AN APPRAISAL OF FUNGICIDES FOR THE CONTROL OF APPLE SCAB IN QUEBEC

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Roger Desmarteau

1952

This is to certify that the

thesis entitled

An Appraisal of Fungicides for the Control of Apple Scab in Quebec"

presented by

Roger Desmarteau

has been accepted towards fulfillment of the requirements for

M. S. degree in Botany & Plant Pathology

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Date March 7, 1952

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By

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Submitted to the School of Graduate Studies of
Michigan State College of Agriculture
and Applied Science in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
Department of Botany and Plant Pathology

1952

THESIS

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ACKNOWLEDGEMENTS

The writer wishes to express his sincere thanks to Dr. George Gauthier and Professor Donald Cation for their help in making this thesis possible. Thanks are due to Dr. Gauthier for his cooperation in permitting the use of the material collected from experiments conducted by the writer as a part of his regular duties with the Plant Protection Service, Quebec Department of Agriculture. Professor Cation's advice and criticism during the preparation of the manuscript were invaluable.

Thanks are also due to the generous aid the writer has received from assistants and workers at the Orchard Protection Station of Quebec during the course of these investigations.

INTRODUCTION

Since the early developments of the apple industry in America, apple scab caused by Venturia inaequalis (Cke.) Winter, has been recognized as one of the most important diseases affecting that crop.

On control alone, a great deal of research has been done since the nineties of the past century when Goff started the first experiments in United States for control of apple scab (13).

Even today, a number of plant pathologists, extension workers and horticulturists devote their time entirely or partly to control measures alone. Each year reports of field tests on spray materials are issued from all over United States and Canada.

During the past 15 years, new developments in the fungicide field have supplied new ammunition for the control of apple scab. The use of the organic fungicides is becoming more and more general among apple growers. However, further development is needed before these synthetic materials will displace the sulphurs as the main combat arm against apple scab, partly because the synthetics are more expensive but also because they are rather selective and may be inconsistent in their performances.

Most recently, a revolution in spray equipment and technique of applying materials to fruit offers new possibil-

ities for control of this disease. This new development, concentrate spraying, when equipment is adequately adjusted to particular orchard needs, or trees modified by pruning or cultural methods to meet equipment deficiencies, should not only effectuate a much needed reduction in cost of the spraying operation, but will possibly provide a better control of apple scab.

Despite the efforts of experimental workers and others, losses due to apple scab are still high. High losses apparently result from poor timing, difficult to achieve in some years because of excessive rainfall and rapid growth, improper use of old standard materials as well as inexperience with the new ones and poor coverage which may be an important factor with new fungicides and spraying machinery.

Recently, McNew, McCallan and Miller have reported, for 1920 to 1939, compilations of loss from the most important diseases affecting apple in United States (14). For a 20-year average covering the period 1920-1939, it was estimated that 10½ million bushels of apples a year have been lost on account of apple scab. According to these writers, this would mean, at present prices, a loss of 25 to 30 million of dollars a year.

In 1945, a severe epidemic struck the northeastern states. No exact figures are available but it was reported as the worst blow in two decades in New York by Burrell (2) and no doubt the loss ran into millions of dollars, though frost and poor pollinating conditions also took a toll in that disastrous year.

IMPORTANCE OF APPLE SCAB IN QUEBEC

The apple industry in Quebec is concentrated in the southwestern part of the province. By far the greatest number of orchards are situated south of the St. Lawrence River in the Montreal Plain and the Appalachian Region.

In the vicinity of Montreal a number of orchards are located on the north shore but most are planted in an area south and east of the metropolis. To the east, most orchards are concentrated around the Monteregian Hills, a series of small elevations of volcanic origin scattered in the plain. The five hills, St. Bruno Mount, St. Hilaire Mount, Rougemont, St. Paul Mount and St. Gregoire Mount are all centers of apple production.

South of the city other orchards lie on gently undulating ground in the valley between the St. Lawrence and its tributary, the Richelieu river. Chateauguay, Huntingdon, Hemmingford and Franklin are the most important centers of that district.

Further east from Montreal, beyond the Richelieu river, other orchards are planted on the edge of the plain and on the slopes of the Appalachian Mountains. The Frelighsburg district in the Missisiquoi county is the most important one in the Appalachian Region. It is a new producing area, the first trees having been planted in 1927 and it now includes around 250 thousand trees.

A most recent survey of the Horticultural Service of the Provincial Department of Agriculture and compilations

by the Department of Commerce and Industry gives statistics regarding the nember of trees of bearing and non-bearing ages for the leading varieties in the province. This information is summarized in table 1 for the Montreal and the Appalachian Regions.

The apple industry also extends in the east of the province, lower in the St. Lawrence Valley. In this third area the Eastern Quebec apple region, small orchards are distributed on both shores around Quebec city. On the south shore orchards extend east into Kamouraska county. A number of trees are planted on Orleans Island, one of the oldest apple districts situated a few miles below the city.

Compilation of statistics is not finished for Eastern Quebec but it is estimated by the Horticultural Service, that there are 250 to 300 thousand apple trees in the area. 50 to 60% of these are the McIntosh variety.

In Southwestern Quebec there is a little over 1 million trees with 55% of the McIntosh variety, an apple of the finest quality and high market value but also very susceptible to scab.

Table 2 gives the annual yield of apples in Quebec from 1933 to the present and the average price obtained for McIntosh and Fameuse, the two leading varieties. These figures give an idea of the importance of the crop in the province.

Table I--- NUMBER OF APPLE TREES IN SOUTHWESTERN QUEBEC

*

Varieties	No. of trees of non-bearing age	No. of trees of bearing age		Total
		15 year old and less	more than 15 years old	
McIntosh	118,723	191,277	259,242	570,242
Fameuse	11,946	53,339	92,231	157,516
Duchesse	3,036	9,332	38,275	50,643
Wealthy	2,335	10,952	19,798	33,085
Melba	12,720	21,069	14,784	48,573
Jaune Transparente	4,395	11,396	14,815	30,606
Lobo	8,172	14,196	2,237	24,605
Cortland	13,728	16,997	3,133	33,858
Others	15,925	33,700	38,833	88,458
Total	191,980	362,258	483,348	1,037,586

Table 2--- TOTAL YIELDS OF APPLES IN QUEBEC AND AVERAGE PRICES PER BUSHEL

Years	Number of bushels	Average prices for McIntosh and Fameuse
1933	986,850	---
1935	504,339	---
1936	324,870	---
1937	561,990	---
1938	445,200	2.74
1939	1,066,305	2.51
1940	1,030,980	2.28
1941	726,154	3.34
1942	1,170,000	3.27
1943	911,000	3.81
1944	900,000	3.57
1945	80,000	---
1946	1,000,000	3.92
1947	1,300,000	3.39
1948	1,005,450	3.04
1949	2,250,000	2.52
1950	1,900,000	1.75
1951	3,110,000	1.75 (about)

Apple Scab in Quebec

There are no statistics available for apple scab in Quebec. However, each year the Canadian Plant Disease Survey issues an annual report in which plant pathologists from all the provinces give an account of their observations on plant diseases of economic importance.

In the province of Quebec, observations on apple scab have been reported from year to year since the start of the Quebec Spray Service in 1929. Though some of the reports are fragmentary, often referring only to particular locations or orchards, they do give an idea of the prevalence and losses from apple scab in Quebec for the past 20 years.

For most of the years from 1929 on, conditions were favorable for scab development. An appreciable loss was reported each year except for 1934, 1941, and 1948 when scab was of little importance.

The approximative percentages of infected fruits in some of the poorly sprayed orchards reported on, may give an idea of the losses that occurred. These percentages ranged from 30 to 60 in the years 1929, 1931, 1935 and 1939. Reduced yields that accompany such heavy infections were not considered in these estimations.

An example of such losses that do occur, is shown in counts by the writer in 1949 in an orchard where sprays were poorly timed. 45% of the fruits of the McIntosh variety were found scabbed, most of them badly. In addition, the setting that had been excellent was reduced

considerably by the disease and also there was only a small crop the following year though scab was under control.

No figures were given in the other years for orchards of this type in which most of the losses from apple scab are likely to occur. Of course, in well-sprayed orchards, scab was much less important and when reported, it ranged from "slight" to 10%. Though during epidemic years the percentage of scabby fruits must have been higher, in general.

1931 and 1932 are mentioned in the reports of the Canadian Plant Disease Survey, as years where scab was "especially prevalent" (3)(4) and 1933 was worse when orchards "usually free from scab, did not escape"(5). Again in 1937, scab is reported as "very destructive"(6).

Apparently, 1943 was one of the worst years for apple scab in Quebec when "scab was usually severe throughout Quebec"(17). A severe outbreak occurred in 1945 when scab was "exceptionally severe and widespread"; "most of the orchards showed infections, often with almost complete defoliation"(7), Petch states, for the province,that "the greatest epidemic in the history of apple growing" occurred that year (18).

Again in 1947, scab struck hard in Quebec. Scab is reported in the Canadian Plant Disease Survey as having caused "great losses in Southwestern Quebec" and "few growers secured clean crops" (18).

For the following years, seasonal scab development

is reported later by the writer and need not be described here.

One point that stands out in reviewing the reports on apple scab in Quebec, is the many times late infection has occurred. Late scab has been a real problem in many years. The relatively frequent heavy precipitation during August and early September results in considerable late infection, causing appreciable losses to apple crop fairly or exceptionally free from early scab.

Fungicides in Use Against Apple Scab in Quebec

Most of the growers in Quebec use Lime-Sulphur and elemental sulphurs to control apple scab. The sales of the main spray materials in Quebec for the past few years are presented in table 3.

There is a progressive decrease in the use of Lime-Sulphur, and when used, it is frequently applied as an emergency for eradicative purposes, though a number of growers are still on a straight Lime-Sulphur schedule.

Elemental sulphurs came into use around the late thirties in Quebec. Kolospray, a proprietary formulation of wettable sulphur, was the first to be generally used. Other proprietary brands of sulphur have been used since. Magnetic 70 sulphur paste was introduced in 1948 and has gained in favor and use by growers.

Organic fungicides have yet to be used extensively, except possibly Ferbam, the iron salt of dimethyl dithiocarbamic acid. Ferbam was not used in appreciable

Table 3--- SALES OF THE MAIN SPRAY MATERIALS IN QUEBEC[I]

Materials	1949	1950	1951
Lime Sulphur	138,600 gals.	128,700 gals.	112,200 gals.
Kolospray	---	---	30,000 lbs.
Magnetic 70	160,000 lbs.	400,000 lbs.	440,000 lbs.
Crag 341 C	---	---	600 gals.
Ferbam	---	---	200,000 lbs.

I--These figures have been obtained from the Cooperative Federee de Quebec.

amounts before 1950 but is now becoming more popular.

Crag 341C, a glyoxalidine formulation, was used for the first time in 1951. The organic mercuries are also of recent appearance and have been used only in isolated cases as emergency spray.

FIELD TESTS AGAINST APPLE SCAB IN QUEBEC

The experiments here reported have been conducted at the Orchard Protection Station, a summer laboratory of the Plant Protection Service of the Quebec Department of Agriculture.

This work has been done in the Frelighsburg district in Missisiquoi county at two different locations. A first series was completed in the years 1948, 1949, and 1950 at Dunham and another series not yet completed was begun at Farnham in 1951.

Methods

At Dunham, the tests were made on 20 year old McIntosh trees while at Farnham, Melba trees were also included in the experiments.

In the first series, each treatment was replicated 4 times in plots arranged in randomized blocks. Trees were uniform in size and planted in diagonal rows. Each block was bordered by rows of Fameuse and Melba. Each plot consisted of 9 trees so that 36 trees were sprayed for each treatment.

In the second series triplicated plots of 9 trees were used. The trees are planted in the square system and are about the same size giving fair uniformity. The plantation was set 18 years ago and trees are bigger than those in the first series at Dunham.

Two of the blocks contained a row of Melba trees that are included in the counts. Data collected from Melba are thus obtained from duplicate plots.

The application of material was done with an ordinary hydraulic sprayer, a small machine manufactured by the John Bean Company. This sprayer has a 200-gallon tank capacity and a possible discharge of about 15 gallons per minute.

The treatments were applied with a "Spray Master de Luxe Gun", the operator spraying from a tower on the apparatus. Pressure was kept at about 550 pounds per square inch.

All treatments were applied by the same operator except in 1950 when, under uncontrollable circumstances, the last 3 cover sprays were applied by another worker.

Timing of the sprays was based particularly on close observations of the rate of development of the trees, state of the weather and several other factors. Thus, the daily expansion of cluster leaves and growth of new shoots was observed to determine the development of uncovered leaf area; the prediction of rainfall, the amount of weathering resulting from previous precipitation, temperature, the humidity (which indicated the rapidity of drying) were all taken into consideration.

Except for 2 cases in 1948, all the protective treatments have been completed the same day. For the materials applied for the express purpose of eradication in 1950 and 1951, the treatments were made only after infection periods.

Within limits, fairly uniform gallonage was attained. Checking was done on this point at frequent intervals during spraying.

Wind in general was not a factor in hindering applications. No spraying was done under really adverse conditions. At Farnham in 1951 where windy conditions prevailed, most of the spraying was done at night under conditions of quiet air.

Data were collected at sometime during the summer on the foliage and on the fruits in the trees, on the windfall apples and again immediately after harvest. The harvested apples were brought inside and classified under the different categories for amount of scab and russeting, more or less according to regulations of the law of commercial classification in Quebec.

These comparative categories were as follows:

1) severe scab: individual spots more than ½ inch in diameter or any cracked open scab or several coalesced spots that cover more than ½ inch in diameter. Apples having that type of infection are considered as "culls" in the commercial classification.

2) light scab: total surface covered, less than ½ inch and no cracking. Apples in this category may be accepted in grade "C".

The categories of scab described above have not been

closely followed at all times and early infections and late infections have sometimes been distinguished and are defined later.

The categories for russeting were:

1) light russeting: a few streaks any place on the fruit or in most of the cases, light russeting in the cavity (depression around the stem). This category is not considered in commercial classification.

2) medium russeting: russeting covering 1/8 to ½ of the surface of the fruit. Such apples are classified as grade "C".

3) severe russeting: involves over ½ of the surface of the fruit. Severe russeted apples are culls.

Foliage data were collected by counting the number of scabby leaves around the tree in a peripheral zone of chest height from the lower limbs and for a distance of arm length of about 3 feet into the trees.

The number of scabby fruits in the trees during the summer was also determined in that zone.

Trees chosen for the counts were approximately of the same shape, spread and height. Always the same operators (2, 3 or 4 men) did the counts in a particular season. The same number of men were not always engaged in the operation but once a count was begun, the same operators stayed on the job until it was finished.

Care was taken to make the counts during a dry, warm spell when there was no scab development or just a few days

after the appearance of the first scab spots in June and then the counts were made in a single day.

Materials Used in the Tests

The following fungicides were used in the tests:

1) Commercial Lime-Sulphur was used only in 1948, at the strength of 2½ gallons (imp.) in 100 gallons of water in the first 2 sprays and at 2 gallons in 100 for the rest of the season. 7½ pounds of hydrated lime was added to the mixture in all the sprays.

2) A mixture of Lime-Sulphur at the strength of 1 gallon (imp.) and Kolospray, at the concentration of 9.6 pounds in 100 gallons (imp.) of water, were used in 1948 and 1949.

3) Kolospray (85% sulphur) was used 3 years at a concentration of 9.6 pounds per 100 (imp.) gallons of water. Kolospray is an elemental sulphur manufactured by the Niagara Sprayer and Chemical Company. According to the manufacturer, it consists of a mixture of 33% "Bentonite Sulphur" (fused sulphur absorbed into bentonite) and an elemental sulphur.

4) Mulsoid (93% sulphur) is a micronized sulphur produced by the Sherwin-Williams Company. The Micronizer process yields very fine particles of sulphur but nevertheless not more so than the pastes and sulphur obtained by the Grinrod process (9). Mulsoid was used only in 1948.

5) Magnetic 70 (not less than 69% sulphur) is a

sulphur paste obtained by the Grinrod process. The particles of this product are among the smallest ones of the elemental spray sulphurs. Magnetic 70 sulphur paste must not be confused with the so-called "Flotation sulphur pastes" which also have very fine particles but are obtained by an entirely different process, being a by-product of the artificial gas industry. Flotation sulphur pastes have a low sulphur content that varies with impurities but generally are around 50% sulphur. Magnetic 70 has been used during the four years at the concentration of 9.6 lbs per 100 (imp.) gallons of water. This product is manufactured by the Stauffer Chemical Company.

6) Ferbam has been used since 1949 as Fermate, a product of the Dupont de Nemours Company. Fermate contains 70% ferric dimethyl dithiocarbamate as the active ingredient. It was used at the rate of 1.8 lbs per 100 gallons (imp.) of water. It is a black powder with the characteristic smell of urae.

7) Tag Fungicide No. 331 an organic compound containing 10% phenyl mercury acetate was used during 3 years. It is a product of the California Spray Chemical Corporation. It is claimed to be a protective and eradicative material for the control of apple scab. In 1949 and 1950 it was used on a protective basis while in 1951 it was tested as an eradicant. Tag Fungicide has been employed at the recommended concentration of ½ pint to 100 gallons (imp.) of water.

8) Puratized Agricultural Spray manufactured by the

Gallowhur Chemical Corporation was used in 1950 and 1951. It is also a mercury compound, consisting of 5% phenyl mercuri triethanol ammonium lactate. It has been tried as an eradicant at the rate of 1 pint in 100 gallons (imp.) of water.

9) Crag Fruit Fungicide 341 C, a mixture of glyoxalidines in isopropanol, was used for the first time in 1951. It was tried at the rate of only 1 pint in 100 gallons (imp.) of water. This product is manufactured by Union Carbide and Carbon Corporation.

10) Merthon 642, a relatively new combination, was used only in 1951. This product is manufactured by the Eastern Chemical Corporation. It is claimed to be a fungicide-insecticide material effective against apple scab, aphis and "red mites". According to the company, the composition of this product is as follows: 10% mercurated pentaethyl triphosphate, 5% mercury as metallic, and 89% pentaethyl triphosphate and other related organic phosphoric esters.

This liquid material is suggested to be used as a supplement ot a sulphur or Ferbam program. Claimed to be eradicative, it is applied in the critical period of the early sprays. In the 1951 schedule it was employed at the rate of ½ pint to a mixture of 3/5 lbs Fermate in 100 gallons (imp.) of water.

Schedules

Adequate protection against insect pests was provided each year in addition to our experimental scab sprays.

To prevent an infestation of the European red mite, in 1948, a superior type oil, Sovaspray, was applied to all plots at the concentration of 2%. This treatment was followed on May 7 by an application of Bordeaux mixture 2-4-100 that constituted the first preventive treatment against scab at delayed dormant.

Again, in 1949, a superior type oil, Sun Superior Oil No. 11, was applied but was combined with Bordeaux mixture 2½-5-100 in the first spray at the delayed dormant stage.

At Farnham, in 1951, the fruit tree leafroller and the European red mite were threatening and a semi-dormant spray consisting of 3% Sun Superior Oil was given on April 27. Later in the season, 2 lbs of DDT 50 W were applied on June 1st to get rid of the larvae of the fruit tree leaf roller that had survived in spite of the oil application to kill the eggs in the spring.

At any time during the four years, lead arsenate was added to the tank in the proportion of 3-3/4 lbs per 100 gallons (imp.) of water, when necessary and especially in July for apple maggot in accordance with the law. However, lead arsenate was never used in conjunction with incompatible materials such as Puratized Agricultural Spray.

Straight-protectant schedules are often inadequate in years favorable to heavy infections. Timing is often

difficult to achieve with rapid growth and frequent rains. In the past, during such years, good control was easier to achieve in general with the use of Lime-Sulphur which has both protective and eradicative properties. However, when long periods of rain occurred, even Lime-Sulphur applied within 50 hours after the beginning of the rain, failed to give adequate control at most favorable temperatures.

With the advent of the organic mercury materials that eradicate scab if applied up to 72 hours or more after an infection period, it seemed more desirable to work out split-schedules for emergencies. Thus when the trees are not adequately covered with protective materials before an infection period occurs, it appears possible that an eradicative material can be applied within sufficient latitude of time to prevent or stop the infection.

With this purpose in mind, Puratized Agricultural Spray, in 1950 and 1951, and Tag Fungicide No. 331 in 1951, were applied only after infection periods.

Because of their mercury content both materials were replaced by Magnetic 70 after the second cover spray. In the early critical periods no other material was sprayed on so that no protection was given to the trees before infection periods in order to determine the eradicative possibilities of the materials.

In 1948, the following materials and their concentrations in 100 gallons (imp.) were used:

Lime-Sulphur, first two sprays.....2½ gallons

others.....2 "

plus hydrated lime.....7½ lbs.

Kolospray.....9.6 lbs.

Kolospray.....9.6 "
plus
Lime-Sulphur.....1 gallon

Magnetic 70.....9.6 lbs.

Mulsoid.....9.6 "

Table 4 refers to schedule followed in 1948.

The following fungicides were used in 1949 at the concentrations per 100 gallons (imp.) mentioned below:

Tag Fungicide No. 331.....1/2 pint

Kolospray.....9.6 lbs.

Fermate.....1.8 "

Magnetic 70.....9.6 "

Lime-Sulphur.....1 gallon
plus
Kolospray.....9.6 lbs.

Table 5 refers to schedule followed in 1949.

In 1950, the following fungicides were tested at the concentrations listed to make 100 (imp.) gallons:

Tag Fungicide No. 331.....1/2 pint

Kolospray.....9.6 lbs.

Fermate.....1.8 "

Magnetic 70.....9.6 "

Puratized Ag. Spray.....1 pint

Table 6 refers to schedule followed in 1950.

The fourth year, 1951, the following products and their concentrations in 100 gallons (imp.) were used:

Tag Fungicide No. 331.....1/2 pint

Table 4 --- SCHEDULE OF THE SPRAYING EXPERIMENTS FOR 1948

Pre-pink	Late Pre-pink	Pink-Late pink	Full bloom	1st. cover	2nd. cover	3rd. cover	4th. cover
May 10	May 13	May 20-22	May 31	June 12	July 1-2	July 14-15	July 27-28
Mulsoid	Mulsoid	Mulsoid	Mulsoid	Mulsoid	Mulsoid	Mulsoid	Mulsoid
Kolospray	Kolospray	Kolospray	Kolospray	Kolospray	Kolospray	Kolospray	Kolospray
Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sulphur plus Hydrated Lime	Lime-sul phur plus Hydrated Lime
Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70
Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur	Kolospray plus Lime Sulphur

Table 5--- SCHEDULE OF THE SPRAYING EXPERIMENTS FOR 1949

Late pre-pink	Late pink	Calyx	1st. cover	2nd. cover
May 5	May 10	May 20	May 27	June 9
Tag fungicide	Tag fungicide	Tag fungicide	Tag fungicide	Tag fungicide
Kolospray	Kolospray	Kolospray	Kolospray	Kolospray
Fermate	Fermate	Fermate	Fermate	Fermate
Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70	Magnetic 70
Lime Sulphur plus Kolospray	Lime Sulphur plus Kolospray	Lime Sulphur plus Kolospray	Lime Sulphur plus Kolospray	Lime Sulphur plus Kolospray

Table 6--- SCHEDULE OF THE SPRAYING EXPERIMENTS FOR 1950

Delayed Dormant	Early pre-pink	Pre-pink	Full pink	Calyx	1st. cover	2nd. cover	3rd. cover	4th. cover	5th. cover	6th. cover
May 9	May 14 May 17	May 19 May 20	May 25	May 31	June 5	June 15	June 20	July 4	July 21	Aug. 4
Tag Fung-icide	Tag Fung-icide	Tag Fung-icide	Tag Fung-icide	Tag Fung-icide	Tag Fung-icide	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic
Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray	Kolo-spray
Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate
Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic
	Pura-tized Ag. Spray (May 17)	Pura-tized Ag. Spray (May 20)		Pura-tized Ag. Spray	Pura-tized Ag. Spray	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic

Table 7---

SCHEDULE OF THE SPRAYING EXPERIMENT FOR 1951

Delayed Dormant	Early pre-pink	Pink	Late pink	Late bloom	1st. cover	2nd. cover	3rd. cover	4th. cover	5th. cover
May 3	May 10	May 14 May 16	May 18	May 25	May 30 June 1	June 7 June 11	June 18	June 26	July 11
		Tag Fung-icide (May 14)		Tag Fung-icide	Tag Fung-icide (May 30)	Tag (June 7) Magnetic (June 11)	Mag-netic	Mag-netic	Mag-netic
Fermate	Merthon Fermate	Merthon Fermate	Merthon Fermate	Merthon Fermate	Fermate	Fermate	Fermate	Fermate	Fermate
Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate	Fermate
Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic	Mag-netic
		Pura-tized Ag. Spray (May 14)		Pura-tized Ag. Spray	Pura-tized Ag. Spray (May 30)	Pura-tized Ag. (June 7) Magnetic June 11	Mag-netic	Mag-netic	Mag-netic
Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C	Crag 341 C

Merthon 642.....1/2 pint
plus
Fermate.....3/5 lbs.

Magnetic 70, until 3rd cover spray.....8 lbs.
from 3rd. cover spray on.....5 "

Puratized Ag. Spray.....1 pint

Crag Fruit Fungicide 341C...1 pint
plus
Hydrated Lime.....3/5 lbs.

Fermate.....1/8 "

Table 7 refers to schedule followed in 1951.

SEASONAL DEVELOPMENT OF SCAB

Previous investigators have shown the importance of climatic factors upon the seasonal development of scab.

In conjunction with the field tests, temperature, rainfall and humidity were also recorded to get a better comprehensive knowledge of the behavior of scab and a more accurate determination of fungicide performance.

Temperature and humidity were obtained with hygrothermographs and maximum and minimum precision thermometers.

Two rain meters were used, a simple rain gauge that serves to record the amount of rain and an automatic rain recorder to give duration and intensity of the rain.

Determination of the Primary Infection Periods

In 1950 and 1951, primary infection periods were closely followed. Determination of the periods were made according to Mills on the basis of hours of wetting of the foliage and the mean temperature prevailing during that time (15).

The approximative length of a wetting period was determined by considering the duration of the rain (recorded by the automatic rain meter) and such factors as the time at which the rain had occurred in the day, observations on humidity, sunshine, wind velocity and particularly by observing the foliage in relation to its wetness.

The mean temperature during a wetting period was calculated from the thermograph diagram. Once obtained, it was then compared with the computations of Mills which gave the length of the wetting period necessary for an infection to occur at that temperature. This indicated whether or not infection had taken place.

An example is given here to illustrate that point. On May 11, 1951, a rain started at 7 p.m. and ended on May 12 at 2 p.m.; the sky remained covered after the rain and there was no wind that day; the leaves did not dry up before 5 p.m. According to Mills' table, 16 hours of wetting is required for infection at 48°F during that period: the leaves had been wet during 22 hours, indicating an infection had taken place.

In several cases it was possible to check the occurrence of the infection periods with the date of appearance of scab spots. Rate of foliage and fruit development, especially of the cluster-bud leaves and the first leaves of the terminal shoots, was closely followed in order to distinguish the dates at which lesions became apparent.

These dates were compared with the interval necessary for scab to become visible at the preceding temperatures.

The incubation period given by Mills (20) was followed for this determination after the mean temperature for the 5 days following the infection had been calculated.

For the rain period of May 11-12, 1951, it was calculated that infection started 16 hours after the beginning of the rain and that there was an interval of 15 to 17 days before scab spots would appear on the foliage. Scab spots did appear after this interval and in that case, it was possible to check the occurrence of the May 11-12 infection period.

From the rain period of May 23, 1951, it was also possible to check the incidence of infection after calculation of the incubation period and the fact that scab spots appeared on the fifth and the sixth leaves of the terminal shoot that were not expanded when the first infection (May 11-12) occurred.

Applications of the eradicants were timed on these determinations wholly based on Mills' indications. The eradicant materials were applied within a number of hours after the start of infection periods indicated according to Mills' tables.

Some of the final primary infection periods could not be checked definitely as secondary infections were also possible toward the end of ascospore discharge. Nevertheless, it is believed that the calculated primary infection periods of May and of the early days of June were delimited and the calculations were of value in timing the organic mercury treatments.

Periods of Ascospore Liberations

No attempt was made to follow closely ascospore discharge but work has been done in connection with that point and may be of some value here.

Over-wintered leaves were gathered from different places in the orchard and only those bearing numerous perithecia were chosen for the work. Leaves were placed side by side in the bottom of a rectangular box of one foot long by five inches wide and five inches high. This box was provided with a fine-wire bottom so that leaves deposited in it had some contact with the soil. The box was open at the top and exposed to rains in the orchard when in operation.

Vaseline-coated slides were used as spore traps. They were placed face down about ¼ inch above the leaves on narrow wood supports.

Tables 8 and 9 show data obtained from examinations of the coated slides at various intervals after periods of exposure to the shooting asci.

The exact amount of rain fallen during the exposure is shown in relation to the dates of liberation and the comparative number of ascospores discharged. Number of spores emitted at the different dates is not strictly comparable as no effort was made to examine all microscopic fields after spores were once found. Nevertheless, dates of first effective emission of ascospores are probably accurate since slides were exposed before buds had expanded and were examined following each rain.

The tables also give an idea of the intensity of the spores liberation though they do not indicate the exact dates of heavier emission.

The extent of ascospore discharge cannot be determined accurately by spore traps. If spores were not collected on the slides, it does not preclude liberation as there were indefinite numbers of perithecia in the orchard. This would be especially true for late spore discharges. However, as the leaves exposed were selected for numerous and mature perithecia, it is believed that the earliest effective emission of ascospores has not been missed.

Spore traps alone were not considered reliable in timing the sprays and determining the infections. In no case, was a rain period considered a non-infection period because no spores were caught on the traps.

In 1950, the first liberation of spores recorded, occurred during the rain of May 16. Apparently heavy discharge occurred with succeeding rains from that date until the first days of June.

Correspondingly, that period of heavy spore discharge was also the most critical for rapid development of leaf growth and fruit bud expansion. This is indicated in table 10. Thus in 3 days, leaves expanded rapidly, increasing in number from 2-3 to 5-6 in each cluster, and in two more days, all leaves were expanded. From May 16 to May 22, during which apparently most of the ascospores were expelled, the vegetation developed from the Early Prepink to Pink

stage, or from a tight close cluster of blossoms to well separated blossoms with pedicels well exposed.

No rains were recorded from May 20 to May 30 but from then on, rain fell each day for a week except on June 5. As a result, more spores were ejected and further primary infections occurred.

In 1951, the growth started earlier and also developed at rapid rate (see table 11). The first emission of spores was recorded during the rain of May 11 and 12 when the trees were at the Prepink stage. However, heavy discharge took place several days after the opening of blossoms which occurred on May 21.

Many of the trapped spores on the slides examined on June 15 (1951) had been expelled apparently several days previous. Some were dessicated and many were already germinated but many more were fresh and plump showing recent ejection.

Thus in 1951, heavy liberation of ascospores seems to have occurred mainly during the rains falling in the last days of May and the whole month of June. Rain was recorded on 14 days during that period.

There is little doubt that ascospore discharge extended over a wide period of time in 1951, at least from May 11 to June 27 when the last ascospores were trapped. A grower in the neighborhood of the experimental orchard, who stopped dusting in the middle of June because of excellent control, found his trees heavily infected at the end of the month.

Table 8--- ASCOSPORE DISCHARGE FOR THE SEASON 1950

Dates of examination	No. of hours of exposure	No. of Spores	Hundreth inch of rain recorded during exposure	Dates this rain was recorded
May 5	20	0	0	---
" 6	24	0	0	---
" 12	--	0	3 8 1	May 8 " 10 " 11
" 14	48	0	46	" 14
" 17	48	125 x	5 6	" 16 " 17
" 19	48	50 x	7 30	" 18 " 19
" 20	24	17 x	3	" 20
June 3	--	10 x	1 24 4 51 16	" 30 " 31 June 1 " 2 " 3
" 7	96	2	39 3 9	" 4 " 6 " 7
" 14	--	0	5	" 11
" 18	--	0	124	" 18

Table 9--- ASCOSPORE DISCHARGES FOR THE SEASON 1951

Dates of examination	No. of hours of exposure	No. of spores	Hundreth inch of rain recorded during exposure	Dates this rain was recorded
May 8	24	0	2	May 8
May 9	24	0	0	---
May 11	60	0	.5	May 11
May 12	24	1	23	May 12
May 17	24	2	35	May 17
May 23	24	2	24	May 23
May 28	72	3	65	May 28
June 15	--	100 x	162	May 30
			45	June 4
			11	June 5
			47	June 7
			13	June 14
			56	June 15
June 18	72	15 x	6	June 17
			6	June 18
June 25	--	26	97	June 22
			88	June 23
			91	June 25
June 27	48	4	1	June 28
July 2	--	0	39	June 30
			11	July 1
			37	July 2

Table 10--- VEGETATIVE STAGES OF THE APPLE TREE FOR 1950

Delayed Dormant	Late del. dormant	Late del. dormant	Early pre-pink	Pre-pink	Pink	Full pink	Bloom	Calyx
1/8" - 1/4" of leaf out	1-2 leaves well expanded	2-3 leaves well expanded	5-6 leaves well expanded	All leaves well expanded	Blossom pink and separated	Blossom pink and petals loosening	Blossom expanded	Petals fallen
May 8	May 11	May 13	May 17	May 19	May 22	May 24	May 26	May 31

Table 11--- VEGETATIVE STAGES OF THE APPLE TREE FOR 1951

Delayed Dormant	Late del. dormant	Late del. dormant	Early pre-pink	Pre-pink	Pink	Full pink	Bloom	Calyx
1 leaf expanded	2-3 leaves expanded	3-4 leaves expanded	5-6 leaves expanded	---	---	---	---	---
May 1	May 3	May 7	May 10	May 12	May 14	May 17	May 21	May 26

Scab Development

For 1948, no data were collected for correlating climatic factors with scab development. However, general notes taken on weather during the season, show that June was relatively dry and followed by a dry and very warm spell in July. May, though rainy, was rather cold. As a result, little or no scab developed and 1948 was a very minor scab year in Southwestern Quebec.

In 1949, primary infections were not closely followed but presumably occurred after bloom since the first scab spots appeared June 6 and development of growth started very early, calyx arriving on May 20 (see table 12).

First ascospore discharge occurred May 13 but rains were scattered and occurred in showers. Presumably, from rain data, one infection took place on May 22-23.

To give an idea of scab development during that season, data obtained from counts of the number of scabby leaves are given briefly here. On June 16 and 17, 78 scabby leaves per tree were found for the least successful treatments. June and July were relatively dry (see table 13) and scab infections increased but they were still relatively few in the third week of July. The least successful treatment gave 476 scabby leaves per tree while data for the best treatment showed only 72, though the last application was made June 9.

On the other hand, August and the first half of September were very wet (5.70 inches and 3.63 inches of rain respectively) and scab developed freely at the end of the

Table 12--- VEGETATIVE STAGES OF THE APPLE TREE FOR 1949

Delayed Dormant	Pre-pink	Late pre-pink	Pink	Full pink	Full bloom	Calyx
April 27	May 2	May 4	May 6	May 7	May 14	May 20

Table 13--- MEAN TEMPERATURE AND RAIN DISTRIBUTION FOR THE SEASON 1949

Month	Mean temperature	Rain in hundreth inch	Days rain recorded	Highest amt. in single period	
				Amount	Date
April (26-30)	43.9	.50	---	---	---
May	55.4	307	12	70 (30 hrs.)	22-23
June	65.4	284	9	118 (19 hrs.)	21-22
July	69.8	368	9	162 (29 hrs.)	10
August	69.3	570	7	388 (38 hrs.)	28-29-30
Sept. (1-16)	59.8	363	10	117	14
Total Amount		1942			

season.

Tables 14 and 17 give primary infection periods of 1950 and 1951. Both seasons were humid and had lower mean temperatures than in 1949. Consequently scab was rather severe in those years.

In 1950, heavy infection occurred during Prepink when massive liberation of ascospores occurred. Timing was difficult because of frequent rain periods and rapid growth. On May 31, the first scab spots appeared on the foliage and increased considerably in number during the following days. Except where the eradicant materials were applied after the infection periods of May 16 and May 18-19, the counts showed between 589 and 816 scabby leaves per tree on June 14.

Scab further developed with the least effective treatments during rains of July August and early September (rain was recorded on 35 days during that period of time) (see table 15). Counts at the end of July showed 1,622 scabby leaves per tree with the least effective spray.

It was more difficult to delimit secondary infection periods but at least 13 were possible,in 1950 the first one occurring with the rain of May 31.

1951 was also favorable for apple scab development and a few growers in the neighborhood of the station who failed to give adequate protection, found their crop ruined literally.

Rains were recorded on 27 days during May and June.

Table 14--- PRIMARY INFECTION PERIODS FOR THE SEASON 1950

Stage of vegetative development	Date of infection incidence	Rain in hundreth of inch during the wetting period	Mean temperature during the wetting period	No. of hours of wetting required (after mills)	Approximate no. of hours of wetting	Dates lesions appeared
Early pre-pink	May 16	11	58°F	10	18	May 31 - June 2
Pre-pink	May 18 - 19	37	50°F	14	30	June 2 - 4
Calyx	June 3 - 4	39	61°F	9	16	June 14 - 16

Table 15--- MEAN TEMPERATURE AND RAIN DISTRIBUTION FOR THE SEASON 1950

Month	Mean temperature	Rain in hundreth inch	Days rain recorded	Highest Amount in 24 hours		
				Amount	Date	No. hours of rain
May (6-31)	57.3	136	10	46	13-14	---
June	63.8	397	12	124	17	---
July	67.9	405	13	96	5-6	11.5
August	63.7	801	14	245	29	7.5
Sept. (1-21)	56.5	323	8	122	15-16	22
Total Amount		2062				

(see table 16). Moreover, as previously mentioned, ascospore discharge was extended over a long period in 1951.

As a result, possible primary infection periods occurred (see table 17). The first infections established themselves on May 11-12 with at least 22 hours of continuous wetting of the foliage, and, as previously calculated, scab appeared on May 27-28-29. It was possible to check the ocurrence of the second infection period of May 23 by recording the date of appearance of scap spots (June 5) but the following primary infection periods could not be verified since they intermingled with the secondary infections. The first scab spots appeared early that year and rains came close together.

As in 1950, numerous scab spots appeared on the foliage during the summer, where only the protectants had been applied.

Rain was recorded for 12 days in July, 14 in August and 7 from September 1 to 15. Nevertheless, infection was confined to the leaves and the fruits were free from scab during the summer. A count in the first week of July showed only 1.77% of infected fruits in the McIntosh plots. Counts in the Melba plots when the fruits were harvested on the 22nd, 28th and 29th of August gave a range of infections from 0.33 to 5.44% showing that scab was under control to date.

However, considerable late infections were present on

Table 16--- MEAN TEMPERATURE AND RAIN DISTRIBUTION FOR THE SEASON 1951

Month	Mean temperature	Rain in hundredth inch	Days Rain recorded	Highest amount in 24 hours		
				Amt.	Date	No. of hours of rain
May	55.7	325	12	1.62	29	5
June	62.3	507	15	97	22-23	9.5
July	68.3	500	12	1.05	4-5	12.
August	64.2	433	14	1.07	16	11
Sept. (1-15)	60.2	368	7	1.26	6-7	9
Total Amount		2133				

Table 17---- PRIMARY INFECTION PERIODS FOR THE SEASON 1951

Stage of vegetative development	Date of infection incidence	Rain in hundreth of an inch during the wetting period	Mean temperature during the wetting period	No. of hours of wetting required (after Mills)	Approximative no. of hours of wetting	Dates lesions appeared
Pre-pink	May 11-12	29	47.5	16	22	May 27-28-29
Bloom	May 23	29	55.9	11	13	June 5-6-7
Calyx	May 27-28	65	53.7	11	17	
1st. Cover	May 29	162	57.4	10	16	
1st. Cover	June 4	56	66.7	9	11	
2nd. Cover	June 6	47	55.0	11	15	
3rd. Cover	June 14-15	69	57.6	10	24	

McIntosh fruits at harvest (September 15). The first lesions of this type appeared in the last days of August and increased in number so that the apples were badly affected in some plots. The last spray was made July 11.

RESULTS OF THE EXPERIMENTS

Results for the Year 1948

Results for 1948 are reported in tables 18 and 19. Nine sprays were applied that year including Bordeaux mixture at delayed dormant. The last one was put on July 27-28.

Scab was not prevalent that year and all treatments gave excellent control. However, results on the leaves give some indication of the relative value of the materials used. Trees sprayed with Lime-Sulphur and those sprayed with the Kolospray-Lime-Sulphur mixture showed practically no scab at all while in the Kolospray plots, there was an average number of 120 scabby leaves per tree on August 2.

On the fruits, all materials gave similar amount of scabby fruits except Kolospray with .72%.

Light russeting that was followed in that year should not be considered as commercially important here. However, the relative amounts recorded gave an indication of greater causticity when compared to Mulsoid and Kolospray, which were milder in their effects and gave slightly better finish.

Table 18--- NUMBER OF SCABBY LEAVES DETERMINED IN 1948 FOR McINTOSH

1st.count 7-13 July [1]	Mulsoid	Kolospray	Lime-sulphur Hydrated Lime	Magnetic 70	Kolospray lime sulphur
Total	532	896	174	468	219
Mean number per tree	44.3	74.7	14.5	39.0	18.3
2nd.count 2-3 Aug. [2]					
Total	142	480	12	189	23
Mean number per tree	35.5	120	3	47.3	5.8

1 Data obtained from 12 trees per treatment distributed in 2 replicata of the plots.

2 Data obtained from 4 trees per treatment distributed in 4 replicata of the plots.

SCAB CONTROL AND RUSSETING

Table 19--- EFFECTS OBTAINED IN 1948 FOR McINTOSH

Materials used	No. of trees treated	Sound apples %	Scabby apples %	light russeting %	Medium russeting %	Severe russeting %	No. of apples examined
Mulsoid	24	49.5	.40	37.2	1.12	.53	22,537
Kolospray	32	53.4	.72	33.7	.98	.62	28,326
Lime Sulphur Hydrated lime	29	43.7	.31	44.2	1.66	.73	13,177
Magnetic 70	30	44.6	.38	42.4	1.40	.81	20,235
Kolospray Lime Sulphur	25	47.9	.35	38.7	.96	.65	17,630

Another point of interest is the reduced number of apples harvested from the trees sprayed all through the season at the usual strengths of 2½ gallons and 2 gallons in 100 gallons (imp.) of water. Only 13, 177 fruits were harvested from 29 trees sprayed with Lime-Sulphur as compared with 22,537 from 24 trees sprayed with Kolospray that allowed the largest crop.

Although there may rightly be some some doubt in comparison of yields for one year of experimentation, the difference was so great, the trees so uniform and well distributed over the orchard and as all had received similar cultural and spray treatments in previous years, there is no doubt that Lime-Sulphur affected the yield in this instance.

Moreover, as is shown later for 1949, the reduction in yield resulting from Lime-Sulphur sprays held over another year, even though another material, Fermate, notable for its mild effect on the tree, was sprayed on the following year.

Burrell (1), Rasmussen (19) and others have well demonstrated that Lime-Sulphur used in a straight schedule year after year was responsible for a considerable reduction of yield. These results confirm their observations.

Considerable damage was done to the foliage by Lime-Sulphur. Yellowing and shedding of numerous cluster leaves after the two first sprays with 2½ gallons in 100 gallons (imp.) of water, prompted a change in the concen-

tration to 2 gallons in 100. Despite this lower concentration, foliage during the summer was thin with much crinkling and curling present.

The mixture Kolospray-Lime-Sulphur sprayed throughout the season also damaged the foliage but much less. Thinner foliage was observed in the trees sprayed with the mixture when compared with those sprayed with Kolospray and Mulsoid.

Results For the Year 1949

In 1949, 6 sprays were applied including the Bordeaux mixture treatment at delayed dormant. The last spray was on June 9.

In tables 20 and 21, results show the protection of the foliage against apple scab during 1949. In 4 counts, Kolospray and Tag Fungicide No. 331 tried as a protectant that year, showed much less protection than Fermate, Magnetic 70 and the mixture Kolospray-Lime-Sulphur.

Fermate was the best of all with an average of 87.5 scabby leaves per tree in the final count on August 30-31. The mixture Kolospray-Lime-Sulphur came next in effectiveness with 146.5 scabby leaves, while Magnetic 70 and Kolospray gave 3 to 8 times less control than Fermate with 289 and 638 scabby leaves respectively.

It should be noted for Fermate that the number of scabby leaves per tree did not greatly increase from the first count to the last one as compared with Magnetic 70

Table 20--- NUMBER OF SCABBY LEAVES DETERMINED IN 1949 FOR McINTOSH

[1] 1st. Count June 16-17	Tag Fungicide	Kolospray	Fermate	Magnetic 70	Kolospray Lime Sulphur
Total	314	237	28	58	1
Mean number per tree	78.5	59.2	7.0	14.5	0.25
[2] 2nd. Count June 28-July 1					
Total	2048	1602	454	474	83
Mean number per tree	170.7	133.5	37.8	39.5	6.9

1 Data obtained from 4 trees per treatment distributed in 4 replicates of the plots.

2 Data obtained from 12 trees per treatment distributed in 4 replicates of the plots.

Table 21--- NUMBER OF SCABBY LEAVES DETERMINED IN 1949 FOR McINTOSH (continued)

[1] 3rd. Count July 20-22	Tag Fungicide	Kolospray	Fermate	Magnetic 70	Kolospray Lime sulphur
Total	4837	5714	847	1848	874
Mean number per tree	403.1	476.2	70.6	154.0	72.8
[2] 4th. Count Aug. 30-31					
Total	1715	2552	350	1156	586
Mean number per tree	428.8	638.0	87.5	289.0	146.5

1 Data obtained from 12 trees per treatment distributed in 4 replicates of the plots.

2 Data obtained from 4 trees per treatment distributed in 4 replicates of the plots.

and the mixture Kolospray-Lime-Sulphur that were about equal or better in the initial determination. On a basis of the initial number of scabby leaves, scab developed considerably in the other treatments, even with Magnetic 70 and the mixture that had a small number of scabby leaves in the first count.

It seems then, that Fermate served to check the development of scab that year, especially following the rains of long duration occurring in August.

In estimating the results on fruits for 1949, we have made the following distinction: infections of the first part of the season or "early and midsummer infection" and infections that appear toward the end of the season or "late scab infection".

According to rain records, the "early and midsummer infections" would have resulted in the latter part of May until the middle of July. Rains during August (5.70 inches) would be responsible for "late infections".

The distinction was made because it gives a better comprehension of the actual performance of the materials since the last spray was applied on June 9 and consequently the trees were not well protected against the unexpected attacks during August.

It was rather easy to distinguish the "late infections" on the fruits. Lesions were recognized as the so-called "pin point" type or they appeared as distinctly visible

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spots grouped mostly near the cavity or around the stem. As apples approach harvest stage, they hang downward from the stem and the stem area is in a position to retain more moisture and received a greater number of spores falling or washed from above.

Counts made on windfall apples (see table 22) on September 2, 9, and 15, seems to justify that distinction since the percentages of "early and midsummer infections" are approximately the same as those obtained on the picked fruits. Percentages of "late scab infections" are lower on the windfall apples than on the picked apples since counts were made later on the latter.

All materials were non-satisfactory in 1949 if only the fruit late infections are considered. But for infections occurring during the first half of the season, Fermate, Magnetic 70 and the Kolospray-Lime-Sulphur mixture did equally well with 1.4, 1.8 and 1.4% scabby apples respectively (see table 23).

Tag Fungicide No. 331 and Kolospray gave less satisfactory results in the control of both early and late infections.

Russeting was more prevalent than in 1948, probably because of cooler and more humid conditions. Except for Fermate that shows a slight difference, all materials gave the same amount of russeted apples.

It is of interest to note the lower yield obtained in 1949 from Fermate-sprayed plots. In these, the trees had

Table 22--- SCAB CONTROL OBTAINED ON WINDFALL APPLES[1] IN 1949 - McINTOSH

Materials used	Scab Early and midsummer infection %	Scab Late infection %	Number of apples examined
Tag Fungicide	151 6.7	151 6.7	2241
Kolospray	302 8.0	268 9.8	3768
Fermate	73 2.4	60 2.0	2983
Magnetic 70	41 1.6	141 5.6	2515
Kolospray Lime Sulphur	53 1.8	164 5.3	3102

1 Data obtained from 16 trees per treatment distributed in 4 replicates of the plots. Apples were collected on September 2, 9 and 15.

Table 23--- SCAB CONTROL AND RUSSETING EFFECTS[1] OBTAINED IN 1949 - McINTOSH

Materials used	Sound apples %	Scab Early infection %	Scab Late Infection %	Russeting Medium %	Russeting Severe %	Number of apples examined
Tag Fungicide	12,211 56.6	1,617 7.5	5,996 27.8	1,769 8.2	738 3.4	21,586
Kolospray	13,012 53.0	2,099 8.5	7,399 30.2	2,145 8.7	852 3.5	24,563
Fermate	11,885 76.5	211 1.4	2,309 14.8	938 6.0	369 2.4	15,531
Magnetic 70	15,835 73.1	408 1.9	3,260 16.3	1,833 8.5	704 3.3	21,647
Kolospray Lime Sulphur	15,136 71.1	294 1.4	3,652 17.2	1,876 8.8	747 3.5	21,279

1 Data obtained from the entire crop of 16 trees per treatment distributed in 4 replicates of the plots, except for Kolospray-Lime-sulphur treatment for which 15 trees were selected.

received Lime-Sulphur at the usual recommended strength the previous year. Though blossoming was abundant in these trees, fruit setting was poor compared to other trees in the orchard. By actual count it was found 40% less fruits remaining on August 16 in those trees sprayed previously with Lime-Sulphur, than on trees having received different previous treatments.

As previous workers have reported bad after-affects from Lime-Sulphur (1)(19) and as the Fermate-sprayed trees recovered in 1950 by more flowering, 61%, when compared to the other trees that showed 30% in the case of Kolospray and 21% in the case of Magnetic 70, it is apparent that Lime-Sulphur rather than Fermate was responsible for the low yield in 1949.

Results For the Year 1950

In 1950 Puratized Agricultural Spray was included in the experiments. It was used to test its eradicative value and as such was applied only after the infection periods calculated as previously mentioned.

Puratized was applied on May 17, 34 hours after the beginning of an infection rain; 52 hours, on May 20; 21 hours, on May 31, and 54 hours on June 3. Later in the season this material was replaced by Magnetic 70 on account of its mercury content. Thus in the split-schedule of 1950, Puratized Agricultural Spray was sprayed on 4 times and followed by Magnetic 70 in 5 applications.

In the straight-schedule, the protectants were applied 11 times in the season. The last spray was put on August 6.

In 1950,Tag Fungicide No. 331 was applied at the same time the protectants were put on. But as weather conditions prompted frequent treatments, some of which were applied soon after infection periods, it is probable that the material also acted in an eradicant capacity.

Because of its mercury content which might leave a poisonous residue and as late treatments were foreseen because of scab prevalence and frequent rains, Tag Fungicide No. 331, as well as Puratized, was replaced by Magnetic 70 after the first cover spray.

Infections of the leaves were determined in two counts in 1950 (see table 24). The first count was made after the heavy infections resulting from the rain period of May 16-17-18-19 had shown. The count at that time showed Tag Fungicide No. 331 and Puratized Agricultural Spray gave outstanding results as eradicants for the control of foliage scab.

Kolospray-sprayed trees resulted in an average number of scabby leaves per tree of 816. Tag Fungicide with 18 was not only much better than the protectants but showed indication of more effectiveness than Puratized Agricultural Spray.

Magnetic 70 and Fermate gave equivalent protection of the foliage in the experiments that year.

Table 24--- NUMBER OF SCABBY LEAVES DETERMINED IN 1950 FOR McINTOSH

1st. Count[1] June 14	Tag Fungicide Magnetic 70	Kolospray	Fermate	Magnetic 70	Puratized Ag.S. Magnetic 70
Total	73	3266	2356	2184	165
Average number per tree	18.2	816.5	589.0	546.	41.25
2nd. Count[2] July 24-26					
Total	304	19,464	5,385	7,214	848
Average number per tree	25.3	1.622	448.7	601.2	70.7

1 Data obtained from 4 trees per treatment distributed in 4 replicates of the plots.

2 Date obtained from 12 trees per treatment distributed in 4 replicates of the plots.

The second count, on July 24-26, showed that Magnetic 70 and Fermate checked development of scab on leaves while Kolospray-sprayed trees showed many spots with an average number of 1,622 scabby leaves.

Both Tag Fungicide No. 331 and Puratized Agricultural Spray showed the least foliage scab in the second count and the results were considered outstanding.

Fermate was found particularly good in checking leaf scab in 1950. Thus, for this material, the second count showed fewer scabby leaves than the first. Only live scab spots were counted in all cases and many of the early spots were dead at the time of the second count. There was an average of 589 scabby leaves in the first count and 448 in the second count.

Investigators of Fungitoxicity in laboratory tests (10)(11)(16) have found a fungistatic effect of Ferbam against the conidia of Venturia inaequalis. The material was found to have an inhibiting effect upon germination when spores had been exposed to it for a period of time.

On the other hand, many workers in the field (12) have reported the odd fact that Ferbam gave better protection to the fruits than to the foliage. Similarly, in these experiments, despite the fact that considerable infection was present on the leaves, only 4.5% were scabbed in the middle of July while 10, 11, and 13.6% scabbed fruits were found for Magnetic 70, Tag Fungicide No. 331 and Puratized Agricultural Spray respectively.

From this fruit count, data reported above on foliage scab, and other results in 1951, this work gives further evidence that the small amount of fruit scab is correlated with the fungistatic effect of Ferbam demonstrated by Guba and others.

The counts on the harvested fruits (see table 25) showed Fermate gave excellent commercial control with 1.9% severe scab and 3.4% light scab.

Kolospray failed in 1950 to give adequate protection as the counts showed 25% severe scab while Magnetic 70 was fairly good with only 4.5% severe scab.

Despite outstanding control of foliage scab obtained with Tag Fungicide No. 331 and Puratized Agricultural Spray, results on fruits were not satisfactory as shown in table 25.

Results for the Year 1951

The 1951 experiments were conducted at Farnham in triplicated plots. Melba as well as McIntosh were included in these tests. Crag 341 C and Merthon 642 were added to the list of materials used.

In 1951, Tag Fungicide No. 331 as well as Puratized Agricultural Spray were employed after calculated infection periods only. However, they have not been applied after all infection periods: for those occurring in the middle of June, it was too late to use these eradicative materials on account of their mercury content.

Table 25--- SCAB CONTROL AND RUSSETING EFFECTS OBTAINED IN 1950 - McINTOSH [1]

Materials used	Sound apples %	Severe scab %	Light scab %	Severe and medium russeting %	Number of Apples examined
Tag Fungicide followed by Magnetic 70	26,149 71.2	3,016 8.3	5,014 13.8	2,646 7.2	36,369
Kolospray	18,449 50.6	9,125 25.0	6,842 18.8	2,488 6.8	36,447
Fermate	40,102 87.5	897 1.9	1,575 3.4	3,593 7.8	45,851
Magnetic 70	30,048 80.8	1,684 4.5	2,542 6.8	2,376 6.4	37,167
Puratized Ag. Spray followed by Magnetic 70	25,197 73.1	3,985 11.6	2,897 8.4	2,100 6.1	34,481

1 Data obtained from the entire crop of 16 trees per treatment distributed in 4 replicates of the plots, except for Puratized Ag. Spray for which 15 trees were selected.

Tag Fungicide No. 331 and Puratized Agricultural Spray were applied 75 hours after the beginning of an infection rain on May 14; 71 hours, on May 25; 61 hours, on May 30 and 86 hours on June 7. It should be noted that the applications were made later after the start of infection periods than in 1950.

In the split-schedule of 1951, the eradicant materials were applied 4 times and followed by Magnetic 70 in 4 additional cover sprays. The protectant materials used in a straight-schedule were sprayed on 10 times during the season. The last spray was put on July 11.

In a combined schedule, Merthon 642 was applied with Fermate only in the early season treatments: at Early Pre-Pink, Pink, Late Pink and Late Bloom. In the other 6 applications, Fermate alone at the regular concentration was used.

1951 was also favorable to scab development as would be expected in considering weather conditions and primary infection periods.

It was more difficult that year to make suitable counts on foliage scab as there was an intermingling of primary and secondary infection periods.

For this season only one foliage count was made on July 17-19. In that count, Tag Fungicide No. 331 and Puratized Agricultural Spray, again showed good eradicative properties. As in the previous year, Puratized was a little less effective than Tag. (see table 26).

Magnetic 70 exhibited about the same protective value as formerly with 671 scabby leaves per tree while Crag 341 C

Table 26--- NUMBER OF SCABBY LEAVES DETERMINED IN 1951 FOR McINTOSH[1]

Block	Tag Fungicide ---- Magnetic 70	Merthon plus Fermate ---- Fermate	Fermate	Magnetic 70	Puratized Ag. Spray ---- Magnetic 70	Crag 341 0
1	33	2047	7074	470	78	393
2	51	1310	1901	622	62	823
3	23	1632	968	921	92	396
Total	107	4989	9943	2013	232	1612
Average number per tree	35.7	1663	3314.3	671	77.7	537.3

1 Data obtained from 3 trees per treatment distributed in 3 replicates of the plots. Date: July 17-19.

used at 1 pint in 100 gallons (imp.) of water was a little better with 537.

Fermate, in 1951, did not show the same behavious as in previous years. There was not only an average of 3314 scabby leaves in the trees sprayed with Fermate but new infections arose from week to week until the middle of the season.

The combination Merthon 642-Fermate, with an average of 1633 scabby leaves, gave the same result as Fermate alone, if we except the anomalous count obtained in one Fermate-sprayed tree which had 7074 scabby leaves. These inferior results on leaves from the combination may possibly be attributed to the Fermate ingredient in the mixture. In fact, Merthon 642, as a supplement of Fermate, did not play an eradicative role since the applications did not follow infection periods except in one spray (May 25).

Counts made on the fruits during the summer showed they were free from scab for a time despite frequent rains and considerable foliage infection. (see table 27, 28 and 29).

Crag 341 C was outstanding in the control of fruit scab during the summer with only 0.37% scabby apples in early July and 0.32% on August 13, in the McIntosh counts, and 0.33% on picked Melba at the end of August.

Fermate still exhibited good fruit protection despite very prevalent foliage scab. On McIntosh, in early July, there was only 0.74% scabby fruits and on August 13, 1.3%

Table 27--- FIRST COUNT: % SCABBY APPLES DETERMINED DURING THE SUMMER FOR McINTOSH - 1951[1]

Materials used	Number of scabby fruits	% Scabby fruits	Number of apples examined
Tag Fungicide ---- Magnetic 70	8	0.34	2382
Merthon plus Fermate ---- Fermate	12	0.50	2392
Fermate	16	0.74	2165
Magnetic 70	43	1.77	2433
Puratized Ag. Spray ---- Magnetic 70	40	1.64	2432
Crag 341 C	8	0.37	2167

1 Data obtained on July 4, 6 and 7 from 3 trees per treatment distributed in 3 replicates of the plots.

Table 28--- SECOND COUNT: % SCABBY APPLES DETERMINED DURING THE SUMMER FOR McINTOSH - 1951 [1]

Materials used	Number of scabby fruits	% Scabby fruits	Number of fruits examined
Tag Fungicide --- Magnetic 70	23	1.2	1924
Merthon plus Fermate --- Fermate	13	0.70	1832
Fermate	22	1.3	1611
Magnetic 70	42	2.3	1785
Puratized Ag. Spray --- Magnetic 70	42	2.1	2022
Crag 341 C	6	0.32	1863

1 Data obtained August 13 from 3 trees per treatment distributed in 3 replicates of the plots.

Table 29--- % SCABBY APPLES DETERMINED FOR MELBA[1]- 1951

Materials used	Number of scabby fruits	% scabby fruits	Number of apples examined
Tag Fungicide --- Magnetic 70	97	2.84	3410
Merthon plus Fermate --- Fermate	34	1.16	2926
Fermate	50	2.49	2012
Magnetic 70	68	2.22	3057
Puratized Ag. Spray --- Magnetic 70	161	5.44	2958
Crag 341 C	10	0.33	3038

1 Data obtained from 3 pickings on 4 trees per treatment - distributed in 2 replicates of the plots. Dates: August 22, 28, and 29.

and in the Melba counts in last August, only 2.5%.

Magnetic 70, with much less foliage infection also gave good protection to the fruits with 1.77%, 2.3% and 2.2% in similar counts.

Though the eradicants gave outstanding results against foliage scab, they did not show more effectiveness than the other treatments on the control of fruit scab during the summer. Puratized Agricultural Spray was the least successful of all the treatments with 5.4% scabby Melba fruits. When compared to Tag Fungicide No. 331, it was less successful in all the counts.

The combined schedule Merthon 642-Fermate gave excellent control to fruits during the summer as seen in tables 27, 28 and 29. Fermate again played a role in retarding fruit scab despite the numerous infections on the leaves.

In the determination of fruit scab on picked McIntosh for the 1951 experiment, samples of apples were examined instead of the entire crop of individual trees as done in preceding years. 6 bushels of fruits were taken at different points in each of the 12 trees chosen per treatment.

When McIntosh fruits picked on September 14-18, numerous late infections were present. These apparently resulted from rainy periods in August.

It should be pointed out that in all treatments except Crag 341 C, "light scab" for that year was of the "pin point" type in most cases. On the other hand, for

Crag 341 C, late infections were so numerous and so well developed that most of the fruits affected could only be commercially classified in "C" grade.

With Crag 341 C at the concentration of 1 pint in 100 gallons (imp.) of water, practically all scabby fruits or 37.82% resulted from late infections while the early control had been outstanding with only 0.43% (see table 30).

The other materials gave more satisfactory results for late scab. Where Magnetic 70 was applied, in a straight schedule or following the eradicative treatments in the cover sprays, the total amount of scab averaged only 6.5%.

Fermate, considering the abundant foliage infection, gave satisfactory control in the end with 8.24% scabby fruits, all in the "light" category.

The mixture Merthon 642-Fermate and Tag Fungicide No. 331 followed by Magnetic 70, were the best treatments for both types of scab infections giving less than 7% scabby fruits.

Puratized Agricultural Spray, when compared to Tag Fungicide was only a little less effective in the counts on picked McIntosh fruits with 9.21% scabby apples.

There is little to state for russeting effect of the materials except that Crag 341 C gave a few more russeted apples than the others. As this is the result of only one years trial with that material and since other factors may also account for russeting, no conclusions can be drawn.

Table 30--- SCAB CONTROL AND RUSSETING EFFECTS OBTAINED IN 1951 - McINTOSH[1]

Materials used	Sound apples %	Severe scab %	Light scab %	Russeted apples %	Number of apples examined
Tag Fungicide --- Magnetic 70	6682 89.6	64 0.85	446 5.98	399 5.35	7456
Merthan plus Fermate --- Fermate	6637 88.2	56 0.74	438 5.81	413 5.48	7527
Fermate	6415 85.9	94 1.25	616 8.24	386 5.16	7469
Magnetic 70	6755 89.0	160 2.10	473 6.22	228 3.02	7594
Puratized Ag.Spray --- Magnetic 70	6299 87.0	127 1.61	550 7.60	291 4.02	7236
Crag 341 C	4278 58.0	32 0.43	2790 37.82	457 6.19	7376

1 Data obtained from 12 trees per treatment distributed in 3 replicates of the plots.

SUMMARY AND CONCLUSIONS

Fungicides were tested for their comparative value in controlling apple scab during the years 1948 to 1951 in the province of Quebec.

Seasonal apple scab development as related to weather conditions is discussed in a study of ascospore discharge, primary infection periods, rain and temperature records and development of foliage scab during the summer.

Lime-Sulphur caused a reduction in yield in 1948 and also in 1949 as an after-effect of the damage done to the trees.

A mixture of Lime-Sulphur and Kolospray, applied in 1948 and 1949, caused some damage to the trees but much less than Lime-Sulphur alone. It gave satisfactory control of apple scab but was not better than the other treatments.

From 1948 to 1950, Kolospray was the least effective of all the treatments. Fermate and Magnetic 70 gave satisfactory control except in 1949 when a relatively high percentage of late infections occurred through all the experimental block. Even that year, both materials were superior to Kolospray.

Fermate gave better protection to the fruits than the foliage. In 1951, Magnetic 70 gave slightly better control of fruit scab than Fermate. Fermate was much less successful than Magnetic 70 in controlling leaf scab of that year.

The mercury fungicides Tag Fungicide No. 331 and

Puratized Agricultural Spray gave outstanding control of foliage scab when applied in an eradicant capacity with Tag showing some superiority. However, for the control of fruit scab, both materials did not give better results than Magnetic 70 and Fermate. In fact, Tag and Puratized were non-satisfactory in 1950 for control of fruit scab. Tag fungicide No. 331 gave inferior results when used in a protectant capacity.

Crag 341 C and the combination Merthon 642-Fermate were used only in 1951 in a new series of tests and it is too early to draw conclusions.

It was apparent from these tests as well as observations on seasonal scab development and data collected on weather occurrence, that spraying must be continued late into the summer to prevent late fruit infection.

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