treatment plots. When moisture is abundant during the growing season, weed control methods of the previous year have no significant effect on crop yield. Chemical fallow or zero-tillage will not be economical until the price of chemicals decreases significantly.

Root hairs and nutrition of the wheat plant. Root hairs apparently do not play a major role in determining the P uptake efficiency of wheat plants. The P uptake/g of root material often was negatively correlated with root hair development, but P uptake/cm of root was positively correlated. The multiple correlation coefficients ranged from 0.1 to 0.3. Even when wheat was grown in soil deficient in P and no P was added, the abundance of root hairs did not increase P uptake.

Biomagnetism. Yield of marketable tubers was greater from Netted Gem potato eyes exposed to a magnetic field (ca. 1,500 oersteds) for 240 hr before planting than from untreated eyes. In an irrigated field test with a plant population of 29,640 plants/ha (12,000 plants/acre), magnetically treated potato eyes yielded 32.0 metric tons/ha (14.2 tons/acre) of marketable potatoes; untreated eyes yielded 22.9 metric tons/ha (10.2 tons/acre).

Irrigation and Drainage

Efficiency of water use. Efficiency of water use may vary more among cultivars of soft spring wheat than among some species of cereals. The soft spring wheats Pitic 62 and Twin produced 0.89 and 0.87 g of grain/liter of evapotranspiration. This efficiency of water use was greater than that obtained with Lemhi and the Lethbridge line 5505-2, which produced 0.79 and 0.77 g/liter. Average efficiency of water use did not differ significantly among species and ranged from 0.93 to 0.97 g/liter. Evapotranspiration by

Lemhi wheat, Rodney oats, and Montcalm barley averaged 49.0, 48.0, and 42.7 cm/growing season over 3 years. The yield of barley was lower than that of the other species.

Irrigation practices. Where green beans were cooled with low-rate sprinklers when ambient air temperature exceeded 26.7 C (80 F), total yield was not higher than that from well-irrigated, noncooled bean plots.

When soil moisture was maintained in the upper half of the available range until Span rape had reached full bloom, the yield of seed was 1,238 kg/ha; but when the same moisture level was maintained throughout the growing season, the yield was more than doubled.

Water tables in irrigated soils. Water-table depth in the Bow River Project during the past 20 years has averaged 168 cm but it has fluctuated considerably during each growing season. After an irrigation the water table sometimes rose to within 10 cm of the surface, then slowly receded at a rate of 7 to 12 cm/day until it leveled off at a depth of 127 cm; further downward movement was very slow. The water table has not risen significantly during this period, but it is so close to the surface that continued efforts are required to improve the efficiency of irrigation that sustains optimum crop growth.

Water and salt movement. An 8-year study showed that the salinity status of an irrigated Chin loam soil improved as a result of irrigation when the level of available soil moisture was at or above 50%. At this level, previously shown to provide maximum crop yields, only about 5% of the water applied moved through the profile as deep drainage, but this amount was sufficient to provide adequate leaching.

Soil Chemistry

Organic matter. Isolation of major portions of the organic matter from Chernozemic soils seems unattainable. The two most promising procedures permitted removal of only 14% of the total C of a Dark Brown Chernozem and 46% of that of a Dark Gray Luvisol. Pretreatment by electrodialysis increased the recovery of C from Chernozemic soils but not from Luvisolic soils.

Total acidity of humic acids was generally higher in Black than in Brown Chernozemic soils. The methoxyl group content decreased from Brown to Black soils, indicating that the organic matter was more humified in the latter soils.

Total organic-P content of Chernozemic Ap horizons varied during the growing season and often increased over winter; thus, total organic-P is related to the time of sampling.

Discs of KBr suspended at four heights above the humus sample in the hangdown tube of the thermogravimetric analysis apparatus were used to capture the volatile products of thermal decomposition of soil organic matter. Examination by infrared spectroscopy showed that methylene and amide groups as well as moisture evolved from humic acids heated to 100 C. As the decomposition temperature increased, the same products volatilized but were captured at greater distances from the sample. Methylene groups disappeared or became weaker in the charred sample as decomposition temperature increased.

Microbiological activity. Microbial characteristics of the rhizosphere of wheat changed qualitatively and quantitatively when a pair of chromosomes that alter root-rot reaction were substituted in the wheat. Inducing the susceptibility to root rot of a resistant spring wheat caused substantial increases in microbes producing glycosides, hydrolases, and amidases. These enzymes may enhance the colonization of roots by the root-rot fungus.

Inhibition of nitrification in grassland soils did not take place after selected grasses and forbs were removed.

Pollution control. Under the semiarid conditions of southern Alberta, four annual applications of 185 kg N/ha as ammonium nitrate to seeded grassland did not increase the NO_3-N content of the soil below the root zone. Excessive rates (940 kg N/ha) increased the NO_3-N content to a depth of 152 cm, the maximum concentration being in the upper 61 cm. In 1963, 975 kg N/ha was applied to native grassland; 9 years later the N had accumulated 60 to 90 cm below the surface and none had leached below 185 cm. Therefore, contamination of ground water is unlikely to occur from leaching through the soil when N is applied to semiarid grassland at the recommended rates of 65 to 90 kg/ha.

In greenhouse studies, wheat yields were not adversely affected by applications of up to 336 metric tons/ha of sewage sludge or manure. This indicates that large amounts of

sludge or manure could be safely disposed of in the soil.

Downward movement of nutrients from animal wastes in soils near feedlots or in fields heavily manured for more than 20 years was limited to 122 cm in fine-textured soils and 244 cm in coarse-textured soils.

VETERINARY-MEDICAL ENTOMOLOGY

Biting Flies

Mosquitoes. In collaboration with the Department of Botany, University of Washington, a method was developed for germinating the resistant sporangia of *Coelomomyces psorophorae* Couch. This fungal parasite has a high natural infection rate during certain years. In 1970 it infected 80% of mosquito larvae at Eight-Mile Lake near Lethbridge. Induction and control of germination are limiting factors in its practical application for biological control of mosquitoes.

Black flies. Infestations of *Simulium arcticum* Malloch increased in the Athabasca region. Attacks on cattle caused serious weight losses, interference in grazing patterns, infertility in some bulls, and mortality in newborn calves. Progress has been made in developing rapid, dependable techniques to assess populations of black flies in large river systems and to identify sources of infestations for future control operations. About 150 miles of the Athabasca River adjacent to areas of livestock production have been charted to indicate their fly production.

Sand flies. The association of two species of *Phlebotomus* with yellow-bellied marmots was confirmed by weekly collections from burrows in Police Coulee and the St. Mary – Oldman River valley. The junction of the St. Mary and Oldman rivers near Lethbridge has been established as a northern limit for the distribution of *Phlebotomus* spp.

Warble Flies

The physiographic and ecological characteristics of aggregation sites of male warble flies in semiwooded foothills of the Rocky Mountains have been determined. Recognition of certain basic features led to the discovery of aggregation sites on the open plain. Differences and similarities of sites between the two types of terrain have been cataloged for future field tests of autocidal control of cattle grubs.

Adults of the northern cattle grub and the common cattle grub were released simultaneously at a known aggregation site to test the feasibility of achieving population control through hybrid sterility. Flies selected specific mating loci within the site and all observed matings were intraspecific, with little interference by males of other species.

Ectoparasites

Studies on population dynamics of the shortnosed cattle louse on cattle showed that infestations were maintained by infection and reproduction at environmentally favorable sites on the host. Single, localized, pour-on treatments with a systemic insecticide did not effectively reduce parasites uniformly at all sites.

Serological Studies on Bloodsucking Arthropods

Rabbits developed pathological lesions but no immunity following either biweekly exposure to the bloodsucking yellowfever mosquito or four consecutive infestations of adults of the Rocky Mountain wood tick. Antibodies to one species of black fly, *S. arcticum*, were not detected by immunoelectrophoretic tests of sera from cattle grazing in heavily infested localities. Extracts of black flies, like those of the sheep ked, contained a hemagglutinin that interferes with the indirect hemagglutination test. Antigens in the salivary glands of tabanids from both prairie and mountain regions were qualitatively similar.

Pesticides

Toxicology. Dermal applications of crufomate at 50 or 100 mg/kg to virgin mice 21 and 35 days before mating reduced conception rates, prolonged gestation periods, and reduced weights of progeny in both the first and second pregnancies. A greater reduction of weaning and mature weights occurred in male progeny in the first pregnancy than in the second pregnancy.

Dermal applications of crufomate at 50 or 100 mg/kg to female mice 7 days after the first mating affected reproduction adversely

for at least two pregnancies. In the first pregnancy, the larger dose caused fetal and maternal mortality in 20% of treated mice, prolonged the gestation period, and retarded growth in male progeny. In the second pregnancy the conception rate was reduced, and the male and female progeny at weaning and the male progeny at maturity weighed less than those of the first pregnancy. The smaller dose retarded growth in all progeny of the second pregnancy.

Efficacy. Phosmet 1.2E applied as a pour-on treatment in September controlled 96% of the cattle grubs on unweaned range calves 4 to 5 months old. The early treatment reduced the risk of acute esophagitis usually associated with applications in autumn.

Grub infestations of cattle continued to decline under the cattle grub extermination program in the County of Wetaskiwin; mean numbers per animal dropped from 7.6 in 1969 to 5.4 in 1970 and 1.5 in 1971.

Residues. Methoxychlor and DDT were equally effective in controlling horn flies on cattle. When applications of methoxychlor at 2.3 liters (2 qt) per animal at 0.5% concentration were repeated at intervals of not less than 1 week during the fly season, residues were less than 2 ppm in the fat 1 week after final treatment. Residues of lindane were less than 1 ppm 4 weeks after final treatment when applications of 2.3 liters per animal at 0.25% concentration were repeated at 3-week intervals.

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Research Station
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INTRODUCTION

This report summarizes the main research findings for 1971 at the Research Station, Agassiz. Additional information may be obtained from the scientific papers and other publications listed at the end of this report. In addition, the Station publishes a Quarterly Report to provide extension specialists, agricultural business, and farmers with up-to-date information on developments in the research program. Copies of this report and reprints of the publications listed are available on request. Correspondence should be addressed: Research Station, Research Branch, Canada Department of Agriculture, P. O. Box 1,000, Agassiz, B.C.

M. F. Clarke
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SOILS

Liming of Alfalfa

The beneficial effects of liming alfalfa were related to changes in soil properties. Reductions in Al and Mn toxicity were the main factors responsible for increased yields and the shorter growth period to reach the harvest stage. Significant correlations were found between plant growth parameters and various measures of extractable Al. Changes in the mineral composition of alfalfa occurred after lime was applied to acid soils. The concentration of Al and Mn in the tops and roots decreased. The levels of Zn in the tops and roots and the Mg content of tops declined, whereas Ca and Mo levels in both plant parts increased.

Adsorption of Micro Amounts of Phosphorus by Soils

Adsorption of micro amounts of P was measured for a heterogeneous group of 343 soils using $KH_2P^{32}O_4$ solution. The method allowed accurate determination of small quantities of P and identified the P under consideration as that added from solution. Simple correlations and stepwise linear regression analysis indicated that soil pH, Ca, P, Al, Fe, organic matter, and particle size significantly influenced the amount of P adsorbed by the soils.

Influence of Soil Properties and Extractable Zinc on Zinc Availability

The Zn content of corn and oats was related to amounts of total Zn and available Zn extracted by six soil-test methods. Several methods showed significant correlation of soil Zn with plant Zn for specific soils. The soil Zn determinations were also related to other soil properties. Total and extractable Zn in the soil were increased with increased acidity, finer texture, and higher organic matter content. Multiple correlation studies indicated that soil pH, texture, and organic matter were also important in predicting the Zn content of corn and oat plants.

Phytotoxicity and Uptake of Cadmium from Several Soil Types

The addition of Cd to 30 surface soils reduced yields and sharply increased Cd levels in lettuce and radish. Although plant Cd was significantly related to ammonium acetate extractable Cd in soil, Cd adsorption capacity of the soil, pH, and organic matter were included in stepwise regression models to predict Cd uptake. Cadmium levels in lettuce and radish were related to concentrations of other elements in the plant parts, especially Ni, Fe, Zn, and Cu.

Lead Uptake by Lettuce and Oats

The application of $PbCO_3$, $PbCl_2$, and $Pb(NO_3)_2$ increased the uptake by lettuce to a greater degree than by oats. The application of lime suppressed the uptake of added Pb by both plants, whereas the application of small amounts of N reduced the uptake of Pb by the roots only of lettuce and oats. The application of $PbCl_2$ lowered the levels of S and P in plants, but levels of other elements studied were not affected by any application of Pb.

VEGETABLES

Chemical Topping of Brussels Sprouts

Three cultivars, Jade Cross, Hybrid Hedda, and Sweet Coastal, were treated on two dates with varying concentrations of Alar (Uniroyal Chemicals), BAS 0660-W (BASF Canada Ltd.), and Ethrel ([ethephon] Amchem Products Inc.). The three cultivars responded differently to the treatments with the growth regulators. Alar was the only effective treatment. The first application of Alar tended to increase marketable yield of Jade Cross and Hybrid Hedda. For Jade Cross, Alar at 2,000 ppm was most effective and for Hybrid Hedda 8,000 ppm gave the best results. Alar appears to offer promise as a means of reducing the high cost of hand topping of Hybrid Hedda. However, the chemical has not yet been approved for use on Brussels sprouts.

Preplant Herbicide Treatments for Bush Beans

The herbicides trifluralin, chloramben, BAS 3921-H (BASF Canada Ltd.), BAS 3870-H (BASF Canada Ltd.), and USB 3584 (U.S. Borax Research) were tested singly and in combinations as preplanting, soil-incorporated treatments for bush beans. The combination treatment of trifluralin at 0.84 kg/ha (0.75 lb/acre) applied preplant followed by a preemergence application of metobromuron at 1.7 kg/ha (1.5 lb/acre) gave excellent control of both broad-leaved weeds and grasses. The preplant mixtures of trifluralin at 0.84 kg/ha (0.75 lb/acre) + chloramben at 1.7 kg/ha (1.5 lb/acre) or BAS 3921-H at 0.84 kg/ha (0.75 lb/acre) + chloramben at 1.7 kg/ha (1.5 lb acre), and the combination treatment BAS 3870-H at 1.1 kg/ha (1.0 lb/acre) applied preplant followed by BAS 3510-H (BASF Canada Ltd.) at 1.1 kg/ha (1.0 lb/acre) applied postemergence gave good control of broad-leaved weeds and grasses. USB 3584 gave good control of broad-leaved weeds and grasses, but injured the bean crop and caused a significant loss in yield.

Plastic Coating of Lettuce to Aid Chemical Weed Control

Greenhouse and field experiments were conducted on muck soil using lettuce seeds coated with 0, 1, 2, and 3 layers of a water-soluble plastic film. In the greenhouse, one layer of plastic delayed seed germination about 7 days, the delay caused by two layers was 12 days and by three layers 18 days. Similar results were obtained in the field, but germination was more erratic than in the greenhouse. Weeds that emerged before the lettuce were effectively controlled by paraquat at 0.6 kg/ha (0.5 lb/acre).

Preemergence Herbicides for Spinach

Lenacil at 1.7 and 3.4 kg/ha (1.5 and 3.0 lb/acre) gave good control of broad-leaved weeds and grasses with no reduction in spinach stand. Norea at 3.4 kg/ha (3.0 lb/acre) gave good control of grasses and was only slightly less effective for broad-leaved weeds. Monuron at 1.1 kg/ha (1.0 lb/acre) gave fairly good weed control. Although it caused some injury to spinach, it did not reduce the stand. Alachlor at 2.2 and 4.5 kg/ha (2.0 and 4.0 lb/acre) gave excellent control of grasses and only fair control of broad-leaved weeds, with a noticeable reduction in stand of spinach. BAS 3870-H, BAS 3921-H, and sulfallate reduced the plant stand and gave only fair control of weeds and grasses.

SMALL FRUITS

Immunity of Red Raspberry Cultivars and Selections to the Vector of Red Raspberry Mosaic

Of 18 red raspberry cultivars recently screened for immunity to *Amphorophora agathonica* Hottes, the vector of red raspberry mosaic, only Reveille was immune. This immunity was derived from the cultivar Lloyd George. Among various immune selections, three appeared to owe their immunity to the tetraploid cultivar, La France, a source of immunity distinct from that of the diploid Lloyd George. Cultivars developed in North America should be screened for their reaction to *A. agathonica* before they are released.

Self-fertility in Red Raspberry Cultivars and Selections

Variations in self-fertility, expressed as percentages of drupelets set, were observed among 69 red raspberry cultivars or selections. The incidence of reduced self-fertility was particularly prevalent among some of the older cultivars, but was also observed in certain selections. In a particular cultivar or

selection, reduced self-fertility usually followed both self- and open-pollination. Reductions from self-pollination seemed to involve self-incompatibility although at least one case was due to reduced pollen fertility. Reductions from open-pollination probably involved reduced numbers of functional embryo sacs.

Suitability of Red Raspberry Cultivars or Selections for Mechanical Harvest

When harvested mechanically, the cultivars Matsqui and Meeker were much superior to Willamette, the principal cultivar grown in British Columbia. Two other cultivars, Malling Jewel and Canby, were totally unsuited to mechanical harvest. A number of selections from the breeding program of the Station showed sufficient promise to warrant further testing.

Postharvest Fruit Rot of Strawberries and Raspberries

Studies were conducted for 3 years to determine the cause of inconsistent results from fungicides used to control postharvest fruit rot. It was found that the fungi that cause postharvest fruit rots in strawberries and raspberries vary somewhat with the crop, greatly with the season, and slightly with the cultivar. Consistent control has not been possible with field sprays of the available fungicides. In strawberries, captan gave the best control of *Penicillium, Rhizopus*, and *Botrytis*. In raspberries, benomyl gave the best control of *Botrytis* and captan of *Rhizopus*.

In 1969, on two picking dates *Penicillium* caused more than 50% of the rots in strawberries within 48 hr of picking; in 1970, *Penicillium* caused only 4%; and in 1971 only 1%. *Rhizopus* was practically absent in 1969 but was a serious problem in 1970. *Botrytis* was important every year on both crops.

ANIMAL SCIENCE

Hay Supplementation of High-moisture Corn Silage

Corn, ensiled at two moisture levels, 29% and 24% dry matter (DM), was fed to high-producing dairy cows alone and with 3.2 kg hay/454 kg body weight. Feeding silage containing 24% DM as the only forage resulted in significantly lower dry matter intake, lower daily milk production, and a slightly lower fat test and percentage of nonfat solids. When 3.2 kg hay/454 kg body weight was fed to cows receiving the 24% DM silage, the forage dry matter intake increased to the same level as that of cows receiving the 29% DM silage and hay, but daily milk production remained significantly lower (23.2 kg vs. 23.7 kg). Efficiency of milk production was lower for cows receiving the 24% DM silage and hay than for those fed the 29% DM silage and hay on the basis of daily milk production and daily body weight gain (0.6 kg vs. 0.3 kg).

Supplementing Rations Based on Corn Silage with Dehydrated Grass

The effect of high levels of dehydrated grass, when incorporated in rations based on corn silage, was studied in lactation and digestion-nitrogen balance trials. Three treatments were compared: (i) a control ration of free-choice corn silage, grass hay at 0.7% of body weight, and concentrate at 0.45 kg/1.6 kg of 4% fat-corrected milk; (ii) a complete ration of 25% concentrate, 55% dehydrated grass, and 19% corn silage (percentages on a dry matter basis); and (iii) a complete ration of 40% concentrate, 41% dehydrated grass, and 19% corn silage.

Cows fed the complete rations, which contained dehydrated grass, outperformed cows on the control ration as to dry matter consumption, daily weight gain, daily milk production, percentage protein, and percentage nonfat solids. This study showed that dehydrated grass had an energy content equal to a concentrate when 15% of the concentrate was replaced with dehydrated grass. Digestion-trial data showed higher digestion coefficients for DM and neutral detergent fiber for cows fed the rations containing dehydrated grass. The efficiency of N utilization was greater for cows fed ration (iii) than for rations (i) and (ii).

Urea-treated Corn Silage vs. Grass Silage for Lactating Cows

Nutrient utilization was examined for lactating cows fed grass silage (24% DM) or urea-treated corn silage (30% DM). On a dry matter basis, the grass silage contained 14.6% protein and the urea-treated corn silage 16.5%. The rations were balanced so that forages supplied 68% of the total dry matter intake and 62% of the total protein intake of

each group of cows. Digestibility data for the two silages when fed with grain indicated that digestibility of dry matter, energy, protein, acid-detergent fiber, and neutral-detergent fiber were higher for the urea-treated corn silage. Cows fed urea-treated corn silage excreted less N in the feces and more in the urine than those fed grass silage. However, the overall efficiency of N utilization was greater for the cows fed the urea-treated corn silage.

Finishing Steers on a Limited Concentration Ration with and without Exogenous Hormones

In order to assess the effect on rate of gain and carcass composition of a high-roughage finishing ration, 60 Holstein-Friesian steers were placed on test after weaning during 1968–70. From weaning until the animals reached a body weight of 385 kg, they received an all-concentrate ration ad lib. Then 20 steers were slaughtered and detailed carcass evaluations were made. The remaining 40 steers were restricted to 1.8 kg of concentrate/day plus hay ad lib. At 454 kg, 20 of these steers were slaughtered, and at 500 kg the last 20 steers were slaughtered. In each of the three groups, half of the steers (10) were implanted with 68 kg of hormones before they reached slaughter weight.

In the first group, which included animals implanted at a weight of 317 kg and slaughtered at 385 kg, the implanted animals had significantly higher rates of gain (31%). This was not unexpected, because up to a weight of 385 kg these animals were on a high-energy intake. However, even with the additional two groups slaughtered at 454 kg and 500 kg and restricted to 1.8 kg of concentrate/day the implanted animals outgained the controls by 28% and 53%. This highly significant response was not expected, because usually steers do not respond well to hormone treatment except on a high plane of nutrition.

Detailed carcass analyses are under way to determine how these differences in growth rate are reflected in carcass fat and lean deposition.

POULTRY

Interaction of Strain, Density, and Ration with Two Light Systems for Broilers

Two experiments were conducted to determine the effect of continuous and intermittent light (1 hr on and 3 hr off) on the performance of broilers. In the first experiment, 3,600 broilers from two strains were grown on 0.093 m^2 and 0.047 m^2 of floor space per bird. The second experiment included 3,000 broilers of one strain, grown on 0.093 m^2 of floor space per bird with 600 birds fed each of five test rations.

Birds grown under intermittent light had lower mortality and better feed efficiency than those under continuous light. The average body weight after 7 weeks was not significantly different for the two light treatments. However, significant interactions were noted for strain × light, density × light, and ration × light. Light treatments did not affect the percentage of grade A carcasses at slaughter. Strain and ration had a significant effect on body weight. Birds grown on 0.093 m^2 were heavier and had a higher percentage of grade A carcasses than birds grown on 0.047 m^2.

Effect of Density and Number of Birds per Cage on Laying Performance

In a replicated experiment, 20 density-number treatment combinations were used in housing leghorn pullets 21 weeks of age. Egg production, feed efficiency, mortality, increased body size, and net egg returns all tended to be linearly related to the size of cage; the greater the space per bird the better was the performance. In terms of birds per cage, the order of preference tended to be 2, 4, 1, 8, and 16. However, significant density × number interactions invariably occurred and one bird per cage at 635 cm^2/bird tended to be superior. Other combinations that rated well were two birds at 476–635 cm^2, four birds at 556–635 cm^2, and eight birds at 476 cm^2/bird.

Influence of Area per Bird and Number of Birds per Cage on Adrenal and Thyroid Weights

Adrenal and thyroid gland weights and plasma adrenal corticoid levels were measured in a sample of 120 birds from two replications of a population of birds housed in cages at 397, 476, 556, and 635 cm^2/bird and at 1, 2, 4, 8, or 16 birds per cage at each

density. The birds had been at their specific density-number combination 336 days before physiological measurements were taken. Birds housed at 556 and 635 cm^2 had significantly higher levels of plasma adrenal corticoid than birds at 476 cm^2, birds at 397 cm^2 had significantly higher levels than birds at 476 cm^2 but lower egg production. The area per bird had no significant effect on adrenal or thyroid gland weight, but thyroid gland weight decreased as levels of plasma adrenal corticoid increased. The number of birds per cage had no significant effect on adrenal or thyroid gland weight or the levels of plasma adrenal corticoid.

Activity of Six Enzymes of Seminal Plasma and Sperm of Chickens

The activity of fumarase, aconitase, lactic dehydrogenase, aldolase, glutamic oxaloacetic transaminase, and aminopeptidase was determined on an individual male basis for sperm and seminal plasma of fresh semen and in vitro semen stored for 2 days at 2–5 C. The percentage of hens fertile, duration of fertility, and percentage fertility were also determined. Family had a significant effect on the fumarase activity of fresh sperm and the aminopeptidase activity of stored plasma and semen. Storage significantly reduced the fumarase, aconitase, and glutamic oxaloacetic transaminase activity of sperm. There was no fumarase or aconitase in fresh or stored seminal plasma. Storage caused a significant increase in the lactic dehydrogenase and aldolase activity of seminal plasma but a decrease in its aminopeptidase activity.

Family had a significant effect on the fertility of fresh and stored semen; the heritabilities of fertility were consistently higher for stored than for fresh semen. Fumarase activity was not correlated with fertility, whereas aconitase activity of stored sperm was correlated with fertility of stored semen. Lactic dehydrogenase activity of stored sperm and semen was negatively correlated with the fertility of fresh and stored semen, whereas the lactic dehydrogenase activity of stored plasma was negatively correlated with the fertility of stored semen. There was no consistent relationship between aldolase activity and fertility. The glutamic oxaloacetic transaminase activity of fresh and stored sperm, seminal plasma, and semen were all negatively correlated with the fertility of the stored semen. The activity of stored plasma was negatively correlated with the fertility of fresh semen. The aminopeptidase activity of fresh and stored plasma and stored semen was negatively correlated with the fertility of stored semen, whereas the activity of stored plasma was negatively correlated with percentage of hens fertile and percentage fertility of fresh semen.

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Research Station
Kamloops, British Columbia

PROFESSIONAL STAFF

J. E. MILTIMORE, B.S.A., M.Sc., Ph.D.	Director; Forage utilization
W. B. G. HOLLIDAY	Administrative Officer
W. A. HUBBARD, B.S.A., M.Sc.	Forage management
A. MCLEAN, B.S.A., M.Sc., Ph.D.	Range and resource management
G. B. RICH, B.A.	Tick–host relationships
A. L. VAN RYSWYK, B.S.A., M.Sc., Ph.D.	Soil fertility and pedology

Departures

J. D. GREGSON, B.A., M.Sc. Retired April 30, 1971	Tick physiology
P. R. WILKINSON, B.A., M.A., Ph.D. Transferred to Research Station, Lethbridge, Alta., July 15, 1971	Ticks

INTRODUCTION

The Research Station at Kamloops, B.C., primarily serves the ranching industry of the southern interior of British Columbia. Information from studies on forage management is also applicable to the dairy industry in this region. This is the only station in the Research Branch that specializes in range management and in studies concerning integrated use of natural resources. In 1971 new studies were started to measure competition between grass and seedling trees and between deer and cattle for winter range. During the past year we have enjoyed extensive cooperation with the agricultural industry; the Agriculture, Fish and Wildlife, and Forestry departments of the British Columbia Government; and the Plant Science Department of the University of British Columbia.

Some of the 1971 research activities are presented in this report.

Highlights of the 1971 results include an average production of 1,632 kg of beef per hectare from corn silage, negligible lindane residues in beef after protection from ticks, and the failure of resting to restore badly overgrazed arid rangelands.

Details on the research are available from the Station and interested persons are invited to enquire. Correspondence should be addressed to the Research Station, Research Branch, Canada Agriculture, P.O. Box 940, Kamloops, B.C.

J. E. Miltimore
Director

LIVESTOCK MANAGEMENT

Ticks

Tick paralysis of cattle is sporadic. Some of the factors responsible for the variability of tick paralysis are now apparent. Cattle are rather resistant to the paralysis. The lowest number of ticks known to cause paralysis of a 181-kg yearling calf is 30, but cattle vary in susceptibility and other comparable calves have not been affected by even 100 similar ticks. Cattle in poor condition were more susceptible to both tick attachment and feeding and to tick paralysis than cattle in good condition. Cattle previously unexposed to ticks were unaware of the first ones that attached and fed. But on subsequent infestation, the animals appeared to be irritated by feeding ticks and attempted to rub them off. Ticks are gregarious in attachment and feeding and so the percentage that attach and feed increases as the number getting on to the animal increases. The highest risk of tick paralysis occurs when animals in poor condition are turned on to an infested range at the peak of seasonal tick abundance during a season of high general tick population.

Analysis of kidney and omental fat from animals treated with lindane for protection from ticks showed that this treatment would not cause the lindane residue to exceed the official level of 2 ppm in beef fat.

Hybridization of tick species. In reciprocal crosses of *Dermacentor andersoni* Stiles and *D. variabilis* Say, only the *andersoni* male × *variabilis* female cross produced viable larvae. The larvae were few in number and only 9 F_1 male adults were produced. These were fed and fixed in Carnoy's fluid and sent to Professor J. H. Oliver for karyological examination.

Tick numbers were not increased through adding larvae to range. Releasing larvae of the Rocky Mountain wood tick (RMWT) in naturally infested fields did not increase tick populations to levels suitable for acaricide tests. Large releases of larvae at Massey Lake in 1970 resulted in a increase in larvae on rodents trapped during the next 3 weeks, but did not increase either the numbers of nymphs in 1970 or 1971, or the number of adults in 1971.

Carbon dioxide attracts only nymphs and adult ticks. Field tests in 1970 showed that nymphs and adults of RMWT were attracted by CO_2 emissions. The adults were attracted up to 4 m in one trial. Both field and laboratory tests in 1971 showed that larvae were not attracted by CO_2.

Beef Yield from Various Feeds

Corn, when ensiled with urea and fed to steers, has produced an average of 1,633 kg of beef per hectare. Alfalfa hay produced an average of 1,166 kg of beef per hectare and pasture produced an average of 956 kg. These average yields of beef, based on the 3 years of tests, were obtained from average dry-matter yields per hectare of 15.7 metric tons of corn silage and 13.5 tons of alfalfa hay. The average grazing season on pasture was 124 days. Average daily gains of 998 g on pasture were higher than the 544 g average for both corn silage and alfalfa hay.

Fertilizer Response on Organic Soil in the Growth Room

A group of 10 soils, representing the Humisol and Mesisol great groups of soils, were sampled to a depth of 25 cm for a trial with reed canarygrass using five fertilizer treatments: NPK, PK, KN, NP, lime, and check. The soils varied in composition from 6% to 36% rubbed fiber; 9% to 40% residue on ignition; 0.28 to 0.50 g/cm^3 bulk density; 5.15 to 7.60 pH (H_2O); and 1% to 23% $CaCO_3$.

All soils responded to N, P, and K fertilization although there were significant differences among these responses. Ranges of percentages sufficiency for N were between 18 and 84, for P between 12 and 47, and for K between 24 and 67. On the soil with a rather low pH of 5.5 and with the lowest $CaCO_3$ content of 1%, the addition of lime resulted in 3.5 times the yield of untreated soil. No other soil gave a significant response to lime. Average total yields from six cuts over a 154-day period, for the 10 soils, ranged between 2,870 and 279 kg/ha for the check, and between 9,282 and 6,035 for the NPK treatment.

Available P soil test values were positively correlated with forage yield, nutrient yield, and percentage sufficiency on both a forage and nutrient yield basis. Corresponding correlations for K were somewhat higher. However, none of the correlations were high enough for a reliable prediction of P and K response from soil test. This may be due to either the limited range in nutrient availability of these soils or the difference in mineralization between the air-dried sample used for the soil test and the field-moist sample used in the growth room.

Bloat Prevention with Copper Sulfate and External Oil

Copper sulfate was used to reduce protozoa numbers in the rumen in order to reduce gas production and hence to reduce bloat. Two grams of $CuSO_4$ per 45 kg body weight was placed in the rumen of one member of each of six sets of fistulated identical twins. Freshly chopped immature alfalfa was fed in a drylot and incidence of bloat was recorded. Incidence was 2.8% in the cattle receiving $CuSO_4$ and averaged 15.5% in the controls.

In a similar study, before the morning feeding, oil was applied externally to the flanks of 10 nonfistulated cattle. There was no bloat in the treated cattle, although there was an incidence of 6.7% in the control herd. Further study is required to confirm the efficacy of this treatment, which relies on the cattle periodically licking their flanks in order to maintain sufficient oil in the rumen to reduce or prevent bloat.

RESOURCE-FORAGE MANAGEMENT

Grazing Values as Related to Tree-crown Covers

Estimation of herbage yields from the ground is too slow to be useful in vegetation surveys where large acreages have to be covered in a very short time. Accordingly, studies were undertaken to determine if estimates of tree-crown cover could be used to estimate herbage productivity. A further object was to determine whether or not estimates of tree-crown cover from aerial photographs would be accurate enough for this purpose. Results suggest that there is a sufficiently close relationship between herbage production and crown cover in coniferous stands to make the technique useful in range surveys. Further, when the ground estimates of crown cover were compared with those made from aerial photographs, similar results were obtained. Also, estimates of herbage yields on a pasture made by using the aerial photographs were almost identical with those established from an earlier grazing trial.

Restoring Productivity of Rangeland

Exclosures to prevent access by cattle were placed on typical kinds of range 30 years ago. Data show that it may take rough fescue grasslands up to 20 years and big sagebrush grasslands up to 40 or 50 years to return to full productivity through resting or nonuse, depending on the soil and the degree of overgrazing. Seeding the range to grass is the only practical means of restoring many of these areas.

In the first 10 years after fencing, little change in plant composition took place inside exclosures that were placed on poor-condition range. It took longer for the sites to progress from poor to fair condition than from fair to good condition. The main plants to increase with protection were bluebunch wheatgrass and rough fescue. The main species to decrease with protection were Sandberg blue grass, low pussytoes, and rabbitbrush. Annuals such as false flax, stickseed, and cheat grass were common invaders on overgrazed range.

Yields of Alfalfa Hay Influenced by Variety and Management

In a test, 14 alfalfa varieties were planted in 1965 and harvested three times annually for 5 years. The average yield in 1966 was 11.2 metric tons/ha, which declined to 7.0 tons in 1970. This decline in yield is not acceptable for a perennial crop. However, an examination of the different varieties showed that three varieties declined by an average of 7.6 tons/ha and produced an average of only 3.8 tons/ha in the 5th year of harvest. In contrast, the recommended varieties Beaver and Vernal declined only 2.0 tons/ha by the 5th year and produced an average yield of 9.2 tons/ha.

In a 4-year test of the varieties Lahontan and Vernal subjected to two, three, four, five, and six cuttings per year, the respective average declines in yield were 3.1, 3.4, 2.0, 1.1, and 4.3 tons/ha. The rather large average decline in yield for the two and three cuttings per year was unexpected. The 4-year average dry-matter yields of 10.3, 11.4, and 10.5 tons/ha, obtained from three, four, and five annual cuttings respectively, were not significantly different. There were no significant differences in yield between the two varieties except when two cuttings were made each year; Vernal then gave higher yields than Lahontan.

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Research

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Research Station
Sidney, British Columbia

PROFESSIONAL STAFF

H. ANDISON, B.S.A.	Director
R. M. ADAMSON, B.A., B.Sc., M.Sc.	Weed control and vegetables
R. G. ATKINSON, B.S.A., Ph.D.	Diseases of glasshouse crops
J. H. CROSSLEY, B.S.A., M.S.A.	Ornamental crops
N. V. TONKS, B.S.A., M.S.	Insects of ornamentals
K. W. CHONG, B.S.A. (Production and Marketing Branch)	Supervisor, Post-entry Quarantine Station

Departure

E. F. MAAS, B.S.A., M.Sc. Transferred to Research Station, Agassiz, August 1971.	Soils and plant nutrition

INTRODUCTION

Research at this Station emphasizes the improvement, culture, and protection of ornamental and greenhouse crops. Accomplishments in 1971 that merit special attention are described in this report. Vendor, a greenhouse tomato variety, was very resistant to blotchy ripening when grown under our newly developed system of sawdust or bark culture and trickle irrigation. This system of culture also proved very effective in the commercial production of several common ornamental evergreen shrubs. New, improved techniques and methods were developed for rooting grapes, tree fruits, and evergreens to provide virus-free stocks for the post-entry plant quarantine repository. The new systemic fungicide benomyl showed much promise in controlling fusarium wilt in greenhouse tomatoes.

Requests for information or publications should be addressed to the Research Station, Research Branch, Canada Agriculture, 8801 E. Saanich Rd., Sidney, B.C. (former address Saanichton, B.C.)

H. Andison
Director

HORTICULTURAL CROPS

Greenhouse Tomatoes

Yield and blotchy ripening. Vantage, the variety commonly used in sawdust culture, is highly sensitive to blotchy ripening. In trials that compared the two varieties, Vendor was significantly less susceptible than Vantage but as a spring crop it tended to lose vigor and setting ability in midseason. Higher N levels tended to increase both yields and the amount of blotch, with blotch more pronounced in Vantage than in Vendor. When transplanting was delayed until a week before the first blossom opened, the incidence of blotch was reduced. It appears possible, therefore, that for Vendor fertility levels could be increased to improve yields, without the danger of quality impairment due to blotchy ripening.

Soilless culture. A method of growing tomato plants in a soilless medium up to the transplanting stage has shown several advantages, particularly for plants that are transplanted to sawdust. A 2:1 peat–vermiculite mixture reliably produced high-quality plants, was lightweight, and required no sterilization. In contrast to soil, this medium added little to the cellulose-decomposing microflora so there was less tendency to accelerate the decomposition of the sawdust. Moisture and nutrient requirements until transplanting were usually met by periodic applications of a complete liquid nutrient solution; however, we are also investigating the use of premixed, dry fertilizers and later applications of water only. Use of slow-release, premixed fertilizers gave higher fruit yields than dilute-solution feeding, but correct fertilizer rates and careful management of moisture and greenhouse temperatures were necessary to avoid excessive rates of release.

Fusarium wilt from sawdust medium. The sawdust growing medium used in local greenhouse tomato production is sometimes contaminated with *Fusarium oxysporum* Schlecht. f. *lycopersici* (Sacc.) Snyd. & Hansen. Of several fungicides applied as preplant drenches to naturally infested sawdust, benomyl at 100 ppm active ingredient (a.i.) increased the yield of two fall crops by an average of 97%, and the yield of a spring crop by 25%. In the 1971 fall crop, thiophanate-methyl at 50, 100, and 150 ppm a.i. also showed promise with yields 31%, 84%, and 96% higher than those of untreated plants. Thiabendazole was toxic even at 75 ppm; it caused marked stunting, abortion of flowers, and yield reductions. Wettable powder and flowable formulations of captan at 50 to 200 ppm were not very effective.

Greenhouse whitefly populations on fall tomatoes. Fall greenhouse tomatoes transplanted in late July had an average of less than 20 scales per 2-cm leaf disc during August. However, an application of naled in late September, when the average counts reached 20 per leaf disc, did not establish control fast enough to prevent honeydew spotting on the fruit.

Emergence and survival of parasites of the greenhouse whitefly. Aerosol and vapor treatments with naled at 10 g a.i./100 m^3 (1 oz/10,000 cu ft) or dichlorvos at 3 g a.i./100 m^3 severely inhibited emergence and survival of adult *Encarsia formosa* Gahan from parasitized whitefly scales. Dichlorvos smoke at 2.3 g a.i./100 m^3 was less toxic; 62% of the parasites emerged compared with 90% from untreated controls.

Effectiveness of control of the greenhouse whitefly by E. formosa. The parasite *E. formosa* did not give economically acceptable control of the greenhouse whitefly until late October on heavily infested greenhouse tomatoes transplanted in July. Parasitism reached 16% by late September, 22% by mid-October, 60% in late October, and 74% by mid-November.

Ornamentals

Ornamental shrubs in soilless media. Fifteen species or cultivars of woody ornamentals were grown successfully in polyethylene cans containing either shredded fir bark or a mixture of fir and hemlock sawdust; a liquid feeding program was used. Results compared very favorably with the growth of plants in a soil–peat mixture, the standard mixture at this Station. The species tested represent a fairly wide range, and results suggest that the lists could be even more extensive. *Cytisus* × *praecox, Cotoneaster salicifolia* var. *floccosa, Picea glauca* 'Conica', *Rhododendron catawbiense*, and the rhododendron cultivars 'Mother's Day', 'Vuyk's Scarlet', 'Anna Rose Whitney', and 'Arthur Bedford' were tested for 2 years; *Chamaecyparis lawsoniana* 'Ellwoodii', *C. lawsoniana* 'Erecta Viridis', *Erica* × *darleyensis, Erica* × *darleyensis* 'Alba', *Juniperus chinensis* 'Pfitzeriana Aurea', *Pyracantha watereri*, and *Thuja occidentalis* 'Pyramidalis' were tested for 1 year.

In a supplementary test with *Pyracantha watereri* and *Erica* × *darleyensis* grown in sawdust or soil–peat, good plants were produced with labor-saving controlled-release fertilizers (14-14-14 and 18-6-12). However, the dry weight of plant tops from the soil–peat medium was significantly greater than from the sawdust.

Plants raised in the soil–peat mixture and the soilless medium became reestablished equally well when transplanted in the field.

Weed control in fall-planted annual flowers. Studies were conducted on the control of weeds in Brompton stock, English daisy, forget-me-not, pansy, viola, wallflower, and sweet William, fall-planted in the coastal area of British Columbia. Lenacil applied as a spray at 2.2 and 4.4 kg/ha, 1 week after planting, proved to be safe and effective against fall-germinating weeds that included chickweed, corn spurry, shepherd's-purse, common groundsel, lamb's-quarters, stork's-bill, and ground-ivy. Control continued through the winter months and only one light hoeing was required in the spring.

Systemic insecticides controlling whitefly on poinsettias. Aldicarb, dimethoate, and oxydemeton-methyl gave good control of the greenhouse whitefly on Dark Red Hegg poinsettias. Dimethoate and oxydemeton-methyl were applied as soil drenches of 114 ml per 18-cm pot, dimethoate 4E at 62 and 124 ml/liter (0.5 and 1 pt/100 gal) and oxydemeton-methyl 25% EC at 186 and 372 ml/liter (1.5 and 3 pt/100 gal); aldicarb 10% G was applied to the soil surface at a rate of 112 kg/ha (100 lb/acre). Four weeks after these treatments, average numbers of pupae per 2-cm leaf disc were 5.0, 1.0, 5.1, 1.1, and 8.4, respectively; the number for the control was 35.2. Plants showed no injury from the treatments.

Propagation of grapes and other woody plants. New, improved techniques for rooting commercial woody plants were developed in the project's first year. The successful rooting of current season's tip growth of grapes (taken during July and August) has increased our ability to produce virus-free stock. The technique was developed in cooperation with the post-entry quarantine station of the Production and Marketing Branch. Common commercial *labrusca, vinifera*, and hybrid softwood cuttings were rooted in 10 days with the use of indolebutyric acid hormone, a coarse sand medium, and bottom heat (with electric soil-heating cables) under an automatic intermittent-mist system.

The propagation of Douglas-fir cuttings is a cooperative project with MacMillan Bloedel Limited and Pacific (C.P.R.) Logging Co. Best results were obtained during December and January with the use of hormones as quick dips and a rooting medium containing sand, granite, styrofoam, and perlite.

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Research

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Miscellaneous

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Research Station
Summerland, British Columbia

PROFESSIONAL STAFF

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E. F. BELL	Administrative Officer
J. C. LAVERY, B.Sc., B.L.S.	Librarian

Agricultural Engineering Section

A. D. MCMECHAN, B.A.Sc.	Head of Section; Sprayer and fruit-handling equipment
P. PARCHOMCHUK, B.A.Sc., M.S.	Harvesting equipment

Animal Science Section

J. M. MCARTHUR, B.A., M.A., Ph.D.	Head of Section; Bloat research in cattle
F. M. CHAPMAN, B.S.A.	Cereals, forage crops

Entomology Section

H. F. MADSEN, B.A., Ph.D.	Head of Section; Integrated control
F. L. BANHAM, B.A.	Stone-fruit 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
A. P. GAUNCE, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry

Fruit and Vegetable Processing Section

D. R. MACGREGOR,[2] B.S.A., M.S., Ph.D.	Head of Section; Biochemistry and microbiology
J. F. BOWEN, B.S.A., M.S.A., Ph.D.	Microbiology
D. BRITTON (Miss), Dip. H.Ec.	Home economist

J. A. KITSON, B.A., M.S.	Process and product development
A. W. MOYLS, B.S.A.	Fruit and vegetable processing

Soil Science Section

J. L. MASON, B.S.A., M.Sc., Ph.D.	Head of Section; Plant nutrition
D. S. STEVENSON, B.S.A., M.S., Ph.D.	Soil physics and irrigation

Plant Pathology Section

M. F. WELSH, B.S.A., Ph.D.	Head of Section; Virus diseases of pome fruits
A. J. HANSEN, Dip. Agr., M.Sc., Ph.D.	Virus diseases of stone fruits and grapes
L. E. LOPATECKI, B.A., B.S.A., M.S.A., Ph.D.	Parasitic tree-fruit diseases
D. L. MCINTOSH, B.S.A., Ph.D.	Parasitic tree-fruit diseases
R. M. ROSHER, B.A., M.A.	Parasitic tree-fruit diseases

Pomology Section

S. W. PORRITT, B.S.A., M.S., Ph.D.	Head of Section; Fruit harvesting and storage
K. O. LAPINS, Agr., M.S.A., Ph.D.	Fruit breeding and hardiness
N. E. LOONEY,[3] B.S., M.S., Ph.D.	Agrometeorology, growth regulators
M. MEHERIUK, B.Sc., B.Ed., M.Sc., Ph.D.	Postharvest physiology, biochemistry

Vegetables Section

L. G. DENBY, B.S.A., M.S.A., F.R.H.S.	Head of Section; Breeding

VISITING SCIENTISTS

National Research Council postdoctorate fellows, 1971–72

K. KATAGIRI, Ph.D.	Fruit breeding
B. SNEH, Ph.D.	Soil microbiology

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[1] On transfer of work to Research Station, St-Jean, Que., January to October, 1971.
[2] On 2-year loan to CIDA, as head of Food Science Department, University of Ghana, from October 1971.
[3] On 1-year transfer of work to CSIRO, North Ryde, Australia, from June 1971.

INTRODUCTION

The objective of the Research Station at Summerland is to serve the fruit and vegetable industry of southern British Columbia, and in some aspects the fruit industries of other regions of Canada. Projects that are of national significance include fruit mutation breeding, self-fertile sweet cherry breeding, the sterile codling moth program, trickle irrigation, the grape program, mechanical equipment for high-density orchards, high-density peach culture, breeding of disease-resistant tomatoes, development of new fruit products, and identification and characterization of fruit virus diseases. In addition, this station is actively engaged in chemical analysis to detect genotypes of alfalfa that are low in the 18S protein fraction, the prime factor associated with ruminant bloat.

Through close cooperation with industry the research program is oriented to problem solving, but at the same time a background of basic research is maintained as the foundation for important new agricultural developments. As indicated by the publications listed in this report, staff members publish widely in scientific journals as well as in popular media. Reprints of most scientific papers are available from authors.

I wish to recognize the excellent support accorded by the staff to Acting Director Dr. H. F. Madsen, who managed the Station so efficiently between the time of the death of former Director Dr. C. C. Strachan, and October 1971, when I took over the directorship.

Mailing address for this station is Research Station, Research Branch, Canada Agriculture, Summerland, B.C.

D. V. Fisher
Director

AGRICULTURAL ENGINEERING

Effect of Rain and Overtree Irrigation on Spray Deposits

A 1.65-cm rainfall that occurred within a few hours of a spray application of azinphosmethyl removed half of the initial spray deposit from apple leaves. Throughout the season the spray deposits on apple leaves were degraded slightly faster when overtree irrigation was used than with undertree irrigation. At harvest, overtree-irrigated plots had slightly higher codling moth infestations than undertree-irrigated plots.

Shake-and-catch Harvesting of Tree Fruits

Sweet cherries, at fresh market maturity, were difficult to harvest by shaking. At cannery maturity they came off readily, mostly without stems. Cherry removal was better at shaking frequencies of 550 to 1,050 cpm than at frequencies of less than 400 cpm.

Apples and clingstone peaches were harvested easily at shaking frequencies of 300 to 1,400 cpm. Fruit damage was considerably higher than in hand-picked controls, but a high percentage of the mechanically harvested fruit was suitable for processing.

ANIMAL SCIENCE

Gel Electrophoretic Procedure for Fraction 1 Protein Analysis

A gel electrophoretic procedure to determine Fraction 1 protein (ribulose 1,5-diphosphate carboxylase) was developed and used to screen alfalfa for nonbloating genotypes. The results showed that very few genotypes were low in Fraction 1 protein, and the amount of Fraction 1 protein present in the 1st year was not indicative of the level in older plants. The alfalfa genotypes with two Fraction 1 proteins did not survive their first winter.

Molybdenum and Copper-to-molybdenum Ratios in Feeds

Thirty-five percent of samples representative of feeds grown in different areas of British Columbia had molybdenum (Mo) concentrations of less than 1 ppm. No very high levels were found, and 92% of the samples had less than 4 ppm Mo. Of the classes of feed analyzed, corn silage and grains were the lowest in Mo and sedge hays were the highest, with concentrations in 19% of the samples greater than 4 ppm. The highest individual value was 9.9 ppm Mo.

The copper-to-molybdenum (Cu:Mo) ratios in all feeds varied from less than 1 to 48; ratios were less than 2 in 36% of the combined grass and sedge samples. The average Cu:Mo ratio was comparatively low in feeds with Cu levels of less than 2 ppm, thus adding to the problems caused by inadequate Cu in feeds.

ENTOMOLOGY

Codling Moth

Autocidal control. For the 3rd consecutive year, gamma-irradiated moths dosed at 25 to 30 krad were released by helicopter three times a week from time of bloom through September in a 40.5-ha block of apple and pear trees. At harvest, the percentage of fruit injured by codling moths was 0.007, compared with 0.02 in 1970. Another 121.5-ha orchard was treated with insecticide in May and June to reduce native moth numbers so that the sterility control method could be used effectively; releases began in July.

During the period of sterile moth release, 8.3 million moths were reared on an artificial diet, an increase of 135% over the number reared in 1970. Automation of some of the rearing procedures and improved environmental control were largely responsible for the increase.

Sex pheromone. A synthetic codling-moth sex pheromone was compared with live virgin females for attractiveness to males. Traps baited with 0.1 mg of synthetic pheromone were more effective than traps baited with five virgin females during the first brood, and equally effective during the second brood. A single charge of 0.1 mg of synthetic pheromone remained attractive to male moths for 79 days, and for 51 days was as effective as 0.1 mg of fresh pheromone replaced weekly.

Fruittree Leafroller

Sex pheromone. Riblure (*cis*-11-tetradecenyl acetate; Zoecon Corp.), the synthetic sex pheromone of the redbanded leafroller, was highly attractive to males of the fruittree leafroller. The addition of dodecyl acetate to Riblure gave increased attractiveness. In eastern North America, where both the redbanded leafroller and the fruittree leafroller are present, Riblure is not attractive to the latter species. The redbanded leafroller does not occur in British Columbia.

Control. Treatment of apples at the pink-bud stage with azinphos-methyl, diazinon, or leptophos (Phosvel) gave good control of the fruittree leafroller. No economic advantage was obtained from another treatment at the petal-fall stage. The data on timing of sprays confirmed observations that most of the larvae had hatched from overwintered eggs by the pink-bud stage.

Cherry Fruit Flies

Biology. At Salmon Arm, the black cherry fruit fly was trapped from June 11 to August 19; peak numbers were caught from June 25 to July 30. Western cherry fruit flies were present from June 25 to September 9, with peak numbers from July 9 to August 6. The earlier flight of the former species probably occurred because the postdiapause incubation period of the pupal stage was shorter. In the laboratory the postdiapause incubation period of the black cherry fruit fly at 21 C was 29 days, whereas that of the western cherry fruit fly was 47 days.

Four percent of cage-reared western cherry fruit flies had no diapause and produced a second generation. If a strain with no diapause can be segregated, chances for developing a system of continuous laboratory rearing will be much improved.

Control. Two sprays of dimethoate at 3.5 kg active ingredient/100 liters (0.35 lb/100 gal) gave complete control of the western cherry fruit fly. Dimethoate was shown to act systemically against eggs and larvae in fruit and adults on foliage and fruit.

Peach Twig Borer and Green Peach Aphid

Control. Applications of azinphos-methyl, endosulfan, and phosalone at the pink-bud stage gave excellent control of the peach twig borer on peaches. Control was not significantly better with two applications, at pink bud and petal fall. With two sprays of chlorphenamidine control was excellent, but one spray was significantly less effective. One or two sprays of endosulfan gave excellent control of the green peach aphid and good control was obtained with two sprays of chlorphenamidine. The other treatments were not effective.

Orchard Mites

Ecology. In 1968 and 1969, the predacious mites *Typhlodromus caudiglans* Schuster and *T. pyri* Scheuten were eliminated by several applications of an organophosphate insecticide in one-half of a cultivated but previously unsprayed orchard. An organophosphate-resistant strain of *T. occidentalis* Nesbitt released into the orchard in 1969 increased greatly in 1969 and 1970. With termination of the insecticide applications in 1969, *T. caudiglans* and to a lesser extent *T. pyri* began to repopulate the trees. By the end of 1970, *T. caudiglans* had attained a greater population density than *T. occidentalis* and by late 1971, *T. occidentalis* was almost totally replaced by *T. caudiglans* and *T. pyri.* Comparisons of host species of mites in the treated and untreated halves of the orchard suggest that predation by *T. caudiglans* and *T. pyri* is more efficient against the European red mite than predation by *T. occidentalis.*

Overtree sprinkler applications of 2.5 cm of water once a week through the summer reduced numbers of the European red mite by 70% compared with undertree sprinkler use. Five centimeters of water applied once every 2 weeks was less effective. Numbers of phytoseiid mites and *Zetzellia mali* (Ewing) were also reduced by overtree irrigation, but tydeid mites were not affected.

The hatch of European red mite winter eggs on Spartan and McIntosh apples stored at 1 to 2 C increased from 3% after 1 month to 70% after 5 months. Mortality after 5 months on other varieties in storage was 54% on Red Delicious, 61% on Golden Delicious, and 84% on Winesap.

Pear Psylla

Ecology. Under constant temperatures, the capacity of pear psylla populations to increase was at a maximum at 27 C. This capacity increased as the temperature level was raised to 27 C, mainly because of a reduction in generation time. Between 27 C and 30 C, the capacity decreased mainly because of mortality of immature stages, and between 30 and 32 C the decrease was almost entirely due to decreased fertility.

In orchards where predation and parasitism were eliminated by selective insecticides, rates of natural population increase were greatest during May, June, and September when moderate temperatures prevailed, and least during hot weather in July and August. Where predation and parasitism were unchecked, rates of natural population increase were reduced in May and June but were unaffected during July, August, and September. Host vigor also was shown to affect rates of population increase.

FOOD PROCESSING

Fruit Aroma Powder

Production of the sugar polymer used to encapsulate high-strength apple aroma has been scaled up to handle 50-kg lots. Also, it has been found possible to make apple aroma powder of 250-fold strength by increasing the rate of addition of 20,000-fold essence to the sugar polymer.

Analysis of apple volatiles stripped from sauce before drying showed that over 80% of the volatiles present could be collected. The aroma powder produced from this essence is quite suitable for use as an aroma enhancer for dry applesauce flakes prepared from the stripped sauce.

Low-SO_2 Cherry Brine

The problem of disposing of large volumes of conventional preservative brines for sweet cherries may be solved by use of a new low-SO_2 brine containing 5% NaCl as the main preservative. With salt used as a preservative and SO_2 as a bleaching agent it is possible to reduce SO_2 levels in brine to 0.2%. This brine can easily be reused if it is filtered and the salt and SO_2 levels are adjusted.

Bing cherries picked at optimum brining maturity, preserved in the new brine, then leached and candied were not significantly different in color, flavor, and yield from controls preserved in regular brine.

Grape Cultivar Testing

Of the 55 grape cultivars made into wine during the 1970 season, two French varieties, Pinot Gris and Auxerrois, yielded outstandingly good white wines and two Russian selections, Michurinets and Severnyi, gave the highest-quality red wines yet produced at Summerland. Other selections that showed promise were Violette Hâtive, Schuyler, New York 35814, Vincent, New York 34824, Riesling Sylvaner, and New York 33873.

Fresh Chilled Peaches

When Fairhaven peaches were preripened to within 1 to 2 days of canning maturity before being placed in an atmosphere of either 5% CO_2 and 3% O_2 or 2% CO_2 and 2% O_2 at 0 C, the storage life of fruit in a suitable condition for processing was extended by approximately 4 weeks.

Fresh-chilled peaches, made from control samples stored at 0 C, developed a bitter-almond or pit flavor within 7.5 weeks. Seventeen weeks after harvest, samples of fruit processed after controlled-atmosphere storage were free from the bitter-almond flavor and were of acceptable quality.

Cooler for Canned Fruit Pulp

Hot-filled 2.8-liter cans of single-strength fruit pulp were cooled from 88 C to 38 C in 3.5 to 8.0 min in a four-track roll cooler designed to use a minimum of water. Because 85% of the cooling water was recycled, water usage at the cooler's maximum capacity of 1,000 2.8-liter cans/hr was cut to 3,410 liters/hr. This represents a fivefold reduction of water usage compared with that of most conventional can coolers.

PLANT PATHOLOGY

Crown Rot of Apple Trees

Survival of *Phytophthora cactorum* zoospores in infested soil was not much affected by soil temperature, but they tended to persist longer at 10 C than at 27 C. Urea added at a rate of 500 ppm N shortened the life of zoospores considerably, but this rate was toxic to apple seedlings. Other common N fertilizers added to soil infested with zoospores had no consistent effect on fungus survival.

Cottony Mold of Apples in Controlled-environment Storage

Cottony mold caused by *Alternaria* sp. frequently develops on the surface of apples and bins in controlled-atmosphere storage at high humidity. Sufficient mycelium can survive packing procedures to downgrade the fruit. In a comparison of fungicides on agar plates, G20072 (Geigy Chemical Co.) completely inhibited mycelial growth at 12 ppm, and sodium orthophenyl-phenate (SOPP) gave the same control at 80 ppm. Thiram, dichloran (Botran), benomyl, captan, maneb, and thiabendazole were inferior. As G20072 is not registered for use in Canada, control is most likely to be obtained with a low-percentage formulation of SOPP.

Control of *Mucor piriformis* by Fungicides

During January 1971, stem end rots of stored Anjou pears caused serious losses. The causal fungus was demonstrated to be *Mucor piriformis* A. Fisch., not previously reported in Canada. The fruits were infected through the abscission layer of the stem, between the time of picking and entry into cold storage. Of eight fungicides tested, only G20072, thiram, SOPP, and thiabendazole had LD_{50} values for suppression of mycelial growth that indicated suitability for postharvest testing.

Ascorbic Acid Dips for Control of Bull's-eye Rot of Apple

Erratic results in earlier tests of ascorbic acid dips have been explained. When ascorbic acid concentration was reduced from 2,600 to 1,300 ppm, suppression of rot increased fivefold. These results support previous findings that polyphenols in the host reach maximum toxicity to the fungus (*Neofabraea perennans*) when they are in a partially oxidized state.

Isolation and Characterization of a Virus from Apple

A virus that is transmitted to *Chenopodium quinoa* by sap from apple trees with leaf pucker symptoms has been tested on a range of herbaceous plants; it induces distinctive white lesions on *Gomphrena globosa*. In clarified *C. quinoa* sap it has a dilution end point of 10^{-8} and retains infectivity at 20 C for 9 weeks. Particle dimensions, as measured by electron microscopy, are 590 ± 10 nm × 13.5 nm. Purified preparations have an absorption peak at 263 to 265 nm. In serological tests against other rod viruses from apple and 12 viruses from other hosts, it has shown a relationship only to clover yellow mosaic virus. It has been isolated repeatedly from cambial and fruit tissues, but not from petal or leaf tissues.

Golden Elderberry Virus in Sweet Cherry

Transmission tests have shown that golden elderberry virus can invade fruiting Bing cherry trees but induces no symptoms. Tests have shown that the golden elderberry virus is serologically related to the European cherry leafroll virus.

POMOLOGY

Comparison of a Spur and Nonspur Sport of Red Delicious

Fruits of Starkrimson (spur) and Harrold Red (nonspur) Delicious apples were picked at five weekly intervals. Water core was more prevalent in Harrold Red than in Starkrimson. Starkrimson from all pickings was firmer than Harrold Red but had lower soluble solids. Acidity was similar for each strain. Starkrimson showed a greater tendency to develop scald after cold storage, but there was no significant difference in length of keeping life between strains.

Characteristics of Terminal and Lateral Fruits of Delicious

Fruit from a block of Red Delicious trees was thinned to leave either a terminal or a side fruit on a spur, or a terminal and a side fruit together as a pair on a spur. Fruit characteristics evaluated at harvest included length and breadth of fruit, depth of stem cavity, and shape of stem. Internal flesh color, acidity, soluble solids, firmness, and weight were evaluated at harvest and except for weight, again after storage for 145 days at 0 C.

At harvest, no significant differences in internal color were found in the various types of apple. The side fruits of the pairs were significantly firmer than either the terminal fruits of the pairs or the single terminal fruits. The position of fruits on the spur had little effect on their acidity, soluble solids, or size. Single terminal fruits did not differ significantly in weight from single lateral fruits or from terminal fruits in the pairs, but the lateral fruits in the pairs were smaller than the terminal fruits.

After storage, internal color, acidity, soluble solids, and scald development showed no significant differences. Firmness was significantly higher for side fruits of the pairs than for either single terminal or single side fruits.

Abnormalities in fruit shape were not common, and were not related to fruit location. The side fruits of the pairs had longer stems than the others and fleshy stems were not evident in terminal fruits, either alone or in the pairs. Shallow stem cavities were most evident in side and terminal fruits of the pairs.

Reduced Growth of Shoots from Adventitious Buds of Compact Apple Mutants

Radiation-induced mutants of McIntosh apple were disbudded in order to force the growth of adventitious shoots. When shoots from adventitious buds and from the original mutant were propagated and their growth was compared, the adventitious shoots showed reduced growth, particularly in the more dwarfed mutants. The growth of the propagules from adventitious material was only 62% to 71% that of the original mutant source. It appears that growth reduction is related to the third histogenic layer, and that material from this source should be able to transmit dwarfing characteristics to its progeny.

Use of a Growth Regulator for Chemical Pruning

The material P 938 (Plant Protection Ltd.) was applied to apple trees in the growth chamber as a chemical pruning agent. Terminal buds were killed without damage to the rest of the tree and without harmful effects on the photosynthetic efficiency of the other leaves. Field applications to cherries had no effect, but a similar application to apples 2 weeks after bloom stopped terminal growth. A later application to apple trees caused some defoliation and some fruit damage.

Self-fertile Sweet Cherry and its Compact Growth Mutants

The self-fertility of the cherry cultivar Stella proved advantageous in 1971 when pollination conditions were poor. In contrast to Lambert and Van, Stella set a very good crop.

A mutant of Stella, 35B-11, with semistandard growth characteristics was similar to the parent cultivar in set, size, and quality of its fruit. This mutant is expected to produce a tree that is about half the standard size. Another mutant of Stella was extremely

dwarfed but produced long-stemmed fruit of nearly normal size. This selection is being tested in the breeding program as a dwarfing interstem piece.

Rootstocks and Tree Spacing

In 1957 McIntosh, Spartan, Golden Delicious, and Winesap apple trees were planted in three blocks at 4.6 × 4.6 m, 6.5 × 6.5 m, and 9.1 × 9.1 m. Rootstocks used in the three spacings were respectively: MM 106, MM 104, and M VII; M II and MM 111; Antonovka Seedling, MM 109, and M 25. Accumulative yield records show the importance of high density planting; yields in 1970 at the closest spacing (1,200 hl/ha) were double those at medium spacing (600 hl/ha) and triple those at the widest spacing (400 hl/ha).

Accumulated Yields of Apples on Dwarf or Semidwarf Rootstocks

A planting of Delicious, Golden Delicious, Spartan, McIntosh, Tydeman, and Quinte apple cultivars on M VII, M 26, and M IX rootstocks and the Polish dwarf root CN IX R.G. was set in 1966 at a spacing of 2.4 × 4.6 m. Accumulated yields of all cultivars in 1971 averaged 750, 650, 540, and 570 hl/ha respectively for M VII, M 26, M IX, and CN IX R.G. rootstocks. Highest yields were from Golden Delicious and Spartan, and lowest from Tydeman and Quinte.

Grape Training

Trained by the Geneva Double Curtain system, Seibel 9549 grapes produced 29.0 metric tons/ha, but only 16.3 metric tons by the Kniffen system. Berry size, cluster weight, and soluble solids were low when the yield was high. Grapes from the high-yielding system had 16.8% soluble solids and from the Kniffen system, 18.7%.

Storage Humidity Affects Spartan Breakdown

High humidity increased the incidence of breakdown in Spartan apples. There was 32% breakdown in fruits stored in vented polyethylene box-liners (about 95% relative humidity) but only 2% in similar fruits stored in open boxes (about 80% relative humidity) at the same temperature. Breakdown was much more extensive at 2.2 C than at −1.1 C, but was somewhat reduced when the apples were held for 2 days at 20 C before storage.

Controlled-atmosphere Storage of Peaches

In 1971, controlled-atmosphere storage was used to extend the storage life of Fairhaven peaches. The peaches were picked 3 to 4 days before eating ripeness, and stored at 0 C in 2% CO_2 + 3% O_2, in 5% CO_2 + 3% O_2, or in air. Before storage all fruits were treated with dichloran to control rhizopus rot. After storage for 6 weeks fruits from all treatments had satisfactory texture and flavor. There was very little decay in samples from the controlled atmospheres, but 20% to 25% incidence in fruits stored in air. After 9 weeks, decay was beginning to appear in about 25% of the controlled-atmosphere fruits and was extensive in air-stored fruit, which was developing a dry texture. The flesh of more than half of the fruits stored in air and in the 2+3 atmosphere had a red, water-soaked appearance, but such evidence of deterioration was generally absent from fruits stored in the 5% CO_2 atmosphere. These tests indicate that Fairhaven peaches can be stored satisfactorily in a controlled atmosphere for 6 weeks, or for up to 8 weeks if additional measures are taken to protect fruits from decay.

SOIL SCIENCE

Effects of Calcium on Breakdown of Spartan Apples

Calcium sprays to reduce breakdown. A practical spray program for reducing breakdown of Spartan apples was developed for Okanagan growers. It is now a recommended practice to use concentrate sprays of calcium chloride at 17 kg/ha, applied seven times at 2-week intervals starting in late June. This recommendation is the direct result of research started 7 years ago to clarify the effect of calcium on apple quality. In 1970 experiments, this spray program reduced breakdown from about 30% to about 6%.

Calcium concentration related to breakdown. Analysis of sections of peeled and cored Spartan apples showed that calcium content was closely related to the percentage of fruits with breakdown. There was negligible breakdown above about 230 ppm (dry weight basis).

Trickle Irrigation for Tree Fruits

A long-established block of dwarf apple trees was put under trickle irrigation in 1970, and the effect of distance between drippers was determined. It was found that any distance up to 2.2 × 2.2 m gave an excellent spread of water in the sandy loam soil. The cover crop dried out only slightly at points midway between the rows, despite the extremely hot weather in July and August. The system operated very satisfactorily.

VEGETABLES

Asparagus variety trials indicated that U.C.66 warrants recommendation for irrigated plantings in the Okanagan, as a fresh market and processing variety.

Grower trials indicate wide interest in the new, early, determinate tomato varieties Summerjet and Starshot (originally misnamed Smoothie). These varieties continued to show resistance to verticillium wilt, and withstood unusually high summer temperatures much better than Fireball and Summerdawn.

Sutomi tomato continued to prove resistant to tobacco mosaic; in commercial trials at Summerland it was 10 to 14 days later than Selandia and comparable in first ripening with Vantage. However, it yielded over 40% more fruit than Vantage. In 1971 Sutomi fruits proved difficult to pick, because the very compact core tended to peel out if the fruits approached full color on the plant.

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H. S. Pepin,[3] B.S.A., M.A., Ph.D.	Root rots; red stele of strawberry
R. Stace-Smith, B.S.A., Ph.D.	Raspberry viruses; virus characterization
H. N. W. Toms, B.A.	Mycology; potato diseases

Virus Chemistry and Physiology

H. W. J. Ragetli, Ir., Ph.D.	Head of Section; Organic chemistry; virology
G. G. Jacoli, B.A., Ph.D.	Biochemistry; virology
J. H. Tremaine, B.Sc., M.Sc., Ph.D.	Biophysics; virology

Departure

M. J. Pratt, B.Sc., Ph.D. Resigned April 20, 1971	Forage crop diseases; legume viruses

VISITING SCIENTISTS

H. O. Agrawal, B.Sc., M.Sc., M.S., D.Sc. National Research Council postdoctorate fellow, 1970–72	Virology
M. Martin, B.S.A. On leave from University of Natal, Pietermaritzburg, South Africa	Plant physiology
M. R. Nelson, Ph.D. On leave from University of Arizona, Tucson, Ariz., USA	Virus purification and characterization
D. G. Walkey, B.Sc., Ph.D. On leave from National Vegetable Research Station, Wellesborne, Warwick, England	Plant virology

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[1]On educational leave, University of Reading, Reading, England.
[2]Resigned as Director of the Station, on May 3, 1971.
[3]On transfer of work at East Malling, England.

INTRODUCTION

This report, the ninth from the Research Station, Vancouver, covers the main contributions by the Station's research personnel to the solution of agricultural problems. Because this Station is the national center for research on plant viruses, much of the work relates to the study of plant viruses and virus diseases at various levels. As much as possible, an attempt has been made to rapidly exchange information between the research and the applied levels, so that both benefit.

Our program on control of pests, diseases, and weeds is aimed toward the minimal use of chemicals, and the substitution of effective biological agents.

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M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Aster yellows disease. Plant tissue culture was used to study early events in the multiplication of the aster yellows (AY) disease agent.

Carrot and aster tissues from infected and healthy plants were grown on agar at 25 C, with the use of a modification of the culture medium of Murashige and Skoog. The cultures became well established in about 60 days. Only in the infected carrot cultures was there a strong differentiation toward regenerating whole plants. The phenomenon was enhanced by light, and it was not observed in the infected cultures of asters or in the healthy controls.

Microscopical observations of the phloem of infected carrot cultures showed the presence of spherical bodies that were between 400 and 900 nm in diam. These bodies were surrounded by a double membrane that contained smaller particles, about 100 nm in diam. As the tissues aged the spherical bodies lost their distinct outlines, became enlarged, and showed tubular structures bound to round virus-like particles about 25 nm in diam.

In the phloem of infected asters, structures were found that resembled mycoplasma-like bodies. In infectivity tests with leafhopper vectors, the AY disease was not transmitted from these cultures.

Virus multiplication in plant tissue cultures. The synthesis of rapidly labeled ribonucleic acids was investigated in plant tissue cultures infected with cucumber mosaic virus. Healthy and infected cultures were incubated at different temperatures. The various populations of ribonucleic acids were isolated and identified after extraction of the cultures and fractionation of the extracts by methylated albumin kieselguhr (MAK) column chromatography or sucrose gradient centrifugation.

Cellular ultrastructure. The tentacles of sundew, *Drosera* sp., were examined by means of light and electron microscopy. The study led to a better understanding of the overall anatomy of the tentacles, and some entirely new anatomical and cytological details were detected. Because of their extreme involvement in the turbulent cellular response to stimulation, the vacuolar contents of the tentacle cells were examined by microanalytical techniques. Three ultraviolet-absorbing compounds were isolated; two were red pigments.

Virus synthesis. Partly purified inhibitor solutions were prepared for use in experiments aimed at isolating an early virus–host complex. These solutions had an inhibitory effect per unit of $OD^{1\,cm}_{275\,nm}$ greater than 95%, when they were mixed in equal volume with a solution of tobacco mosaic virus (TMV) containing 110 μg virus/ml. These experiments provided additional support for an earlier conclusion that the inhibitor acts early in the establishment phase of the virus.

Properties and amino acid composition of viral proteins. Molecular weights of virus protein subunits of cowpea chlorotic mottle virus (CCMV), broad bean mottle virus (BBMV), and brome mosaic virus (BMV) were determined by means of polyacrylamide gel electrophoresis. The values obtained were 19,200

for CCMV, 16,400 for BBMV, and 16,200 for BMV. The amino acid compositions of the three viruses were determined, and they agreed with values that were reported previously. Based on these data, CCMV, BBMV, and BMV were found to possess 179, 152, and 150 amino acid residues per protein subunit, respectively.

Trypsin treatment of the CCMV subunit gave one component with a mol wt of 16,400 and 154 amino acid residues. Unlike CCMV, in which only certain lysyl and arginyl bonds in the N-terminal portion of the protein were hydrolyzed by trypsin, BBMV did not show any selective response, and some of the virus particles were completely digested by trypsin. Thus the protein subunits of BBMV are much more susceptible to tryptic action than those of CCMV. Chymotrypsin treatment of BBMV completely hydrolyzed some virus particles, whereas the protein of a small fraction was only partly hydrolyzed. The results suggest the presence in BBMV of peptide bonds that are susceptible to attack by enzyme at either the C- or N-terminal of the molecule. Trypsin treatment of BMV produced at least four components. By the use of gel chromatography and density gradient centrifugation a stable spherical particle 16 nm in diam (36 *S*) with an amino acid composition different from that of the virus and containing 6% RNA was isolated. However, a precipitate that formed during the digestion was found to contain three components with mol wt of 11,000, 9,700, and 8,800. Chymotrypsin treatment of BMV had no effect.

Cytology and physiology of virus-infected plants. Infection of *Chenopodium quinoa* Willd. and *C. amaranticolor* Coste & Reyn. with an apple virus, HMV-A, isolated from a Virginia crab apple tree, resulted in marked hypertrophy of 10–15% of the mitochondria of mesophyll cells in the center and at the borders of necrotic lesions. The hypertrophied mitochondria had enormously increased diameters, 10–15 times those of normal mitochondria, and contained lamellar inclusions in the matrix, which are believed to be collapsed cristae, in addition to the normal cristae. One or more electron lucent areas in almost every giant mitochondrion contained filaments, fibers, or granular bodies, which are probably mitochondrial DNA. Pleomorphic mitochondria and others, apparently in active division, were also observed. These mitochondrial changes suggest that the virus infection blocks mitochondrial functions, thus setting up a requirement for increased production of mitochondria and mitochondrial enzymes. This increased production involved a reactivation of the appropriate DNA, and so the cells reverted to a juvenile or embryonic condition as a result of the virus infection.

The study of the development of carnation viruses within the plant-host cells was continued with carnation ringspot virus (CRSV) in *Dianthus barbatus* L. and *Vigna sinensis* Savi (cowpea). CRSV is the only one of the common carnation viruses that has a host other than Caryophyllaceae. It was found that, unlike some of the other polyhedral viruses, CRSV formed intracellular crystals only occasionally. However, anomalous structures were observed in the nuclei of the infected cells that appeared to be tubules containing spherical particles closely resembling the CRSV particles. Because the nucleus has been postulated as the site of intracellular virus synthesis, on the basis of biochemical evidence, the development of these tubules was carefully studied. It was found that the formation of virus particles in the cytoplasm preceded by a few hours the formation of the tubular inclusions. Thus, no evidence was found that virus synthesis occurs in the nucleus.

PLANT PATHOLOGY

Potatoes

Control of mild and latent viruses. Twenty-three potato selections were treated for eradication of potato virus X (PVX) and potato virus S (PVS) by nutrient culture of axillary buds excised from heat-treated plants. Since 1966, 88 selections have been treated. All but seven of these are being maintained and tested annually for PVX, PVS, potato virus M, and for mild strains of leaf roll and spindle tuber viruses. Thirteen cultivars derived from virus-free stocks are propagated by Elite seed growers in British Columbia, and 25 have been sent to other provinces and countries.

Small Fruits

Control of mummy berry of highbush blueberry. Plots of the cv. Rancocas were treated five times between March 30 and June 2 with benomyl (Benlate; Du Pont of Canada Ltd.) at 0.56 kg and 1.12 kg active ingredient/ha; TD-5124-A (Pennwalt Corp.) at 2.24 kg; thiabendazole (Tecto 60; Merck & Co. Inc.) at 1.12 kg; Cela W524 (Cela Landwirtschaftliche Chemikalien Gesellschaft MBH) at 0.56 kg; BAS 3201-F (BASF, Ag. Chem. Dept.) at 1.12 kg; and thiophanate-methyl (NF-44; Nippon Soda Co.) at 1.12 kg. Benomyl was also applied twice at 0.56, 1.12, and 2.24 kg, and once at 2.24 kg. Only Cela W524 was effective against ascospore infections of leaves and flower clusters. Conidial infections resulting in mummied fruits were reduced by five applications of benomyl at both rates, by Cela W524, BAS 3201-F and thiophanate-methyl. All treatments except TD-5124-A resulted in increased yield, but benomyl at 1.12 kg applied five times and Cela W524 gave the largest yield increase.

Control of thornless boysenberry (youngberry) virus. Young plants showing severe mosaic-type symptoms were grown at 34–36 C for 12 weeks. During the heat treatment, shoots were removed for propagation. From each shoot a small tip cutting and five one-node stem cuttings were excised, rooted in sand, and later transplanted to soil. Half of the cuttings taken after 4 weeks treatment developed into symptomless plants, and the proportion of normal plants increased with greater length of treatment. A virus tentatively identified as tobacco streak remained in some of the symptomless plants, but the virus that caused the mosaic symptoms has not been identified.

Golden elderberry virus. In cooperative studies with the Research Station, Summerland, the golden elderberry virus was purified and some of its physical properties were determined. The polyhedral virus, about 30 nm in diam, sedimented as two opalescent zones on a sucrose gradient. Both bands were infective and serologically identical. Particles had sedimentation coefficients of 114 *S*. The virus was serologically unrelated to several other polyhedral viruses, but it was distantly related to cherry leaf roll virus.

Nematodes

Survey on bulbs and tree fruits. In cooperation with the British Columbia Department of Agriculture, surveys were undertaken of nematodes of economic importance. In 107 samples from bulb fields at the coast, nine parasitic genera were found. *Pratylenchus penetrans* was found in 82% of the samples. A survey of apple, pear, and cherry was conducted in the Okanagan Valley to determine the distribution of possible virus vectors as well as other parasitic species in the region. In 56 samples, nine parasitic genera were found; the vector species *Xiphinema americanum* was second in prevalence (36% of the samples) to *Pratylenchus* (68%). A second vector genus *Trichodorus* was found in one field.

ENTOMOLOGY

Vectors

Mycoplasma-like bodies. Small bodies 53–139 nm in size were seen in electron micrographs of salivary sheaths made by the leafhopper *Scleroracus dasidus* Med. The species transmits witches' broom disease of potatoes. Rickettsial bodies were found in salivary sheaths from the leafhopper *Scaphytopius delongi* Young. This species is an occasional vector of aster yellows disease, and it appears also to cause chlorotic areas near the edges of clover leaves on which it feeds.

Morphology and fine structure. After two dendrites were found in the central canal of each mandible of green peach aphids, the stylets of related species were examined in the transmission electron microscope. The same innervation occurred in cabbage aphids, *Brevicoryne brassicae* (L.); bean aphids, *Aphis fabae* Scop.; pea aphids, *Acyrthosiphon pisum* (Harris); strawberry aphids, *Pentatrichopus fragaefolii* (Cock.); filbert aphids, *Myzocallis coryli* (Goeze); and shallot aphids, *Myzus ascalonicus* Donc. This discovery suggests that the condition is general among aphids. Two dendrites were also found in each mandible of pear psyllas, *Psylla pyricola* Foerster, and greenhouse whiteflies, *Trialeurodes vaporariorum* (Westwood).

In the aster leafhopper, *Macrosteles fascifrons* (Stål), both the mandibular and

maxillary stylets are innervated. Each mandible contains three dendrites and each maxilla contains five.

The green peach aphid was shown to have 16 nerves running to 16 large sensory setae at the tip of the labium. Scanning electron micrographs show that these setae are mechanoreceptors.

Root Weevils

Barriers and strawberry cultivars. In the field, five cultivars were tested for susceptibility to larvae of the black vine weevil, *Otiorhynchus (Brachyrhinus) sulcatus* (F.), in four adjacent plots, each enclosed by a Fluon-coated plastic barrier 20-cm high. Each plot contained 36 plants. The treatments consisted of the introduction of 1 or 0.5 marked adult per plant, 30 eggs per plant, and a control with no introductions. The barriers were highly successful in enclosing the nonflying adults. One year later, the yields from the plots with 30 eggs or 1 adult per plant were significantly reduced from that of the control plot, but the yields from the plots with 0.5 adult per plant were not reduced. The variability within plots was too high to demonstrate differences in susceptibility among the cultivars BC-25, Cheam, Siletz, British Sovereign, and Northwest. Some replicates of all cultivars were severely damaged or killed. Large numbers of adults emerged in the three infested plots, and these were allowed to feed and oviposit within the original barriers as a further test.

Leatherjackets

Chemical control. On grassland, single applications in the fall of alpha gammachlordane, chlordane, diazinon, or bromophos, in emulsions or granules, effectively reduced very high numbers (from 1,250 to 1,420/m^2) of the European cranefly, *Tipula paludosa* Meigen. Against spring populations of 327/m^2, diazinon granules, methiocarb wettable powder and bait, and emulsions of pirimiphos-methyl, diazinon, alpha gammachlordane, propoxur, and azinphos-methyl were almost equally effective in reducing the numbers by more than 83%.

Root Maggots

Carrot rust fly, Psila rosae *(Fab.).* At two sites in organic soils, late carrots were treated at seeding with granules of carbofuran, fensulfothion, thionazin, ethion, and chlorfenvinphos, then sprayed with the same compounds 30, 50, and 70 days after seeding, or 40 and 70 days. Samples were taken 100 days after seeding. Residues of fensulfothion were found. There was little damage in the control plots at this time, but by 140 days 50% of the crop had been damaged by carrot maggots at one site and 20% at the other. In plots treated with carbofuran, fensulfothion, and thionazin, the damage was below 4%.

Compatibility. Fifteen herbicides were tested singly or in combination as preplanting, preemergence, or postemergence treatments for weed control in direct-seeded brassica crops in silt loam. Soil and spray applications of carbofuran, fensulfothion, or thionazin were included in the design, for control of root maggots, *Hylemya* spp. In some cases, where there was good control of broadleaved weeds and grass, the stand of brassicas was reduced. Thionazin and fensulfothion caused some reduction in emergence, but carbofuran had no detrimental effect. Late seeding, about July 8, avoided attack from first- and second-generation maggots and the herbicide treatments reduced damage to low levels. In the untreated plots, the damage to broccoli was 23%, cabbage 18%, cauliflower 23%, and rutabaga 13%. None of the herbicides had any insecticidal properties or affected the efficiency of the insecticides.

Potato Flea Beetles

Chemical control. In the interior of the province, in two types of soil, granular carbofuran, fensulfothion, and fonofos were tested in 30-cm bands or broadcast to control the tuber flea beetle, *Epitrix tuberis* Gent. Three supplementary drenches were applied at intervals of about 2 weeks to control the emergence of second-generation adults. In silt loam with a relatively light infestation, untreated plots yielded 31% marketable tubers and plots treated with fonofos in bands, only 40%. The other treated plots yielded 92–100% marketable tubers. In sandy loam the infestation was heavy, and no marketable tubers were produced on the control plots.

Only four treatments were effective: carbofuran, band 70% and broadcast 97%; fensulfothion, band 96% and broadcast 95%. The plots that were given the recommended treatment with carbaryl produced only 10% marketable tubers.

Residue Chemistry

Organophosphorus residues. Methods were developed for determining residues of fensulfothion and its sulfone in muck soil. The residues in soil that had been treated against the carrot rust fly ranged from 100 ppm of fensulfothion plus its sulfone 60 days after treatment to 26 ppm after 80 days.

Carrots from soil treated with ethion had residues of 0.34 ppm 10 days after treatment, and 0.20 ppm after 50 days. Chlorfenvinphos residues ranged from 0.50 ppm 10 days after treatment to 0.24 ppm after 50 days.

Carbamate residues. The microcoulometric method of detecting carbofuran was improved. By modifying the gas chromatographic column packing and the transfer line from column to furnace, a substantial improvement was achieved in the response of 3-hydroxycarbofuran.

Methods were developed for determining residues of carbofuran and its 3-hydroxy metabolite in carrots and strawberries. In field-treated carrots the total residues were 0.46 ppm 10 days after treatment and 0.10 ppm after 50 days. In strawberries the residues were 0.38 ppm 45 days after treatment and 0.07 ppm after 52 days.

The use of the microcoulometer in the nitrogen mode rather than in the sulfur mode for direct determination of methomyl (Lannate) was found practical. No derivatization step was needed and the sensitivity was doubled.

PEDOLOGY

Classification and Mapping

Field surveys were completed for the Horsefly, Alexis Creek, Hanceville, Chilcotin, Churn Creek, and Taseko Lakes map sheet areas in the central interior of the province, and the soil and capability maps for these areas are in various stages of preparation. Approximately 1,149,300 ha of land were surveyed at the reconnaissance level and soil capability maps were prepared for 3,698,900 ha. Fourteen soil capability maps for the Peace River area were completed and await publication.

Detailed soil surveys of 12,150 ha were made on seven Indian Reserves in the Cariboo district. Soil studies were also carried out in the Mackenzie Mountains, Mackenzie Plain, and Great Slave Lake Plain of the Northwest Territories. These studies were designed for the Conservation of Terrestrial Communities (IBP/TC) section of the International Biological Program, whose purpose is to preserve natural and seminatural areas considered important for the future of biology and human welfare.

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PROGRAM STRUCTURE
RESEARCH BRANCH CANADA AGRICULTURE

June, 1971.

AIM	OBJECTIVES		GOALS
	FORAGE CROPS	1 To improve the efficiency of production and the quality of forage crops. Man Years 81.2	1 By 1974, through the development of superior varieties and by improved management practices, to raise the unit yield of dry matter or seed of legume crops by 10%. 2 By 1974, through the development of superior varieties, and improved management practices, to raise the unit yield of dry matter or seed of grass crops by 10%. 3 By 1974, to classify the vegetative cover and potential productivity of range-land and other permanent-type pasture, and to determine those management practices that will increase production by 10%.
	OILSEED CROPS	2 To improve the efficiency of production, adaptability and quality of oilseed crops. Man Years 27.9	1 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of rapeseed and mustard by 10%, and to improve quality to meet market demands. 2 By 1973, through the development of superior hybrids and varieties, and improved management practices, to increase the unit yield of sunflowers by 10%. 3 By 1974, through the development of superior varieties and improved management practices to increase the unit yield of soybeans by 10%. 4 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of flax in western Canada by 10%, while maintaining quality to meet market demands.
	HORTICULTURAL CROPS	3 To improve the efficiency of production and the quality of horticultural crops. Man Years 187.0	1 By 1974, through the development of superior varieties and improved management practices, to increase the unit yield of tree fruits by 10% while maintaining required standards of fresh and processed quality. 2 By 1973, through the development of superior varieties and improved management practices, to increase the unit yield of small fruits by 10% while maintaining required standards of fresh and processed quality. 3 By 1973, through the development of superior varieties and improved management practices, to increase the unit yield of vegetable crops by 10% while maintaining required standards of fresh and processed quality. 4 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of potatoes by 5% while maintaining or improving the required standards of fresh and processed quality. 5 By 1973, to develop superior varieties of ornamentals and turf grasses, and to improve their management practices.
	CEREAL CROPS	4 To increase the efficiency of production and the quality of cereal crops. Man Years 136.1	1 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of durum, winter, and spring wheats by 10%, while maintaining quality of each crop to meet market standards. 2 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of barley by 15%, while maintaining the quality to meet market demands. 3 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of oats by 10%. 4 By 1972, to produce superior variety inbreds and hybrids of grain and silage corn which, when used with improved management practices, will give 10% greater unit yield return and increase the area of adaptation. 5 By 1973, through the development of superior varieties and improved management practices to increase the unit yield of rye by 5%.
	FIELD CROPS	5 To improve the efficiency of production and the quality of field crops such as tobacco, buckwheat, field peas and beans, and sugar beets. Man Years 19.8	1 By 1973, to improve the quality of tobacco by 20% to meet current demands, through the development of superior varieties and by improved management practices and still maintain or increase the yield. 2 By 1974, through the development of superior varieties and improved management practices to increase the unit yields of field peas by 10%. 3 By 1972, through the development of superior varieties and improved management practices to increase the unit yield of buckwheat by 20%. 4 By 1974, through insect, weed, and seedling disease control and better agricultural practices, to increase the returns from sugar beets by 10%. 5 By 1973, to complete the assessment of 10 new crops which may be suitable for Canadian production and specific markets. 6 By 1975, through the development of superior varieties, and improved management practices to increase the unit yields of white beans by 5%.
	PLANT PESTS	6 To develop and improve methods for the protection of crop plants from insects and related pests. Man Years 43.2	1 By 1974, to define some physiological and biochemical target sites for mode of action and basis for resistance to selected insecticides. 2 By 1974, to define factors influencing selected soil insecticides effectiveness, behavior, persistence and effects on non-target soil invertebrates. 3 By 1974, to elucidate chemical properties and methods of analysis for residues, metabolites and degradation products of selected insect chemical control agents. 4 By 1974, to develop pest control programs using methods that do not employ, or make least possible use of, persistent non-selective chemicals.
	PLANT DISEASES	7 To maintain or increase productivity and quality through reduction of losses from plant diseases. Man Years 30.3	1 By 1973, to have developed techniques for the determination of plant disease losses and to have applied the techniques to selected crops. 2 By 1973, to have developed information on the specificity, uptake and degradation of synthetic fungicidal compounds; on the presence and chemical nature of naturally occurring compounds and the mechanisms by which they confer resistance to diseases; and to apply this information in plant disease control. 3 By 1973, to have obtained further information on the properties of plant viruses and mycoplasma, their mode of transmission, and the mechanisms and consequences of infection. 4 By 1973, to have developed further information on the physiology, biochemistry and ecology of soil-borne pathogens. 5 By 1973, to devise control measures for economically important nematodes.
	WEEDS	8 To develop and improve methods for the control of weeds. Man Years 19.5	1 By 1974, to have identified the major weed situations in Canada which are amendable to biological control and to have established control of selected weeds on a priority basis. 2 By 1974, to have developed environmentally safe and effective methods for the control of weeds with herbicides, including mode of action, methods of application, and their persistence in the environment. 3 By 1976, to have completed ecological studies on the economic importance, spacial occurrence, life cycles, reactions to herbicides and other biological characteristics, of selected weeds.
IM ing agricultural rnational prices.	PLANT ENVIRONMENT	9 To explore and identify environmental factors and examine their effects on plant growth and development and show how such knowledge may be	1 By 1974, to have established priorities for, and derived selected meteorological and climatic parameters which will improve agricultural decision making and

DEPARTMENTAL

To develop a viable and self-sustaining industry based on free trade and

	Man Years 16.1	2 By 1973, to explain physiological activity in plants related to winterhardiness and to show how the information can be used to improve the efficiency of crop production.
SOIL MANAGEMENT	10 To develop improved soil and water management practices and to obtain a better knowledge of soil factors affecting the efficiency of crop production and the long-term productivity of the soil. Man Years 32.9	1 By 1973, to develop improved methods of irrigation, drainage, and desalinization to increase the efficiency of production by 10%. 2 By 1974, to elucidate and quantify selected chemical, physical and biological reactions which influence soil fertility through the supply of plant nutrients. 3 By 1974, to elucidate and quantify selected chemical, physical and biological properties of soils which affect their physical capacity as a medium for plant development, as a reservoir for water, and ability to withstand erosion.
SOIL SURVEY	11 To obtain a reliable inventory of Canadian soil resources (nature, extent and distribution pattern of total environment) and to interpret the capabilities of these resources for agriculture and other uses. Man Years 40.0	1 By 1973, to complete the inventory of our basic resources for the following regions and to interpret the capabilities of these resources based on our present state of knowledge. 2 By 1974, to develop an improved basis for classification of soils for a more accurate interpretation and grouping of soils for more efficient land use.
BIOSYSTEMATICS	12 To improve our understanding of the taxonomic relationship of plants, insects, and micro-organisms. Man Years 60.6	1 By 1974, complete the taxonomic revision of selected orders of economically important plants, and maintain a national collection of vascular plants. 2 By 1974, to complete the taxonomic revision of selected groups of economically important agricultural and forest insects, arachnids and nematodes, to maintain and develop the Canadian National Collections of insects, arachnids and nematodes, and to provide an efficient identification and information service arising from this function. 3 By 1973, to complete the taxonomic revision of selected groups of economically important fungi, to provide for a continued growth of the National Collection of fungal specimens and cultures, and to maintain an identification function in mycology.
DAIRY CATTLE	13 To improve the efficiency of production and the quality of dairy products. Man Years 24.1	1 By 1978, to develop improved breeding procedures for dairy cattle to result in 10% greater efficiency. 2 By 1974, to develop improved nutritional, physiological, environmental and management procedures for dairy heifers and cows which will improve growth rate and increase milk production efficiency by 10%. 3 By 1974, to develop new methods of processing milk and new or modified dairy products.
BEEF CATTLE	14 To improve the efficiency of production and quality of beef products. Man Years 36.4	1 By 1978, to develop improved breeding procedures for beef cattle to result in 15% greater efficiency. 2 By 1974, through elucidation of nutrient requirements, physiological processes, levels and availability of nutrient in feeds and management procedures, improve quality of beef and veal and increase production by 10%. 3 By 1974, develop new ration concepts and new systems of management for the pregnant and lactating beef cow in cold climates to reduce the cost of wintering by 25%.
SHEEP	15 To improve the efficiency of production and the quality of products from sheep. Man Years 4.9	1 By 1975, to develop procedures for increasing the productivity of sheep by 25%, with emphasis on year-round lamb production.
SWINE	16 To improve the efficiency of production and the quality of products from swine. Man Years 9.8	1 By 1974, through breeding and physiology, develop procedures for improving carcass quality and increasing productive efficiency in swine by 10%. 2 By 1974, to develop improved nutritional, physiological, environmental and management procedures for swine which will improve carcass quality and increase pork production efficiency by 10%.
POULTRY	17 To improve the efficiency of production and the quality of products from poultry. Man Years 18.3	1 By 1974, through elucidation of nutrient requirements, nutrient level and availability in feeds, improve the quality of eggs and meat and increase production efficiency by 10%. 2 By 1974, to develop improved breeding procedures for meat and egg stock poultry which will increase productive efficiency by 5%. 3 By 1974, to develop improved poultry management procedures which will increase production efficiency by 10%.
OTHER ANIMALS AND HONEY BEES	18 To improve the efficiency of production of other animals and beneficial insects and the quality of their products. Man Years 3.1	1 By 1971, through breeding and improved management, to increase the productivity of honey bees by 5%. 2 By 1974, to elucidate selected nutritional requirements and physiological processes of fur bearers which will increase efficiency of production by 25%.
ANIMAL PHYSIOLOGY	19 To elucidate selected physiological function of animals including reproductive and growth processes. Man Years 6.0	1 By 1974, to clarify certain of the control mechanisms in animal reproduction to permit a 20% increase in reproductive efficiency. 2 By 1970, to elucidate metabolic processes related to pesticides, growth and metabolism of animals and birds.
ENVIRONMENTAL QUALITY	20 To identify and measure pollutants affecting the utilization or quality of soil, plants, animals, food, air, and water (ground, surface, irrigation water); to establish criteria and methods for management of pollutants of agricultural origin, to establish methods for protection against pollutants of other origin harmful to agriculture. Man Years 6.4	1 To develop new technology for the management processing, and storage of animal and crop wastes to permit disposal of these materials without polluting the environment. 2 To develop new technology for the management of pesticides and their residues in soil, plants and domestic animals to minimize pesticide contamination of the environment. 3 By 1975, to have developed a model or models for predicting the maximum levels of plant nutrients which may be tolerated in agricultural soils without creating fresh water pollution using soil, crop, hydrological and climatic parameters. 4 To develop technology for the identification of non-agricultural pollutants and to study their significance to soil fertility, yield and quality of agricultural products.

PROGRAM STRUCTURE
ACTIVITIES OF RESEARCH ESTABLISHMENTS

OBJECTIVES / ESTABLISHMENT	Forages	Oilseed crops	Horticultural crops	Cereal crops	Field crops	Plant pests	Plant diseases	Weeds	Plant environment	Soil management	Soil survey	Biosystematics	Dairy cattle	Beef cattle	Sheep	Swine	Poultry	Other animals and honey bees	Animal physiology	Environment quality
St John's West	•		•								•									
Charlottetown	•		•	•	•			•					•							
Kentville	•		•	•		•											•			
Fredericton	•		•	•							•		•	•	•					
L'Assomption					•															
Lennoxville	•			•									•	•	•	•				
Sainte-Foy	•			•					•	•	•		•							
Saint-Jean			•																	
Delhi					•															
Harrow		•	•	•	•			•												
Ottawa	•	•	•	•			•											•		
Vineland Station			•				•													
Animal Research Institute													•	•	•	•	•		•	•
Chemistry and Biology Research Institute						•	•	•	•					•		•	•	•	•	
Entomology Research Institute												•								
Food Research Institute		•	•	•	•									•	•	•	•			
Plant Research Institute			•						•			•								
Soil Research Institute										•	•									•
Research Institute, Belleville						•		•												
Research Institute, London						•	•	•												•

Engineering Research Service	•	•	•	•	•	•	•	•	•	•			•	•	•	•	•			•
Statistical Research Service	•	•	•	•	•	•	•			•		•	•	•		•	•			
Brandon	•			•										•		•	•			
Morden		•	•	•	•															
Winnipeg				•	•						•									
Indian Head	•	•	•	•																
Melfort	•	•		•										•		•				
Regina								•												
Saskatoon	•	•		•		•		•		•	•			•						
Swift Current	•			•						•				•			•			
Beaverlodge	•	•	•	•														•		
Lacombe	•		•	•						•				•		•				
Lethbridge	•		•	•	•	•				•			•	•	•		•			•
Agassiz	•		•										•	•			•			
Kamloops	•																			
Sidney			•																	
Summerland	•		•											•						
Vancouver	•		•	•		•	•				•									

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