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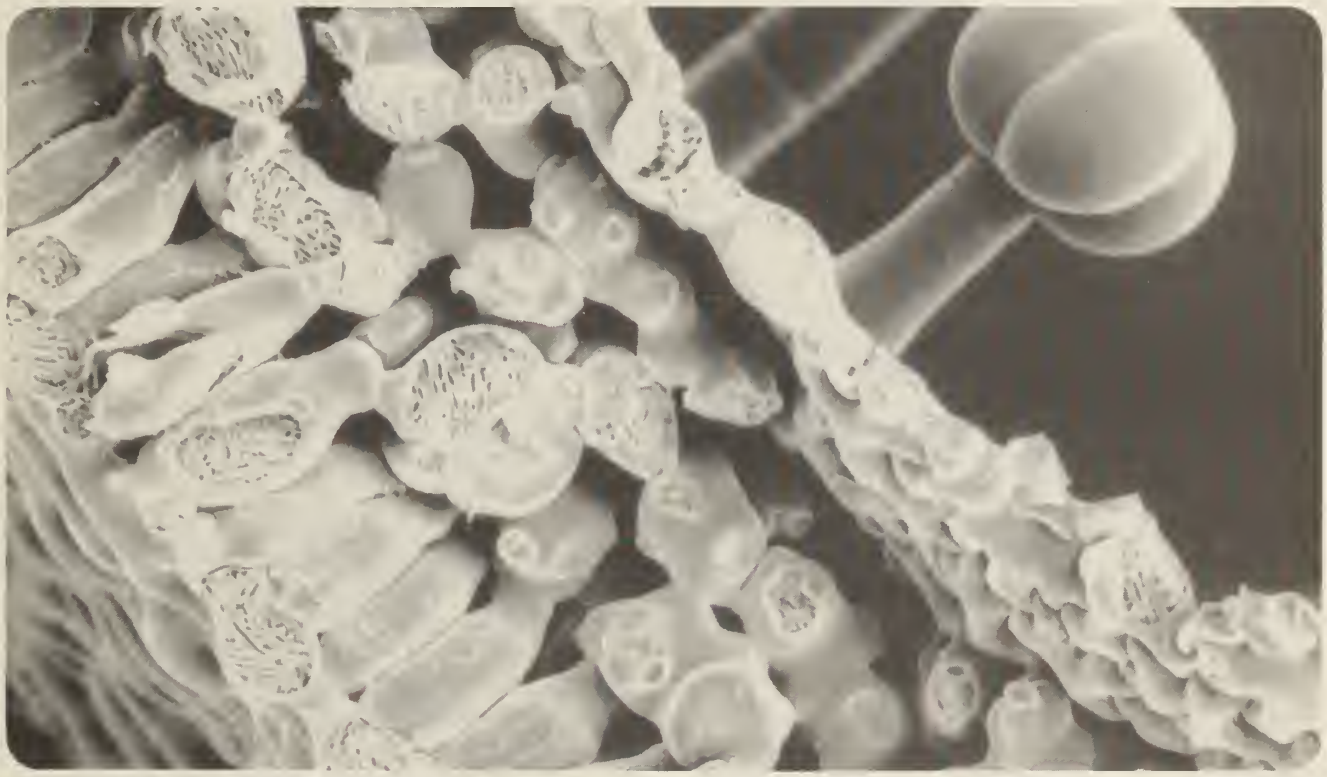

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Cover
Two-row potato digger at Fredericton Research Station in 1940's.
Title page
Potato, cv. Shepody, leaf from tissue culture as seen through a Scanning Electron Microscope.

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INTRODUCTION

In 1912, the Dominion Department of Agriculture purchased 182 hectares of land, at the present site of the Fredericton Research Station, as part of the chain of experimental farms stretching across Canada. Also in 1912, an Entomology Laboratory was established on the University of New Brunswick campus. In 1915, a Pathology Laboratory was opened in facilities in downtown Fredericton. In 1959, the Science Service and the Experimental Farm Service were combined into the Research Branch of the Canada Department of Agriculture. Permanent facilities were established in the present laboratory-office building in 1961.

In the late 1940's sub-stations were established at Alma, Tower Hill, and McGowan's Corner. All have since been closed, however, the potato evaluation trials were transferred from Alma to a new sub-station at Benton Ridge in 1975. In 1978 the Hervé J. Michaud Experimental Farm was established at Bouctouche, N.B. to develop technology for fruit and vegetable producers in south-eastern New Brunswick.

Today the Fredericton Research Station focuses it's attention on the following areas.

- **Potato Breeding** - The center for the National Potato Breeding Program in Canada.
- **Potato Pest Management** - Bacterial and viral diseases of potatoes and entomology.
- **Potato Management** - Physiology, tissue culture, disease screening, and pesticide residue chemistry.
- **Engineering** - Improvement of agricultural machinery and crop preservation.
- **Livestock** - Dairy and beef nutrition.
- **Livestock Feeds** - Forages and regional cereal evaluations.
- **Soils** - Drainage, erosion and fertility.
- **Fruit** - Apples, strawberries and blueberries.

In the following pages, scientists from the Fredericton Research Station have documented some of the Station's history by highlighting the major research accomplishments and providing some background to put these findings into perspective.

CHAPTER 1

Potato Breeding Research

D.A. Young

The potato had become an important crop in New Brunswick by the early 1900's, both for use as a staple food on the farm, and for sale off the farm. Reports from the period 1910-1915 indicate that crops in New Brunswick and Prince Edward Island showed significant percentages of mosaic, and in 1915 a potato inspection service within the Division of Botany started in a small way. Although results from this certification activity were positive and dramatic, interest grew in controlling potato diseases through plant resistance. This interest was spurred on, in part, because of the close ties between the Fredericton Experimental Farm and the potato research and potato breeding effort of the USDA in Maine.

The first crossing at Fredericton was undertaken in 1929 (Green Mountain x Katahdin) but it was 1933 before an official project was established. Nineteen thirty-four saw a total of 10,339 seedlings growing in the field. Breeding objectives were originally set to obtain resistance to mosaic and late blight. Scab resistance was included as an objective in 1936. As a result of the leafroll epidemic of 1937, resistance to potato leaf roll virus (PLRV) was added as an objective in that year. By comparison, major breeding objectives in 1985 number approximately 25 and include such diverse interests as 12 disease resistances, early sizing, 5 characteristics of French fry quality, yield stability under stressful environments, tuber resistance to bruising, etc.

Breeding for late blight resistance commenced in 1934 when crosses were made between a collection of Solanum demissum obtained from the great Russian plant explorer Vavilov, and Katahdin, (Irish Cobbler x Katahdin) and USDA S45075. This marked the beginning of a long involvement in late blight research that saw the breeding project play a part in the definition of the role of physiologic races of late blight, and which led to the release of the variety Keswick in 1950. Originally billed as immune to late blight, Keswick was later shown to possess both an R gene for the hypersensitive type of reaction, as well as possessing a significant level of the multigenic type of resistance. Based on its quality, earliness and late blight resistance, Keswick went on to become a major market and home-garden variety in New Brunswick and Nova Scotia for the next 25 years.

A 1933 crossing list shows that only 5 parents (Green Mountain, Katahdin, Irish Cobbler, Chippewa, S45075) were used to make 7 different

cross combinations. This germplasm base grew rapidly with the introduction of S. demissum, S. polyadenium, President, Bliss Triumph and Epicure in 1934. The interest in scab resistance is reflected by the introduction of Hindenburg, Arnica, Richter's Jubel and Parnassia in the late 1930's. Over the years, as new breeding objectives were set, parents with the desired characteristics were sought and introduced into the breeding program from areas all over the world. The present collection of parents within the variety development program constitutes about 400 lines, 70 or 80 of which are used in any given year. Although the number of parents in use in our program and other North American breeding programs is large, the genetic base of these parents is, in fact, quite narrow. This is the result of the small number of original introductions into Europe from South America and the sample of this which went on to form the basis of the North American breeding populations. A recognition of this fact, and a major change in breeding philosophy resulted in the initiation in 1969 of the breeding program based on the South American cultivated tetraploids, and an additional program in 1972 of breeding at the diploid level.

Interest in disease resistant potato varieties was, of course, not limited to the Maritime Provinces. Rather than set up a number of breeding sites across the country, the Experimental Farm Service named Fredericton as Canada's potato breeding center and a management committee was set up in Ottawa (1943) to establish the policy and priorities of the program. A national trial system was put into effect in 1947. Efforts to have input into this trial system resulted in the formation of 5 regional potato evaluation committees in 1956 and 1957. All participants involved in the breeding and evaluation of potatoes in Canada sat down together at the National Potato Breeding Advisory Committee in 1958. This group still meets each March, and has gone on to become what is probably the most influential professional potato committee in Canada.

Early in the development of seed certification it was noted that some geographic areas had less spread of mosaic than others. Over time, the value of control by isolation from infection sources became recognized. In order to reduce the mosaic and leafroll infection pressures that existed at the Fredericton Experimental Farm, it was decided in 1942 to seek a new operational site for the project. A number of sites were examined, several of which were on the North Shore, and after operating the project out of both Enniskillen (2 years) and Alma (3 years), Alma was chosen in 1947 as the permanent field site for the potato breeding project. For the next 27 years this site, with its very low infection pressure for aphid-borne diseases, produced quality seed for use and distribution by the project. By the early 1970's, as a result of a large professional staff, a restricted land area at Alma, and a requirement for sizeable plot areas of uniform soil type, the search was on again for a new site. After an extensive search, the Benton Ridge Potato Breeding Station, located 20 km south of Woodstock,

was opened in 1975. A new physical plant designed specifically for potato breeding activities was constructed, and approximately 125 hectares of quality plot land with adequate isolation is available. Although modest in appointment, Benton Ridge is a showplace of potato breeding research.

A major review of the potato breeding program took place during the period 1967-1969 and the significant changes in nature and direction that took place as a result of this review, have characterized the program from that time forward. From this review, the need for a new expanded field site with quality plot land was established. Research conducted in the '60s using several species as sources of resistance to viruses, scab and late blight was at the forefront of such work at that time. Building on this, two new major germplasm research programs were established. One uses material derived from primitive cultivated potatoes in crosses that show hybrid vigor, a wide range of quality characteristics, numerous disease resistances, etc. The second program facilitates access to the vast diploid germplasm resource of wild species where tolerance to stressful environments, and resistance to diseases and pests are to be found. A capability in quantitative genetics and later in disease resistance evaluation was added. The resultant 5-person team is a unique group of talents associated with a potato breeding program. Research on breeding and selection methods, germplasm utilization, stability analysis, inheritance patterns and data handling systems have made the Fredericton Research Station a world center for potato breeding research. From 1977-1985 Fredericton was the recipient:operator of the International Potato Center's major 'Tuberosum' research contract. The program has developed equipment and systems that have been adapted by other programs:--specific gravity calculator, specific gravity measuring equipment, plot digger and complex data handling with broad capabilities. The full impact of this multi-disciplined approach to potato breeding is just now impacting on the output from the new variety introduction phase of the program.

Historically, the potato industry has been slow to change varieties and the survival of the old standards, Russet Burbank, Katahdin, Kennebec, etc., with their wide adaptability attests to this point. More recently, breeding programs have produced varieties with specific characteristics (e.g., chipping quality, nematode resistance, etc.) that are aimed at specific market segments. The point has now been reached where we will probably not again see a multi-use variety grown extensively from coast to coast. Three examples from the Fredericton breeding program illustrate this point.

Jemseg is a high-quality, attractive, early table potato with significant levels of virus resistance. Although total planted acreage has not been large, this variety has filled an important niche in New Brunswick, Nova Scotia, Ontario and Ohio.

The need for a French fry variety better suited to eastern Canadian conditions than Russet Burbank was first identified by the breeding program in 1960. A number of research initiatives were undertaken to define the parameters of French fry quality, and to develop screening techniques to identify lines of superior quality. Crosses were being made specifically for French fry quality by the mid-1960's. A product of this research, the variety Shepody, was licensed and introduced in 1980. This variety produces high yields with excellent tuber shape and quality. Shepody will produce an optimal yield in a 2-week shorter period than Russet Burbank, and do so with a 20% reduction in applied fertilizer. The rate of acceptance of Shepody by the processing industry is unprecedented in Canada. In addition, Shepody is under commercial evaluation in the U.S.A., Netherlands, Great Britain, and Spain, and under trial in numerous other countries.

Maritime Canada has a significant off-shore seed market and this market has traditionally used North American varieties with proven wide adaptability. In the mid-1970's, a breeding objective to meet the requirements of the off-shore market was formalized. Characteristics of interest included yellow flesh, small tuber size, wide adaptability, drought resistance, disease resistances specific to the market country, etc. Through contacts of the breeding project and through the facilities of Potatoes Canada, advanced seedlings were evaluated annually in 15-25 countries overseas. The first output from this initiative, the variety Donna, was licensed in 1986. This variety is yellow-fleshed, an excellent yielder, good quality, golden nematode resistant, and has performed well in trials in a number of Canada's market countries. This variety is unique in that it was developed for production in locations quite distant from Canada. In addition, the exclusive release format used for the introduction of Donna is unique in Canada. Widespread trial and evaluation of a new variety immediately after introduction is critical to its survival. Exclusive release grants the use of the variety exclusively to a private sector organization with royalties being paid to the Government of Canada. This format for introduction, which is under periodic review, anticipates that the private sector will be willing to invest substantial sums in evaluation and market development overseas in return for the exclusive rights for this variety in those markets.

CHAPTER 2

Pest Management Research

R.H. Bagnall

Plant Pathology

The Dominion Laboratory of Plant Pathology at Fredericton was first opened in 1915. It was located on the second floor of the old Post Office Building on Queen Street, the present location of the New Brunswick Sports Hall of Fame. Field trials were initiated at the local Experimental Farm.

Early activity included the introduction of sprays for the control of fungus diseases such as late blight of potatoes and apple scab. Potatoes in many countries had recently suffered through a period of 'degeneration', largely due to the leaf roll and mosaic diseases. Thus, there was a demand for healthy seed potatoes. When some potato stocks free from 'degeneration' were found in New Brunswick in 1916 and 1917, the stage was set for the development of a prosperous seed export trade. Neither the infectious virus nature of the degeneration diseases, nor transmission by aphids had yet been recognized in scientific publications, but we find in correspondence of 1916 the phrase "infected with mosaic".

The practices of seed selection, use of isolated seed plots, and prompt roguing of diseased plants were urged upon growers. The newly organized seed potato certification service was attached to the Fredericton laboratory. Development of standards for potato certification was a major part of the work through the 1920's. But studies of the different fungal, bacterial, and virus diseases of the potato and other crops were increasingly emphasized.

Some of the early work in North America on boron deficiency was done at the Fredericton laboratory. This involved troubles as diverse as brown heart of turnips and bitter pit of apples, and received wide publicity throughout eastern Canada and United States. There was interest, too, in magnesium deficiency in potatoes--alleviated by means of magnesium sulfate in fertilizer or as a spray on the foliage.

When a national potato breeding program was set up at Fredericton, there were two objectives: potatoes resistant to 'mild mosaic' (potato virus A) and to the late blight fungus. Need was soon seen for resistance to the common scab disease, which thrived on land that had been limed for clover during rotation of fields. Then from 1937 into the mid 1940's, the leaf roll virus, with the attendant 'net necrosis'

became the most serious problem. Rugose mosaic (potato virus Y) also became prevalent, as did the bacterial ring rot organism. Resistance to these diseases, in most instances, has been introduced from a number of outside sources. Fredericton contributed resistance to the latent potato virus S, and elucidation of its inheritance as a simple recessive. Much of the disease resistance is hereditary and there has been some success in combining resistance to several diseases (i.e., Jemseg to PVS, PVX, and PVY). Yet an early account of the breeding program contained a warning that we must also concentrate on desirable horticultural qualities. Since resistance has often been derived from relatively crude forebears, whilst refinement or quality has seemed almost to be associated with susceptibility to many diseases, this has proved to be a slow and painful process.

The postwar years brought an emphasis on researach into new techniques in the study of plant viruses. Some Fredericton work attained international recognition. There was demonstration that potato virus Y was normally carried only for moments (thus non-persistent) by aphid vector, largely at the tips of the stylet tubes. Further, without affecting the aphids, spread of the virus could be reduced as much as 80% by application of a film of oil to potato plants by spraying with a water-oil emulsion. Several other non-persistent viruses were identified, and as the search was taken up elsewhere, many more were found, affecting crops world-wide. Oil sprays are used in areas--mostly sub-tropical--where intensive spread by aphids makes this type of control cost-effective.

In other work, the latent potato virus S and a newly described potato virus M were separated from a complex disease. The two viruses had similar particles when viewed in an electron microscope, and were serologically related. But unlike closely related strains of a single virus, they had only small antigenic fractions in common. Further, they could be complexed and separated at will by means of differential host plants, rather than by chance-like lesion selection. With newly developed 'high titre' antisera, this 'distant serological relationship' was better defined and a third virus, from caranation, was added--the first plant virus 'group'. Improved antisera and serological relationships became matters of interest in virtually every plant virology laboratory. Today there are 46 members of the original 'Carlavirus' group and 30 other groups of plant viruses. Each group is distinct, but within many of them, the viruses are serologically interrelated.

The potato spindle tuber disease has an intriguing story involving Fredericton in several ways. Known in the United States from the early 1920's and apparently due to a virus, the disease was difficult to study until a severe strain and then a convenient host plant were found. When attempts were made to purify the virus, local workers and others abroad almost simultaneously realized that something was

different. This was not a normal virus with nucleic acid core and protein coat, but a naked ribonucleic acid (RNA). Our search for an antiserum to the 'virus' led, instead, into studies of the effects of viruses on protein metabolism of the host plants. A shift to RNA technology and use of polyacrylamide gel electrophoresis (PAGE) identified an RNA of particularly low molecular weight. The competition became keen as, again, laboratories in the United States and Europe took an interest in our work. PAGE became a valuable tool in detecting viroids as the naked RNA's were called; and even more sensitive complementary DNA (cDNA) testing was developed. More than a dozen viroid diseases have been discovered. Meanwhile Fredericton's contributions continued. Predominance of mild strains in the field explained earlier failures; some new host plants were found for diagnosis; there was a chemical inhibitor; and resistance was found in a wild potato. The potato spindle tuber viroid (PSTV) does not spread rapidly in potatoes. New lines coming out of the provincial seed farm literally flushed the disease out of our seed stocks. A new survey confirmed this. Except for another quirk of viroids, discovered by a Fredericton worker, the whole study might have become academic to potato people. PSTV is transmitted through true seed. Breeders had a problem, but thanks to the PAGE and cDNA tests they have rapidly cleaned up their parental stocks and seedlings.

Techniques of meristem culture to free existing potato cultivars of latent viruses, plus improved serological techniques for testing, have virtually revolutionized seed potato production. The role of our pathologists has been one of antiserum production and assessment of techniques in plant culture and serology. There have been problems. Reinfection by viruses occurs, so that testing must continue--perhaps indefinitely. Meanwhile, in the challenge to produce resistant cultivars, we have the means to eliminate all of the common potato viruses from New Brunswick.

There was significant work, too, on fungi and bacteria. The late blight problem has continued. New sprays and new regimes of spraying were tested. Forecasts, based on weather surveillance, were developed to improve timing and thus economy of applications.

Hopes were raised in the 1950's by the prospect that potatoes immune to specific strains of the late blight fungus could be developed. Commercial potato cultivars were interbred with wild relatives. But the fungus proved so adaptable, that new strains seemed to arise as fast as new lines of resistance could be introduced.

More stable resistance was sought, and one of the most promising was found in the South American potato, *Solanum verrucosum*. The resistance in this self-compatible and easily crossed species approaches immunity to virtually all strains of the fungus.

Biochemical studies of the fungus-host interaction revealed an important role of purine metabolism in the potato plant in conditioning late blight resistance. In further work, a protein product of a late blight resistance gene was isolated. This is a key step in selecting the specific gene and inserting it into some of our favorite cultivars by means of recombinant DNA techniques or "genetic engineering".

On the basis of morphology, the common potato scab organism, Streptomyces scabies, was thought by many biologists to be intermediate between the fungi and the bacteria. Fredericton pathologists in the 1960's, in the process of characterizing different strains or biotypes, showed that the organism had a narrow population of DNA molecules. This feature places S. scabies clearly amongst the bacteria.

The first half of the eighties witnessed as well the development of new immuno-diagnostic procedures and the use of DNA probes for the large-scale monitoring and diagnosis of the bacterial ring rot disease.

Entomology

Before 1959, entomology and plant pathology were part of two divisions separate from the Experimental Farms Service. In 1912, the Division of Entomology of the Experimental Farm Service opened a small laboratory on the University of New Brunswick campus. Early work involved insect surveys, biological and taxonomic studies, studies of insecticide use in orchards, potatoes and a number of other crops, as well as extension work.

The Divisions of Entomology and of Botany and Plant Pathology were affiliated when the Science Service of the Canada Department of Agriculture was set up in 1938. Both were included in the Research Branch of the Department in 1959. Distribution surveys and the systemic classification of aphid species were undertaken from Fredericton and a small field station set up near Woodstock in the New Brunswick potato growing area. Further insect studies were done at Maugerville on vegetables, at MacDonald's Corner on strawberries, and at Tower Hill on blueberries.

Entomologists, during the leaf roll epidemic in the early 1970's, initiated an aphid warning program 'Aphid Alert', to advise on early top kill dates. Leaf roll subsided once again, and attention was turned to the identification and ecology of the aphids responsible for spread of the mosaic viruses. Pathologists cooperated to develop means of determining times of intensive spread. A comprehensive survey of insect fauna of potato fields revealed 565 different species or groups. A few are harmful to the crop, some prey upon other insects, but most are merely incidental inhabitants or passers-by. Some native parasitic insects and predators were shown to have potential in biological control of potato pests.

The Colorado beetle has become more abundant and is developing resistance to insecticides. This situation is being monitored. Also, new pesticides are being studied against this and other foliage feeders, as well as for prevention of the transmission of aphid-borne viruses.

Toxic Chemicals

Concerns for the agricultural environment and possible toxins in food products have risen dramatically in recent years. Early work at Fredericton was concerned with toxic residues such as arsenics and organophosphates used in orchard sprays. Today we are concerned with complex breakdown products of pesticicides--some of them more toxic than the original substances. Fredericton has shared in this work by developing innovative methods for analysis of ethylene thiourea, a carcinogenic derivative of ethylene-*bis*-dithio carbamate fungicides; highly toxic sulfoxides derived from sulfide-containing pesticides; diquat and paraquat herbicides; maleic hydrazide sprout inhibitor; and the mycotoxin, vomitoxin, from wheat contaminated with *Fusarium* fungi.

Plant Physiology

Plant physiology has been pursued from time to time by staff members trained in horticulture and plant pathology. Early work in the 1950's on the promotion of tuberization *in vitro* on etiolated potato sprouts laid the foundation for subsequent studies by other workers. The present commercial production of tissue cultured "micro tubers" uses some of the concepts developed at the Fredericton Research Station.

A safe means of dormancy break was needed to permit virus testing of seed potatoes for the early export trade. Trials suggest that bromoethane is suitable. Cold hardiness and chemical treatments have been evaluated as means to combat winterkill in apple orchards--a serious problem in New Brunswick.

CHAPTER 3

Livestock Research

J.W.G. Nicholson

The land for the Experimental Station, Fredericton was purchased in September 1912. It consisted of 182 hectares made up of farms belonging to J.O. Adams, W.W. Boyce, D. Gunter, H.C. Jewett and A.H. Waterhouse. Only about 42 hectares had been in crop.

Work was started immediately to bring into production the 121 hectares between the river and the CP tracks. Land not ready for breaking was used for rough pasture. Experiences with these rough pastures set the stage for extensive research in the 1920's and 30's on pasture renovation and management.

The first animals were four grade Clydesdale mares sent from the Central Experimental Farm, Ottawa in December of 1912. A small flock of Barred Plymouth Rock and Rhode Island Red hens was purchased in January 1913 to supply eggs for the staff (30¢/dozen). On January 8, 1914 the first 34 head of beef cattle (3-4 year old steers) were bought for 12¢/Kg to study the feed costs of beef production. This represented the beginning of livestock research.

The first 2 dairy cows were purchased in May of 1913. The herd was increased the next year to about 35 cows, including purebred dual-purpose Shorthorn, Ayrshire and Holstein and 18 grade cows to demonstrate the advantages of grading-up through breeding to purebred bulls.

There were 13 draft horses and a driving mare on Station that year including 3 purebred Clydesdale mares. This was the start of a Clydesdale breeding program and a Clydesdale stallion was maintained for public service until the Station changed over to Percherons in 1935.

Part of the orchard was fenced for poultry runs and breeding pens of White Wyandottes, Barred Plymouth Rocks and Rhode Island Reds were established in colony houses. Cockerels for breeding were selected from dams having good records as layers. Two incubators were purchased for comparison, thus starting poultry research in 1913.

Animal research during the teens was mainly a matter of collecting information on feed costs of all aspects of animal production including rearing foals, wintering non-working draft horses, milk production, rearing heifers, beef feeding, egg production, sheep production, and angora goat production. The goats were obtained in 1917 to evaluate

their ability to kill brush on rough pasture. They proved quite effective on birch and maple but not alders so they were sold in 1922.

Sale of breeding stock and hatching eggs was an important contribution to livestock improvement in the region. Turkeys were added in 1918 but mortality was high from blackhead. The grading-up trial with dairy cattle got off to a good start with the first calf heifers producing as much or more than their mature dams. Corn silage was more profitable for beef than a mixture of silage and roots and 2 Kg of grain per head per day was more economical than 3 Kg per head per day. A Yorkshire pig herd was established in 1917.

In the 1920's, the Shorthorn, Holstein and Ayrshire cows produced some notable production records. A bull barn was built and provision of breeding service to nearby farms was a priority.

The New Brunswick egg laying contest was started in 1920 and continued for nearly 20 years. As a result of this test New Brunswick bred Barred Plymouth Rocks, and especially the Station flock, received international recognition for high egg production. By 1922 the other breeds of chickens were dropped to concentrate work on selection in the Barred Plymouth Rocks.

Major animal research in the 1920s continued to be the collection of cost of production data for all types of animals. Trials were conducted on early weaning of lambs, comparison of feeds for production of high quality bacon, the value of roots and silage, including sunflower silage for cows, skim milk, tankage and fishmeal were compared as protein supplements for both pigs and poultry.

The dairy cow grading-up trial started in 1914 was producing promising results but outbreaks of tuberculosis and later brucellosis reduced the numbers to the point where the project was abandonded and all grades sold in 1923. The dual purpose Shorthorn bull, Kentville Champion, used in the early 1920's threw very poor milking daughters--"illustrating the danger of using an unproven sire". This led to the decision to disband the Shorthorn herd in 1927.

Work was done on rearing capons, lamb fattening trials, use of rape pastures for sheep, dipping for tick control and various treatments for worms. Trials with both hens and pigs led to the conclusion that buckwheat was equal to corn and better than barley in feeding value. Alfalfa leaves proved better than sprouted oats in winter diets of laying hens. Boiled potatoes proved a suitable substitute for corn in the diet for layers when they were cheap. An experiment, much before its time, was started in 1924 on scanty vs liberal feeding of dairy heifers. The value of iodized salt was demonstrated with sheep. The Station played a role in designing and implementing a system of advanced registry for swine.

Pasture improvement studies continued to be a major area of research in the 1930s, including rotational grazing (started in 1928). In 1936 the Superintendent wrote "The pastures on the average farm in New Brunswick are less fertile than when the land was first cleared". The pastures on the Station were equally bad in 1922. Growth was largely brown top with a mixture of other grasses, weeds and moss. The dairy heifers on pasture in 1922 lost an average of 13 Kg over the summer season. A major effort was started on pasture improvement. By 1935 pastures had improved on the Station to the point where lactating cows maintained their yield through the summer with little, if any, grain feed and no supplementary roughage until October. This was a new concept in the area at the time.

The pasture program included rotational grazing, lime and fertilizer treatments, mowing in June to control weeds and tall grass, harrowing in the fall to spread droppings and the use of aftermath or annual crops to spread production through the season. It was demonstrated that complex seed mixtures were not necessary for establishing pastures as within three years all swards were essentially the same. Applying nitrogen in late June rather than early spring stimulated summer growth. Orchard grass was shown to give a useful early spring pasture. The pasture research of the Fredericton Station was widely recognized and it was ably demonstrated on the network of about 15 Illustration Stations throughout the Province.

In the early 1930's extensive feeding trials were carried out to evaluate potatoes for dairy cows, pigs and hens. Ten Kg of potatoes could replace 20 Kg of mangels for dairy cows. Young pigs did not relish raw potatoes while older pigs could use them with "fair success". In 1936, experiments were started on raw or cooked potato silage and dried ground potatoes for pigs. The cooked potato silage gave the best results. The Ayrshire herd was transferred to Quebec in 1935, after the main barn was destroyed by fire.

The Percheron stud was well established by 1940 with the peak of breeding (70 mares) being in 1941. Feed costs of all aspects of animal production were recorded. Experiments were carried out with clover silage starting in 1939 and its advantage over hay for our climate was noted. By 1947 clover silage had largely replaced roots as a succulent feed.

Advanced registry was used as a selection tool in the Yorkshire pig work; the development of a strain free from birth defects and possessing desirable bacon type was the objective. Trials with cooked potato silage showed 45 Kg would replace 15.5 Kg of barley for pigs.

The Barred Plymouth Rock hens were progeny tested and several selection methods used. Intensive poultry breeding research began in 1947. Hatchability of eggs was greatly improved by better storage and

handling of the eggs and improved nutrition of the hens. The biggest gains were made by adding dried cereal grass or alfalfa to the winter diet. Other nutrition trials included a comparison of riboflavin sources and methods of rearing pullets on range.

The livestock research from 1948-52 was mainly on breeding. The dairy herd was still used on pasture research but most animal research was with the Yorkshire pigs and poultry (the Barred Plymouth Rocks were still maintained). The Station received a Master Breeders Shield from the Holstein-Friesian Association of Canada in 1956.

By 1953 poultry breeding was concentrated on crossbreeding and the development of a dominant white broiler strain. Limestone was shown to be a suitable substitute for oyster shells in diets for laying hens.

Swine breeding focussed on developing two inbred strains and crossing them. The first pigs from a new strain were sold as breeding stock in 1956. Nutrition studies included a comparison of slop vs dry feeding (a subject attracting attention again in the mid 1980's). The slop-fed pigs took longer to reach market weight but had better feed conversion and carcass scores.

Other trials of note included a determination of the value of early cut hay vs later cutting for dairy cows and the value of potatoes for feeding lactating dairy cows. The practicality of an open-front pole barn for pigs was demonstrated and the effect of housing on gains in winter and summer were determined.

In the early 1960s breeding research continued with all species. In the dairy cattle project it was shown that there was a negligible relationship between quality and quantity of milk produced. With poultry, selection of broiler strains for large size reduced egg production. The inheritance of plumage color was studied to develop its use in sexing chicks, to create a white broiler strain and to determine its association with production parameters. A trial on floor space for pigs established that 1.5 m^2 was adequate for group pens but several cases of lameness occurred with single pig pens when less than 2.4 m^2 was allowed.

In 1966 there was a major shift in emphasis for the livestock program from genetics to nutrition research. The Fredericton Research Station was declared the Atlantic Center for research on animal nutrition and on forage production, conservation and utilization. Two animal nutritionists and an agricultural engineer were added to the staff in 1966 and two more nutritionists in 1967.

A major new area of research was on the nutrition and management of calves and lambs. Trials were conducted to evaluate formulas of milk replacers and on the management of dairy calves. It was shown that

suitably prepared protein concentrates from plant or fish sources could replace part or all of the milk protein in milk replacers. The value of fermented or chemically preserved colostrum was demonstrated and basic work was done on the chemical changes of nutrients in colostrum during fermentation. The value of buffers such as sodium bicarbonate, limestone and cement kiln dust for lambs and cattle was investigated extensively. An organism responsible for abomasal bloat in lambs fed milk replacer was identified and its control by the addition of a low level of formaldehyde to the milk substitute was demonstrated. In recent years research has concentrated on basic studies on the metabolic changes occurring in the rumen epithelium of calves as they change from a preruminant to a functioning ruminant.

Forage conservation work has included practical evaluation of new forage handling equipment as it became available. Machines evaluated included round balers, stack formers, self loading-unloading wagons, self-loading bale wagons, silo presses, a low-cost, flexible-wall horizontal silo, and horizontal silo unloaders. Basic research was done on factors affecting the rate of hay drying. The effects of various additives and treatments on the preservation of feed as silage have been investigated including formic acid, ground barley with or without malt, commercial and experimental inoculants and other types of commercial additives. Among the unusual feeds which have been successfully ensiled are mixtures of potatoes and forage, broiler litter, paunch residue from a slaughtering plant and potato vines.

Considerable effort has been spent on developing new or improved methods of forage analyses and on providing a forum for discussion and standardization of forage analyses in government, university and private labs across Canada. Several papers and proceedings have been published on these procedures and activities. One outgrowth of this work was the development of a forage quality forecast for predicting the nutritive value and growth of forage crops during the harvest season. Promising research was sponsored on the use of white rot fungi that increase the nutritive value of lignocellulosic feeds. Difficulties in scaling up the process have, so far, prevented practical applications.

In dairy cow nutrition the emphasis has been on utilization of locally produced feedstuffs and most recently on maximizing production of milk from forage. A system for producing high-quality timothy silage, using four cultivars with widely different dates of maturity and a two-cut system, provided about 30 days for making silage near the crop's optimal stage of maturity. Other trials have looked at cereal head chop silage, whole plant cereal silages, dehydrated alfalfa pellets, formaldehyde treatment of protein, oxygen-limiting silos vs conventional silos, rye grain, mash vs pelleted grain, fine grinding vs rolling, rapeseed meal vs soybean meal, barley vs corn, use of ryegrass for pasture and, most recently, methods of supplementing high protein alfalfa silage to maximize milk production.

The work with beef cattle has emphasized the use of opportunity feeds and the development of beef production systems for the Atlantic area. By-products of the potato crop provide much useful feed for beef in the Atlantic area and feeding systems have been developed to optimize their use. Rumen microorganisms and ensiling were shown to reduce the toxicity of potato glycoalkaloids. Other by-product feeds investigated have included crabmeal, fishmeal, paunch residue, cull carrots, peas and canola screenings. Cultivars of red clover and timothy have been evaluated for digestibility and palatability by animals. Causes of weight loss when cattle are turned out to pasture were investigated. The factors affecting intake of grass silage, such as level of nitrogen fertilization and feeding protein with high-bypass values, have been studied. Ensiled high-moisture barley was compared with dry barley. The effect of rate of seeding corn on its yield and nutritive value was established. A selection index for corn evaluation was developed that accounts for maturity, grain content and yield. The once-calved beef heifer concept was shown to have economic merit but found little favor with producers. Cold environment was shown to reduce the digestibility of forages by sheep.

CHAPTER 4

Livestock Feeds Research

J.W.G. Nicholson

The land at the Station was rocky. W.W. Hubbard, the first Superintendent, wrote "much of the land requires drainage to secure maximum crops". In the early years tile drains were installed by hand and "the use of picks was constantly necessary in order to loosen the stiff subsoil found under about 30 cm of topsoil." This compacted basal till still plagues the Station.

Crops research started in 1914. Oats was a main crop and 6 varieties or strains were compared that year. Buckwheat and turnips were grown extensively and trials were set up to demonstrate the value of fertilizer. Unfortunately, in that first trial the increased yields were not sufficient to cover the cost of the fertilizer. There were variety trials with sugar beets and forage carrots. The number of varieties tested of various crops increased throughout the 1910's and included the first alfalfa trial in 1915. The alfalfa seed was inoculated and when the roots were examined nodules were found, showing that nitrogen fixing bacteria were present. This first trial included a comparison of lime vs no lime for alfalfa. The problem of birds attacking corn and cereal crops was so severe a boy with a shotgun was kept in the field from 4:00 a.m. to 8:00 p.m. Seventy years later there is still no more effective way of dealing with this problem.

Crops of the common grasses and clovers were sown with and without a nurse crop and tests were conducted to determine the effect of cutting during the seeding year on survival. There was considerable winterkilling on all plots of clover and many grasses in 1915-1916 causing the comment that "the value of alfalfa for this district has not yet been proven". This statement has been echoed in various ways until very recently.

Research throughout the 1910's on crops included variety trials and sources of fertilizer (including dried seaweed and fish scraps), on wheat, fall rye, oats (Victory was the highest yielder and continued to be recommended until 1957), buckwheat, rye, barley, swede and white turnips, mangels, sugar beets, oats-peas-vetch for silage, forage corn, alfalfa and the common grasses and clovers. Flax and hemp were grown for fiber. The latter yielded 10 872 kg per hectare--an indication of the potential for this crop and its modern relative in New Brunswick. During World War I a major effort was launched on the Station to grow turnip seed.

Three year crop rotations were changed to 4 years in 1921 and 6 years in 1927. This was to reduce the proportion of land in hoed crops and to increase hay production. About 1927 they began reporting crop yields on a dry matter basis which made the results more meaningful. Victory oats and Charlottetown No. 80 barley were the main cereal crops. Work with alfalfa and grasses and clovers included establishing with and without a nurse crop, date of cutting and frequency of cutting. The alfalfa was cut three times in 1922, the last on September 18th. The following winter there was extensive winterkilling of the stand. This was blamed on the September cutting. It is still recommended that alfalfa not be cut in September.

Cereal variety testing included fall wheat and hulless oats (Liberty); crops which have resurfaced in the mid 1980's as having promise for the region. Breeding work was carried on to improve turnips (Kangaroo) and forage corn (Twitchell's Pride). Much testing was done to find clubroot resistant varieties of swede turnips and to find a control for brown heart.

Weed control became a major concern in the early 1930's and continued at the Station until about 1980. In the early 30's, lime was being recommended in all rotations except those involving potatoes. Soybeans were tested with the earliest cultivars ripening satisfactorily. Laurel hulless oats gave excellent yields at the Station. It had good strength of straw, did not shatter easily and had better disease resistance than earlier varieties. Mixtures of various cereals with and without peas were grown with good success.

In the 1940's, the highest yielding oats were Victory and Erban, but Abegweit, introduced in 1947, was considered promising. Charlottetown No. 80 was still the most widely grown barley variety. The forage work included experiments with roots, corn and various annual, biennial and perennial hay and pasture plants and special crops such as soybeans. Corn hybrids were first tested in 1942. Lapin beans for baking were licensed for the Station in 1956. The strain was selected and improved at Fredericton from seed obtained from Ottawa in 1939 but which originated in Russia.

About 286 strains or varieties of oats were evaluated over the five year period, 1948-1952, as oats were grown on ten times as many hectares as other grains. A chemistry lab established in 1952 to complement the plant nutrition studies added a new level of sophistication to the research. Soil fertility work increased and the value of 2,4-D for weed control in pastures was demonstrated. Silos began to increase in the Province during these years and that increased interest in corn for silage.

Progress was being made in oat breeding with Fundy (introduced in 1957--bred at the Central Experimental Farm) being the highest

yielding. Victory which had been one of the highest yielding since the beginning of variety testing on the Station was now 12th. Charlottetown No. 80 was still the most popular barley because it grew well in cold-wet springs and had excellent threshability. Other varieties were higher yielding under favourable conditions.

Forage trials were concentrated on timothy which outyielded all other grasses for hay. The effects of date of cutting and timing of fertilizer applications on total season yield of nutrients were investigated as were seeding with or without a nurse crop and with or without a legume. Yields were not increased by including a legume but less nitrogen fertilizer was needed. The need for adding boron to fertilizer for alfalfa in New Brunswick was established.

In crop production persistence of timothy was shown to depend upon the balance of nutrients in the fertilizer. Both nitrogen and potassium in proper proportions are needed. Plots established in 1957 to show this are still in existence with good stands of timothy where the fertilization has been correct. The first trials on sod seeding of legumes to replace those winterkilled were reported in 1962.

The role of aluminum in determining the availability of phosphorous in New Brunswick soils was understood by 1964. It was also shown that Charlottetown No. 80 barley was resistant to aluminum toxicity and this is why it had proven to be the most popular variety for so many years. When the pH was brought above 5 and adequate phosphorous applied other varieties (e.g. Herta) outyielded No. 80 by a wide margin. The growth depressing effect of aluminum in acid soils could be alleviated by liming and banding phosphorous near the seed.

The introduction of Clair timothy, an early maturing variety, was considered a breakthrough because its optimum time for cutting corresponded with that for companion legumes. Early cutting of later maturing timothy varieties weakened the plants. The moisture equivalent test for soils was found to give a good indication of their suitability for growing alfalfa. An extensive program was begun in 1984 to improve the persistence of legumes in forage stands. This included work on soil drainage, structure, and fertility as well as crop management.

Fababeans received a flurry of interest in the early 1970's. They were evaluated for yield as seed or as silage and their feeding value was determined with cattle. They were compared with sunflowers and peas as well as common forages (corn, grass, legumes). New studies on the feeding value of Tartary buckwheat showed it had about 85% of the feeding value of barley for ruminants. The mineral content of over 1000 forage samples grown in New Brunswick was determined and these results were related to the nutritional status of dairy animals for zinc, cobalt and selenium.

CHAPTER 5

Agricultural Engineering Research

G.C. Misener and C.D. McLeod

The agricultural Engineering program at the Fredericton Research Station has focused on the development and evaluation of functional mechanization packages suitable for a wide range of farm sizes and crops grown in Atlantic Canada. Emphasis has also been placed on the reduction of energy inputs to all sectors on the farm, improved product quality and reduction of soil loss caused by erosion.

The first agricultural research engineer to join the Research Branch in Atlantic Canada did so at Fredericton in 1966. Initial work dealt with the testing of potato harvesters and grain combines. Major emphasis was directed towards reducing mechanical injury of potatoes during harvesting. Systems such as potato windrowing and bulk handling were evaluated on commercial farms. Research was also directed towards the evaluation of grain harvesting with the identification of the amount of grain losses occuring during the harvest season. Results from this initial work are still often referred to today.

Agricultural engineering played an important role in the development and evaluation of forage harvesting and preservation methods. Performance criteria were determined for the use of large round balers and stackers. Equations were developed to predict the drying of hay. The environmental term, latent evaporation, which describes the ambient weather conditions, was found to relate well to the drying rate of hay. Effort has been re-initiated in forage conservation research by the establishing of two projects studying the effectiveness of silage preservatives and the development of a large round bale dryer.

In 1971, research effort was initiated in the soil conservation area with many on-farm site monitoring projects. Soil loss was measured as affected by slope and crop management practices. Engineering structures designed to reduce soil erosion were also monitored. Today research is being undertaken on the farm scale testing of commercial deep tillage equipment for loosening the compacted soil in New Brunswick. Drainage research is determining the effectiveness of the drainage systems installed on farms.

A prototype apple harvester was built and demonstrated. This unit was designed to accommodate the orchards in Nova Scotia. A unique catch frame was incorporated in the harvester to allow bruise-free harvesting of the apples. Shaker design was also undertaken in order that effective harvesting could take place. The harvester was found to work well in the orchards of Nova Scotia.

With the introduction of contracting out research and development and the establishment of the Development Research and Evaluation in Agricultural Mechanization (DREAM) program in Agriculture Canada in 1974, the engineering group became involved in farmer related short term projects. It became feasible to evaluate equipment options involving substantial capital costs where these options appeared to offer a potential to lower farm input costs and/or increase productivity. The emphasis was to evaluate equipment sized and priced for the small farm. The Fredericton engineers were involved at the regional and national levels for screening and selecting projects. Most of the regional projects approved had Fredericton-based scientific authorities. There was a mixture of development and evaluation projects with an emphasis on evaluation. Farmer-related development projects included: mechanical blueberry harvesters, rutabaga seeder, potato harvester and hollow heart detection. Of these projects there has been enough further work to produce a commercial blueberry harvester and expanded developments on potato harvesting at Fredericton.

Evaluation projects for addressing farm production problems include: a Webster fertilizer and lime applicator, European rotary and disc mower conditioners, European forage wagons, silage packages using hay stack equipment, a dryer for pasturizing poultry waste for feed recycling, a portable steam unit for treating standing forages, for top-killing potatoes and for pruning blueberries, and a study for using insulation to provide a lower cost frost-free foundation for farm buildings.

In addition to this program, a similar effort evolved in the late 1970's for energy related research and development. The program became known as ERDAF (Energy Research and Development in Agriculture and Food) and Fredericton engineers again were involved at the national selection level and regional scientific authority level. Many of these projects occurred on-farm and these included: using solar energy for preheating ventilation air for poultry buildings, nutrient fluid heating for heat supplement in hydroponic greenhouses, a straw burner for grain drying and space heating, and retractable insulating curtains for greenhouse energy conservation. Again, the experience gained with the on-site projects with its inherent technology transfer function partially compensated for the difficulties encountered in obtaining consistent data in operating situations. The nutrient film heat supplement system and the retractable insulating curtains are still in operation and the straw burner for use in grain drying continued after the termination of the project.

With the shift from below ground potato storages to above ground bulk storages, the engineering program at Fredericton focused on determining the environmental conditions required in the modern storages to maintain the quality of the potato throughout the storage season. Commercial storages were monitored over several years to determine

optimal ventilation rates and patterns. Computer simulation models were developed describing the heat and mass transfer between the tubers and the cooling medium to give a better understanding of the cooling characteristics of potatoes stored in bulk. Studies were also conducted which showed the influence of loose soil mixed with the potatoes on the airflow resistance of the cooling air. The results of the study stressed the importance of assuring complete separation of soil from the potatoes prior to storage.

Detailed evaluation of the accuracy of seed piece placement was determined for several types of potato planters. Seed piece size and shape were found to significantly affect the accuracy of the planters. A single row potato digger was developed which was capable of digging potatoes and placing them on the surface of the ground while not mixing tubers from adjacent hills.

Research was initiated recently to develop a machine to process off-grade potatoes into two usable components. The research is to develop a simple inexpensive machine to be incorporated into storages for processing the off-grade potatoes. The end components can be fed wet or dry as animal feed or the starch could be transported to a starch processor for final upgrading.

The development of a full scale prototype potato harvesting system was initiated in 1981. The overall goal of the project was to develop a harvesting system which would achieve both reduced potato injury and lower field machinery costs for conditions in Atlantic Canada. To date, a prototype harvester has been built and evaluated. Work is now being directed towards the development of improved bulk transport units and graders.

CHAPTER 6

Soil Research

T.L. Chow

Soils of New Brunswick, in general, are acidic and very low in natural fertility. Fertilization and liming are needed on all newly cleared lands for the profitable production of crops. With these requirements, crop response to fertilizer and lime has naturally become a major component of the field husbandry research since the establishment of the Dominion Experimental Station at Fredericton in 1912.

During the early days, general fertility practices with many horticultural and field crops consisted mainly of the application of barnyard manure as the chief source of plant food with commercial fertilizers (N, P and K) being added in a supplementary role. Therefore, most of the early soil research (1912-1930) dealt with type of fertilizers, proportion between N, P and K and rate and time of application for a wide range of crops. Lime experiments were also initiated at this time. Although most of the research was largely oriented toward demonstration, providing information on the economic production of agricultural crops, the results also formed a sound foundation on fertilization for modern agriculture. Achievements worthy of mentioning included the discovery of the significant increases in yield for virtually all crops when commercial fertilizers were applied. This provided farmers with information on types, formulation and rate of fertilizers for different crops to maximize returns. Lime was found to be beneficial to most crops with the exception of potatoes in terms of quantity and quality of produce. Potatoes were found to be badly affected with scab on lands where excessive lime (2265 Kg/ha) had been added. In addition to these research findings, experiences gained from clearing and draining new lands at the station were also valuable to the farmers.

During the early 1930's, revolutionary changes took place in the ideas of fertilizer practices. The occurence of physiological disorders in many crops, disproved the original concept that ordinary soils contained sufficient quantities of minor elements essential to plant growth. Minor elements must be added if normal growth is to be obtained and satisfactory yields secured. The Station at Fredericton has made some notable contributions in this regard. The first instance of a proved boron deficiency on this continent was recorded by this Station working in co-operation with the laboratory of Plant Pathology in 1933. It was demonstrated that brown-heart of turnips was due to a deficiency of boron and could be readily controlled by the application of borax to

the soils. Similarly other deficiency diseases in the province, such as magnesium and boron deficiency of potatoes, and corky core of apples were studied extensively during the period from 1931 to 1947. It was discovered that the corky core of apples could be controlled by the application of boron to the soil. The fears of growers on boron toxicity of potatoes were eased through a number of experiments conducted at the Station. This research concluded that application of borax at a rate of 9 and probably 13.5 kg/ha in the drill was proven not injurious to potatoes and on the other hand, it was found that actual increases in yield was resulted from light borax application on certain soil types. The need for a nutrient balance between N, P and K was also noted. Research conducted during this period provided concrete evidence that the day of the old method of fertilization was past and fertilizer application must be tailored to suit individual situations for economic crop production. In addition, the adverse effect of fertilizer treatment on cooking quality of potatoes was first reported.

Soil survey work was begun in New Brunswick in 1938 in co-operation with the Provincial Department of Agriculture. By the early 1950's, soils of several of the important agricultural areas were classified and mapped. With the available soil information, the objective of soil fertility research was shifted to obtain information on fertilizer and lime requirements of different crops under varying soil conditions. Most of this research was carried on through the medium of Illustration Stations. Through a series of field and laboratory experiments, the general framework of fertilizer recommendation based on soil test was established. As a result of this development, a substantial increase in crop production was achieved. Critical levels of lime application to sustain a potato-grain-hay rotation was recommended to farmers for minimizing the incidence of potato scab and at the same time, to provide adequate pH for rotational crops.

As a result of continued intensive cultivation of soils for monoculture potato production, deterioration of soil structure with declining yields was noticed during the late fifties. To combat this problem, a portion of the soil research effort was diverted towards the study of soil physical properties in relation to crop production. Soil aeration in terms of oxygen diffusion was proven to be proportional to aggregate size and continuous cropping to potatoes reduced the percentage of water-stable aggregates and also porosity, organic matter content, available water capacity and cation exchange capacity. Research on improving soil physical properties using various kinds of soil conditioners such as VAMA, Krilium and waste sulphite liquor (a by-product of paper industry), was conducted extensively. Although research found that soil conditioners were highly effective, their practical application in commercial fields has not materialized due to their high cost. Fertility research during the sixties continued to refine fertilizer recommendations on both macro- and micro-nutrients.

The adverse effects of heavy agricultural machinery on soil physical properties and crop yields were studied during the late sixties and the early seventies. One major achievement was the discovery of the beneficial effects of the soil's stone content (up to 12%) on potato yields. This beneficial effect was attributed to higher soil temperatures and moisture content. Stone removal from potato fields was also found to increase soil compaction and accelerate soil erosion. The solution to this problem is yet to be found because stone removal is essential to facilitate the use of mechanical harvesters. Research was also conducted on salt tolerance and other problems related to the reclamation of marshland soils at the head of the Bay of Fundy. Gypsum was a superior amendment for amelioration of the marshland soils in terms of water movement and salt removal.

With increasing public concerns on the effect of intensive agriculture on water quality, an environmental research program was established in the early seventies. A three-year assessment of nutrient, pesticide and sediment discharge from three hydrometric stations representing forested, moderate and high agricultural intensities in the Upper Saint John River Valley showed that concentrations of most chemicals increased with increasing agricultural production intensity but in most cases the levels were quite low as compared to data reported from other regions. Trace amounts of DDT, dieldrin and endrin were found occasionally in some samples but no organophosphorus pesticides were detected. Chemical concentrations of samples collected from tile drain effluent and domestic wells were much higher than the stream samples. The relatively high levels of nitrate nitrogen (10 ppm) and phosphorus encountered in a number of domestic wells was found to be related to a traceable point source of pollution such as sewage systems, sink drains on potato storage houses.

With the completion of the land capability classification for agriculture in New Brunswick during the early seventies, the productive potential and constraints of our soil resources were reassessed. Based on this classification, there are no soils of top quality in the Atlantic Region because of low natural fertility and adverse climatic conditions. Other unfavorable soil conditions such as dense subsoil, excessive wetness and vulnerability to erosion and compaction, impose severe restrictions on the type and level of crop production. In view of these limitations and the need to achieve a more competitive advantage in the production of agricultural commodities, there was a major shift in the direction of soils research in the late seventies.

To overcome the problems of dense subsoils, deep tillage research was initiated in 1976. Greenhouse and field experiments showed that loosening of compact subsoil greatly improved yield of alfalfa by permitting deeper root penetration and improving moisture and air movement. It was found that a combination of subsoiling and tile drainage was the most effective means of increasing yields. However,

the beneficial effect of subsoiling was short-lived. Yield increase attributable to subsoiling decreased yearly indicating that the treatment would need to be repeated every few years. To prolong the beneficial effects of subsoiling, organic amendments (sawdust, manure and peat moss) were incorporated into the subsoil. Significant improvements in the soil moisture and thermal regimes with overall increase in crop yields were found on fields where these organic amendments were incorporated into the subsoil. Based on these results, it was concluded that the incorporation of organic amendments together with subsoiling was the most effective method for ameliorating the problems of dense subsoils. Field evaluation of heavy duty subsoilers are being conducted under the Agri-Food Development Agreement. As to the impact of this research on industry, some progressive farmers are already subsoiling their fields with farm-scale subsoilers and subsoiling has become a component of the Land Development Program where financial incentives are provided to carry out the operation.

Apart from the aforementioned achievements, the application of DIHB (3.5-diiodo-hydroxybenzoic acid) was also found to be very effective in root elongation in dense subsoil. However, due to the high cost of the chemical, it is not recommended for commercial use. Research on developing effective means of removing excess water from soils underlain by dense subsoil and the corresponding crop performances was also initiated in the early eighties.

The problems of soil structure deterioration as a result of intensive monoculture of potatoes were addressed in the late sixties, but due to the high cost of soil conditioners, a shortage of lands for rotation and other socioeconomic factors, the situation continues to worsen. As results of structure deterioration and poor surface water management, the potato belt of New Brunswick has become one of the most seriously water eroded areas in Canada. In addition to poor structure, accelerated soil erosion is escalated by the rolling topography, the presence of dense subsoils and/or flow restricting horizons at shallow depths, high intensity rainstorms and the frequent winter freeze-thaw cycles. Also contributing to soil erosion during the past 20 years are the intensification of agricultural practices which include monoculture of potatoes, intensive tillage, use of heavy machinery, up and down slope cultivation, increased field size and lack of suitable rotations. Sound conservation is vital to the long-term stability and development of the agri-food sector.

The need of a comprehensive research program to supplement the ongoing soil conservation work was identified. In 1980, a major soil research effort was directed towards the problems of soil erosion and conservation with the initial objectives of establishing soil and nutrient loss under different cropping and tillage practices; assessing their effectiveness for soil conservation; and evaluating the validity of the soil erodility factor for conservation terrace design. Results

indicate that in fields with 11% slope, annual soil loss may be as high as 38 t/ha under potatoes planted up and down the slope but less than 0.2 t/ha for grain. The loss of 38 t/ha/yr means 3 cm of top soil in 10 years. Soil loss may be reduced to less than 2 t/ha/yr by planting the potatoes along the slope contour providing that no water flows across the rows. Potato yields from contour planting were also significantly higher than for those planted up and down the slope. Annual nutrient losses in fields with potatoes planted up and down the slope, were 45 kg/ha of nitrogen on 8% slope and 71 kg/ha of nitrogen on 11% slope, while phosphorus and potassium losses were 8 to 13 kg/ha. Total costs of nutrients lost under potato production were as high as $59 at 8% slope and $87 at 11% slope. These results demonstrate the alarming situation of soil erosion and provide land owners with information on the potential benefits from soil conservation.

Other research related to soil conservation includes the studying of the long-term effect of soil degradation on potato yield and product quality; and the monitoring of the impact of intensive agricultural production on the quality and quantity of stream discharge. The effectiveness and economic returns of various means of soil conservation currently used in N.B. and the development of methods to restore soil productivity of badly eroded lands are being conducted under the Agri-Food Development Agreement.

Fertilizer and plant nutrient requirements for crop production on shallow soils underlain by dense subsoils and badly eroded lands are also conducted at the Fredericton Research Station.

Within the province, agriculture is the second highest contributor to the provincial domestic product. Also, New Brunswick has large quantities of land that are under utilized. There is potential to market both larger quantities and better quality agricultural products. Major opportunities exist in potatoes, livestock feed production and horticultural crops. The opportunity exists to increase the level of self sufficiency in livestock feeds through increasing the production of high quality forages combined with increasing yields and acreage of cereals. The expansion of New Brunswick's agricultural production is highly dependent on improving the productivity of the land base by overcoming the limiting factors inherent to our soils and minimizing soil quality deterioration. Soil research conducted at the Fredericton Research Station plays a key role in the evaluation of present technologies used for land improvement and in the development of innovative solutions that are more suitable to and economical for the region.

CHAPTER 7

Horticultural Research

G.W. Wood

The horticultural program at Fredericton has always been directed at the special problems and needs of New Brunswick farmers. Since the establishment of the Experimental Station in 1912, up-to-date information has been provided on cultural methods, production costs, and varieties of fruits and vegetables best suited for New Brunswick conditions. Townspeople as well, relate to "the farm" as the agricultural center for the province, and they are especially appreciative of the flower gardens and demonstrations of hardy shrubs and hedges.

From the beginning the adoption or modification of outside technology has been accompanied by detailed and fundamental studies, and because of accomplishments in research and development at Fredericton, horticulture in Atlantic Canada and in general has been enriched. For many years the entomologists and plant pathologists carried out extensive trials with insecticides and fungicides for control of orchard pests, and they are credited with being among the first in eastern Canada to use and recommend organophosphate insecticides.

In the late 1920's brown heart began appearing in swede turnips grown in the Maritimes and by 1930 it was so severe that there was danger of losing the New England market. A major research effort was started at Fredericton and other Stations in the region to find the cause and a cure. The reports of this research from 1930-1933 reads like a detective novel with many clues and blind alleys being explored. By 1933 it was concluded that it was a physiological disease (not an infectious disease) and it was decided to try applying some trace elements. Boron proved to give complete control of the problem. The work was coordinated by a central committee composed of personnel from the Experimental Stations and Plant Pathology Labs in the Maritimes with assistance from Ottawa. The 1933 project conducted at several sites in the Maritimes, including the Fredericton Experimental Station, is credited with the discovery of the cause and cure of brown heart.

Losses from winter injury are a major concern in New Brunswick, particularly in strawberries and apples, but our research has significantly lessened the impact of this problem. The time of mulching strawberries is critical to winter survival, and a method for timing based on records of minimum daily temperatures was developed at Fredericton. In another project it was demonstrated that stem-building with hardy varieties was an effective way to protect more tender scion varieties against winterkilling.

Fredericton pioneered research in the domestication of the ostrich fern or "fiddlehead" and played a key role in development and expansion of the lowbush blueberry industry. Not only did our scientists contribute valuable information on the physiology and management of lowbush blueberry, but they were primarily responsible for establishing the importance of its insect pests and in developing an effective control program. Other significant entomological achievements on horticultural crops included the development of an improved rearing method for the cabbage maggot, and effective technique for rearing adults of the apple maggot on a chemically-defined diet, and a control for cranberry fruitworm based on the seasonal development of the host.

Concern for the practical application of research encouraged experimentation under typical field conditions, and it was for this reason that horticultural field stations were established in the center of major production areas. A field laboratory was established in Maugerville to study the biology and control of vegetable pests, a sub-station at Tower Hill, Charlotte County, was used to develop a multidisciplinary approach to resolving problems in lowbush blueberry, and a similar sub-station at McDonald's Corner in Queens County concentrated on strawberry and other horticultural crops. These stations were later closed when the decision was made to reduce horticultural activities in New Brunswick and transfer the responsibilities for these programs to Kentville, Nova Scotia.

The special needs of horticulture in New Brunswick are continuing to be capably addressed. While research activities have been reduced, regional evaluations and tests are still carried out at Fredericton, and a new station has been established on the east coast of the province. The Hervé J. Michaud Experimental Farm located near Bouctouche in Kent County, has provided a much needed service to the francophone farming community, and made some important contributions in variety evaluations and the introduction of special crops and management practices for the area.

Canada