


Smithfield Experimental Farm

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SMITHFIELD
EXPERIMENTAL FARM
1944-1985

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CHAPTER 1

EARLY HISTORY

The roots of the Smithfield Experimental Farm, which began its existence as the Dominion Horticultural Substation, Smithfield, Ont. go back to the 1930s. Although the need for a research establishment in the fruit and vegetables areas on the north shore of Lake Ontario and in the St. Lawrence Valley was evident before 1940, the outbreak of World War II prevented the establishment of a station. During the prewar period the research programs at the Division of Horticulture, Central Experimental Farm, Ottawa, were expanded, and it became necessary to work directly with growers in their orchards and fields.

Historically, the areas along the St. Lawrence River in Ontario and the north shore of Lake Ontario have been important apple production areas in Canada since the region was first settled. As early as the first decade of the 20th century, apple production was well established in the Iroquois-Morrisburg area on the shores of the St. Lawrence River and in the counties of Northumberland, Durham, and Prince Edward along Lake Ontario. Estimated production in Ontario in 1901 was 13 million bushels (115,500 tonnes) and between 1900 and 1910 annual yields were estimated at well over 170,000 tonnes.

Many new apple varieties were selected in the area and they became important in Canadian production. Such varieties as Canada Red, Ontario, St. Lawrence, and Scarlet Pippin originated in this production area. The most important introduction was the McIntosh variety selected by John McIntosh on his farm in Dundela, Ont.

Vegetable processing has also been important in Northumberland, Prince Edward, and Durham counties both before and since the turn of the century. Some of the earliest canned vegetables processed in Canada were grown and processed in Prince Edward County. As late as the 1930-1940 this county was one of the most important areas in Ontario for production of crops for processing, particularly canning tomatoes, peas, and corn.

As early as 1927, scientists at the Central Experimental Farm in Ottawa set up studies to develop uniform winter-hardy apple rootstocks for the orchards of eastern Ontario and Quebec. Some of the first studies were related to orchard grass-mulch studies and were conducted near Abbotsford, Que., starting in 1928. This work was expanded to include orchard pollination, fire blight, and nutritional studies in the next 2-3 years. The studies were conducted by the research staff in Ottawa in cooperation with an orchardist in the Abbotsford area of Quebec. The very promising practical results of these studies proved the value of extending horticultural research beyond the limits of the Central Experimental Farm into areas of well-established horticultural production. Such an approach allowed orchardists to see the results of research in their orchards without the need to travel to experimental stations.

In the mid 1930s, the research staff at the Division of Horticulture became aware of the need for research on specific orchard problems in the production areas along the shores of the St. Lawrence River and in the counties along the north shore of Lake Ontario. The winter of 1933 and 1934, which was most severe and unusual, caused much damage to the fruit trees in eastern Ontario and Quebec. Production was reduced by 60-70% over the previous 5-year average. The pomological research staff in

Ottawa immediately saw that a major change would be necessary in the methods of producing apple trees and in their management in the orchard. These new methods of propagation and management would have to be evaluated in each of the major areas of production. Test plantings were established in several grower orchards, and the results were evaluated for hardiness and production over the next 10 to 15 years. Studies continue on the development of methods of overcoming low temperature losses in the orchard.

At about the same time, many promising apple and pear selections were coming out of the Ottawa breeding program. These had to be evaluated in horticultural production areas that had more potential than those represented by the Central Experimental Farm. Consequently, in the mid 1930s many of the new varieties were propagated in large numbers and distributed throughout eastern Ontario for evaluation in test orchards on grower properties. The evaluation work was supervised by the research staff of the Division of Horticulture in Ottawa.

Although the nutrition of apple trees as related to performance and production had for many years been of interest to the research group in Ottawa, it was with the appointment of H. Hill as research assistant that major expansion in this field of research took place at the Division of Horticulture. The early work was on potted trees under controlled conditions. Under Dr. Hill's direction, management and fertilizer plots were set up in grower-owned orchards in Northumberland and Prince Edward counties to obtain experimental results and to serve as demonstration plots.

A comprehensive survey was conducted on the soil types, tree root characteristics, and cultural and fertilizer practices in 184 orchards. Concurrent with this work, almost every tree in the Waite orchard near Brighton Ont. was affected with corky core in 1934. This condition demonstrated that there was a widespread nutritional problem in the orchards of eastern Ontario. Work was started immediately to solve the problem. Chemical solutions of borax injected directly into limbs of trees showed that corky core was the result of boron deficiency. Over the next few years, a method of control was established. The solution to the problem was so successful that many requests were received for detailed research on solving problems in the orchards around Trenton. The staff in Ottawa were requested, for instance, to investigate the problem of bitter pit in eastern Ontario orchards, particularly on the Northern Spy variety, and to identify the cause and develop control for magnesium deficiency.

It became apparent that as research at the Division of Horticulture at the Central Experimental Farm became more complex, it was necessary to move at least a portion of the research away from the Ottawa base to the main centers of production in Ontario and Quebec. The initial moves, as noted above, were to grower properties where experiments were conducted by the Ottawa research staff. This was, however, a temporary measure, and it was equally apparent that the permanent establishment of a horticultural research center in the production area would be a much better solution.

The first permanent establishment of a horticultural research substation in association with the Division of Horticulture at the Central Experimental Farm was on the muck soils in the Eastern Townships of

Quebec. In 1936 at Sainte Clothilde, Que. the Dominion Horticultural Substation for Mucklands was established. At about the same time, requests were being considered to establish a substation in the production area of eastern Ontario. It was not, however, until 1944 that funds could be obtained to purchase land for the establishment of a research facility in the Trenton area.

CHAPTER 2

DOMINION HORTICULTURAL SUBSTATION

(1944-1960)

THE PHYSICAL PLANT

In 1944 M.B. Davis, Dominion Horticulturist at the Division of Horticulture, Central Experimental Farm, requested permission to establish a substation of the Division of Horticulture in the Trenton area of Ontario.

At this time, Trenton was the largest and most-profitable apple-producing area in Ontario, but it had to rely for most of its technical advice on experiments conducted in regions whose climate and soil were quite different. Although Trenton still had much potential as an apple-producing area, it had slipped in recent years because of a lack of information on such problems as the major tree kill that had occurred as a result of the severe winter of 1933-1934.

In an attempt to find a solution to some of the problems of the district, the Division of Horticulture in 1934 completed an arrangement whereby evaluation of one or two grower-owned properties could be conducted. In 1937 arrangements were made with another grower, as an emergency measure, to find answers to an outbreak of alarming physiological problems in the district. Studies showed that this orchard had become unprofitable because of soil deficiencies. As a result of this work corky core of apples was eliminated using boron sprays and the unprofitable orchard again produced good crops.

Before land was purchased, the Soils Department of the Ontario Agricultural College in Guelph was requested to make a detailed soil survey of the property. The soil survey revealed that the proposed site of the new farm contained three main soil types. Sixty percent of the soil was classified as Percy Fine Sandy Loam, 30% Bond Head Loam, and 10% Brighton Sandy Loam. The Dominion Experimental Farm Service and the Soils Department of Ontario Agriculture College conducted a general soil survey of the orchard-growing areas of Northumberland and Durham counties in 1937-1939. In addition, a detailed horticulture soil survey was made of 184 individual orchards. These surveys showed that soils in each of the orchards of Northumberland and Durham counties had a number of soil types occurring within a comparatively short distance and varying greatly in physical and textural characteristics. The soils occurring in the two counties could be grouped into four divisions, the soil in each division having the same general characteristics. The Percy Fine Sandy Loam, which represented 60% of the area in the projected Smithfield Substation, was found in 35% of the orchard soils surveyed, particularly those in the Newcastle, Ont. area. The Bond Head Loam soil made up 30% of the substation and was represented in 25% of the orchards surveyed. The Brighton Sandy Loam, which represented 10% of the area of the substation was found in 25% of the orchards in the survey. The three soil types occurring on the projected substation property represented a large proportion of the orchard soil of the two counties, and 86% of the orchards had soils similar to those found on the substation.

The Dominion Horticultural Substation, Smithfield, Ont., was established on October 27, 1944 and was placed under the direction of D. S. Blair the officer in charge. It was located 4 miles (6 km) west of

Trenton and 1 mile (1.6 km) north of Highway No. 2. The substation comprised 100 acres (40 ha), 80 of which were under cultivation, and was to be operated as a unit of the Division of Horticulture, Central Experimental Farm, Ottawa. The substation was designed to undertake experimental work in fruits and vegetables on crops grown in the region extending from Toronto to Kingston. Of the 50 acres (20 ha) allocated to fruit investigations at the new substation, 35 acres (14 ha) were set aside for long-term apple experiments dealing with orchard management studies, including contour planting, building hardy trees and rootstocks and varietal trials. Twenty acres (8 ha) were allocated to investigations on vegetable crops for canning, including a series of rotation plots using peas, corn, and tomatoes as cash crops; fertilizer application methods with tomatoes; control studies on blossom-end rot of tomatoes; chemical control of weeds in peas and corn; spacing trials with corn and tomatoes; tomato transplant studies; and pea, corn and tomato varietal trials.

Initially, Smithfield was established as a substation, rather than as a full-fledged experimental farm operated as an independent unit. Experience at Sainte-Clothide, P.Q. had indicated that substations could be operated at low overhead if they were managed from Ottawa using the services of the technical staff in Ottawa during the summer to supervise and conduct the experimental and research work. Instead of appointing a full-time superintendent and technical staff located at Smithfield, it was believed that a full-time resident foreman and a minimum number of full-time farm laborers would meet the requirements.

The first permanent staff appointment was G.E. (Ernie) Wilson, farm foreman. Ernie began employment with the Division of Horticulture, Central Experimental Farm on April 1, 1936. He was transferred in mid October 1944 to the newly established substation at Smithfield. The land did not become available until the spring of 1945, because the tenant had a lease with the previous owner. Arrangements were made for Mr. Wilson to start work on a foreman's cottage including the installation of a septic tank and the drilling of a well on the property during the fall and winter of 1944-1945. Arrangements were also made to have electricity installed and to purchase some equipment for working the land in the following spring.

On arrival at Smithfield Experimental Farm, Mr. Wilson hired five carpenters to build the house in which he would live for the next 30 years. Mr. Blair also received permission from the tenant to allow Mr. Wilson to fall plow the farm after the corn and tomato crops had been removed. It was therefore, possible, to get the land ready for seeding in the spring of 1945. The research staff at Ottawa had already propagated a number of trees to be laid out in a small orchard and were preparing to set out a few experimental vegetable trials on the new substation in the spring of 1945.

In the spring and early summer of 1945 a number of seasonal laborers were taken on strength to look after work in the field. Two of these employees, Gerald Herrington and Douglas Potter, have spent their entire working careers on the experimental farm. Gerald Herrington has since retired, and Douglas Potter is now the station foreman. In the spring of 1945, work had begun on the construction of an implement shed and an office building to house the foreman's office and to be used by staff moving to and from Ottawa. The office building included a small laboratory for the use of the research staff from Ottawa, with an office for the farm foreman on the first floor. The second floor of the building housed a dormitory for research and technical staff visiting the station.

In 1945 the original tenant building on the station, which at the time of purchase was only a tarpaper-covered structure on a cement foundation, was renovated. This work included the installation of water, electricity, and new siding similar to that used on the foreman's house. The house was then used by the assistant foreman, G. Westrobe, one of the 1945 appointees to Smithfield. Little experimental work was set out in the field in 1945, and the field hands and carpenters hired continued with the construction program, getting fences, roads, and other buildings in order, clearing land, and seeding cover crops in preparation for a major initiation of field trials in 1946.

During 1946-1947 a number of orchard trials were established including orchard management (contour planting, soil management, hardy framework, and rootstock trials) and tree fruit evaluation (variety trials, advanced breeding, and seedling blocks for selection of new varieties). Some 30 acres (12 ha) of land were used for these purposes.

Also during these first 2 years, extensive vegetable trials were initiated. The trials included rotation studies on crops in canning, using peas, corn, and tomatoes as indicator crops; variety trials with vegetable and small fruits; soil management with pickling cucumbers; spacing trials with peas and corn; and fertilizer trials with tomatoes. As a result of the establishment of these trials, the first substation field day and open house, on August 14 and 15, 1947 was made possible. From the start, these field days have been held annually and have been well attended.

The shortage of water on the station property necessitated the excavation of a large dugout pond to supply water for orchard spraying and for potential irrigation of vegetables and small fruits. The first of these ponds was established in 1947 and is still in use. The system was later expanded to include two additional ponds as emphasis on irrigation studies increased. In 1952 a fertilizer and spray material shed was constructed beside the original farm pond.

By 1950 five cold-storage rooms in a fruit-storage building had been completed and the equipment installed. Starting with the harvest of 1950, cold-storage studies were begun by W.R. Phillips of the Division of Horticulture, Ottawa. The unit used various types of insulation including cork board, fiber-board, and fiber glass for long-term tests. All storage rooms were cooled with floor-mounted blower coil units with an electric defrost element and multiple-speed fan motors. The type of unit installed not only provided uniform temperature distribution throughout the storage room, but could also deliver high air velocity for initial cooling and slower air movement for holding. The short water supply on the station necessitated the use of an air cooled condenser.

From 1946 to 1960 all the field experiments were planned and supervised by the research staff of the Central Experimental Farm. As well as the officer in charge, D.S. Blair, who had his own research trials in the field at Smithfield, many of the Ottawa group conducted trials at the experimental substation. Apple breeding, variety and rootstock trials and strawberry and raspberry variety evaluations were conducted by D.S. Blair and L.P.S. Spangelo. Orchard and canning crop management and nutritional trials were conducted by H. Hill and H.B. Heeney. Vegetable trials and experiments were conducted by W. Ferguson, L.H. Lyall, and J.J. Jasmin. Cold-storage studies were conducted by W.R. Phillips. Potato investigations, including portions of the national variety tests, were conducted by N.M. Parks.

The movement of this research group and their associated technical staff between the division headquarters at Ottawa and the substation at Smithfield created a situation for the farm foreman, Ernie Wilson, and his wife, Lillian Wilson, that was not usually associated with the duties of the farm foreman. In those early days the group from Ottawa, sometimes as many as five or six at a time arrived at Smithfield and used the second floor of the small office laboratory building as a dormitory. Mrs. Wilson supplied three meals a day to this group while they were at the station. The Wilsons were gracious hosts, and many of the group from Ottawa spent pleasant evenings in their home. Some of them saw television for the first time in the Wilsons' home on Mr. Wilson's home-made 8-inch television screen in the early 1950s. Another problem that Mr. Wilson had with the group from Ottawa was that travel to and from Smithfield was commonly by train. No matter when the train arrived or left Mr. Wilson always found time to provide transportation.

By 1952 it had become apparent that use of the property by the research staff at Ottawa was increasing at such a rate that land for expansion of field trials would soon be so limited that work would have to be postponed. In addition, plans had been made in Ottawa to proceed with an extensive program of development of scab-resistant apple varieties. Land would be required for thousands of seedlings to set out for evaluation. Sufficient land was not available on the present 100 acres of land.

In 1953 the decision was made to purchase 200 acres (80 ha) of land adjoining the west boundary of the substation. On the purchase date, Sept.30, 1953 the property contained a large old farmhouse and two tenant houses. One of the tenants houses was unsuitable and was torn down along with an adjoining barn. The other tenant house was repaired and updated and is still being used as an employee residence. The old farmhouse was completely remodeled and was made into a double residence. Both sides of this double are still being used by employees of the station. During the next 2 to 3 years, much of the land on the second 200 acres (80 ha) of station property was cleared of woodlot and prepared for planting. It was found that the single farm pond located on the first 100 acres (40 ha) would not be sufficient to supply the water required for present and future experiments. A second dugout was therefore excavated on the extreme west of the second 200 acres (80 ha).

In 1956 the amount of fieldwork being conducted at Smithfield had increased and included more intensive field trials on vegetable and small fruit management and on variety development in apples, as well as irrigation crop studies with both small fruits and vegetables.

It was apparent that enough work was being conducted at the station to justify the appointment of a resident research officer to work in association with the various research personnel in Ottawa. Walter M. Rutherford was appointed to work directly under the officer in charge, D.S. Blair, to assist the Ottawa staff in conducting their experiments and to initiate chemical weed control and management trials on small fruits and vegetables.

At the annual convention of the Ontario Canning Crop Growers held in Hamilton Ont., on December 1, 1955, a resolution was passed requesting that the Canada Department of Agriculture establish a pilot processing plant at the Smithfield Horticultural Substation to further study the relationship of raw product grades to finished grades of the processed crop. The extensive variety evaluation, variety development, and management trials being conducted at Smithfield were, in the opinion of the fruit and vegetable growers, not a complete study unless the product were taken to the final stage of the processed product. Steps were taken in the next 2 years to design a pilot processing plant to be constructed at the Dominion Horticultural Substation, Smithfield. E. A. Asselbergs scientist in charge of food-processing studies in Ottawa played a key role in the design of the plant and in selecting equipment. This facility permitted processing, by canning or freezing of all the fruits and vegetables being developed as varieties or under management trials at the Smithfield Horticultural Substation. The plant included a large processing bay, a preparation bay, a series of cold-temperature rooms, a quality-control laboratory, and a fully equipped kitchen where food could be cooked for sensory evaluation. Construction on the building was started in 1958 and completed in 1959.

The building was officially opened in August 1959 by J.C. Woodward, assistant director general in the Research Branch, representing the Minister of Agriculture. A large number of industry and grower representatives were in attendance.

At this point in the history of the Dominion Horticultural Substation, the staff located at Smithfield consisted of a resident research scientist, a farm foreman, and his assistant, 6 year-round laborers, and four plotpersons to conduct the work in the field. In 1959 there was a general reorganization of the research divisions of the Canada Department of Agriculture the Science Service Division and the Central Experimental Farm Services were united to form the Research Branch. As a result of this reorganization many changes took place in the various stations across the country, including Smithfield. During 1959 the officer in charge, D.S. Blair, died suddenly after a short illness. The decision was then made in August 1960 to change Smithfield from the status of a substation to that of an independently operated experimental farm.

PRINCIPAL ACCOMPLISHMENTS (1945-1960)

During this period, the Dominion Horticultural Substation in Smithfield was operated as a section of the Horticulture Division, Ottawa, and accomplishments recorded at Smithfield were, of course, the results obtained by the research staff located in Ottawa who used the substation as a field laboratory.

Tree fruits

From crosses made by the Horticulture Division, Ottawa, more than 10,000 apple seedlings were planted for fruit evaluation. By 1960, 70% of these had fruited and of these, 27 seedlings were selected for a second test evaluation. These selections were promising as early and late maturing materials, and would require further testing before they could be released to the apple industry. From the extensive testing of apple varieties established in the early years of the station, it was apparent that Spartan was an excellent variety in the McIntosh season and that Melrose was a promising winter variety.

In 1949 a program was initiated in Ottawa by L.P.S. Spangelo to determine the possibility of developing commercial apple varieties resistant to apple scab. Many crosses were made at that time. After the second 200 acres (80 ha) of land was purchased for Smithfield in 1956, large numbers of scab-resistant seedlings from crosses made in Ottawa were established at the Smithfield Horticultural Substation. By 1960 many of these scab-resistant seedlings had fruited, and 11 promising selections were made from crosses containing Jonathan, Rome Beauty, and Malus floribunda. Although none of the 11 selections produced high-quality fruit, it was believed that when they were used as parents in crosses with good-quality varieties such as Melba, McIntosh, and Sandow their progeny would segregate to produce fruit of commercial size and quality.

Studies on apple rootstock and frame work set out at Smithfield in 1946 and 1947 showed the value of Malus robusta No. 5 as a hardy understock for the eastern Ontario area. These studies provided recommendations for growers of standard trees in eastern Ontario. By

1960, in trials set out in 1948 showed that the Malus robusta No. 5 rootstock was quite compatible with most of the common apple varieties grown in the area whether the Malus robusta No. 5 were used as a rootstock, an intermediate-, or a double-worked tree. Pruning trials conducted on a 30-year orchard showed that even severe pruning of old McIntosh trees improved quality without appreciably reducing yield. As many of the orchards in the area were 30 years old or older, the procedure became widely accepted by growers who wished to reduce the height of their trees, thus making them more economical to handle.

In 1953 D.S. Blair, S.N. Nelson and W.M. Rutherford extended their studies on chemical thinning of apples and on the reduction of harvest and preharvest drop of apples using foliar applications of chemicals in trials in the Smithfield area. They made recommendations based on their studies on 40 apple varieties. Because of the effect of weather conditions on the timing and effectiveness of the chemicals, it was necessary to recommend that growers proceed on a trial basis until they had made a study of their own particular conditions. At this time, it was impossible to lay down hard and fast recommendations to fit all conditions.

As a result of a trial on orchard soil management set up in 1948 by H. Hill and H.B. Heeney, the sod or sod mulch system became the standard recommendation and was followed by almost all orchards in the area. With the appointment of W.M. Rutherford to Smithfield in 1956, work was initiated in the chemical control of grass and weeds in the orchards. Because of the importance of both storage quality and efficient production of tree fruits to the grower, Hill and Heeney initiated a program to show the relationships among foliage analysis of producing trees,

fertilizer requirements of these trees for maximum production, and the storage quality of the fruit. A study was conducted in the Smithfield area and in grower orchards from Kingston to Toronto. The critical level of nitrogen in the foliage in mid July was shown to be approximately 2.1%. It was also shown that as nitrogen increased beyond this level, storage quality decreased. The results also indicated that the ratio between nitrogen and potassium should not exceed 1.25. Partly as a result of these studies, a foliage analysis service was established for Ontario by the Ontario Ministry of Agriculture and Food and is still being widely used by growers to estimate fertilizer requirements for maximum production and optimum storage quality of fruit. As a part of these nutritional studies, zinc deficiency of apples was identified in eastern Ontario, and foliar applications were devised to deal with the problem.

Small fruits

Extensive tests with various small fruits were started in 1955 to determine the suitability of varieties for the area serviced by the substation. Emphasis was placed on the evaluation of strawberries, raspberries, and rust-resistant black currants developed at the Central Experimental Farm. These studies contributed to the widespread planting by the growers of the four Ottawa strawberry varieties--Redcoat, Cavalier, Guardsman, and Grenadier. In strawberry management studies, the width of row was shown to vary considerably, from 30 inches (76 cm) down to 12 inches (30 cm) depending upon whether total yield or early production was the important factor.

Vegetables

The breeding of vegetables and the evaluation of varieties for canning had been emphasized from the beginning, although in the early years all breeding was done at Ottawa by W. Ferguson and L.H. Lyall. Regarding tomatoes, emphasis was placed on selections of determinate growth types, with fruit uniformly green and highly resistant to defects. A number of promising lines were tested commercially, and one of them, Ferguson, was released to the industry. The observation that most of the Ottawa selected lines yield better than varieties brought in from other sources emphasized the importance of developing varieties specifically suited to eastern Ontario. The varieties needed had to have good fruit-setting abilities under cool night conditions, as well as considerable resistance to fruit cracking, blossom-end rot, and other commercially important tomato diseases.

Using field trials at the substation and on grower properties, H. Hill and H.B. Heeney established the relationship between soil analysis and fertilizer requirements for tomato canning crops on the alkaline soils of eastern Ontario. Since that time, similar work has been conducted in other areas of the province, and soil calibration tables have been established for this crop throughout the province. Tentative tables for potatoes on the same soils were also set up. On eastern Ontario alkaline soils, it was found uneconomical to apply nitrogen fertilizer at high rates to peas or to the foliage of any canning crops, except in exceptional seasons. Critical levels of nitrogen, phosphorus, and potassium in the foliage for maximum yield were established for the three major canning crops (peas, corn and tomatoes) and for potatoes.

A long-term rotation study on canning crops, including both short-and long-term rotations, established by H. Hill in 1948 was continued until 1960. This study showed that for canning crops, short rotations, which included the use of green manure crops and light application of barnyard manure were equal or superior to the long-term rotations frequently used by the growers. These studies showed that the proper use of short-term rotations of the three canning crops did permit annual canning crop production without deterioration of soil nutrient levels or soil organic matter. The rotations or modifications of them were rapidly accepted by many vegetable growers in the area. The results did not mean that long-term rotations of canning crop were not recommended, but that short-term rotations could be used on properties where there was only a limited amount of good soil for processing crops.

Long-term studies of climate indicate that 15 July to 15 August is relatively dry in the Smithfield area. This is a period when many canning crops have a relatively high moisture requirement. As water for irrigation is usually available in Prince Edward County, a series of studies on irrigation with canning crops was set up by H.B. Heeney in 1955. During the early part of this study, irrigation was applied using perforated pipes for plot trials. In the late 1950s, the Smithfield Horticultural Substation, in cooperation with the engineering services in Ottawa, designed a plot irrigator that made use of a water pump to operate a portable rotating irrigator. Several of these portable irrigators were constructed, making it possible to conduct trials not only on the station property but on grower fields as well.

When these studies were initiated, the only method of determining water requirement, was a rule-of-thumb procedure suggesting that 0.75 inches (10 cm) of water should be applied every 7 rainless days. Obviously, better methods of estimating the necessity of irrigation were required. Procedures were therefore developed using the Bouyoucos soil moisture blocks and a Bellani plate apparatus to estimate potential evapotranspiration; both proved to be superior to rule-of-thumb methods. Over several years, results indicated that irrigation increased yields of peas by an average 28% and that irrigation was needed primarily during the last week of June when the pods are filling. The main problem was that unless the system was engineered to give uniform moisture across the whole area, the delay in maturity caused by wet areas compared with dry areas would result in extreme variation of maturity within a field of peas. Between 1955 and 1958 yields of tomatoes were increased by an average of 53.4% when water was applied according to requirement as indicated by either Bouyoucos test blocks or Bellani plate evapotranspiration. This meant the application of 1-6 inches (2.5 - 15 cm) of water from 15 July to 15 August depending on the growing season. It was also noted that blossom-end rot was reduced to a negligible amount when irrigation was used in tomato fields. These irrigation effects persuaded growers to increase the use of irrigation for tomatoes. The use of the Bouyoucos blocks and Bellani plates became common. After the problem of inadequate moisture was solved, various studies on spacing were initiated at Smithfield on tomatoes and on peas, in particular. It was soon demonstrated that plant populations of tomatoes should be considerably higher than the standard 6800 plants per ha commonly used by growers.

Spacing trials at Smithfield demonstrated to the growers that tomato production could be doubled using irrigation and close spacing of plants, up to 25,000 plants per ha. As a result, growers gradually began to increase the number of plants per hectare in canning crop tomatoes. The resulting increase in yield has helped to maintain a tomato industry in this area that compares favorably with areas that have a milder climate.

With the appointment of W.M. Rutherford in 1956, emphasis was placed on the use of chemical weed control in the canning crops. Since 1956, studies have been conducted using a number of chemicals on varieties of canning peas. Under Smithfield conditions the preliminary results indicated that dinitros as a preemergent treatment appeared to be superior and caused no injury to the peas. Also postemergence sprays were shown to have potential for use on peas 4-5 inches (10-12 cm) high. In the late 1950s experiments showed that simazine on sweet corn applied as a postemergent spray when the corn was 3-4 inches (7-10 cm) high reduced the weed population without any detrimental effect on corn yields.

In 1955 increased availability of soluble fertilizers and advances in spray equipment focused attention on the use of major nutrient sprays applied to the foliage either as a substitute for or a supplement to soil fertilizers. Studies were conducted for a 3-year period between 1955 and 1957 on the value of nutrient sprays. Recommendation of these sprays on tomatoes, either as replacements or as supplements to proper soil fertilizers, were shown to be unjustified. They might be of value as a supplement during seasons in which adverse growing conditions existed, but even then the timing of applications was critical. Total marketable yield increases were associated with foliage applications only when insufficient

quantities of fertilizer had been applied or when the plants could not obtain enough nutrients from the soil as a result of an adverse growing period (such as when soil moisture became a limiting factor).

CHAPTER 3

SMITHFIELD EXPERIMENTAL FARM

1960-Present

THE PHYSICAL PLANT

With the reorganization of the Department of Agriculture in 1959, Smithfield changed status from substation to an independently operated experimental farm. On 15 August 1960, H.B. Heeney was appointed superintendent and was transferred from the Plant Research Institute in Ottawa to Smithfield to take up his new duties. Although he was thoroughly familiar with the Smithfield location and area as a field laboratory since 1949, Mr. Heeney was now moving from a position in Ottawa where he was head of a nutritional unit consisting of two research scientists, three technicians, and a very well equipped laboratory. In 1960 Smithfield had the newly opened processing laboratory, only one research officer located at the station, and no technical help. However, an extensive field program in tree fruit, small fruit, and vegetable crop research was in place, which was supervised by research and technical personnel from the Central Experimental Farm.

The initial problem was the lack of laboratory and other research facilities. As a temporary measure, the dormitory in the office building was dismantled to permit office space for the superintendent, the resident research scientist W.M. Rutherford, and the farm foreman on the second floor and a small laboratory, supplied with equipment moved from Ottawa on the main floor. In late 1960, a clerical position was established at Smithfield and Majorie Semple was appointed to this position.

Immediate attempts were made to increase the research and technical staff during 1960-1963. W. P. Mohr from the Food Research Institute in Ottawa, who had conducted the evaluation program in the new processing laboratory during the previous year, was transferred to Smithfield to take over responsibility for the processing evaluation of horticulture crops.

In the spring of 1961, R.G. Adair was taken on strength to supply technical assistance to Dr. Mohr and to serve as stationary engineer. Mr. Adair had several years' experience managing a vegetable canning plant in Prince Edward County. S.R. Miller who had worked with H.B. Heeney at the Plant Research Institute since 1956, also moved to Smithfield to continue his program in tree fruit nutrition and physiology. Because he was on educational leave, he did not report until 1963.

To handle the vegetable breeding and evaluation program that was to be expanded at Smithfield, H.D. Madill was taken on strength in 1961. Several field hands were moved into technical positions to supply technical assistance to this small research group. Three members of the group were recent graduates of the Kemptville Agricultural School. J.G. Metcalf was assigned to H.D. Madill in the area of vegetable breeding. D.E. Hoskin was assigned to H.B. Heeney in nutrition, and L.C. Hunt was moved into a technical position with S.R. Miller. C.L. Potter, who had worked with W.M. Rutherford and the pomology research group from Ottawa for a number of years, was removed from his duties as assistant foreman to allow him to work full time as a pomological technical assistant under Mr. Rutherford. In 1962, V. Warren was taken on strength as a technician to work directly with H.B. Heeney in the expanded vegetable management, herbicide, and irrigation program.

In 1961, in order to allow for the expanded tomato breeding program being initiated by H.D. Madill, a plastic quonset style greenhouse, 25 feet X 50 feet (7.6 m x 15 m), was constructed and a series of heated hotbeds were installed beside it. Adding to the problems of establishing facilities at Smithfield was a fire of unknown origin that destroyed the office building in October 1961. The small staff suddenly found itself without office or laboratory space. Fortunately, most of the records were saved. The processing building had a large basement room that had been designed originally for the evaluation of processed products. This room was converted to temporary office space for the office manager, the farm foreman, and the three research officers, W.M. Rutherford, S.R. Miller and H.D. Madill. The superintendent was located in what had been W.P. Mohr's office, and Dr. Mohr set up office space in the quality control laboratory. The problem of laboratory space for soil and plant analytical studies and for physiological studies was resolved by the establishment of two new laboratories, one in the implement shed and one in the basement of the apple storage building. It might be of interest to recall that most of the benches, fumehoods, and equipment in these laboratories came from surplus benching from three buildings in Ottawa: K. W. Neatby, Science Service Chemistry, and the Tobacco Division barn. Facilities were a hodgepodge of various bits of laboratory benching. Laboratories were not particularly attractive, but they were functional.

Because so many of the labor positions had been converted to technical ones, there was in this early period a constant labor shortage. In 1961 H.B. Heeney was approached by the authorities at the Kingston Penitentiary to see if they could set up an arrangement whereby they would supply the station

with daily prison labor in return for some of the surplus produce from the experimental tree fruit, small fruit and vegetable trials. For a 2-year period prisoners were transported daily from Kingston to Smithfield. This arrangement supplied approximately eight field hands from 9 a.m. to 4 p.m. from 15 May to 15 October. After 2-years, the Department of the Solicitor General requested and received permission to set up a trailer camp on the Smithfield property in which they housed 10 prisoners, a cook, and two custodial officers from the medium security facility at Joyceville, Ont. The camp was established from a period 15 May to 1 November each year from 1963 to 1968. The trailer camp was dismantled in 1968, and after that time assistance was obtained on a daily basis from the Warkworth Institution north of Smithfield. The program was finally dropped in 1972. The type of labor supplied by this program was not fully adequate and was often frustrating to the technical and labor crew at Smithfield. However, because the station had access to the labor, it was possible to expand some programs at Smithfield and to continue others for a longer time. The loss of this source of labor in 1972 made it necessary to drop much of the small fruit program conducted at Smithfield at that time.

In 1963 H.D. Madill resigned, and the tomato-breeding program established during the previous 2-years was placed under the direction of J.G. Metcalf, his technician. Mr. Metcalf carried on and expanded the program with some assistance from L.H. Lyall, Ottawa Research Station, and E. Kerr, Ontario Ministry of Agriculture and Food, Horticultural Research Institute, Vineland. During the next two or three years, Mr. Metcalf demonstrated that he was fully capable of carrying on the tomato-breeding and vegetable-evaluation program with limited assistance. It was therefore possible to strengthen the pomology program, and S.J. Leuty was appointed in

1966. At that time the program of research conducted at Smithfield included plant nutrition, irrigation and weed control (H.B. Heeney), plant physiology and biochemistry (S.R. Miller), crop management and fruits (S.J. Leuty), food processing (W.P. Mohr), and vegetable breeding and evaluation (J.G. Metcalf).

By 1965 it was apparent that the water supply for irrigation and spray application was inadequate for the size of the program. Several changes were made, including enlarging the second pond, developing of a third pond on the west borders of the property, and purchasing and installing a 6-inch (15 cm) portable pipeline supplied with hydrants to join the three ponds together. A 50-horsepower electric-powered irrigation pump was installed in the fertilizer and spray shed to permit pumping the water to almost any location on the station. A 6-inch (15 cm) line was buried from the electrical pump to the building area to permit installation of a fire hydrant. Enough equipment was purchased so that some fire protection could be provided to the main building area of the station. With the completion of this system, a sprinkler system purchased about the same time allowed irrigation trials at any location on the first 200 acres (80 ha) of land on the station. Also at this time equipment storage was becoming a problem, and in 1965 a large metal-clad pole barn was constructed to protect much of the field equipment purchased since 1960.

With an increase in both the fruit and the vegetable programs by 1965, the plastic greenhouse was found to be inadequate. In 1965, a Lord and Burnham glass greenhouse, 25 x 100 feet (7.6 x 30 m), was erected. This greenhouse had three individually controlled growth rooms and was located on a site adjacent to but far enough from the existing processing laboratory to

permit a future office and laboratory to be added to the processing laboratory. Some time was spent in the late 1960s planning for such an addition to Smithfield Experimental Farm, but it was soon apparent that it would be difficult to obtain funds, and alternative methods of accomodating the staff had to be found. In the meantime, one of the four bays in the new greenhouse was modified to serve as a header house, with separate heating, lighting, and water-supply systems. To further simplify the greenhouse facilities, the plastic greenhouse originally constructed in 1961 was dismantled and moved to a location adjacent to the new glass greenhouse. Each of the three separate compartments in the new glass greenhouse had an independently controlled thermostat and all were fully equipped with fluorescent lighting to permit maximum use during the winter.

At the beginning of 1967, it was apparent that although Smithfield was operating as a completely separate experimental farm, the program being conducted was still so closely associated with the program at the Ottawa Research Station, particularly the tree fruit program, that some basic organizational change was required. The Research Branch decided that the Smithfield Experimental Farm should report administratively to the Ottawa Research Station under the direction of A.W.S. Hunter. Financially the station would still be operated independently but it would report through the Ottawa Research Station for program assessment, program development, and program reports.

In 1967 it was also apparent that the physiology and biochemistry unit under S.R. Miller and the vegetable breeding and evaluation work under J.G. Metcalf required further technical assistance if the programs were to be effective. S. Williams was appointed as the second technician under Dr. Miller and H. H. Brown was added to the section on vegetable breeding headed by Mr. Metcalf.

For the next 2-3 years, few changes were made to the physical plant, but by 1969 improvements in office accommodation were needed, particularly as W.P. Mohr, who had been on educational leave for the past 3 years, was returning. At the same time the foreman, G. Ernest Wilson, was interested in moving off the station. When he vacated the original farm foreman's residence in 1969, the building was modified to provide office space for the Smithfield staff. In the winter of 1969-1970, the house was completely remodeled, and in 1970-71 a two-storey addition, with basement, was added. At the same time, the assistant foreman's house was modified to provide lunch-room space for the farm laborers, an office for the farm foreman, and a laboratory for the staff of the Vegetable and Plant Breeding Section. Concurrent with these changes, improved laboratory facilities were constructed for the plant physiology and biochemistry section, headed by S.R. Miller, in the basement of the apple-storage building. The space formerly used in the basement of the processing laboratory was turned over to S.J. Leuty for his work in pomology. Thus, by 1971 the Smithfield Experimental Farm, for the first time, had adequate laboratory space and adequate office space for the superintendent, clerical staff, and research staff.

In 1972, a new dimension was added to the program at the Smithfield Experimental Farm with the transfer of two entomologists from the Belleville Research Institute. Until this time, any work conducted at Smithfield in the area of entomology had been the result of cooperative studies with the staff at the Belleville Research Institute or with the horticultural extension specialist, M. Webster, of the Ontario Ministry of Agriculture and Food, Brighton. Office and laboratory space was provided for L.G. Montieth and his

technician, J.A.D. Berube, who were transferred from Belleville. Mr. Monteith took over responsibilities for the spray programs, particularly the entomology program, for all units at Smithfield. As well he continued with the program on insect monitoring that had been part of his work at the Belleville Research Institute.

In addition, H.L. House and his technician, M.C. Rouse, were transferred from the institute at Belleville in 1972 . Office and laboratory space were provided for these two employees in the basement of the office building. The garage associated with the office was modified to become an insectory for Dr. House. Dr. House continued his program on biological control of insects, which he had been conducting at the Belleville Research Institute.

Since this period, minor changes have been made in the physical plant owing to the resignation and appointment of staff members. The only other major change made since that time has been the complete modernization of the apple-storage refrigeration units. Whereas the original refrigeration had been provided by a single system located in the basement of the cold-storage building, the new system provided individual refrigeration units for each of the five cold-temperature rooms in the building.

Since the early to mid 1970s a number of changes have occurred in the staff, starting with the retirement of several original or long-time employees of the farm including the following: the farm foreman G. Ernest Wilson, retired in 1972; Gerald Herrington, one of the original employees taken on strength in 1945, retired in 1974; and Cecil Whitney who had over 20 years of service with Smithfield Experimental Farm, retired in 1975. Douglas Potter one of the original employees at the farm, was appointed farm foreman and another long time employee, M. Cooney, was appointed his assistant.

Two other changes of significance occurred in 1974-1975. Since its establishment, Smithfield has had a very close relationship with the growers and with the extension staff of the Ontario Ministry of Agriculture and Food (O.M.A.F.). In 1974, because of the close association with O.M.A.F. extension specialists, the station was asked to provide office space for an O.M.A.F. employee at the Smithfield Experimental Farm. John Warner was located at Smithfield in 1972, and since that time an O.M.A.F. extension specialist has had a position at the farm. In 1975 S.J. Leuty, who was the head of the Pomology Section at Smithfield, resigned to take a position with the Horticultural Research Institute of Ontario, O.M.A.F., Vineland. With Dr. Leuty's resignation, it was necessary to reorganize the tree fruit program. S.R. Miller and H.B. Heeney shared the program because the work was too important to delay until a new appointment could be made.

While the Smithfield Experimental Farm was developing during the period up to 1975, the fruit and vegetable program at the Ottawa Research Station was being gradually terminated. Major portions of the tree-fruit-breeding program were transferred to the Saint-Jean Research Station. The evaluation work on the Ottawa rootstock trials both at Smithfield and Ottawa, and the evaluation of the extensive scab resistant seedling program at Smithfield, were turned over to the Smithfield staff. By 1975 the Ottawa tomato-breeding program had been transferred to Smithfield. It therefore did not seem realistic for the Smithfield Experimental Farm to remain associated with Ottawa Research Station, as there was now little of common interest in the programs of the two units. At the same time, the Smithfield program had become much more involved with the protection of fruits and vegetables, particularly in terms of entomology. On 1st April 1975 the decision was made

to place Smithfield Experimental Farm in association, administratively, with the Vineland Research Station. This union placed research personnel with specialized knowledge in production, management, and protection of fruits and vegetables under one umbrella for the eastern Ontario area.

In 1979 H.B. Heeney retired and S.R. Miller was appointed the new superintendent.

In recent years several significant changes have occurred. Both Mr. Monteith and Dr. House, who were transferred from the Belleville Research Institute, retired in 1979-1980. Because of the association of the Smithfield Research staff with the Vineland Research Station, it was possible to carry on a portion of Mr. Monteith's work by appointing a technician, S. Hay in 1981 to work in conjunction with E. Hagley of the Vineland Research Station staff. V. Warren retired in 1978. He had been a technician since 1962 and was responsible for the herbicide studies on tree fruits and vegetable crops under Mr. Heeney. N. Smits was taken on strength in 1978 to work on the herbicide program and part of the vegetable management program. By 1980 it was apparent that the major weakness in the professional staff at Smithfield was the absence of a pomologist to carry on the program originally established by Dr. Leuty. J. Warner was appointed to this position in 1981. Mr. Warner was thoroughly familiar with the program at Smithfield, as he had served as horticultural extension specialist for the OMAF from 1972 to 1980.

The program at Smithfield had been developed with a minimum number of research staff members. As a result, the availability and development of a highly qualified technical staff was of considerable help in conducting the program. J.G. Metcalf had taken over full responsibility for the breeding and evaluation of tomatoes and vegetable crops. V. Warren conducted a very

successful program on herbicides for horticultural crops particularly with direct seeded tomatoes and strawberries. R.G. Adair, who retired in 1981, carried on a program of processing evaluation of canning crops from 1960 until his retirement. Without these people taking major responsibility for the work, it would not have been possible to carry on Smithfield's extensive program.

The present program at Smithfield is still divided into five sections. S.R. Miller, the station superintendent, is conducting research in plant physiology, orchard density, and meristem culture with the help of three technicians. W.P. Mohr is conducting a full program on food processing and food technology with two technicians. N.J. Smits is conducting the program on vegetable management and herbicides. J. Warner is conducting the program on orchard management, pest management, and variety and rootstock evaluations on tree fruits. Mr. Warner has a technician and a senior plant propagator on his staff. J.G. Metcalf and his technician are conducting the program on tomato breeding and vegetable evaluation including responsibility for the Ontario grain corn committee trials. David Ridgway, appointed in 1981, is OMAF's horticultural extension specialist located at Smithfield.

CHAPTER 4

RESEARCH PROGRAM (1960 to the present)

The main function of the Smithfield Experimental Farm, as established in 1960, was the study of the problems important to the fruit and vegetable industry in eastern Ontario, particularly the area bordering on the north shore of Lake Ontario. The crops to be studied were tree fruits, (particularly apples), small fruits (particularly strawberries), and vegetable crops (peas, corn and tomatoes). To accomplish this task, the research program was divided into a number of sections in the following areas: plant nutrition, irrigation, and weed control; crop management; plant physiology and biochemistry; food processing; and plant breeding. A brief summary of the research and staff follows.

TREE FRUITS

Variety evaluation and development

The Smithfield Experimental Farm served as an extension of the Ottawa Research Station in a program to evaluate new apple varieties for conditions in eastern Ontario and for development of varieties with and without resistance to apple scab. In these early years the program was primarily directed from the Ottawa Research Station under L.P.S. Spangelo. At Smithfield evaluation was conducted initially by W.M. Rutherford until his resignation in 1964. S.J. Leuty took over responsibility for the Smithfield portion of the work in 1965 and accepted full responsibility in 1969 when Dr. Spangelo became director of the research station at Beaverlodge. Since 1975 the evaluation work has been directed by H.B. Heeney (1975-1979) and J. Warner (1981 to the present).

Some 50,000 seedlings have been set out over the years at the Smithfield Experimental Farm. The best of these were selected for inclusion in second test orchards on a number of different rootstocks and were finally released to growers for field evaluation. Most notable among the selections released were the following nonscab-resistant cultivars: Quinte (1963), an early, red, winter-hardy apple; and three very promising late maturing selections, Lindel (1971), Sandel (1978), and Loyalist (1979). Second test orchards of the most promising scab-resistant selections were set out in 1956 on Robusta 5 and a seedling rootstock, Antonovka. In 1976 seed test orchards on M 26, O-3, MM 106, and Robusta 5 rootstocks were set up. The last of these second test orchard trials was set out to provide information for the new selections on the more commonly used rootstocks. The first of the promising scab-resistant cultivars released was Macfree (1974). Other promising cultivars are Moira (1978), Murray (1978), Britegold (1979) and Trent (1979).

In 1971 an orchard for evaluating cultivars was started at Smithfield to evaluate apple, pear, and plum cultivars for this region. Differences in hardiness of cultivars was noted following the severe winter of 1980-1981. Yield and quality differences between strains of McIntosh and Delicious are being assessed. In 1984 a new trial to evaluate several new plum cultivars was set out. Although there will be a continuing program of evaluation of named cultivars of apples, pears, plums, and other tree fruits, as well as the evaluation of scab-resistant selections in second test orchards, the breeding program for the development of scab-resistant apples was transferred from Ottawa to the research station in Saint-Jean, Que.

Tree fruit rootstocks

One of the principal problems of the orchardist is the selection of rootstocks for their cultivars. This problem has become more complex with the ability to modify the growth and performance of a cultivar through rootstock selection. Also, any rootstock selected for the apple-growing areas of eastern Ontario must be sufficiently winter-hardy to withstand the climatic conditions. The introduction of the East Malling series of rootstocks in the late 1930s gave the orchardists, for the first time, the material needed to produce a preselected tree size for orchard planting. In colder areas such as eastern Ontario, ability of some of these rootstocks to withstand the temperatures experienced during the winter has been of some concern. Initial interest in the development of hardy rootstocks arose as a result of the disastrous loss of trees in eastern Ontario in 1933-1934. As a result of breeding and selection trials in Ottawa, one rootstock appeared to be superior. This was Malus Robusta No. 5. This rootstock was thoroughly tested with a wide range of cultivars at Smithfield and during the 1960s was highly recommended as a winter-hardy, standard-size clonal rootstock for eastern Ontario. Malus Robusta No. 5 was also compared in field studies with a number of the Malling rootstocks including M7 and MM2 on both droughty gravel soil and on heavier Bondhead soil. When planted at densities of 272 trees per ha trees on M7 were only slightly more productive at 18 years than trees on M. Robusta No. 5 and M2 rootstocks growing at densities of 180 trees per ha. The differences were small, particularly on the droughty Brighton sandy soil. This slight yield improvement on M7 would not compensate for the lack of hardiness.

In previous periods of stress, winter injury had occurred in the trunk of the tree. In the attempt to give maximum hardiness potential to trees, the rootstock from hardy M. Robusta No. 5 was double-worked using 10 different apple cultivars. By 1967 this trial, established in 1946, showed that although double working M. Robusta No. 5 to give a hardy frame to the tree may be of benefit in terms of cold-temperature tolerance, there was little or no benefit in terms of fruit production. Double-worked trees tended to be 10% larger, which was not necessarily beneficial. Unless extreme trunk hardiness is required, double-working the trees would not be justified because of the increased cost of production.

Since it had become apparent that size control would be as important as winter-hardiness in orchard production, a trial was set up in 1955 to test the influence of a number of different intermediate stems and various lengths of Robin intermediate stems on trees growing on M. Robusta No. 5 rootstocks. The use of a dwarfing rootstock as an interstem on winter-hardy M. Robusta No. 5 rootstock was shown to dwarf the trees enough to permit this hardy rootstock to be used in high-density orchards. Results indicated with an M9 interstem the rootstock could be used in dwarf-high density plantings, and with the M7 as an intermediate M. Robusta No. 5 could be used in semidwarf planting. With Robin as an intermediate on M. Robusta No. 5 rootstock, there was clearly both an optimum length of intermediate and an optimum height at which the intermediate should be inserted. On the basis of these results there does not appear to be any justification for changing the present practice of using intermediates 10-15 cm long and inserting the intermediate 10 cm above ground level.

In more recent years, eastern Ontario growers, like those in other apple growing countries, have found it necessary to plant more trees per acre in order to remain competitive. The trend in orchards towards small or compact trees at higher densities is clearly evident. Large trees are too costly for disease and insect control and for harvesting operations. From the standpoint of the eastern Ontario grower, it is unfortunate that it has been necessary to use less winter hardy rootstocks such as M7, M26 and MM106, since hardier stocks are not yet available. In the Ottawa rootstock program to develop new hardy rootstocks L.P.S. Spangelo selected a number of rootstocks with a range of size controlling capabilities. These rootstocks were set out in 1967 at both Ottawa and Smithfield on two different soil types. The potential tree sizes range from a dwarfing potential, similar to M9, to the standard trees similar to those on Robusta 5. The trials included the check rootstocks, M26, MM106 and Robusta 5. From these trials Ottawa 3, a dwarfing rootstock which produces trees similar to those produced by M26, was released to the industry. Ottawa 8 which produces trees similar in size to MM106 is still under evaluation. Ottawa 3 produces trees small enough to permit setting trees out at 1,000 trees/hectare compared with 900 trees per hectare on M26. Production at these densities is similar on both scion cultivars tested, although there is some indication that the Quinte performed better on the Ottawa 3 than on M26. In these trials the Ottawa 8 rootstock at 500 trees/hectare performed better than MM106 rootstock with both McIntosh and Quinte as the cultivar. It would seem, therefore, that where hardiness is a factor such as in eastern Ontario, Ottawa 3 might be an excellent

replacement for M9 or M26, and Ottawa 8 might be a potential replacement for MM106. The main problem with the Ottawa rootstock series is that as a whole they are not particularly productive in stool beds. Work conducted by S.R. Miller would indicate that the propagation of this material using tissue culture might be the most promising approach. Until this problem is resolved, these rootstocks may not become widely used. The use of Ottawa 3 as a size-controlling interstem is of interest and evaluation of Ottawa 3 for this purpose continues.

In the early 1980s another series of rootstock trials were established to evaluate size-controlling winter-hardy rootstocks from the USSR, Poland, and the United States. The performance of self-rooted cultivars produced by tissue culture or from softwood cuttings is also being investigated.

Orchard management

Under the direction of H.B. Heeney the nutritional studies of tree fruits previously conducted at Ottawa were transferred to Smithfield with particular emphasis given to problems of micronutrient elements, the relationship of plant nutrition to frost resistance, and the effects of viruses on production and nutrition. It was demonstrated that orchards in eastern Ontario's alkaline soils could and frequently did suffer from a deficiency of zinc. Methods were developed to permit the correction and prevention of this deficiency using foliar sprays in the early part of the growing season. Zinc also had an effect on the ability of blossoms to survive freezing temperature when in full bloom. Studies indicated that when levels of potassium in foliage in July were kept above 1.7%, blossom kill caused by frost was significantly reduced. When zinc was applied in addition

to a high level of potassium, blossom kill resulting from 1 or 2° of frost dropped from 80% to approximately 10%.

Most growers are now attempting to plant virus-free rootstocks. A study established in 1971 was designed to show the effect of a complex of viruses, including spy decline, chlorotic leaf spot, stem-pitting, rubbery wood and apple stem grooving virus, on the performance and nutritional levels of the McIntosh apple grown on a wide range of rootstocks. These studies, initiated by S.J. Leuty and finalized 12 years later by J. Warner, showed that trees varied considerably in their sensitivity to virus infection depending on the rootstock on which they were grown. It seems that some of the Ottawa hybrid rootstocks as well as the recently released Ottawa 3 were relatively tolerant of virus infection. In this study, virus inoculation improved yield efficiency on some rootstocks in the early years; however, by 1982 the virus-inoculated trees on all rootstocks except Ottawa 3 were no more efficient than the noninoculated ones; inoculated trees on Ottawa 3 rootstock were more efficient than noninoculated trees. Virus inoculation also resulted in reduced levels of nitrogen, phosphorus, potassium and calcium in the scion variety. One positive effect noticed with virus-inoculated trees was some improvement of red fruit color, which was probably a result of better light penetration into the smaller trees. It was also possible that nutritional effects contributed to the improved fruit color.

Control of unwanted vegetation, weeds, and grass, under orchard trees has been a constant problem and rapidly became of increasing importance as the number of trees planted per hectare increased with the increasing use of dwarfing and semidwarfing rootstocks. Extensive herbicide

studies were conducted by W.M. Rutherford (1960-1963), V. Warren and H.B. Heeney (1963-1979), and N. Smits (1979 to the present). A wide range of herbicides were tested and methods were established and recommended to the grower to permit the chemical control of unwanted vegetation without significant change in the growth and production of the trees. It was shown that although repeated annual applications of several herbicides would control vegetation, some of these chemicals accumulated in the soils below the trees which could result in their uptake by the fruit. Studies were conducted and methods released to growers recommending the use of a rotation of herbicides that did not accumulate in the soils but that had all the benefits of weed control. In nearly all weed control studies, annual yields of fruit were higher when growth under trees was controlled by either a rotation of herbicides or the annual application of specific herbicides. Chemical weed control has now become a standard practice in the area, but work is continuing under Mrs. Smits to find herbicides for use on apple trees in both the nursery and the first few years after planting.

Since the establishment of the station, studies have been conducted on orchard irrigation requirements of mature standard trees and of closely planted blocks. These studies include the use of trickle irrigation in high-density plantings and sprinkler irrigation in the older orchard blocks. In general, studies have shown that a lack of moisture is not a major problem in the orchard area of eastern Ontario, except for years when it is hot and dry during August when early apples such as Melba and Quinte are sizing up. A significant finding was the suggestion that mature Spartan trees require twice as much of water as Red Delicious and Red Spy. Over a 5-year period the Spartan cultivar showed increased terminal growth and total yield as a

result of sprinkler irrigation, particularly in dry years. The increase in total yield was due primarily to the percentage of fruit larger than 7 cm. Studies initiated by S.R. Miller and continued by J. Warner are being conducted to determine the value of trickle irrigation, particularly in densely planted orchards. Results indicate that irrigation in the first few years after planting is most critical to get the trees established and into production.

Trickle irrigation applied to mature McIntosh trees on three different rootstocks showed little response to water; however, it increased terminal growth and reduced bitter pit in a dry year. Fruit size was also increased, although no increase in total yield was obtained when trickle irrigation was started after the trees were established in the orchard. On the other hand, when trickle irrigation was started soon after planting, a much greater response was obtained. Both tree size and yield were greater on irrigated trees after 7 years in the orchard. Fruit size was also increased by irrigation, although fruit firmness of McIntosh may be reduced some years. Studies on trickle irrigation are continuing.

Inconsistencies in the response of apples to chemical thinning sprays suggest that fruitlets reach a specific stage of development at which they are most sensitive to growth-regulator sprays. S.J. Leuty believed that over a number of years, the diameter of the average fruit is a more reliable index than previously used indices, such as days after full bloom or days after petal fall. He showed, however, that the recommended average diameter varies with the cultivar. Spy and Spartan responded best between 10 and 11 mm, Delicious between 7.5 and 8.5 mm and McIntosh between 8.5 and 10 mm.

In the mid 1960s it was obvious to those working in tree fruit management that orchards of the future would be quite different from those of the past. Such innovations as dense planting, dwarf plantings, and tree walls would create a whole new set of problems in orchard management. With Dr. Leuty's appointment in 1965, orchard management became a major area of research, and orchards were established to study the problems of pruning and harvesting associated with dense plantings. With the use of various combinations of spacing and rootstocks, trees were planted at densities ranging from 350 to 1500 trees per 0.40 hectare. By the time Dr. Leuty resigned in 1975, production from plantings of various densities indicated that eastern Ontario orchards of the 1980s would probably consist of one of the following: a wall maintained at a height of approximately 4 m, using semidwarfing rootstocks such as MM106 or Ottawa 8 planted in rows approximately 5 m apart; or a wall maintained about 2 m high, using the more dwarfing M9, M26 or Ottawa 3 rootstocks planted in rows 2-3 m apart. It was also apparent from these early studies that the use of two-, three-, or five-row beds was not feasible and created more problems than was justified by the increased early production. Dr. Miller took over this program from Dr. Leuty in 1975 and incorporated a series of pruning and harvesting studies on the trials. With the assistance of the Engineering Research Service in Ottawa, Dr. Miller and Dr. Leuty helped in the design and development of a pruning and harvesting aid specifically designed for tree walls. Dr. Miller also made use of mechanical pruning rather than dormant pruning only, and dormant pruning plus summer pruning on the tree walls. In general, the studies indicate that production increases when tree walls are used, particularly when semidwarfing rootstocks are used, and that mechanical

pruning saves time and produces a higher percentage of fancy fruit on the tree, therefore giving a greater financial return per hectare of harvested fruit. The studies are now being expanded to include such factors as the use of trickle irrigation and growth regulators.

Dr. Leuty and Dr. Miller were also responsible for a pear-spacing trial established on a clay loam soil in 1973 with densities between 510 and 1300 trees per hectare. By the end of 1983 the trials showed that for both Bartlett and Clapp Favorite, it was advantageous to allow 1.8 m of space between trees and 4.25 m of space between rows.

Dr. Miller took a mature, 25-year orchard containing McIntosh, Delicious, and Red Spy apple trees and managed it as a juice block for seven seasons. He used minimum spraying and pruning programs, and as a result encountered problems with leafminer, thrips, spring-feeding caterpillars, apple maggot, and apple scab, which eventually required corrective action. He also used excessive applications of nitrogen to maintain a high rate of production. A review of the production and management costs showed that the orchard produced a profit to the grower in most seasons. The grower could thus be advised to manage these old trees as a juice block at a profit rather than as a fresh-fruit block at a loss because of high costs. In cooperation with the Engineering Research Service in Ottawa, equipment was designed to pick up juice apples in such a block. The use of such equipment further reduced the cost of producing apples from this type of orchard.

Studies in the propagation of apples, both rootstocks and scion cultivars, have been conducted by Dr. Miller since the early 1970s, when it became apparent that some of the Ottawa rootstocks, although they performed well in the field, did not propagate well in stool beds. At present, 14

rootstock clones have been propagated by meristem culture and have been maintained under sterile conditions. With the use of meristem culture, the rootstocks are being increased to allow field testing under Ontario conditions. It is interesting to note that Ottawa 3 and Malling 26 both show rapid shoot multiplication and good to excellent rooting ability in agar. The meristem culture of apple rootstocks is probably more promising than the scion rooting of the rootstocks. Dr. Miller is also studying the growth of scion cultivars on their own roots. Eleven cultivars, including commonly grown ones, have been propagated on their roots from softwood cuttings and planted out into the field. In general, cultivars on their own roots are smaller than the same cultivar on M. Robusta No. 5. The self-rooted trees are now approximately the size of the same variety on either Ottawa 8 or MM106. All have survived the severe winter of 1980-1981 and although some trunk splitting did occur, it did not appear to be any more severe than that which occurred with Malling 106.

Physiology and biochemistry

S.R. Miller's work on the physiology and biochemistry of rootstock dwarfing was transferred from Ottawa in 1962. He was able to show that there was an excellent correlation between the vigor of the rootstock and the respiration of the leaf tissue. And he was also able to extract growth inhibitors from apple leaves that would give an indication of their rootstock dwarfing potential. As part of the studies, the height of 4-year grafted trees was found to be closely related to dry weight of leaf samples from ungrafted Ottawa rootstocks grown either in stool beds or as free-standing nursery trees. This indicates that the dry weight of leaves might

serve as useful selection tool for predicting dwarfing potential of apple rootstocks.

At the time of Dr. Miller's appointment to Smithfield, a number of chemicals were being promoted for use in the orchard to control or modify tree and fruit growth. Extensive studies were conducted on the effects of these new materials on such factors as biennial bearing of trees, delay of fruit maturity, development or delay in fruit color, and increase in production of high-quality fruit. He demonstrated early that Alar reduced fruit drop, and growers quickly began using the material on trees to extend the picking season, thus permitting storage of fruit of a higher quality. Alar applied 50 days before harvest delayed the onset of the preclimacteric minimum by at least 7 days and ethylene detection by at least 10 days. The starch test and pressure test for optimum maturity were delayed 14 and 9-14 days respectively. Although Alar did control fruit drop, when it was used alone it caused fruit clustering and reduced fruit size the subsequent year, seriously reducing its value to the orchardist. Dr. Miller showed that the most desirable time and rate of application of Alar over the harvest season, with a minimum of clustering and reduction of fruit size depended on the orchards previous production history. The size of the crop normally produced by the orchard, as well as the normal size and color of the fruit, had an effect on the desirable time and rate of application of Alar.

In the late 1960s Dr. Miller showed that Ethephon applied to trees increased the red color of most varieties of apples at harvest. As well, Ethephon did affect fruit abscission. To prevent excessive fruit drop, the fruit on treated trees had to be harvested approximately 2 weeks after spraying. As a result of these and other studies growth regulators have

become recognized as useful tools available to the commercial grower for controlling vegetative growth, fruit production, annual cropping, and fruit drop. In many cases individual growth or fruiting requirements dictate the materials and the timing of application.

Alar, Ethrel and other growth regulators affect the tree itself, as well as the fruit. Dr. Miller showed that Alar applied to young Spy trees on M26 rootstocks reduced tree size by 16, 22, and 50%, respectively, when applied during one, two, or three successive seasons. Reduced tree size was associated with increased flower bud formation and control of the amount of barren wood caused by blind buds. Since it was first shown that Alar would have an effect on the reduction of vegetative growth on trees, many attempts have been made to utilize this characteristic in the production of trees. Work is currently being continued by Dr. Miller to determine the proper balance among the rate of application of Alar, the time of application, the reduction of vegetative-shoot growth, the clustering of fruit, and the reduction in fruit size of subsequent crops. Experience over the years has shown that Alar applied to control vegetative growth does cause a significant reduction in fruit size. Alar and Ethrel treatments early in the season have been used to effectively control the growth of relatively young trees growing in hedge rows. Alar applied early in June to the top third of vigorous McIntosh trees has been shown to reduce shoot growth in the top of the trees by 40-50% with little effect on the bottom. Fruit size in this case was reduced slightly in the top of the tree, but there was little effect on fruit produced on the bottom half of the tree. Dr. Miller also showed the effect of the regulator Promalin on the shape of Red Delicious apples. The application of this material to Red Delicious when the king blossom was open

tended to make the average fruit somewhat longer than the fruit of untreated trees, although the diameter was reduced slightly. Recently, foliar applications of Promalin have also been shown to increase the number of shoots per tree on young 1-year-old apple trees on M26 rootstock. A Promalin-latex paint mixture applied to the trunk of four cultivars on M26 rootstock 2-3 days after planting significantly increased the number of shoots per tree and the total terminal growth on Vista Bella but inhibited bud development on Jonamac, Jerseymac, and Paulared.

Entomology

During the 1960s entomology was not a part of the Smithfield program, and both disease and insect problems in the trials were controlled primarily by following general recommendations and consulting with the OMAF extension specialist. The principal objective was to obtain complete control so that disease and insect problems would not affect other research. In the late 1960s and early 1970s several cooperative studies were set up with the staff of the Belleville Research Institute at the Smithfield Experimental Farm, including such disease and biological control studies as the use of sound waves to control corn borer and the use of inert materials to control potato beetles. In 1972, with the closure of the Belleville Research Institute, H.L. House and L.G. Monteith were transferred to Smithfield with their programs, giving the station an entomology input for the first time.

Mr. Monteith, continuing a program started at Belleville, demonstrated that newly emerged laboratory-reared apple maggot females placed alive in tanglefoot bait traps increased the proportion of trapped male flies. Mr. Monteith also showed that modifications of the flora on the surface of

the orchard, both as to height and species, favored the increase of predaceous mites and entomophagous insect predators and eliminated or reduced the need for chemical control of mites, aphids, or scale for a 3-year period. Mr. Monteith advocated the use of trap trees in the periphery of a large block of trees to decrease the need for insecticides. When he retired in 1978, this work was continued for a number of years with the technical help of S. Hay, working under the direction of E. Hagley of the Vineland Research Station. The workers expanded the program of estimating insecticide requirements using monitoring of insect populations. Peripheral trapping of certain insects showed higher catches around the outside of the orchard than in central blocks. Modifications to spray programs showed certain insecticides could be reduced or eliminated in central blocks without adversely affecting fruit quality.

With the appointment of J. Warner in 1981, the entomology studies were continued and evaluation of insecticides, miticides, and fungicides in orchards was expanded. Sterol-inhibiting fungicides have provided up to 96 hours of kickback against apple scab, which is the major pest affecting apples in Ontario. Monitoring and control techniques have been developed for the dogwood borer, which is a pest recently found invading weak or injured areas on trunks of apple trees. Studies to control tentiform leafminer, codling moth, and mites were also carried out during the 1980s.

During the term at Smithfield (1972 - 1979) Dr. House completed the program he initiated at the Belleville Research Institute. He developed procedures to eliminate needs for host insects in laboratory propagation of Itoplectis conquisitor. He developed an artificial host--an encapsulated medium for in vitro oviposition, eclosion, and larvae development of a parasitoid, and developed an artificial diet to feed the adult predator.

SMALL FRUITS

Studies on small fruits formed an important part of the Smithfield Experimental farm program in the 1960s. Because of staff limitations, the program was gradually deemphasized in the early 1970s, and work on small fruits was finally stopped by 1975.

Cultivar evaluation

At Smithfield, cultivar evaluation for the eastern Ontario region was conducted with both strawberries and raspberries by W.M. Rutherford until 1963 and by S.J. Leuty after his appointment in 1965. As there was no breeding program at Smithfield, the work consisted of testing named cultivars from various programs in Ottawa, Vineland, Kentville, and the United States, as well as advanced breeding lines from many of these programs. As a result of these studies, a number of cultivars were recommended to the rapidly expanding industry in the area including Redcoat, Veestar, Bounty, Guardsman, and Sparkle strawberries. Similar studies were conducted on raspberries, and as a result the cultivar Bonanza was recommended.

Nutrition

H.B. Heeney studied the relationship between foliage analysis and yield of the strawberry. His results indicated that the mature leaves collected from mid July to mid August should contain 2.25-2.7% nitrogen, 0.25-0.30% phosphorus and 1.4-1.7% potassium for maximum yields. These studies also showed that winter survival was lower when foliage levels dropped below 2.3% nitrogen and 1.6% potassium. Studies indicated that blossom damage caused by spring frost was significantly lower when zinc levels in the foliage were above 25 ppm.

Irrigation

In the early 1960s strawberry production showed a dramatic increase in the eastern Ontario area as pick-your-own fruit operations became more common. H.B. Heeney and W.M. Rutherford started a series of irrigation studies in 1960 to develop methods of estimating the irrigation requirement of strawberries. They showed that irrigation was absolutely essential for optimum production in this area, which normally has a dry period between mid July and mid August. Over a 4-year period, Mr. Heeney and Mr. Warren showed that irrigation during the planting year to promote plant development and fruit-bud formation was as important as irrigation during the fruiting year. Using yield increase per inch (2.5 cm) of water applied as an index of efficiency of irrigation management, they obtained best results when 1 inch (2.5 cm) of water was applied, when available soil moisture at 6 inches (15 cm) dropped below 50% during the period from planting to mid August, and when available moisture dropped below 50% at 3 inches (7.6 cm) after mid August. These results became much more important as the plant density of the new planting increased.

Weed control

From the time that Smithfield was first established in 1945, the principal problem facing the grower was the control of weeds and grass. From 1956 to 1979 there was a continuing program to find methods of controlling this problem. Initially, the program was directed by V. Warren. As chemical control of weeds and grass appeared to be the best approach, many chemicals were tested over the years. The most promising material for eastern Ontario conditions has been terbacil. This material was shown by Mr. Warren to be

useful when applied before planting, and incorporated in the soil in the spring, or as a direct application 4 weeks after planting. There was also the possibility of using it in late November on renovated planting. The principal problem was the failure of terbacil to fully control pigweed and dandelion. This problem was brought under control by carefully directed application of 2,4 D before mowing the plants during the renovation process. Although some damage occurred, fruit production was not significantly reduced. The use of these chemicals now allows the grower to change from a procedure of planting 1 year and harvesting for a maximum of 2 years to the present commercial procedure of planting 1 year and harvesting for several years. At Smithfield we have harvested 10 crops from a single planting site.

Storage of fresh fruit

H.B. Heeney and W.M. Rutherford, in cooperation with the Commercial Products Division of Atomic Energy of Canada, conducted a study between 1960 and 1962 on the effectiveness of gamma radiation from a cobalt-60 source on the storage life of freshly picked strawberries. They showed that gamma radiation at a dosage rate of 110,000-330,000 rads prevented fungal development on strawberries stored at 40-70°F for up to 26 days at the high dosage of radiation and low temperature. Organoleptic tests indicated that the fruit was commercially acceptable for up to 20 days. The high cost of treatment was the main limiting factor.

VEGETABLES

Since its establishment in 1960, Smithfield was given responsibility for an extensive program on canning vegetable crops. To carry out this program the vegetable work in crop management led by H.B. Heeney was transferred to

Smithfield from Ottawa, a breeding and variety evaluation program under H.D. Madill was set up in 1961, and the processing evaluation of all material in the trials was set up in the new processing laboratory under W.P. Mohr. Since the vegetable program at the Ottawa Research Station was gradually reduced during the 1960s and effectively eliminated by 1972, the vegetable program at Smithfield was the last remaining Agriculture Canada vegetable research program in eastern Ontario.

Cultivar evaluation

On his appointment, H.D. Madill set up a program of cultivar evaluation that has been continued to the present under the direction of J.G. Metcalf. Many vegetable crops have been evaluated, and the results have been used in provincial cultivar recommendations. Crops for which results have been obtained include the three major canning crops--peas, corn, and tomatoes; potatoes, as part of the national potato trial; fresh and pickling cucumbers; green and wax beans; fresh-market and processing corn; cole crops including cauliflower, broccoli, Brussels sprouts, and cabbage; and zucchini, squash, and pumpkin. Partly as a result of these trials, the findings of which are distributed to growers each year, some of the crops were introduced to the area and are now being produced, including zucchini, broccoli, and cauliflower. All materials from the trials have been checked for processing characteristics and the results have been used by local processors.

Tomato breeding and evaluation

The tomato breeding program, set up by H.D. Madill in 1961 and carried on and expanded by J.G. Metcalf after Mr. Madill's resignation in 1963, has

had as its principal objective the development of high-colored, high-yielding, hand or machine-harvest cultivars for eastern Ontario, with disease resistance and desirable juice and whole-pack processing characteristics. Since Smithfield was established in 1945, cultivar evaluation has shown that cultivars developed from other geographical areas are not fully satisfactory for eastern Ontario. Mr. Madill incorporated the High Crimson and High Pigment genes into the early breeding program. As introduced, both these lines, although highly colored, were too late maturing for eastern Ontario. Also included in these early crosses were the so-called Birdsnet lines, a very compact plant type. This line of breeding was not carried on by Mr. Metcalf who took over the program in 1963 to permit greater emphasis on developing high-colored early cultivars. From crosses between Blitz and High Crimson 14, Mr. Metcalf selected ST-8, which as a high-coloured determinate plant broke the link between the High Crimson color and the indeterminate plant type. From this start he and plant breeders in Canada and the United States were able to incorporate High Crimson color into commercial processing cultivars.

When it became apparent in 1965 that the tomato breeding program at the Ottawa Research Station was being phased out, Mr. Metcalf made arrangements with L.H. Lyall to gradually take over the Ottawa Research Station's verticillium wilt resistance program. During the next 2 years this included the evaluation of all Smithfield selection material for verticillium wilt. It was then decided that the total Ottawa program, including the culture of the organism, should be transferred to Smithfield. As a result of this technology transfer, many of the Smithfield releases are resistant to verticillium wilt. Two other diseases have also been incorporated into the

Smithfield program, bacterial canker (1972) and tomato speck (1980).

Since 1962 the Smithfield program has been very successful, and a series of cultivars have been developed which have been utilized extensively not only by industry in the Smithfield area but by companies in other major production areas, such as southwestern Ontario. As early as 1966, Trent was released, and for a number of years it was grown successfully in the area even though it did not contain high-color genes. In rapid succession, cultivars were released with the high-color genes incorporated. These included Trimson (1971), Moira (1972), Quinte (1975), Earlirouge (1977), Earlibrite (1980) and Bellestar (1982). This group of cultivars, released from 1971 to 1982, contained progressively more and more of the desirable characteristics needed by the industry, including high color, desirable size, minimum core and scar, earliness, jointlessness, concentration of maturity, wholeness retention, and high production. In addition some of the more recent lines have resistance to verticillium wilt. Progress has been made in the development of lines resistant to bacterial speck. Recent crosses had resistance in at least one parent, and a backcrossing program has incorporated resistance into more promising lines including Quinte, Earlirouge, and Bellestar. Breeding for resistance to bacterial canker has not been as successful, and although no lines have been found to be totally resistant, some lines with a high degree of field tolerance have been found.

As part of the Smithfield program, a series of cooperative annual field and processing tomato variety and advanced seedling trials were set up by the various plant-breeding programs. Included were the breeding programs at OMAF stations in Simcoe and Ridgetown, at Agriculture Canada stations in Harrow and Smithfield, and at the University of Guelph. The results from

these trials conducted across Ontario were summarized using computer programs prepared by Mr. Metcalf, and the summaries were used by the various institutions to make recommendations for the growers and for future programs.

Irrigation

From the time of his appointment in 1960, H.B. Heeney emphasized the need to study the irrigation requirements of vegetable canning crops, particularly tomatoes as a continuation of his studies while he was on the staff of the Ottawa Research Station in the 1950s. Partly as a result of Smithfield studies, the use of irrigation became a routine management practice in the tomato-processing industry by the mid to late 1960s, as it was apparent that supplemental water was essential for efficient production of this crop in eastern Ontario. Growers generally accepted that an instrument was needed to estimate the requirement for water, and either the Bellani plate atmometer or plaster of Paris resistance blocks were commonly put to use. The studies indicated that even at only moderate densities (10,000 plants per hectare) yields were 50% higher with irrigation. At higher plant populations, up to 25,000 plants per hectare, consisting of yields of 40-50 tonnes per hectare, were the norm with proper irrigation. As an added bonus, irrigation plantings produced commercially desirable tonnage 4-5 days earlier and fruit size was not reduced significantly when plants were irrigated at high plant populations. The combination of breeding for tolerance to blossom-end rot and providing adequate irrigation has greatly reduced the problems caused by this physiological disorder in commercial fields. Irrigation studies also indicate that adequate irrigation increases considerably the success rate of direct seeding of tomatoes in eastern

Ontario. Recently, tomato irrigation studies were terminated, and attention was turned to studies on high-density population, including direct seeding made possible by efficient irrigation.

Plant density

When the station was established in 1960, the density of tomato transplants was commonly in the range of 7500-12500 plants per hectare. As irrigation became more readily available and as reliable chemical weed control procedures were developed, H.B. Heeney increasingly emphasized studies on the density of canning tomatoes. Field trials were set up ranging from 7,500 to 100,000 plants per hectare with the use of irrigation. With cultivars available in the 1960s it was shown that commercially acceptable yields (51 tonnes/ha) were obtained somewhat earlier with increased populations. The suggestion was made and accepted by many growers that plant populations of up to 25,000 plants per hectare were desirable. Above this population, there was generally no increase in total yields. These studies were repeated periodically as new cultivars became available, and as late as 1982 N. Smits demonstrated that the Smithfield cultivars EarliroUGE, Quinte, and Bellestar were considerably more productive when plant populations were increased from 14,000 to 28,000 plants per hectare. The more compact types require a higher density.

Although in the mid 1950s direct-seeded tomatoes were shown to produce a commercial crop, the lack of good procedures for chemical weed control did not make this method practical. As chemicals became available to control weeds in the 1970s, studies were conducted by H.B. Heeney and J.G. Metcalf on more efficient methods of planting tomato seed. A cone seeder gave higher

seedling counts and higher yields when compared with two types of plug mix seeders and a gel seeder. Problems with rapid desiccation of pregerminated seed in the plug mix suggested that planting ungerminated seed directly into the soil was the most satisfactory system for eastern Ontario soils and climatic conditions. These studies suggest that although direct seeding of tomatoes in early May can be successful, no more than 15% of the total crop area should be planted in this way because of the danger of frost kill of the seedlings.

Weed control

Use of chemicals to control weeds in tomato plantings did not become practical until the early 1960s. V. Warren was given responsibility to evaluate, on a continuing basis, the various potentially effective chemicals in an expanded weed-control program. His recommendations for transplanted tomatoes were rapidly adopted by growers, and by 1975 it was apparent that weed control in tomato fields was no longer a major problem. Chemical control had become a routine practice in eastern Ontario fields. Although the chemicals used changed with continued testing, chemical control of broad-leaved weeds and grasses was now possible using preplant-incorporated or postplant treatments. Because weeds and grass in direct-seeded plantings were a limiting factor in the expanded use of this method of producing tomatoes, Mr. Warren directed his research to finding chemicals for control of weeds in direct-seeded tomatoes. As early as 1966 Mr. Warren had shown some benefit with preemergence application of a diphenamid. Other chemicals tested to this date proved to be too variable. Studies conducted in the 1970s showed that combinations of trifluralin, metribuzin and sonalan were

commercially effective in the control of weeds and grasses in direct-seeded tomato plantings. After Mr. Warren's retirement in 1978, the work was continued by N. Smits (Parks). Mrs. Smits is currently evaluating the use of a number of promising new materials. At present the major problem is that most chemicals applied early in the season do not give full-season control of weeds. A further problem being studied is the failure of chemicals to control specific weed species, e.g. nightshade.

Growth regulators

During the late 1950s the first of a series of chemicals that affected plant growth and performance became available. In the mid 1960s H.B. Heeney and V. Warren initiated a series of studies using a number of chemicals including Ethrel and morphactin in a range of application rates and times of application. By 1970, Ethrel was shown to be very effective in tomato production, particularly as it affected early maturation of tomato fruit. Applications of 1250 ppm in the 1-3 true-leaf stage in the flat was shown to increase the set of fruit in the first two fruit clusters and to produce earlier yield. Applications of 0.36 kg per 0.40 ha when 5-10% of fruit were ripe dramatically increased early ripening of fruit except when temperatures were above 85-95°F. If the chemical is applied later in the year (September) higher application rates are required. V. Warren and later N. Smits showed that the beneficial effects of Ethrel varied with the cultivar. These recent findings indicate that the seedling plus the fall applications gave the best results. The findings are now being used routinely on eastern Ontario tomato plantings, particularly during seasons with cool temperatures in August and September. Other chemicals including morphactin were tested by Mr. Heeney

and Mr. Warren and later by Mrs. Smits. Although this material significantly increased the percentage of early, mature fruit, it was not of practical value at the concentrations used because much of the fruit was parthenocarpic, and sufficient damage was caused to the plant that total yields were significantly reduced.

Pickling cucumber trials

Along with the pickling cucumber cultivar trials and plant density trials conducted by J.G. Metcalf, H.B. Heeney and V. Warren studied the effects of Ethrel and morphactin on the returns from a once-over destructive harvest of pickling cucumbers. The results between 1970 and 1974 showed that Ethrel applied at the third true-leaf stage (250 ppm) plus morphactin (100 ppm) applied in late July gave returns up to 48% higher than untreated controls. They showed that returns from this treatment over the 3-year period averaged \$2700/ha. The economic benefit derived by these treatments appears to be the result of an increased percentage in the number of cucumbers in the high-value grades of 1-3.

Cauliflower management trials

As the processing of frozen foods expanded in eastern Ontario, a need developed for greater production of cole crops, particularly broccoli and cauliflower. J.G. Metcalf conducted variety trials to determine the most suitable varieties. W.P. Mohr evaluated processing quality, and Mr. Warren and J.G. Metcalf evaluated management practices. This work was taken over by N. Smits in 1979. Density of planting studies began in 1975 and showed that yields increased as plant density was increased to 63000 plants per

hectare. Over the years various herbicides have been evaluated by Mrs. Smits on both direct-seeded and transplanted cauliflower. She showed that although alachlor used alone before planting or combined with dacthal gave weed control in transplants, it did decrease plant vigor. Direct seeding into undisturbed seedbeds to which paraquat had been applied gave excellent control with no injury. These studies are being continued. One of the major problems with cauliflower for processing is uniformity of maturity. Mrs. Smits has shown that cool treatment of seedlings (8-10°C) for 2 weeks before they are transplanted permitted an average of 70% of the heads to be harvested at one time compared with an average of 15% when not so treated. Other trials are being conducted on mechanical methods of tying cauliflower to keep heads white. The machine being used was developed by the Engineering and Statistical Research Institute in Ottawa.

FIELD CROPS

Although Smithfield's main function has been to conduct research on horticultural crops, studies in cooperation with other stations have also been undertaken. Until 1975 Smithfield was one of the units taking part in the national potato trials. Since the eastern Ontario area represented by Smithfield is not a potato producing area, the work was transferred to the Kemptville Agricultural College. Cultivar trials for the Ottawa Research Station continue to be conducted on wheat and soybeans.

Grain corn

Since 1961 Smithfield has been taking part in the Ontario corn committee tests to evaluate hybrids of grain corn for eastern Ontario conditions and to

make recommendations to the seed and grower industries. Annual performance and official tests of up to 90 selections or cultivars have been tested each year. From the initiation of the trials hybrids tested have improved consistently. Average yields between 1960 and 1963 were 83.0 hL/ha. Between 1972 and 1975 the average yields of the trials were 126.8 hL/ha. For eastern Ontario considerable effort has been expended on the development of cultivars that mature earlier. Earliness as indicated by percentage of moisture and time of harvest has also been improved considerably. At the start of the trials, the average percentage of moisture of the cultivars at harvest was 28-30%. At present, the average moisture has dropped to 22-26%, with the two earliest hybrids showing an average of 20-22%.

PROCESSING STUDIES

With the completion of the new processing laboratory in 1959, it was possible to staff and equip the facility. The initial program established in the laboratory was primarily one of service to other sections on the station working on plant breeding, evaluation and crop management. The program was to ensure that no cultivar or other recommendation was made that would be detrimental to the processed food. It was thus established that the evaluation of processing characteristics of breeding lines, new cultivars, and material from cultural trials would be a major and continuing part of the program. Also studied were methods of processing, factors contributing to processed quality and yield, relationships between fresh and processed product, and objective tests for measuring quality. Since its completion the laboratory has been under the direction of W.P. Mohr, who was transferred

from Ottawa in 1960. Initially Dr. Mohr was provided with support by R.G. Adair, appointed in 1961. Mr. Adair, who had many years of experience in a commercial canning plant, was responsible for much of the actual processing while Dr. Mohr directed his attention to the more scientific experiments.

Processing evaluation of fruits and vegetables

Over a period of years all the apple cultivars grown in experimental trials at Smithfield were tested for physical and sensory quality characteristics. Apple samples were evaluated for juice production, applesauce, canned and frozen slices and pie filling. These comparative studies were published by W.P. Mohr. Results have shown that some of the new selections and cultivars from the breeding program, such as Lindel, Spigold, Wayne, and Idared, were as satisfactory as Northern Spy as processed products. Because of the importance of cider industry in Quebec, Dr. Mohr, in cooperation with the Research Station Saint-Jean, set up an evaluation of 26 of the commonly grown cultivars in eastern Ontario and Quebec as to suitability for cider production. Promising selections in breeding programs were similarly evaluated. They were tested for properties important in commercial juice extraction and for content of acid, tannin, and soluble solids.

Strawberries and raspberries were evaluated as frozen slices, frozen whole berries, and jam. For the most part, new selections were not considered for further testing if the quality of the processed products was not an improvement over Redcoat products.

Dr. Mohr and the processing laboratory were responsible for evaluating

the quality of potato chips and French fries using tuber samples from all the regional potato trials conducted at stations throughout Ontario. These tests included the evaluation of all materials for specific gravity and their commercial potential for chips and French fries. The results were used annually to help make recommendations on retaining or dropping selections from national and regional potato-breeding programs. In addition, the results were used to make recommendations on licensing.

A wide range of vegetable crops for processing were evaluated over the years, as canned or frozen products. The greatest emphasis was placed on tomatoes, as this was the crop receiving the most attention at Smithfield. Since its establishment, Smithfield has evaluated a wide range of processing crops suitable for eastern conditions in Ontario, including pickling cucumbers, pumpkin, squash, zucchini, cabbage, cauliflower, broccoli, Brussels sprouts, snap and wax beans, sweet corn and peas. These studies included the determination of the correct statistical size of sample for processing evaluation and the development of methods for determining the optimum maturity at which crops achieve the best processed yield and quality. All tomatoes under test at Smithfield were evaluated as juice and whole-packed canned product. The tests included physical and sensory evaluation of the canned product during the winter. The results were used to permit efficient evaluation of the progress of the breeding program. Since this program was established, every cultivar that has been named and released to growers has met stringent processing evaluation tests. Those that did not meet the requirements were not named or released. These same procedures were applied to material from all the public breeding and evaluation programs across Ontario. The various breeders conducting these programs used Smithfield's results to determine, at least partly, the future direction of their breeding program.

Development and assessments of processing techniques

W.P. Mohr and the staff of the processing laboratory have conducted studies, with apples and tomatoes in particular, aimed at improving processing techniques and developing of methods of assessing the fresh or processed product for qualities important to industry.

The work initiated in Ottawa on the use of infrared heat to blanch or peel crops was continued at Smithfield. The use of a continuous belt infrared tunnel resulted in improved flavor and texture of celery, apples, and French fries. Apple slices from infrared-blanching packs or syrup-vacuum packs were unchanged in shape after baking, whereas water-blanching or frozen packs had poor shape and texture retention. Studies on infrared tunnels showed that although infrared energy peeled fruits and vegetables efficiently the processing technique was not cost efficient.

Yields of apple juice, of vital interest to the industry, were improved by modifying prepress conditions. A normal recovery of 70-72% could be increased to 80% by slight heating of the crushed apples, adding an enzyme, holding for half an hour, and using press aids such as rice hulls and shredded paper. These juice-extraction techniques can also be used to increase juice recovery with apples stored late in the season, which ordinarily give a low recovery on pressing.

The explosive, puffing dehydration of some apples, pears, peaches and blueberries used for fruit snacks, as well as diced carrots and potatoes, was demonstrated. A new satisfactory product was produced from tart apples (McIntosh) for the snack trade, for instant applesauce, and as an additive to cereals. The product was at least as suitable as freeze-dried apples, but because a satisfactory coating method to prevent water uptake could not be

found, the product was not commercially desirable, even though it had superior flavor.

The increased use of various types of hand-held pressure testers for evaluating firmness and maturity of fresh fruit has resulted in a variation in the interpretation of findings. Extension specialists have found it necessary to evaluate the various instruments under controlled conditions. Differences in readings between operators were shown to be small, and between various instruments were no greater than the range of readings obtained with any one instrument. The factors that had to be standardized were location on the apple where reading was taken and apple size. Using a 10-apple sample, the results could be used to evaluate maturity.

Tomato color became a much more important consideration with the development of lines containing the High Pigment (hp) and High Crimson (og^C) genes. The intensity of the colors necessitated a new evaluation of methods of color assessment. It was shown that fresh samples could be used to indicate the color differences that could be expected after canning. It was also shown that these lines could be processed when the fruit was slightly immature, without a loss of juice quality.

Using processing and microscopic techniques, the laboratory assessed factors that determine wholeness retention in whole-pack tomatoes. The ratio of drained solids of canned tomatoes was shown to be very high with og^C high-color cultivars. Even after considerable shaking in the can, they were graded Canada Choice, whereas older cultivars without the og^C gene were below standard grade. Studies of fruit anatomy showed that the generous amount and distribution of pericarp tissue relative to locule size was the major factor. This finding suggests that such components as pectic materials,

calcium, cellulose and callose were necessary to wholeness retention. In cooperation with the Engineering and Statistical Research Institute, a very sensitive, nondestructive method of measuring whole fruit compressibility was developed, and the results were converted to firmness value. The results were correlated with wholeness retention of the processed product after shaking, particularly with the new firmer tomato cultivars.

Studies on the relationships between cultivar, yield, and maturity in shelled peas helped to formulate provincial grading regulations for canned and frozen peas. Methods were established to estimate the maturity at which peas grown in eastern Ontario should be harvested for maximum yield and quality. Joint work with Engineering and Statistical Research Institute, Ottawa, led to the development by that institute of an improved pea Tenderometer for objectively measuring maturity. This Ottawa pea Tenderometer was a quality-control type model of the more general purpose texture measuring instrument subsequently developed, the Ottawa texture measuring systems (OTMS).

The OTMS, fitted with a 13-kg force transducer and a back extrusion cell, was shown to measure tomato juice viscosity. Subtle reproducible differences in viscosity could be distinguished. Various features of the chart-recorded curve were related to such viscosity characteristics as serum viscosity and pulp particle size.

Various methods of peeling tomatoes were compared in an attempt to improve efficiency of this phase of processing in eastern Ontario plants. Hot-water peeling was shown to be the least efficient method--the peel separated several layers of cells from the epicarp. More efficient methods, when optimum conditions were found for each, were freeze-heat (using liquid

nitrogen), lye, and steam. The liquid nitrogen method resulted in the lowest waste (only paper "skin" was removed) but the cost of liquid nitrogen prohibited its use in many areas. The use of steam had an advantage over lye in that the peels removed in whole-pack preparation could be made into other tomato products.

Problem solving

From the time the laboratory was established, the processing industry and horticulturists in other research fields such as breeding, cultivar evaluation, and crop management made frequent requests to the laboratory to solve problems of processing or processing evaluation. McIntosh, the major cultivar produced in the area, is not particularly good for processing and methods of using it would be of importance. McIntosh was shown to make a highly acceptable dessert with firm texture, good color and excellent flavor when processed as vacuum-prepared pieces (cut in chunks or diced) packed in apple juice. The pieces also made an excellent addition to commercial fruit cocktail mixes.

The industry requested an explanation of the differences in the texture of applesauce. It was shown that the differences were due to particle-size distribution. Coarse sauces (e.g., Delicious) were due to large particles, the most desirable grainy sauces (e.g., Northern Spy) to medium-sized particles, and smooth sauces to small particles. The number of cells adhering in a cluster was the result of cell-wall structure. The differences in pectin and other constituents affected the ease of cell separation during sauce preparation, and thus affected particle size and resulting texture.

The occasional problem of poor sulfur penetration in frozen sulfured slices prepared for the pie trade, resulting in discoloration and loss of flavor, was shown to be associated with a low acid content of the fresh apples used. The problem was corrected by lowering the pH of the sulfur dioxide dip with acid additives to the bath. Varieties low in acid, particularly near the end of the storage season, required this treatment.

Color retention and general quality of processed cherries, particularly the canned Montmorency type, have been a constant problem. Appearance, especially brightness and color after canning, was materially improved by the addition of erythrosine at 39 ppm. Although taste panels indicated the product with added erythrosine was superior, the industry could not obtain permission to use the additive. Other studies showed that in bulk-frozen packs of Montmorency cherries, the best results were obtained with the use of fully ripe fruit, rapid cooling to 4-7°C, and limiting chilling and soaking ice water from 4 to 12 hours. Subsequent pitting, addition of sweetener and freezing must follow promptly.

In the mid 1960s on W.P. Mohr's return from educational leave, studies were initiated on the ultrastructure of fruit and vegetable tissue. Tissues damaged by freezing and thawing that were viewed under an electron microscope showed that the damage was due largely to the rupture of protoplasmic membranes and to the subsequent loss of the moisture-retaining capacity of the cells. Intermediate rates of freezing and thawing caused the least amount of structural damage by allowing the removal of some cellular water before solid freezing occurred. The minimal textural change that certain tissues (e.g., immature pea seeds) undergo was shown to be the result to the protective effect of large starch granules.

Studies on the fine structure of tomatoes, with the use of light and electron microscopes, have been useful in extending our knowledge of pigment bodies responsible for color of fruit and vegetable tissues, other relationships between tissue anatomy and edible qualities, and physiological phenomena including senescence. Soft and firm types of tomatoes, for example, differ with respect to the gradation of cell size from the outer fruit surface inward. In soft-fruited cultivars cell size increased abruptly from endocarp to mesocarp, whereas in firm-fruited cultivars a gradual increase in cell size took place.

In the early 1970s Ethrel became widely accepted as a treatment for ripening tomatoes quickly and achieving concentrated maturity. Ethrel at 0.72 kg/ha on 16 cultivars of tomatoes was shown to have no deleterious effect on wholeness retention or on observable factors processing quality. Infact, most of the 16 treated cultivars showed a slightly higher wholeness retention.

Reassessment of the methods of evaluating the color of fresh tomatoes fruit color and its relation to processed color became necessary with the greater use of High Crimson (og^C) and High Pigment (hp) genes in tomato-breeding programs. These studies involved the interrelation of the Hunter and Agtron instruments and the sensory evaluation of processed tomato juice color. It was shown that the color of tomatoes depended on the ratio of lycopene to beta-carotene. In the various lines of the tomato-breeding materials the ratios obtained were as follows; normal color lines (12:1); hp lines (14:1); og^C lines (38:1); a combination of hp and og^C lines (up to 51:1). Studies on tomato color are helpful in formulating new provincial grading regulations.

During the past five years, the processing industry has increased the production of tomato puree and paste to reduce the importation of these products. The laboratory has set up a program to identify the components of the tomato that determine the characteristics of yield and flow of the thin pulp and puree, which are of importance to commercial manufacture of puree, paste, and ketchup. Serum viscosity, an index of the pectin component, and water-insoluble solids were identified as major factors determining the consistency of either juice or concentrate. Although soluble or total solids have little or no relation to the consistency of a cultivar as juice or puree, the ratio of water-insoluble product to total solids is apparently related to the consistency of the tomato concentrate. Among the several methods of measuring consistency differences, the Bostwick Consistometer corresponded very well with subjective ratings. It was also shown that the OTMS with a back extension cell effectively measured the graininess as well as consistency of tomato juice.

Dr. Mohr and the processing laboratory are studying the nutritional composition of tomatoes to determine the levels of various minerals, vitamin C, dry-matter content, and nitrogen content of fresh and canned products. Such data collected over a number of years are expected to provide a reference source, thus permitting a comparison of eastern Ontario tomatoes with those produced in other areas.

At the request of the industry, the problem of soggy-centered French fried potatoes was investigated. Using light and electron microscopic techniques the soggy areas were shown to correspond with the tuber pith region, which had a lower content of starch and a higher content of absorbed

fat. The results suggested genetic manipulation as a practical remedy to the problem.

Mineral imbalances associated with physiological disorders in crops are being studied-e.g., hollow heart in potato and cauliflower, black speck on cabbage, blotchy ripening in tomato. The electron microprobe used in this work permits the analysis of lesion tissue and nearby nonlesion tissue as it exists in the intact plant part. Work on hollow heart in potato showed an increase in potassium and a decrease in chlorine from the stem to the apical end of the tuber, lower calcium in the stem end, and higher levels of all elements in the central pith. The magnesium content was also shown to be much higher in the small necrotic spots that characterize early symptoms of the disorder. These results suggest that a calcium deficiency associated with a localized magnesium toxicity triggers the onset of the cell necrosis in the pith and the resulting hollow heart.

TECHNOLOGY TRANSFER

From the time of the station's establishment, information obtained from experiments was passed on to the growers and to the processing industry as quickly as possible. All the staff members at Smithfield have taken part in this transfer of knowledge at annual field days and at the various local and regional grower association meetings. The professional and senior technical staff have served on the various commodity committees in Ontario including the Fruit Research Committee, Vegetable Research Committee, Ontario Corn Committee, Strawberry Council of Ontario, Ontario Fertilizer Committee, Ontario Crop Protection Subcommittees, and Ontario Soils and Crops Committees. Professional staff have been members and have served on

executive of the various scientific organizations related to horticultural crop research, including the Canadian Society of Horticultural Science, Agricultural Institute of Canada, Canadian Soil Science Society, Canadian Society of Food Technologists, American Society of Horticultural Science, and Canadian Phytopathological Society.

Since its establishment, Smithfield has maintained a close working relationship with representative of the Ontario Ministry of Agriculture and Food, agricultural representatives, horticultural extension specialists, and people in the processing industry. Since 1972 the provincial horticultural extension staff have been located on the Smithfield Experimental Farm, also resulting in close relationships among research staff, extension workers, and growers.

The results of the Smithfield research program briefly summarized in this report have been presented to the industry in various forms. Completed research has been reported in various scientific journals, and departmental and station technical bulletins. Preliminary reports have been published annually in the Research Branch Report and in reports of the Canadian Horticultural Council, and the Fruit and Vegetable Research Committees. Since 1973, the Smithfield Experimental Farm has prepared an annual report that is distributed to growers and other research scientists. In addition, station results are periodically published in local newspapers, farm newspapers, and for the local radio stations.

Professional staff located at the Division of Horticulture, Ottawa, with major research projects at the Horticultural Substation Smithfield 1944-1960:

L.P.S. Spangelo Ph.d.	1944-1960
S.N. Nelson Ph.d.	1946-1956
H. Hill	1945-1959
H.B. Heeney M.Sc.	1949-1960
W. Ferguson M.Sc.	1945-1956
L.H. Lyall M.Sc.	1946-1960
N.M. Parks B.Sc.	1946-1956
W. Phillips M.Sc.	1946-1960
E.A. Asselbergs Ph.d.	1956-1959
W.P. Mohr Ph.d.	1958-1960
J.J. Jasmin Ph.d.	1946-1952
S.R. Miller Ph.d.	1956-1960

Ontario Ministry of Agriculture and Food

horticultural extension specialists located at Smithfield Experimental Farm:

G. Comly

J. Warner M.Sc.	1972-1981
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D. Ridgway B.Sc.	1981-
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APPENDIX A

Permanent staff who have worked for least 1 year at the Smithfield
Experimental Farm:

DIRECTORS

D.S. Blair B.S.A.	1944-1959
H.B. Heeney M.Sc.	1960-1979
S.R. Miller Ph.d.	1979-

PROFESSIONAL STAFF

W.M. Rutherford B.S.A.	1956-1964
W.P. Mohr Ph.d.	1959-
H.B. Madill M.Sc.	1961-1963
S.R. Miller Ph.d.	1962-1979
S.J. Leuty Ph.d.	1965-1975
L.G. Monteith B.Sc.	1972-1979
H.L. House Ph.d.	1972-1980
J. Warner M.Sc.	1981-
N. Smits B.Sc.	1978-

OFFICE AND CLERICAL STAFF

M.R. Semple	1960-1980
A.M.T. Connolly	1966-1967
J.L. Metcalf	1967-
B.J. Donaldson	1981-1985
H.A. Chatten	1985-

TECHNICAL STAFF

R.G. Adair	1961-1981
V. Warren B.Sc.	1962-1978
J.G. Metcalf	1958-
L.C. Hunt	1959-
D.E. Hoskin	1960-
H.H. Brown	1967-
S. Williams	1967-1981
J.A.D. Berube	1972-1974
M.C. Rouse	1972-1980
R. Williams	1974-1978
G.M. Jamieson	1978-
S.E. Hay B.Sc.	1981-1985
D.J. Craven B.Sc.	1981-
D.M. Gregoire Trepanier	1981-1983
C.L. Potter	1962-

FOREMEN

G.E. Wilson	1944-1972
D.E. Potter	1972-

ASSISTANT FOREMEN

G. Westrop	1945-1948
C. Potter	1948-1960
D. Potter	1960-1972
M. Cooney	1972-

OPERATIONAL STAFF

C. Maybee	1944-1945
W. Smith	1944-1945
C. Clark	1944-1945
G. Greenley	1944-1945
G. Murray	1944-1945
R. Herrington	1945-1946
G. Herrington**	1945-1974
G. Ireland	1945-1946

OPERATION STAFF CON'T

D. Potter	1945-1972
G. Westrope	1945-1948
C. Potter	1947-1949
	1960-
C. Gerow	1949-
C. Taylor	1949-1954
P. Charlesworth	1945-1950
V. Potter	1950-1955
G. Potter	1950-1953
C. Potter	1951-1962
W. Potter	1951-1958
W. Kemp	1951-1952
C. Hadwen	1951-1952
C. Martyn	1951-1954
W. Bigford	1952-1953
H. Hanna	1953-1958
C. Whitney	1954-1975
D. Smith	1954-1955
H. Rhebergen	1954-1958
M. Cowan	1954-1955
T. Palmer	1955-1957
F. Wiggers	1955-1956
A. Bowen	1956-1967
N. Alyea	1958-1984

OPERATIONAL STAFF (CONT.)

P. Whaley	1957-
J. Simmons	1957-1958
B. Rhebergen	1957-1959
L. Chouinard	1959-
E. Ruttan	1962-
E. Covell	1956-1975
M. Goodsell	1962-1986
M. Sabo	1973-1985
W. Talmadge	1977-

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