DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF BOTANY

INTERIM REPORT OF THE DOMINION BOTANIST

H. T. GÜSSOW

FOR THE YEAR ENDING MARCH 31, 1922

Bean pod spot or anthracnose.

Printed by Authority of the Hon. W. R. MOTHERWELL, Minister of Agriculture, Ottawa, 1922
41174—1

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1922

DIVISION OF BOTANY

Report of the Dominion Botanist, H. T. Güssow, for the Year ending March, 31, 1922

The work of the Division of Botany divides itself into two main sections, viz., Plant Pathology and Economic Botany, and an account is herewith presented of the activities of the division during the year, relating to routine work and dealing with certain phases of investigational or research nature.

The headquarters of the division at Ottawa serve principally as a bureau of information on many and varying phases of interest to the individual inquirer, but it is also the centre of administration for the work of the entire division and its field laboratories. The time of one officer is almost exclusively devoted to routine examinations, and his spare time is devoted to investigational phases of work, in which, in consequence, only a small amount of interrupted research is possible. As conditions permit, improvements in this regard are contemplated. One special phase in plant pathology, viz., forest pathology, is looked after by an officer who, by nature of his training, is well able to specialize in the conservation of our forests and their protection from destructive diseases, as far as such is possible under existing lumbering practices.

One of the principal phases of work dealt with at headquarters is the potato inspection and certification service, carried on under authority of the Destructive Insect and Pest Act, and extending now to all provinces except British Columbia. The object of this work is to render uniform service to all farmers of the Dominion interested in producing high-grade seed potatoes. This uniformity of inspection and certification under one administration is a decided advantage over practices prevailing in other countries where this service is done independently by different authorities. The pursuance of this uniform policy will effectively place a recognized and superior quality of seed potatoes on the markets of the whole continent, and no doubt is likely to arise as to the meaning of the standards of quality set by the Dominion authorities every year.

Among the routine work, most interesting phonomena are frequently encountered, but these, while of interest to individuals, are rarely of sufficiently wide application to warrant inclusion in the annual report. Every year, however, one is able to add interesting specimens to the collections of the division, and eventually it is hoped to have a substantial and important mycological herbarium comprising the pathogenic and other fungi of Canada and other parts of the world. Nowadays it is realized that many serious and destructive diseases have been brought in from abroad, and it is obvious that a comprehensive reference collection at headquarters, of fungi causing plant diseases in other parts of the world, will be a most useful addition to the natural science collections of Canada, of which there are regrettably few.

The main lines of work carried on at the Central Laboratory, Ottawa, or directly supervised from there, are as follows, and are under the immediate charge of the members of the staff indicated:—

Economic Botany—John Adams.
Forest Pathology—A. W. McCallum.
Potato Inspection and Certification—George Partridge.
Nitro-Culture Work—F. L. Drayton; R. A. Inglis.

ECONOMIC AND GENERAL BOTANY

Many inquiries were received during the year relative to weeds, poisonous plants, medicinal plants, wild rice, and various miscellaneous topics including chicory, table mustard, oil-bearing seeds, silk trees, henna tea, carob trees, orris root, hellebore powder, and literature on Canadian wild flowers.

The number of specimens sent in for identification amounted to 686. In this total a number of seaweeds were included whose value for fertilizer was determined by the Dominion Chemist.

Seeds were exchanged with the following Botanical Gardens: Vancouver, B.C.; St. Louis, Missouri, U.S.A.; New York, U.S.A.; Brooklyn, N.Y., U.S.A.; Buenos Ayres, Argentine Republic; Montevideo, Uruguay; Sydney, New South Wales; Glasnevin, Dublin, Ireland; Trinity College, Dublin, Ireland; Edinburgh, Scotland; Oxford, England; Kew, England; Christiania, Norway; Gothenburg, Sweden; Lund, Sweden; Upsala, Sweden; Copenhagen, Denmark; Amsterdam, Holland; Gronigen, Holland; Brussels, Belgium; Lyons, France; Nancy, France; Lausanne, Switzerland; La Mortola, Italy; Palermo, Italy; Siena, Italy; Berlin-Dahlem, Germany; Schkopau, Saxony; Warsaw, Poland; Tabor, Czecho-Slovakia; Cernauti, Roumania; Cluj, Roumania.

A quantity of seed of wild rice was sent to the Experimental Sub-station at Beaverlodge, Alta., and a number of seeds of various shrubs were forwarded to the Experimental Station at Morden, Man. Altogether, 1,385 packages of seeds were received and 1,176 packages were sent out. In addition, 6,000 willow cuttings, representing seventeen different species and varieties, were supplied for planting on sandy soil in the province of Ontario. Experiments were continued with castor oil and broom corn from selected seed of the previous year. As the variety of castor oil was one which did not scatter its seeds when ripe, a large number of ripened seeds were obtained.

The broom corn was a black-seeded variety which has been grown on the Central Experimental Farm for a number of successive years. Nine of the best plants gave an average length of brush of twenty-seven inches.

Another variety of broom corn known as Canadian Evergreen, of which the seed was obtained from the United States, produced a much shorter average length of brush, but in one plant it reached twenty-six inches.

Part of the grounds of the Arboretum were laid out as a series of plots devoted to the wild flowers of Canada, grouped according to their proper families, and a considerable number of species were planted during the year.

Press articles on "Destroying Weeds by means of Chemicals," "Buffalo Bur," and "Wild Duck Foods," were sent forward for publication.

Some time was devoted to a continuation of physiological experiments on the effect on plants of shortening the daily period of light.

FOREST PATHOLOGY

WHITE PINE BLISTER RUST IN EASTERN CANADA

During the season of 1921 the work done in connection with white pine blister rust was mainly a continuation of that carried on in the preceding year, i.e., the inspection of the control areas which were established to secure data concerning the distance over which infection could spread from currants to pines, and of the pine woodlots in southern Ontario which were established to ascertain to what extent native pines were affected by this disease. In addition, the establishment of check plots for the control areas, the examination of white pine plantations of European origin, and the marking of infected trees to study the results of infection were under-

taken. Unfortunately, the late date—May 17—at which the inspector for this work was appointed prevented it being done as completely as was desirable.

The purpose of the control areas and a description of each has been given in previous reports. The most important observations made in regard to these areas this year follow:—

Control Area No. 1.—Welland county, Ont. Established in 1918. One tree previously reported infected could not be located this year. In the area 13 wild *Ribes* were found and eradicated. One of these showed rust. In the 500-yard sterile zone 69 wild *Ribes* were found, 13 of which were infected. These were also eradicated.

As a check for this control area, plot No. 6 of the White Pine Woodlot Survey has been chosen. This woodlot, which has an area of about ten acres and contains about 2,500 young white pines, lies six miles northwest of Control Area No. 1. It is owned by Mr. Samuel Culp, of Vineland. Wild *Ribes* are present to the extent of about 40 plants to the acre, and infection is present on gooseberries.

Control Area No. 2.—Bowmanville, Ont. Established in 1918. This year 87 diseased pines were found. No *Ribes* were found in the area itself, but 53 plants, 16 of which showed rust, were found and eradicated in the sterile zone.

The plantation of white pine on the farm of Mr. William Ratcliffe, near Oshawa, was selected as a suitable check for this area. It contains about 5,500 trees, set out in 1907, 1909 and 1911. This plantation is about ten miles west of Control Area No. 2, and the trees have been planted on the banks of a creek.

Control Area No. 3.—St. Andrew's East, Que. Established in 1918. No infected pines. In the 500-yard zone 82 *Ribes* were found, 12 of which showed rust. These were all eradicated.

No check for this control area has been located yet.

After a careful inspection of Control Area No. 4, situated at Berthierville, Que., it was decided not to maintain it as one of the control areas as it was unsuited in several ways for such a purpose. The great majority of the trees upon this area are much too large to permit of inspection and, moreover, as far as is known there is no rust in the district.

Control Area No. 5.—Lachute, Que. Established in 1919. No infected pines were found on this area. No *Ribes* were found in the area itself, but one uninfected cultivated black currant was found in the sterile zone and eradicated.

As a check for this area the northwest corner of a Government plantation, about three miles east of Lachute, on the North river, has been chosen. There are about 1,000 trees in the part of the plantation chosen, and infection on *Ribes* is present on two sides of these pines.

It is, as yet, too soon to draw definite conclusions from the results obtained on these control areas. It is to be expected, however, that the data secured through a period of years will show that, if infection is not entirely absent, the amount present is negligible. In other words, the eradication of *Ribes* both within and around it for a distance of 500 yards on all sides will probably adequately protect an area. The rust that is present in some of the areas is the result of infection previous to their selection as control areas.

During this year it was only possible to examine 9 of the 42 white pine woodlots. A study of the results obtained shows that of a total of 10,034 trees there were 73, or 0·7 per cent, infected with blister rust. Had all the woodlots been gone over this year it is very likely that the results would have shown that a similar percentage of trees was infected as in the preceding three years, i.e., about 2 per cent. It is felt that, as these woodlots have now been under observation for four successive years, they have served the purpose for which they were established, which was to determine to what extent the native white pine in southern Ontario was affected by rust. As the region in which these woodlots are situated is an agricultural district and the amount of white pine is small, results obtained here are not indicative of what conditions

might be in an area containing commercial stands of white pine. When the woodlots were located, however, the blister rust had not spread northward far enough to have reached such areas. Since then rust has been found in the Muskoka and Petawawa districts and it would be of value to have similar studies made in these localities.

The white pine plantation on Mr. A. Joly de Lotbinière's seigniory at Pointe Platon, Que., was examined during the latter part of May. There are about 400 trees in the plantation, which was set out in 1908, the nursery stock being secured from Germany. Some of this stock must have been infected when it was received, and the rust has gradually developed since then until now, of the 372 trees, 246, or 66 per cent, bear infections which are in the blister stage. There are also 20 dead, standing trees, 13 of which have apparently been killed by the rust. The conditions for the development of rust are very favourable here, as in a garden about 200 feet from the pines there are 250 cultivated currants and gooseberries. This is probably the most heavily infected pine plantation in the country. It is planned to have these trees destroyed.

Some further work in pine inspection was done in the counties of Norfolk and Brant, in the examination of white pine plantations the stock of which originally came from Europe. These plantations were made between 1907 and 1914 and in many cases the trees were no longer in existence. However, a total of 21,850 trees were inspected but no rust was found on any of them. These results furnish additional evidence that the average percentage of infected pine in southern Ontario is very small.

IN BRITISH COLUMBIA

On September 6 Mr. J. W. Eastham, Plant Pathologist for British Columbia, discovered the currant stage of blister rust on leaves of cultivated black currants which had been grown in North Vancouver. Later in the season, infected black currants were found at Chilliwack and Sardis, in the Fraser Valley, and at several points in and around Vancouver. On Vancouver island similar conditions were found at Victoria, Courtenay, and Comox. A good deal of scouting was done in representative areas of the Kootenay District—Slocan City, Nelson, Willow Point, Proctor and Kaslo—but no rust was found. In Stanley Park, Vancouver, some diseased white pines (*Pinus Strobus* L.) were found. These had apparently produced aecidia. As they had been grown from seed in the nursery there, however, they afforded no evidence as to the origin of the rust in British Columbia. It is very probable that the rust was brought into the west on infected pine nursery stock as was the case in the east. Between 1910 and 1914 about 1,300 such pines were imported into British Columbia, chiefly from Europe. Whether the rust which was later in the season discovered at several points in the state of Washington was of independent origin from that found in British Columbia is not known at present.

There are three species of white pine native to British Columbia—*Pinus monticola* D. Don., *P. flexilis* James, and *P. albicaulis* Engelm. Of these only the first occurs in sufficient quantities to render it commercially valuable. This tree is rather limited in distribution, occurring only in the coastal wet belt and in the interior wet belt Even in these areas it is characteristic of it that it does not form pure stands but occurs as a scattered tree in mixture with Douglas fir, cedar and hemlock. *Pinus flexilis* occurs as a timber line tree—25 to 30 feet in height—in the southern Rockies. *Pinus albicaulis* is also an alpine species found at elevations of from 3,000 to 7,000 feet in the Rockies, Selkirks and Coast Ranges. This species may serve to distribute the rust, as it occurs in the area of known infection, and it is believed that *Ribes* will extend well up to the timber line.

Fortunately, then, white pine is one of the less valuable timber trees of British Columbia. It forms about four-fifths of 1 per cent of the total stand. Another promising feature is the fact that it occurs in two distinct areas. It is hoped that infection can be confined to the coastal area.

To prevent the rust from being distributed to the interior by artificial means, the Provincial Government is enacting a quarantine prohibiting the movement of currants, gooseberries and five-leaved pines from that part of the province to the West of the Cascade mountains to that part to the east. More definitely, the line will pass through Princeton, Spence's Bridge, Lillooet and Hazelton. In addition, the Dominion Government is changing the regulation made under the Destructive Insect and Pest Act relative to importation of currants and gooseberries from foreign countries to read as follows:—

"The importation into Canada of the following is prohibited:—

"All species and varieties of currants and gooseberries (*Ribes* and *Grossularia*), but not including the fruits of these, from all foreign countries; provided, however, that the importation of said vegetation shall be permitted without any restriction into the province of Ontario from the state of New York."

For the sake of uniformity it would be very desirable to prohibit entirely the importation of these plants.

It is planned to maintain a staff of inspectors in British Columbia during the coming season for purposes of eradication and scouting.

WHITE PINE WOODLOT SURVEY

No.	Total No. Pines	1918			1919			1920			1921		
		No. inspected	No. infected	Per cent infected	No. inspected	No. infected	Per cent infected	No. inspected	No. infected	Per cent infected	No. inspected	No. infected	Per cent infected
1....	a 320	320	27	8·4	.....	.....	.....	300	20	6·6	Trees cut down.		
	b 2,200	2,200	0	0·0	607	15	2·5	1,500	0	0·0			
	c 420	400	1	0·2	.....	.....	.....	420	1	0·2			
2....	1,275	1,275	2	0·1	1,200	0	0·0	680	4	0·6	600	5	0·8
3....	833	663	0	0·0	700	0	0·0	650	0	0·0			
4....	2,700	1,004	18	1·8	1,022	21	2·0	1,025	25	2·4	2,000	18	0·9
5....	300	260	4	1·5	200	3	1·5	300	18	6·0	260	3	1·3
6....	2,200	2,121	15	0·7	1,800	11	0·6	2,200	22	1·0	2,000	0	0·0
7....	1,500	763	2	0·3	1,100	4	0·4	1,200	3	0·3	1,500	0	0·0
8....	385	385	1	0·3	(Trees all cut down)								
9....	2,500	1,259	0	0·0	1,000	0	0·0	1,250	0	0·0	2,500	0	0·0
10....	155	155	52	33·5	155	45	30·0	125	37	30·0	104	23	22·1
11....	1,875	875	0	0·0	(Not examined)			875	0	0·0			
12....	200	100	0	0·0	.....	.....	.....	100	0	0·0			
13....	260	260	0	0·0	200	0	0·0	260	0	0·0			
14....	65	57	0	0·0	(not examined)			62	0	0·0			
15....	65	58	0	0·0	60	0	0·0	60	0	0·0			
16....	260	250	1	0·4	.....	.....	.....	260	0	0·0			
17....	50	50	0	0·0	(not examined)			50	0	0·0			
18....	75	70	0	0·0	.....	.....	.....	75	0	0·0			
19....	504	504	0	0·0	400	0	0·0	380	0	0·0			
20....	50	50	0	0·0	50	0	0·0	50	0	0·0			
21....	140	136	6	4·4	136	6	4·4	140	7	5·0			
22....	98	98	19	20·0	100	20	20·0	50	6	12·0			
23....	475	160	20	12·5	460	40	8·7	475	57	12·0	(Not located)		
24....	200	137	16	11·7	150	11	7·3	140	14	10·0			
25....	330	330	36	11·0	296	21	7·0	300	22	7·0			
26....	1,000	350	0	0·0	400	0	0·0	350	0	0·0			
27....	55	50	0	0·0	55	0	0·0	50	0	0·0			
28....	500	200	0	0·0	350	0	0·0	210	0	0·0			
29....	many	a 150	11	7·3	60	4	6·6	100	18	18·0	100	20	20·0
		b 152	34	22·3	60	2	3·3	100	22	22·0			
		c	..	...	107	29	27·1	100	28	28·0			
30....	300	280	1	0·4	286	0	0·0	300	0	0·0			
31....	100	85	0	0·0	83	0	0·0	80	0	0·0			
32....	125	107	1	1·0	111	0	0·0	100	0	0·0			
33....	1,000	340	1	0·0	440	0	0·0	600	0	0·0	1,000	4	0·4
34....	100	100	2	2·0	(not record ed)			100	0	0·0	(Trees cut down)		
35....	300	...	.	...	240	0	0·0	250	0	0·0			
36....	150	.....	.....	.....	88	0	0·0	120	0	0·0			
37....	50	(Established in 1919)			36	0	0·0	50	0	0·0			
38....	75				60	0	0·0	72	0	0·0			
39....	85				72	0	0·0	78	0	0·0			
40....	250				250	0	0·0	250	0	0·0			
41....	400				350	0	0·0	350	0	0·0			
42....	many	260	1	0·4	210	1	0·5	250	1	0·4			

SUMMARY OF PINE SURVEY, 1921

District	Pine Woodlots			Pines examined	Pines diseased	Per cent diseased Pines
	Examined	Diseased	Free			
Niagara Peninsula	9	6	3	10,034	73	0·7
Oakville	0	0	0	0	0	0
Simcoe	0	0	0	0	0	0
Total	9	6	3	10,034	73	0·7

WHITE PINE PLANTATIONS OF EUROPEAN ORIGIN

Owner	Address	No. Pines	Infection
Norfolk County:—			
Fred Maybe	Vittoria	5,500	none
F. C. Ryerse	Port Dover	3,400	none
Brant County—			
Jas. Pate	Brantford	6,300	none
Mason and William	Harrisburg	150	none
J. A. Eddy	Brantford	4,300	none
P. N. McCrea	Glen Morris	200	none
H. R. Nixon	St. George	2,000	none
		21,850	

ARMILLARIA ROOT ROT

During the past season, the month of August was spent in northern Ontario in a preliminary field study of the root rot of trees and especially of conifers, caused by *Armillaria mellea* (Vahl.) Quel. the honey fungus. In this connection it was especially desired to secure data bearing upon the parasitism of this fungus. While there is every reason to believe that this form at times becomes actively parasitic, this has yet to be definitely demonstrated. In the Timagami district *Armillaria* was found on the roots of living balsam, black spruce, cedar, white pine and jack pine, but most commonly upon balsam. In the course of this study, many small trees were carefully uprooted and their root systems examined. This is strenuous work, but several specimens of diseased roots were obtained in this way which indicated apparent parasitism from the manner of the growth of the new wood at the extreme point of advance of the mycelium. The tree seems to endeavour to protect itself when attacked by the fungus by producing wound wood which sometimes stops the advance of the mycelium. This wood in turn is invaded by the fungus and at times is destroyed.

The simplest method to determine whether a root is infected with *Armillaria mellea* is to remove the bark by slitting it along one side with an axe. If the honey fungus be present it is indicated by the presence of a dense layer of white mycelium, often fan-shaped, occupying the cambial area. Sometimes rhizomorphs are found on the bark of diseased roots but by no means always. In trees in which the fungus has been present for some time, this layer of mycelium is found to extend to a height of several feet above ground. Where there is sufficient space the mycelium readily passes from the filamentous state to the form of rhizomorphs which, however, are usually flattened when growing beneath the bark. This mycelium and the sapwood immediately beneath it are beautifully phosphorescent. This phosphorescence, though, which is presumably an indication of viability, is retained for but a few days after being collected. Another diagnostic feature which is sometimes helpful in determining

the presence of *Armillaria* is the resin flow which, in certain species, follows infection. This resin exudes from wounds in the bark at or below the point where the fungus is working, and, mixing with the soil, forms a hard, compact mass. While, in literature, this phenomenon is usually mentioned as common to all coniferous trees, we have only observed it to a marked degree in the case of black spruce and, to a lesser extent, in white pine. Possibly, varying amounts of resin secreted by different species may account for this.

There can be no doubt concerning the economic importance of the honey fungus. It works principally in the sapwood, causing a yellow rot and, by destroying the roots or by occupying the cambial area around the base of the trunk, probably is responsible for the death of more trees than any other fungus. It is not confined, as are many fungi, to one or several hosts, but exhibits a surprising catholicity in its range of hosts. Besides attacking all coniferous trees it has also been reported on most of the deciduous species and there is no reason to believe that any are immune. Outside the forest it is interesting to note that it is believed to be the cause of much destruction in orchards, and it has also been found on the grape, potato, various kinds of cultivated berry bushes, and the Virginia creeper. No woody plant, apparently, is immune.

In the matter of dissemination, the honey fungus is better equipped than are most other similar forms. Besides the usual method of reproduction, *i.e.*, by spores, *Armillaria* possesses a very efficient secondary means of distribution in its rhizomorphs which grow through the soil from the roots of one tree to those of neighbouring trees. As development continues in a tree for a long time after its death, it is apparent that all adjacent trees are very likely to become infected.

A few days were spent at Long Lake, Que., where the Entomological Branch of the Department of Agriculture has established several one-acre sample plots to study the effects of the work of the spruce bud-worm. This insect feeds upon the foliage of spruce and balsam and is usually believed to be responsible for the subsequent death of these trees. There are, however, several secondary agents which attack these trees, and it has not been established just what part these play in the death of the trees. Among these agents are various bark beetles and *Armillaria mellea*. The forest floor seems to be full of the rhizomorphs of this fungus, and as soon as a tree becomes weakened from any cause it is immediately invaded by these rhizomorphs. It will require considerable further study to determine to what extent the fungus is responsible for the death of these trees.

To secure data upon the parasitism of *Armillaria*, one hundred young balsams, white and black spruces, and white pines were selected for inoculation purposes. The method of inoculation was to remove the earth from one of the larger roots, scrape a small portion of the root clean, wash the bark with alcohol and then make a slit in it using a knife which had been dipped in alcohol. Each tree was then numbered so that it could be located again. Every fourth tree was used as a control. The bark was slit as in the others but no inoculum was inserted. The inoculum used was taken from the mycelial sheets on recently collected diseased roots and from rhizomorphs.

NEEDLE BLIGHT OF WHITE PINE

This disease of white pine was apparently as prevalent as usual in the Timagami district. There is no doubt that the immediate cause of this trouble, as pointed out in the report for last year, lies in the death of a large portion of the root systems of affected trees. For a detailed account of this disease reference must be made to the reports of Dr. J. H. Faull, of the University of Toronto, who has been engaged in a study of needle blight for the Ontario Government for four successive years. The results of his work are to be found in the annual reports of the Minister of Lands and Forests for Ontario, for the years 1918, 1919, and 1920. His reports present the results of the first serious effort which has been made to discover the cause and nature

of this interesting disease. This disease must not be confused with the blister rust of white pine which is caused by a specific organism (*Cronartium ribicola* F. de W.). Needle blight is characterized by the reddening and death of the distal portions of the new needles soon after their emergence from the buds. Blister rust can be recognized by the appearance of groups of small orange-yellow blisters which break through the bark of the limbs or stems of small trees during May. Each of these blisters is filled with yellow spores which are carried by the wind for long distances as soon as the peridium has been ruptured. According to present knowledge, blister rust has not yet reached the forests of Northern Ontario where needle blight seems to be most prevalent.

DESTRUCTIVE INSECT AND PEST ACT

REPORT OF POTATO INSPECTION AND CERTIFICATION

During 1921 this work was conducted along lines similar to those of previous years, with the exception that, it having been found advisable to disregard for certification purposes all fields which failed to come within the standard set for qualification as Grade No. 1, the grade formerly known as No. 2 was abolished. This was followed up by a second field inspection just before maturity (the first inspection being made at the time the plants are in bloom) of all fields which came well within the No. 1 standard at the time the first inspection was made. Although this procedure entailed the covering of most of the seed-growing districts twice during the growing season, an opportunity was thereby afforded the inspectors of deciding whether any element of doubt which may have existed with regard to the classification of some fields upon the first inspection, was justified or not. It is satisfactory to note that in the large majority of cases the favourable conditions obtaining earlier in the season were fully maintained throughout the growing period.

A considerable extension of territory was included in the year's activities. The provinces of Saskatchewan and Alberta, where in 1920 only a limited survey was made, were more generally surveyed, and a number of fields submitted for inspection. Many of these being found worthy of consideration for seed purposes, the growers were encouraged to submit their crops for certification, a considerable amount being accordingly certified to. It is hoped that a further extension of the work in these two provinces will be possible during next season.

The total number of fields inspected throughout the country was 2,646, containing an acreage of 7,900. Of these, 1,634 fields containing 4,290 acres passed the two field inspections, an average of 61·7 and 58·7 respectively. The amount certified to up to the time winter brought the work to a conclusion in some of the provinces, was approximately 310,000 bushels. When in the spring it is possible to complete the certification of the 1921 crops, this amount will be considerably increased.

Following will be found a tabulation of the work by provinces:—

POTATO INSPECTION WORK

	No. of fields inspected	No. of fields passed	Acreage inspected	Acreage passed
Prince Edward Island	285	178	963	541
Nova Scotia	184	121	276	208
New Brunswick	254	172	951	639
Quebec	1,131	520	4,106	1,726
Ontario	218	176	486	431
Manitoba	404	367	613	520
Saskatchewan	88	38	374	159
Alberta	82	62	131	66
Total	2,646	1,634	7,900	4,290

The following table gives a comparison between the results of the field inspection of 1920 and 1921—the provinces being placed in order of merit, calculated from the results of 1921. A table showing a comparison of yields per acre, between certified seed crops and the general crop, also follows:—

COMPARISON OF FIELD INSPECTION RESULTS, 1920 AND 1921

Province	1920			1921		
	Acreage inspected	Acreage passed No. 1	Per cent passed No. 1	Acreage inspected	Acreage passed No. 1	Per cent passed No. 1
Ontario	472	256	54·2	486	431	88·6
Manitoba	594	275	46·3	613	520	84·8
Nova Scotia	379	298	78·6	276	208	75·4
New Brunswick	1,413	661	46·8	951	639	67·2
Prince Edward Island	886	523	59·0	963	541	56·2
Alberta	.....	.....	.....	131	66	50·4
Saskatchewan	.....	.....	.....	374	159	42·3
Quebec	3,868	837	21·7	4,106	1,726	42·0

COMPARISON OF YIELDS PER ACRE BY PROVINCES, BETWEEN POTATO CROPS SUBMITTED FOR INSPECTION AND CERTIFICATION, AND THE CROP IN GENERAL, 1921.

	Yield per acre Certified Seed	Yield per acre General Crop
	Bush.	Bush.
New Brunswick	283·4	216·25
Quebec	277·4	162·5
Prince Edward Island	247·6	201·75
Manitoba	235·6	166·5
Ontario	233·4	103·5
Saskatchewan	231·8	176·5
Alberta	220·0	158·5
Nova Scotia*	183·7	163·75
	239·1	168·66

*It should be borne in mind that a large proportion of inspection and certification work in Nova Scotia is done amongst the Garnet Chili variety, which does not appear to be such a prolific yielder as some of the white varieties grown in other provinces and inspected by us. This fact, therefore, is responsible for making Nova Scotia's average yield appear low in so far as certified seed averages are concerned.

As a result of the analysis of the records for the purpose of making this comparison, it may be stated that the very satisfactory increase in the percentage of acres which passed inspection during 1921 may be attributed to the employment of improved methods of seed growing and to the more general use of certified seed. This feature is particularly outstanding in Ontario, Manitoba and Quebec, where the percentage increased from 54·2 to 88·6, from 46·3 to 84.8 and from 21.7 to 42.0, respectively. In Manitoba especially, a large quantity of certified seed from northern Ontario and Minnesota was judiciously distributed and submitted for inspection. Had the weather conditions been more propitious during the earlier part of the season, the results would have undoubtedly been still more gratifying.

In New Brunswick, where considerable difficulty has been experienced during the past few years owing to the prevalence of mosaic among the Green Mountain variety of potatoes in some districts, special emphasis was placed by the inspectors upon the importance of rogueing the fields in those districts where conditions do not appear so favourable for the production of this trouble. Rogueing was not advocated in fields

where mosaic was present to the extent of more than 5 per cent, but following the introduction of certified seed, in which the amount of mosaic present was infinitesimal, into some of the potato-growing districts along the north shore of the province, followed by a thorough rogueing of the fields in 1920 and 1921, a valuable seed crop was produced in the latter year, a large amount of which was quickly purchased by growers from the United States who had surveyed the fields during the season. There is still a considerable quantity of this stock available, and as it was chiefly responsible for raising New Brunswick's percentage from 46·8 to 67·2, no opportunity is lost of recommending its multiplication within the province.

In Nova Scotia the percentage of fields passing inspection was not quite so high as in 1920. There was apparently no increase in the amount of disease present, the abnormally hot, dry season being responsible for indifferent growth in some districts. An unfortunate occurrence of wilt in a number of fields in Prince Edward Island late in the season somewhat reduced the percentage passing inspection. Great enthusiasm on the question of seed potato production has been aroused in this province during the past two or three years, due to the efforts of the inspection service and the officials of the Potato Growers' Association, and the occurrence of wilt was the only factor preventing a far better showing. As previously noted, inspection was conducted in Saskatchewan and Alberta for the first time in 1921, therefore no comparison can be made. However, the past year's results may be considered very promising.

Owing to the vast territory covered by this work, and in which many and varied climatic and soil conditions prevail, it has been found preferable not to adopt permanent standards, but, for the sake of uniformity, to revise them year by year should conditions render revision advisable. Only a very slight revision was found to be necessary in 1921.

In classifying the fields inspected, to some extent the standards set and current reports are used as a guide. Owing, however, to the difficulty experienced in some years and during certain periods in almost any year, in recognizing the presence of such diseases as mosaic and leaf roll, it is felt that anyone not thoroughly acquainted with the inspection system might consider that, if classification is based entirely upon current reports, sufficient precaution against possible non-recognition of these diseases is not provided for. This, however, is dealt with at headquarters, by the maintenance of a special card system which contains the history and behaviour of hundreds of lots of seed inspected year by year, together with their origin. By this means it is possible to trace the history of such seed for several years back, which often results in the rejection of a field, even though a current report may be favourable; the right being reserved to base the classification not only upon present status, but more so upon past history in so far as mosaic and leaf roll are concerned. Experience has taught that a system of potato inspection not taking into consideration the record which certain strains have previously made, will not afford such an exclusive guarantee of freedom from systematic diseases as is possible by the method outlined.

A gratifying feature of potato inspection and certification is the continued eagerness on the part of growers across the border to procure seed potatoes certified to under the system. Last autumn sixty carloads were consigned in that direction from Prince Edward Island and thirty-four carloads from New Brunswick, at prices well in advance of those obtainable for ordinary, uninspected stock, and quite acceptable to the producers. A profitable business is becoming established, which promises to increase materially within the next few years.

Thirty inspectors were employed on the work for varying periods during the year and, with the exception of temporary transfers which were made as the exigencies of the work demanded on several occasions, their services were utilized in the various provinces as follows:—

Prince Edward Island	3
Nova Scotia	2
New Brunswick	4
*Quebec	6
*Ontario	7
†Manitoba	5
Saskatchewan	2
Alberta	1
	30

*Including three men supplied by the provincial Department of Agriculture.
†Including four men supplied by the provincial Department of Agriculture.

It is desired cordially to acknowledge the interest evinced, and the co-operation extended by the provincial Departments of Agriculture, the officials of which, as in previous years, rendered every possible assistance towards the successful conduct of the work. Such co-operation is a valuable asset, and, in expressing the hope that it will be continued, it may be said that the somewhat difficult task of maintaining uniformity of methods in the inspection proper has been lightened to a large extent by the courtesy of the provincial officials, who have always been ready to supply information with regard to the conditions prevailing in their respective provinces, and who, by their efforts in numerous other directions, have assisted in the efficient discharge of the work.

As an indication that the annual revision of the standards set for certified seed—referred to earlier in this report—has for its object the gradual raising of such standards to the highest possible level, a comparison of those set for 1920 and 1921 is given below:—

FIELD INSPECTION STANDARDS

	1920	1921
	Per cent	Per cent
Black-leg	3	3
Curly dwarf and leaf roll	2	2
Mosaic	2	2
Wilts	3	3
Weak plants	3	No allowance
Foreign	5	1
Misses	not taken into consideration	not taken into consideration
Black-leg or wilt alone	7	7
Black-leg and wilt combined	7	7
Leaf roll or mosaic alone	6	6
Leaf roll and mosaic combined	5	5

TUBER INSPECTION STANDARDS

	1920	1921
	Per cent	Per cent
Bacterial rot or wilt	2	2
Late blight and dry rot	3	3
Net necrosis	3	3
Internal spotting	3	3
Common scab; occasional spots	10	10
Common scab; severe	2	1
Powdery scab	1	1
Rhizoctonia; slight and severe	3	10
		occasional spots*
Rhizoctonia; severe	.....	5
Silver scurf	3	3
Slightly damaged	.....	2
Bruised or cut	1	
Foreign	2	1
Frost injury	No allowance	No allowance
Off type	2	2

*In 1921 some modification was found to be advisable in the case of rhizoctonia, as its occurrence was so generally distributed. Observations made from year to year encourage the opinion that soil temperature is the controlling factor of the severity or otherwise of this trouble. This opinion is supported by a statement made at the annual meeting of the American Potato Association in 1920 by Jones, of Wisconsin, who, in discussing rhizoctonia, said; "It is everywhere, it cannot be restricted, and damage from it depends upon soil temperature. I do not think rhizoctonia a factor which needs to be considered in certification."

NITRO-CULTURE WORK

While the total number of bottles sent out for the season 1921, namely, 994, fell slightly under the total for 1920, yet the opening of the season for 1922, judging by the number of requests for nitro-cultures coming in, gives evidence that the educational work on the benefits of inoculation of legume seeds is bearing fruit amongst the farming community.

The Division of Illustration Stations, in their farming demonstrations, have found a decided improvement in crops treated with cultures over adjacent non-treated lots, and will, in the forthcoming season, employ these cultures on a wider scale than ever before, and practically from coast to coast.

Despite repeated notices in the agricultural press of the Dominion that the distribution is strictly limited in scope to experimental trial, requests are frequently received for supplies of cultures on a more or less wholesale, commercial scale. Hitherto the number of bottles sent out to any individual has been limited to three, sufficient to treat some 180 pounds of seed of a particular leguminous crop. In view of the overwhelming volume of requests now coming in, it may be necessary in future to limit the quantity sent an individual to one bottle, sufficient for the treatment of a bushel of seed.

It may not be amiss here to emphasize the fact that legume cultures are a commercial article carried by the larger seed dealers. Our object has been, and is, primarily to aid the farmer, by the supply of a small quantity of culture gratis, to start his legume crops in the best possible manner, and to extend as widely as possible the use of these important fertilizing crops in regions where they had not been previously established.

It is not, therefore, the purpose either to supply cultures wholesale gratis or at a price. The sole object is to convince farmers, by a small sample quantity supplied them for their own experimental use, that there is a gain in the use of legume-inoculating cultures.

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, CHARLOTTETOWN, P.E.I.

(J. B. McCURRY, *Plant Pathologist, officer in charge*)

During the past year the work of the laboratory has been pursued along several more or less distinct lines. Of these the most important is the conducting of experimental work on the nature, effect and control of potato diseases. The experimental plots cover an area of over two acres at the Dominion Experimental Station. A general survey of a considerable portion of the province was made with respect to plant disease conditions, recording the prevalence and distribution of the various diseases which were observed. Visits were paid to various parts of the province in order to become acquainted with local conditions, the general practices pursued, and the more important diseases of the various crops grown. During the year numerous specimens of plant diseases were submitted to the laboratory, both from this province and from Nova Scotia, for identification and recommendations for their control. Considerable time was devoted to the seed potato certification work, particularly during the fall inspection and shipping period. Since a number of men are growing certified seed potatoes for the first time, advice in connection with the production of disease-free potatoes is much in demand. Exhibits of the more important diseases of field crops were set up in conjunction with the Dominion Experimental Station exhibit at fall fairs held at Georgetown, Charlottetown and Souris. These proved of considerable interest and were considered very instructive, which was manifested by the many inquiries regarding the control of the various destructive diseases shown and referred to. It is hoped that during the coming season an opportunity may be afforded to extend this phase of the work.

Projects 46 and 47.

LATE BLIGHT (*Phytophthora infestans* (Mont.) de Bary)

Spraying for late blight and rot during the season of 1921 was carried out on a more extensive plan by the growers than in any previous year. Although the season was too hot and dry for late blight to develop, the spraying was done regularly and thoroughly in anticipation of its appearance at a later date. The results which were obtained from the extensive experiments conducted in connection with the control of this disease by spraying with Bordeaux mixture, were for the most part negative, due to the absence of any serious infection.

Projects 69 and 71.

COMMON SCAB (*Actinomyces scabies* (Thax.) Güssow).

Since common potato scab causes considerable loss every year both in the growing of potatoes for table stock as well as in the production of certified seed, a series of soil treatment experiments was conducted at the suggestion of the Dominion Botanist with the object of devising control measures which might prove possible of practical application. The materials used in this experiment were ammonium sulphate, flowers of sulphur, commercial fertilizer (ammonium sulphate, acid phosphate, and muriate of potash), and a commercial sulphur inoculated with bacteria known as "Bac-Sul." The different chemicals, instead of being applied broadcast, were sown in the drills and thoroughly incorporated with the soil before the sets were planted. The "seed" used had been subjected to formalin treatment (1:240 for two hours) before cutting; each plot in the experiment was duplicated and six check plots were kept.

COMMON SCAB EXPERIMENT, 1921

1	Ammonium sulphate, 400 lbs. per acre.	Flowers of sulphur, 200 lbs. per acre.	15
2	Ammonium sulphate, 300 lbs. per acre. Acid phosphate, 300 " " " Muriate of potash, 150 " " "	Bac-sul, 100 lbs. per acre	14
3	Check (untreated)	Check	13
4	Bac-sul, 400 lbs. per acre	Ammonium sulphate 100 lbs. per care Acid phosphate 100 " " " Muriate of potash 50 " " "	12
5	Flowers of sulphur, 600 lbs. per acre	Ammonium sulphate, 100 lbs. per acre	11
6	Ammonium sulphate, 200 lbs. per acre	Flowers of sulphur, 400 lbs. per acre	10
7	Ammonium sulphate, 200 lbs. per acre Acid phosphate, 200 " " " Muriate of potash, 100 " " "	Bac-sul 200 lbs. per acre	9
8	Check	Check	8
9	Bac-sul, 200 lbs. per acre	Ammonium sulphate 200 lbs. per acre Acid phosphate 200 " " " Muriate of potash 100 " " "	7
10	Flowers of sulphur, 400 lbs. per acre	Ammonium sulphate, 200 lbs. per acre	6
11	Ammonium sulphate, 100 lbs. per acre	Flowers of sulphur, 600 lbs. per acre	5
12	Ammonium sulphate 100 lbs. per acre Acid phosphate 100 " " " Muriate of potash 50 " " "	Bac-sul, 400 lbs. per acre	4
13	Check	Check	3
14	Bac-sul, 100 lbs. per acre	Ammonium sulphate 300 lbs. per acre Acid phosphate 300 " " " Muriate of potash 150 " " "	2
15	Flowers of sulphur 200 lbs. per acre	Ammonium sulphate 400 lbs. per acre	1

NOTE: Each plot 1/300 acre
Each plot is duplicated,—Combined 1/150 acre
Seed treated throughout—formalin 1:240 for 2 hours.

COMMON SCAB

EFFECT OF CERTAIN SOIL TREATMENTS AND FERTILIZERS ON THE AMOUNT OF COMMON SCAB

Treatment	Pounds per acre	Percentage by weight of duplicate plots	
		Scabbed	Clean
Sulphur	200	44·54	55·46
	400	53·51	46·49
	600	53·95	46·05
Bac-sul	100	52·17	47·83
	200	39·27	60·73
	400	65·46	34·54
Ammonium sulphate	100	53·89	46·11
	200	40·00	60·00
	400	64·03	35·97
Ammonium sulphate Acid phosphate Muriate of potash	100 100 50	58·11	41·89
Ammonium sulphate Acid phosphate Muriate of potash	200 200 100	38·74	61·26
Ammonium sulphate Acid phosphate Muriate of potash	300 300 150	77·06	22·94
Check	1	65·31	34·69
	2	60·16	39·84
	3	69·18	30·82
Check—Average of 6 plots	.....	64·88	35·12

From the foregoing table it will be observed that the treatments which yielded the most satisfactory results were:—

Treatment	Pounds per acre	Percentage by weight duplicate plots	
		Scabbed	Clean
Ammonium sulphate Acid phosphate Muriate of potash	200 200 100	38·74	61·26
Bac-sul	200	39·27	60·73
Ammonium sulphate	200	40·00	60·00
Sulphur	200	44·54	55·46

In all other tests with the same materials applied in either increased or decreased amounts, the results obtained in this first year's work were less satisfactory, since the amount of scab which developed (ranging from slight to severe) was too large to justify their use. Nevertheless, it is not possible to draw any definite conclusions from only the one year's work. Slight "russet" injury to the tubers occurred in one plot where ammonium sulphate was used at the rate of 100 pounds per acre. It is not probable, however, that this was due to the treatment used, since no such injury resulted in any other plots where the same treatment was applied.

It is intended to continue these experiments on a larger scale during the coming season, when land more severely infested with the scab organism will be available. *Project 109.*

BLACK LEG (*Bacillus atrosepticus* van Hall)

This disease is propagated from year to year only through the use of infected seed, and the organism is not capable of wintering over in the soil. Moisture and a moderately low temperature are conducive to the rapid development of the causal organism,

making the disease more severe during a wet season. The season of 1921 was extremely dry, which condition hindered the development, to any great extent, of the disease.

Experiments were conducted to ascertain:—

1. Whether apparently sound tubers from plants affected with black-leg would produce diseased plants the following year.

2. Whether, and to what extent, healthy sets would become infected through being cut with a knife which had been used for cutting diseased sets.

3. Whether, and to what extent, diseased sets would affect healthy sets when cut and placed in the same receptacle in a warm place for two or three days before being planted.

All sets, including diseased as well as artificially inoculated ones, in all the above experiments produced healthy plants, presumably as a result of the local weather conditions referred to.

Project 8.

LEAF ROLL

Extensive experiments conducted in previous years have shown that this disease causes a serious reduction in yield whenever an appreciable number of plants is affected, and in severe cases the yield may be reduced to 25 per cent of the normal crop. In an endeavour to ascertain in what manner and to what extent this trouble is capable of being spread from diseased to healthy plants, a number of experiments were conducted taking into consideration the possible relation of the transfer of infection to certain conditions such as the presence of certain insect pests, and the proximity of healthy and diseased plants. Another experiment had for its object the furnishing of data as to the influence of the eradication of diseased hills upon the prevalence and spread of disease. All efforts to produce the disease by root contact of healthy and diseased plants have so far yielded negative results. This has also been the case where insects—aphids and potato beetles (both adults and larvæ)—were used.

Experiments to Note the Effect of Planting Healthy Sets in Leaf Roll Pulp

In 1920 a number of healthy tubers of the Irish Cobbler variety were cut in halves and one-half from each tuber planted in direct contact with inoculum which had been prepared by grinding tubers from leaf roll plants. The other half of each tuber was planted in the same order in an adjacent row, no pulp being used. In continuing the experiment, seed from this material was again used in similar fashion the following year. In both cases negative results were obtained.

PRINCE EDWARD ISLAND SEED POTATOES AT THE SEED SOURCE TEST, LONG ISLAND, N.Y.

The fourth annual seed source test inspection tour held in Suffolk county, Long Island, N.Y., on June 29 and 30 proved to be a great success. It was well attended by seed potato growers, county agricultural agents, plant pathologists, inspectors, and other agricultural workers from New York, New Jersey, Vermont, Maine, New England States and Canada.

The object of these tests is to demonstrate to the farmers of Suffolk county and others, where the best seed can be obtained, as well as to show the loss in yield caused by the various diseases, when grown under Long Island conditions.

There were over sixty different strains entered in the official Green Mountain test, from New York, Maine and Canada. The half bushel sample sent of each lot is

cut and divided into two equal parts and planted in separate tests in different parts of the county. At a suitable time the inspection of the growing plants is done by the Department of Plant Pathology of Cornell University.

Eight samples in all were entered from Canada, five of which came from Prince Edward Island, and three from New Brunswick. There was also one lot taken from ordinary Canadian market stock. From a disease standpoint the Prince Edward Island seed showed up remarkably well, two of the lots being absolutely free from mosaic and leaf roll,—the two diseases which the Long Island grower fears mostly on account of the loss sustained when a high proportion of tubers from plants so affected is present in the seed which he buys. The average amount of disease present in the five Prince Edward Island samples was 0.2 per cent mosiac, and 0.8 per cent leaf roll. Weak plants were also scored as well as black leg and foreign varieties. There was an average of 3 per cent and 1 per cent black leg in the samples from this province.

In both the tests, the Canadian seed was best from a disease standpoint. While this is a very important point in our favour, and one which the Division of Botany has been emphasizing for some years past, nevertheless, there are other points which require the Canadian grower's careful attention before he can hope to compete successfully with other seed-producing areas. One of these points was convincingly brought to notice in the results obtained in last year's Long Island test, namely, "The Production of High Yielding Strains". Our seed growers must aim at freedom from disease and high yields. In no other way can they hope to build up and keep a market for their seed stock.

It was evident that Prince Edward Island has been widely advertised as a source of good seed potatoes, as on all sides during the inspection tour could be heard favourable comments on the apparent good quality of our seed in the field.

PLANT DISEASES IN PRINCE EDWARD ISLAND IN 1921

The general survey of plant diseases was commenced in 1920, but owing to lack of the necessary assistance could not be carried on systematically. This work was continued in 1921 by the staff of the laboratory whenever possible. Owing to the severe drought which extended from the latter part of June until about the middle of August, the loss from plant diseases was greatly reduced.

Besides the officer-in-charge, the observers were Messrs. S. G. Peppin, G. O. Madden, and L. J. Howatt.

Project No. 110

Barley.

Stem Rust (*Puccinia graminis* Pers.).—This disease was common wherever the host was grown, but caused little damage.

Naked Smut (*Ustilago nuda* (Jens.) K. & S.).—General throughout the province, infection varying from 0.5 per cent to 10 per cent.

Covered Smut (*Ustilago Hordei* (Pers.) K. & S.).—Not observed.

Oats.

Stem Rust (*Puccinia graminis* Pers).—This disease although not general, was severe in a few instances.

Leaf Rust (*Puccinia coronata* Cda.).—General, especially in Queen's County, but not severe.

Loose Smut (*Ustilago Avenae* (Pers.) Jens.).—Common, causing considerable damage. Infection from 1 to 23 per cent.

Wheat.

Stem Rust (*Puccinia graminis* Pers.).—Very little damage was caused by stem rust on account of the dry weather conditions. In no instance was the wheat crop found to be badly attacked.

Leaf Rust (*Puccinia triticina* Eriks.).—Very prevalent—numerous fields in all parts of the province ranging from 60 to 90 per cent infection. It would, however, be difficult to estimate the damage, owing to drought.

Loose Smut (*Ustilago Tritici* (Pers.) *Rostr.*).—General throughout the province. Loss about 2.5 per cent.

Stinking or Bunt Smut (*Tilletia Tritici* (Bjerk.) Wint.).—General, but not severe. Damage about 2 per cent.

Scab (*Gibberella Saubinetii* (Mont.) Sacc.).—This disease occurred but to a very slight extent, only a few specimens being collected. Weather conditions prevented its usual general appearance.

Alfalfa.

Leaf Spot (*Pseudopeziza Medicaginis* (Lib.) Sacc.).—Infection was general, but little apparent damage resulted.

Apple.

Scab (*Venturia inaequalis* (Cke.) Wint.).—Scab was of comparatively little economic importance this year. Unsprayed trees showed from 0.5 to 7.5 per cent infection. Sprayed trees examined were almost entirely free.

Fire Blight (*Bacillus amylovorus* (Burr.) Trev.).—Present to a slight extent in a few orchards.

Currant and Gooseberry.

Leaf Spots (*Mycosphaerella and Pseudopeziza*).—These diseases were general, but caused little damage.

Powdery Mildew (*Sphaerotheca mors-uvæ* (Schw.) B. et C.).—Two cases of slight infection were found on gooseberries.

Cluster Cup Rust (*Puccinia Pringsheimiana* Kleb.).—This rust of gooseberry was found only once, in a kitchen garden in Prince County.

Pear.

Fire Blight (*Bacillus amylovorus* (Burr.) Trev.)—This disease was found in a few orchards, averaging 0.7 per cent twig infection.

Plum.

Black Knot (*Dibotryon morbosum* (Schw.) T. et S.).—Several severe cases were observed in neglected trees. About 5 per cent twigs affected.

Raspberry.

Leaf Curl (Cause undetermined).—This disease was found wherever Cuthbert raspberries were grown. Affected canes averaged 6 per cent of the planting, the loss would be about the same figure. Herberts were entirely free. Occasional cases of leaf curl were found among wild raspberries.

Mosaic (Cause undetermined).—This disease was general, averaging 17 per cent.

Spur Blight (*Mycosphaerella rubina* (Pk.) Jacz.).—This disease was only found in one plantation where 19 per cent of the canes were affected.

Strawberry.

Leaf Spot (*Mycosphaerella Fragariae* (Schw.) Lindau.).—Present in all strawberry patches examined, though to a comparatively slight extent.

Bean.

Anthracnose (*Colletotrichum Lindemuthianum* (S. & M.) B. et C.).—This disease was entirely held in check by the dry weather. Only a very few lesions were observed throughout the season.

Mosaic (Cause undetermined).—Five moderate cases of this disease were observed. Infection averaged 1.5 per cent.

Tomato.

Mosaic (Cause undetermined).—This trouble was found to a moderate exent. Average occurrence about 3.5 per cent.

Turnip.

Club Root (*Plasmodiophora Brassicae* Wor.).—This disease was observed in slight to moderate amounts in different parts of the province.

Project 111.

PLANT DISEASES IN NOVA SCOTIA IN 1921

The plant disease survey was commenced in Nova Scotia this year. The work was engaged in by the local staff of the Division of Botany whenever opportunity permitted. Owing, however, to the lack of additional collaborators, a systematic survey of the province was not possible. Since there are no records of the general prevalence of plant diseases in previous years a comparison could not be made. The report is, of course, incomplete since it was not possible to engage in this work throughout the season.

Owing to the prolonged drought conditions which prevailed during June, July and August, losses due to fungus diseases were greatly reduced.

Besides the officer in charge, observers in this province were Messrs. W. K. McCulloch, P.M. Simmonds, and S. C. Partridge.

Barley.

Stripe Disease (*Helminthosporium gramineum* Rab.).—Very prevalent practically throughout the province. Usually about 30 to 50 per cent of leaves affected.

Oats.

Stem Rust (*Puccinia graminis* Pers.).—General and occasionally severe. Several fields showed 25 per cent infection. Average 8·1 per cent.

Leaf Rust (*Puccinia coronata* Cda.).—Very common and often severe. Twenty-nine reports averaged 18 per cent of leaf area affected.

Smuts (*Ustilago Avenae* (Pers.) Jens. and *U. levis* (K. et S.) Magn.).—This disease was very prevalent, ranging from 0·5 to 20 per cent infection. Thirty-seven reports averaged 5·3 per cent.

Wheat.

Stem Rust (*Puccinia graminis* Pers.).—Common but not serious. Average infection 4·6 per cent.

Leaf Rust (*Puccinia triticina* Eriks.).—No appreciable damage caused. Leaf surface affected, 6·1 per cent.

Loose Smut (*Ustilago Tritici* (Pers.) Rostr.).—Common. One report 14 per cent; average infection 5·2 per cent.

Turnip.

Club Root (*Plasmodiophora Brassicae* Wor.).—Numerous cases reported, infection varying from 1 to 7 per cent. In one case in King's County, however, 45 per cent of the crop was affected.

Apple.

Scab (*Venturia inæqualis* (Cke.) Wint.).—Owing to the unusually dry spring and summer, scab was much less severe than usual. In unsprayed orchards, however, leaf and fruit infection averaged 13·5 and 38·7 per cent respectively.

Twig Blight (*Bacillus amylovorus* (Burr.) Trev.).—Very little of this disease was reported this year.

Black Rot Canker, and Leaf Spot (*Physalospora Cydoniae* Arn.).—From reports and observations, this disease appears to be prevalent throughout a wide area in the Annapolis Valley, causing considerable damage to leaves and twigs. Leaf infection varied from ·005 per cent slight to 55 per cent severe, averaging 8·85 per cent. Twig infection varied in severity from 3 per cent to 25 per cent, averaging 13·1 per cent.

European Canker (*Nectria galligena* Bres.).—This disease was found to be very prevalent in the Annapolis Valley and other points, causing considerable twig injury.

Cherry.

Brown Rot (*Sclerotinia cinerea* (Bon.) Schroet.).—Reported severe in several localities, loss varying from 3 to 80 per cent.

Leaf Blight (*Coccomyces hiemalis* Higg.).—This disease was more or less general. Leaf infection varied from ·02 to 25 per cent, averaging 3·8 per cent. The resulting damage, however, would be difficult to estimate.

Black Knot (*Dibotryon morbosum* (Schw.) T. et S.).—There was a noticeable amount of this disease but damage was slight.

Plum.

Brown Rot (*Sclerotinia cinerea* (Bon.) Schroet.).—Occasionally severe. One report recorded 40 per cent. The average, however, was low.

Plum pockets (*Exoascus Pruni* Fckl.).—Although not generally distributed, several severe infections were reported, 7 to 60 per cent. Average loss about 6 per cent.

Black Knot (*Dibotryon morbosum* (Schw.) T. et S.).—Several severe cases were reported from the Annapolis Valley.

Peach.

Leaf Curl (*Exoascus deformans* (Berk.) Fckl.).—Comparatively little in evidence. One report recorded as high as 25 per cent leaf injury.

Currant and Gooseberry.

Leaf Spots (*Mycosphærella and Pseudopeziza*).—These diseases were present but were of comparatively little importance this year.

Powdery Mildew (*Sphaerotheca mors-uvae* (Schw.) B. et C.).—Present to a considerable extent on English varieties. One report gave 25 per cent infection.

Currant Rust (*Cronartium ribicola* F. v. W.).—One severe case on cultivated black noted at Kentville. One hundred per cent of leaves were infected moderately to severely.

Pear.

Scab (*Venturia pyrina* Aderh.).—This disease was occasionally severe on the leaves, but comparatively little fruit injury was reported.

Leaf Spot (*Mycosphaerella sentina* (Fr.) Schroet.).—Very little in evidence. Occurrences averaged 9 per cent leaf infection.

Raspberry.

Leaf Curl (cause unknown).—Present but not general. Four reports recording this disease averaged 5 per cent of bushes affected, usually severe in form, causing a loss to that extent.

Mosaic (cause unknown).—This disease appeared to be more or less general in distribution, but did not cause much immediate damage.

Blackberry.

Orange Rust (*Gymnoconia interstitialis* (Schl.) Lag.).—Several cases of this disease occurred on a wild species.

Strawberry.

Leaf Spot (*Mycosphaerella Fragariae* (Schw.) Lindau.).—Leaf spot was not general in Nova Scotia this year. The disease was observed in a number of plantations, but only slight injury was caused.

REPORT OF DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, FREDERICTON, N.B.

(G. C. CUNNINGHAM, *Plant Pathologist, Officer in Charge*)

GENERAL CONDITIONS IN THE PROVINCE

The spring and summer of 1921 were exceptionally dry and hot, so that plant diseases which are generally destructive did not develop to serious proportions. In fact, such troubles as late blight of potato, bean anthracnose, apple scab and many leaf spot diseases did not make their appearance until late in the season. As a result of the weather conditions some of the control and observation experiments failed to produce results that could be utilized, and several experiments had to be abandoned.

During the past year, experiments started in previous years were continued, including investigations on bean and potato diseases. Considerable attention was again given to the improvement of seed potatoes in Sunbury and Restigouche counties, accompanied by successful steps towards introducing the stock into other districts. The potato inspection was carried on along the same lines as previously, but under great difficulties, owing to the unfavourable season in the early part of the year. The dry weather complicated mosaic symptoms, and, it is believed, caused leaf roll symptoms in plants which were not actually infected with true leaf roll. Observations were made on several other diseases, which are not included in the list of experimental studies.

Project 112.

CLUB ROOT OF TURNIPS CAUSED BY *Plasmodiophora Brassicæ* Wor.

Club root of turnips continues to be a problem in certain sections of New Brunswick and Quebec. Heretofore, investigations on this problem were not conducted because the infected land on the Experimental Farm was not available for our work. A portion of the plant disease area has now been sufficiently infected to permit of work being inaugurated.

Method of Infection.—In 1920, drills were made and infected soil transferred to them. Turnips were then planted on this soil. These were allowed to mature and decompose in the soil with the result that this season a heavy infection was obtained over the entire area.

In the spring of 1921 the infected area was planted with different varieties of turnip seed for the purpose of further infecting the soil and obtaining data on varietal resistance. The data obtained are tabulated below.

CLUB ROOT OF TURNIPS—VARIETAL RESISTANCE

Row No.	Name of Variety and Source of Seed	Per cent of plants infected with Club Root		
		Slightly	Severely	Free
	From D. M. Ferry Co., Windsor, Ont.			
1	Early Purple Top Strap Leaved	38·9	50·0	11·1
2	Early White Flat Dutch Strap Leaved	30·0	56·7	13·3
3	Improved Purple Top Yellow	28·2	58·9	12·9
4	Purple Top White Globe	21·2	45·5	33·3
5	American Purple Top, or Improved Long Island (Rutabaga)	9·09	81·81	9·09
6	Early Purple Top, Strap Leaved	18·7	75·0	6·3
7	Hartley's Brouse Top (Rutabaga)	26·0	24·	50·0
8	D. M. Ferry Co's Improved Purple Top Yellow (Rutabaga)	18·	29·	53·
9	Monarch, or Tankard (Rutabaga)	33·	17·	50·
10	Orange Jelly, or Tankard Ball	17·	30·	54·
11	Purple Top White Globe	15·	36·	49·
	From J. A. Simmers, Ltd., Toronto, Ont.			
12	Aberdeen Green Top Yellow	11·	40·	49·
13	Aberdeen Purple Top Yellow	8·	30·	62·
14	Cowhorn	7·7	86·5	5·8
15	Elephant Monarch or Jumbo (Swede Turnip)	28·4	49·2	22·4
16	Greystone	7·3	87·8	4·9
17	Hall's Westbury Swede (Swede Turnip)	15·9	77·3	6·8
18	Hazard's Green Top. " "	47·2	41·7	11·1
19	Improved Purple Top Mammoth	11·9	85·7	2·4
20	Swede Turnip, Kangaroo	60·	26·7	13·3
21	Ne Plus Ultra (Bronze Top) (Swede Turnip)	23·3	62·8	13·9
22	J. A. Simmers' Champion Purple Top Swede	22·	39·	39·
23	Simmers' Defiance (Swede Turnip)	23·3	41·7	35·
24	Simmers' Derby Bronze Top (Swede Turnip)	31·7	24·	44·3
25	Universal Purple Top or Canadian Gem	33·9	27·4	38·7
26	White Globe	16·	51·	33·
27	White Giant Green Top	20·	33·	47·
	From The Ontario Seed Co., Waterloo, Ont.			
28	Canadian Gem (Swede Turnip)	17·	21·	62·
29	Kangaroo (" ")	34·5	29·8	35·7
30	Lord Derby (" ")	30·2	11·6	58·2
31	Our Ideal (" ")	13·1	36·4	50·5
	From Steele, Briggs Seed Co., Ltd., Toronto, Ont.			
32	Swede Canadian Gem	24·	25·	51·
33	Swede Hartley's B.T.	28·	42·	30·
34	Swede Skirvings	25·5	41·8	32·7
35	Swede Monarch	24·2	66·1	9·7
36	Swede Bangholm	32·2	26·8	41·
37	Swede Champion	18·5	38·5	43·
38	Swede Durham	23·	40·	37·
39	Swede Good Luck	21·9	29·3	48·8
40	Swede Hazard's	12·	39·	49·
41	Swede Imperial	22·	28·	50·
	From Steele, Briggs Seed Co., Toronto, Ont			
42	Swede Kangaroo	26·03	32·88	41·09
43	Swede Perfection	30·5	36·6	32·9
44	Swede Selected P.T.	27·4	40·3	32·3
45	Swede Westbury	38·7	32·3	29·
46	Bangholm	33·3	23·3	43·4
47	Perfection	37·3	17·9	44·8
48	Hazard's Improved B. Top	24·7	35·	40·3
	From Ewing & Co.,			
49	Garton Superlative	21·4	32·2	46·4
50	Best of All	35·6	25·5	38·9
51	Mammoth Clyde (Purple Top)	39·9	32·4	27·7
	From Bronces.			
52	White Swede	22·9	35·7	41·4
53	Holborn Invicta	30·2	23·2	46·6

Project 113.

LEAF SPOT OF TOMATO.—(*Septoria Lycopersici* Speg.)

This disease is probably the most common disease of the tomato in Eastern Canada, and has been causing considerable loss to the growers. It appears during the latter part of July or early August and by the last of August the plants have become defoliated or so badly injured that little fruit, and that of poor quality, is produced. Some of the growers in the Grand Lake and lower St. John River Valley sections report from 50 to 75 per cent of a crop. Large plantings have been examined where the plants were just commencing to produce when checked by the disease.

Spread.—The fungus is probably carried over from year to year on old tomato vines lying around the green house or starting frames and in the soil used for starting the young plants. The plants are started in greenhouses or hot beds and kept under glass until early June when the plants are almost in blossom. An excellent opportunity for infection of the young plants and spread of the fungus is provided while the plants are crowded in the frames. The spores are further dispersed during transplanting and when setting in the field. Further spread takes place during cultivation when the plants are wet and possibly by spattering rain drops.

Suggestion for Control.—As a means of lessening early infection the grower should start his plants on clean soil which has not been previously used in the frames and under no conditions should the same soil or frames be used for propagating young plants which had been used the previous year. All unused plants and refuse should be burned after the crop is transferred to the field and not left in the vicinity of the next season's potting operations. After the crop has been harvested, all vines should be raked off the field and burned.

Spraying with Bordeaux mixture has proven successful. Where the plants are retained for long periods in a crowded condition in crates or frames, one or two applications should be made before setting in the field, the next spray being applied as soon as possible after transferring to the field so as to destroy the spores which were spread during the setting operations. Two or three applications after the plants have been set in the field will probably suffice to hold the disease in check until the plants are destroyed by frost. A 2:2:40 Bordeaux should be applied to the plants in the frame and not stronger than 4:4:40 in the field. As a precaution against burning, an excess of lime may be used.

Project 114.

STEM ROT OF VEGETABLES CAUSED BY *Sclerotinia libertiana* Fckl.

This fungus has been long recognized as a destructive agent to certain vegetable crops, particularly in green houses and gardens where intensive culture is practised. During the last four years it has been frequently observed causing considerable loss in gardens in New Brunswick. The soil in part of the Dominion Experimental Station garden at Fredericton, N.B., has become infected and few plants grown on this section have escaped infection. The following host plants have been noted: Beans, beets, carrots, celery, cabbage, parsley, sunflowers, tomatoes, potatoes and several species of flowering plants.

In order to have material available for experimental purposes, an attempt was made to introduce the disease into the pathological plots, but without success. This attempt, however, is worth recording as indicating that the disease is not readily transferable under certain conditions. The soil of the plots is of a light, sandy loam nature, open, rather low in humus and with good natural drainage. Infection was attempted by two methods.

(1) Bean straw heavily infected with the fungus was passed through a straw cutter and then worked into the soil.

(2) Infected soil from the garden was transferred to the experimental plots and worked into drills.

The plots were then planted with the Detroit, a variety of wax bean, which had proven very susceptible in the garden plots. Care was taken to place the seed in contact with the straw or infected soil. Beans have been planted on these plots during the last two seasons and no infection has been noted. The failure to obtain infection was probably due to the soil conditions, or soil temperature, a factor more and more recognized as most important.

Infection of bean and pea plants was obtained with pot experiments in the laboratory. Soil supposedly free from the disease was sterilized and placed in pots:—to one series of pots, broken up bean pods infected with the fungus were added, and to another series, broken up sclerotia obtained from bean plants,—typical infection was obtained in both cases. It must, however, be observed that the soil was kept damp and the plants were under more or less crowded and humid conditions. These tests show that the fungus may attack the plants when the soil is infected, and that it is not necessarily confined to infection by the ascospores.

That the infection frequently takes place by the dispersal of ascopores is indicated from the fact that the primary infection usually develops at the base of branches or in the axils of leaves. Later in the season infection probably is more common from diseased and healthy parts coming in contact.

Stem Rot of Potato.—During the last few years the writer has not infrequently found this fungus attacking potato plants. In no case did the trouble reach serious proportions, but it seems sufficient to point out that it is present and causing potato disease in many fields and at widely different points in the province. It is possible that the fungus may become sufficiently abundant in our extensive potato growing district to cause serious loss under favourable conditions.

Cotton (*Journal of the Board of Agriculture,* London, March, 1919) discussing its occurrence in England states that, "The stalk disease of potatoes is most destructive in the northern and damper parts of the country. In the west of Ireland the loss occasioned by it is so great that, with the exception of ordinary potato blight (*Phytophthora infestans*), it has been stated to be the most serious disease with which growers have to contend."

It is, therefore, possible that this disease may continue to spread and become serious under the moist, cool climatic conditions usually prevailing in the Maritime Provinces. The present practice of planting one potato crop after another on the same land will undoubtedly tend toward permitting the disease to become established.

Control Measures.—The most promising measures of control are: (1) Raking up and burning the potato crops immediately after harvesting the crop. (2) Practising a two- or three-year rotation.

Projects 87 and 88.

BEAN MOSAIC

In 1915, bean mosaic was noted in Kent county, Ontario, and in 1918 it was found to be common and abundant in the bean fields of southern Ontario and parts of Quebec. It was also noted, but not reported as serious, in Manitoba and the Maritime Provinces. It has also been reported by workers in the United States, particularly in New York State where some work has been done on it. In 1919, some investigations were commenced and observations made which may be of interest until further knowledge is obtained.

The leaves of infected plants show irregular, mottled, and crinkled or puckered areas. The raised or crinkled area is of a normal green and the remainder of the leaf

smooth and of a dry texture and yellow-green in colour. At first only a small portion may be of the yellow-green colour: this, however, gradually increases until the whole leaf and perhaps all the leaves on the plant assume the same shade and texture. Infected plants are usually small and readily crowded out or hidden by the more vigorous, healthy ones.

Under normal field conditions, the plants set few or no pods, and the pods produced are usually small. This, naturally, greatly reduces the yield, depending on the percentage of infected plants in the field. Diseased plants, however, are found producing normal or nearly normal yields. These plants may have been infected late during the growing season. Seed from diseased plants is usually, but not invariably, infected, and produces diseased plants. Such seed has a low germinating quality and frequently produces weak plants. Sufficient is known concerning the loss which may be caused by this disease to justify every grower in taking precautions to avoid and eliminate it.

It is carried in the seed from year to year and spreads from diseased to healthy plants under field conditions. Just how this transmission takes place is not known. However, it has been transferred by crushing diseased leaves and then rubbing the extracted juice on the leaves of healthy plants. It has also been transferred by injecting the extract from diseased plants into healthy plants. As this can be done quite readily it is possible that it may be spread by pickers, cultivating machinery, or, possibly, by insects.

Control.—In view of the fact that diseased plants produce diseased seed which in turn produces diseased plants, and that the disease spreads in the field under normal conditions, there are certain precautions which should be taken until more satisfactory methods have been discovered. The grower should obtain his seed from fields or stock which was not infected the previous season. If he does not know of a disease-free field, he should obtain the seed from exceptionally high-yielding fields. Following this, he should go over his seed-producing field repeatedly during the summer, removing all diseased or weak plants. He will also gain an advantage by selecting his seed from healthy, vigorous, high-yielding plants.

Hand-selection of seed, seed treatments, or spraying will not control the disease.

Projects 81 to 86.

BEAN POD SPOT OR ANTHRACNOSE

(Frontispiece)

LOSS CAUSED BY THE DISEASE

A conservative estimate of the decrease in value of the Canadian bean crop, caused by this one disease, is probably over 10 per cent. In some localities and during some seasons it is undoubtedly much more; many fields have been examined where the crop was reduced by from 50 to 75 per cent. The total annual loss on the dried bean crop alone amounts to over 300,000 bushels, and to this must be added the loss caused to beans which are grown in every garden. This loss is manifest in several ways. The first and most important is decreased yield, which loss may vary from little or nothing to almost a complete failure. Beans from badly and even moderately infected fields are not suitable for seed purposes unless very thoroughly hand-picked, and, even then, diseased beans are sure to escape. Probably the growers of string beans, where the green pods are used for table or canning purposes, suffer the greatest proportional loss, as infected pods are unmarketable. The plants in some of our tests have been almost completely destroyed, while in others the crop was useless.

SPREAD AND DEVELOPMENT OF THE DISEASE

The disease, as previously stated, is propagated from year to year, chiefly by planting diseased seed and to a lesser extent by using infected bean refuse as

fertilizer, or failure on the part of the grower to practise a reasonable crop rotation. The spread and development of the disease in the field is influenced to a large extent by the prevailing climatic and soil conditions. During a bright, dry season little damage is caused, but during wet, cloudy weather it spreads and develops rapidly. This is because of three conditions: (1) The spores have a mucilaginous envelope which holds them together when dry and retards their being carried from the diseased lesion to healthy plants by the wind. (2) The spores are produced most abundantly during wet weather. (3) They can germinate and gain entrance to healthy tissue only when moisture is present. Rain drops spattering from diseased leaves or infected soil carry the spores to healthy plants.

Beans grown on low, wet, or poorly drained soil are usually more severely injured than those grown on high, dry soil. This is probably due to a greater amount of moisture in the atmosphere surrounding the plants and to the fact that an abundance of soil moisture encourages an early, rapid growth of the fungus contained in, or on, the infected seed during germination. The same condition is brought about even on high soil if the seed is planted too early and during wet weather.

Healthy leaves become infected by brushing against moist, spore-bearing lesions. Spores are carried from one plant to another by cultivating machinery and on the hands of the picker. It is, therefore, advisable to avoid working among beans when the foliage is wet. Our experiments have not yet been successful in demonstrating this spread, as they were planned and executed during the last two seasons, which proved to be dry and warm. Our observations during wet seasons and the observations of others, however, amply substantiate the contention that it is spread by working the crop during wet weather.

CONTROL MEASURES

Numerous suggestions for the control of anthracnose have been made from time to time but these have failed, partly because of their inefficiency but largely due to the fact that the growers have failed to put them into practice carefully and continuously. The chief point to keep in mind is that diseased seed produces diseased plants and these serve as a source of infection to healthy plants. Our experiments conducted over a period of five seasons indicate that a combination of control measures will give the best result. The various steps are here described separately but should be practised collectively.

Pod Selection.—Disease-free seed can be most easily obtained by gathering sound pods from a field as nearly disease-free as is available. In selecting these pods, care should be taken to select from plants which appear resistant to the disease, high yielders and true to the desired type. Our attempts at obtaining disease-free seed by selecting apparently disease-free beans, while reducing the amount of disease present, have not lessened it to the same extent as has selecting disease-free pods. Pod selection has enabled us to produce several exceptionally good strains.

As an additional precaution, the pods should be immersed in one of the following solutions for two or three minutes:—

(*a*) Copper sulphate, 1 pound in 80 gallons of water.
(*b*) Formalin, 1 pint in 30 gallons of water.
(*c*) Corrosive sublimate, 1 ounce in 8 gallons of water.

The pods are then thoroughly dried, threshed and the seed stored in a clean sack; care should be taken to avoid reinfection of the seed. If it is impracticable to select enough pods to supply seed for planting the whole of the next year's crop, sufficient should be selected for a seed plot.

Seed plot.—A seed plot is nothing more nor less than a plot on which is propagated desirable seed, of pure variety, true to type, high yielding and free from diseases, in sufficient quantity to supply seed for planting the main crop the following year.

The very best seed obtainable should be secured for planting the seed plot. The practice has given excellent results with other crops and might profitably be practised by bean growers.

Seed selection.—Where pod selection has not been practised, and even if it has, the beans should be carefully hand-picked, removing all discoloured, spotted, shrunken, or inferior seed before planting. This will not remove all the infected seed but will materially reduce the amount. Several preliminary experiments in careful hand-selection gave very promising results, not only as a control for anthracnose but as a means of eliminating inferior seed and disease in general.

A number of tests with diseased and healthy seed have been conducted but the results of one given below will substantiate the above suggestions. The diseased and healthy seed were selected from the same sample. The healthy seed was hand-selected and free from disease only in so far as the eye could detect. The diseased seed showed a distinct spot but was not sufficiently injured to prevent germination.

Project 82.

DISEASED AND HEALTHY BEAN SEED

WITH WHITE PEA BEAN

Condition of Seed	Total Yield (Bush. per acre)	Free from spots	Slightly spotted	Spotted
		%	%	%
50 healthy	15·40	89·2	10·8	0·
47 healthy and 3 diseased	12·68	88·7	11·2	0·1
45 healthy and 5 diseased	16·08	85·6	13·8	0·6
37 healthy and 13 diseased	13·81	93·1	6·3	0·6
5 healthy and 25 diseased	12·00	90·3	9·2	0·5

Seed treatment.—Treatment of seed beans has not given wholly reliable results, probably due to the fact that the organism causing the disease penetrates deeply into the tissue, and cannot be easily destroyed without injuring the germinating quality of the seed. Nevertheless, after the seed has been carefully hand-selected, treatment will help by destroying slight surface infections. Experiments with various seed treatments indicate that soaking the seed for three minutes in any of the solutions given above reduces the amount of disease and increases the yield. Treatment, however, will prove of little value unless the seed has been previously carefully selected.

Experiments on seed treatment during 1919, 1920, and 1921 have not consistently given beneficial results. However, the mass of data accumulated would tend to show that a proper method of seed treatment may be developed which will materially assist. The table given below is a summary of the results of twelve tests conducted at the Fredericton Station during the last three seasons.

SUMMARY OF DATA FROM BEAN SEED TREATMENT EXPERIMENTS AT FREDERICTON, 1919–1921

Treatment of Seed	Yield in bush. per acre	Per cent of clean Seed	Per cent slightly spotted Seed	Per cent badly spotted or weathered
Immersed in Bordeaux mixture 4:4:40 for 5 minutes	13·4	77·1	10·7	12·2
" formalin 1:300 for 5 minutes	12·4	73·0	10·5	16·5
" copper sulphate 1:80 for 3 minutes	11·8	78·5	9·0	12·5
" water at 55° C. for 10 minutes	11·6	74·5	11·9	13·6
" corrosive sublimate 1:1000 for 3 minutes	11·6	78·1	8·1	13·8
Control (no treatment)	11·2	74·5	12·7	12·8
Moistened and dusted with Bordeaux powder	10·3	72·5	11·5	16·0

Copper sulphate and corrosive sublimate are poisons and beans treated with them should not be used for table purposes or fed to animals.

SPRAYING.—Spraying beans for the control of anthracnose has not proved entirely successful or economical; the disease can be checked to some extent but not controlled. When great importance is attached to freedom from disease, such as on a seed plot, or where beans are being grown for seed purposes, they should be sprayed with a 2:2:40 or 4:4:40 Bordeaux mixture, the first application being made when the plants are quite small, and succeeding applications at intervals of one week or 10 days.

Spraying tests conducted in 1918 gave exceptionally promising results as indicated by greater freedom from disease, larger yield and a better quality of seed. The tests conducted from 1919 to 1920 were not promising. It is probable that under certain seasonal conditions, such as moist, cool weather, spraying may prove beneficial, while under dry, warm conditions the reverse would be true. Spray injury was not noted in the earlier tests while it was quite pronounced with the later tests.

In addition to the above practices, the grower should observe the following precautions:—

1. Select a marketable variety known to show resistance to the disease in his neighbourhood.

2. Plant on dry, well-drained soil.

3. Avoid the use of bean refuse as fertilizer on the bean field.

4. Plant beans in the same field not oftener than once in three years.

5. Avoid cultivating, picking, or doing any other work among the beans during wet weather.

REPORT OF DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, ST. CATHARINES, ONT.

(W. H. RANKIN, *Plant Pathologist, Officer in Charge*)

When the work on raspberry yellows (leaf curl type) was begun in 1920 as a minor subject for investigation, it was not apparent that within a year this disease (the mosaic type especially) would assume such great economic importance as it has. The yellows this year has proved to be the most important disease of fruits in the district. With a leaf curl loss of around ten per cent and an average of twenty to thirty per cent of the stand affected by mosaic throughout the district from the Niagara river to Oakville, the immediate future of red raspberry culture may be viewed with apprehension. This condition, coupled with the fact that practically nothing was known regarding the cause, infectiousness, or control of this disease, led us to spend practically our entire time on this problem.

The extremely hot and dry weather of the early summer seriously interfered with the work on raspberry yellows. The most important facts which could not be determined, especially the actual proof of the transmission of mosaic by the raspberry aphid, are being studied in the laboratory this winter. Also the work on the histology of raspberry leaf curl is being continued. No report can be made at present on this phase because it is as yet too incomplete. It may be stated that no immediately practical results are being sought in the histology work. The main attention is being given to the location and nature of the cause of the disease. To this same end, also, a variety of isolation cultures have been made and will be continued during the winter. The following report has been made in some detail in view of the fact that this is the first assembling of any data on many points regarding raspberry leaf curl and mosaic.

SUMMARY

1. The name yellows has been used to refer to two distinct diseases of the cultivated red raspberry. The names leaf curl and mosaic are proposed for these two diseases, since they are descriptive and will come into use naturally.

2. A bush once affected by leaf curl is a permanent loss.

3. The average percentage prevalence of leaf curl in the various townships in the Niagara fruit district varies from 2·1 per cent to 6·1 per cent for Cuthberts, 0 per cent to 2·5 per cent for Marlboros, and 0 per cent to 1·5 per cent for Herberts.

4. Misses in the plantations, which are largely due to rogueing for leaf curl, together with the leaf curl present, make the apparent loss in these townships in the last two or three years, from 4·9 per cent to 13·8 per cent for Cuthberts, 0·1 per cent to 5·3 per cent for Marlboros, and 0·8 per cent to 6·3 per cent for Herberts.

5. In the Cuthbert plantations of the entire district, about one-fourth show more than 5 per cent leaf curl, and one-third have over 5 per cent misses. The apparent cumulative loss is, therefore, over 10 per cent in from one-fourth to one-third of the Cuthbert plantations.

6. The amount of leaf curl increases with the age of the plantation. The average for all Cuthbert plantations under six years old was, 2·4 per cent leaf curl present, 3·1 per cent misses, or 5·5 per cent apparent cumulative loss; and for plantations six to twelve years old, 5·4 per cent leaf curl present, 6·5 per cent misses, or 11·9 per cent apparent cumulative loss.

7. Leaf curl is a systemic disease and the canes are dwarfed. The fruiting laterals are short and stand upright. The leaflets are very lark green, and the mid-rib and main lateral veins arch downward, causing a curling of the entire margin of the leaf. The tissue arches between the veins and causes a puckering along them. Many leaves on the fruiting canes do not curl markedly but have the characteristic colour, a slight arching of the interveinal tissue, and are smaller than normal. The fruit develops very little pulp and is worthless.

8. All three of the varieties grown in the district are susceptible. The disease is rarely found in Marlboro or Herbert plantings, while it is present in practically every Cuthbert plantation. Leaf curl has been found on cultivated black raspberries, and is reported common in wild red raspberries (*Rubus strigosus* Michx.) in northern Ontario and in Manitoba.

9. The average prevalence of leaf curl in Cuthbert plantations under the shade of fruit trees was 5·0 per cent, and in plantations in the open, 3·7 per cent. This factor seemingly accounts for the higher percentage of leaf curl found in Grimsby township where about nine-tenths of the plantings are under trees.

10. Type of soil and state of cultivation were not found to have any appreciable effect on the prevalence of leaf curl in a plantation.

11. Aphids (*Aphis rubiphila* Patch) were found correlated with the spread of leaf curl in the field in May and June. Fourteen hundred plants (an equal number of curled, healthy next to curled, and healthy distant from curled plants) examined by turning over two or three leaves, proved that aphids were present on curled plants and on healthy plants next to curled as compared with healthy plants distant from curled in the frequency ratio of twenty to one.

12. Numerous attempts to transmit leaf curl by rubbing, injecting the expressed juice of diseased plants, and by root contact have failed.

13. In six instances leaf curl has been transmitted by transferring aphids (*Aphis rubiphila*) from curled leaves and petioles to healthy plants. In all cases the plant showed definite symptoms in from two to four weeks and was systemically affected thereafter.

14. In one instance known, a grower has controlled leaf curl by the eradication of diseased bushes early in the spring. As high as five per cent leaf curl is often found in plantations where growers regularly remove curled plants in June or July. A two-year eradication experiment was conducted in a plantation showing 4·4 per

cent leaf curl in 1919. It contained in 1921, 1·0 per cent leaf curl. Considering that the eradication was done in June and July, after the aphids had dispersed from curled to healthy plants, the results are better than would be expected.

15. Mosaic of red raspberries is epiphytotic in the Niagara fruit district, varying in prevalence in Cuthbert plantations in the various townships from an average of 9 per cent to 28 per cent, in Marlboros from 20 per cent to 40 per cent, and in Herberts from 1 per cent to 6 per cent.

Plant previously healthy showing pronounced leaf curl six weeks after the transfer of aphids from a leaf curl plant.

16. In Brant, Norfolk, Middlesex, and Frontenac counties, where several large commercial plantations were examined, very little mosaic was found.

17. Mosaic is a systemic disease, and the canes are dwarfed in a year or two after infection. The leaflets, or new growth in the spring, show large green blisters with yellow-green tissue between. In summer and autumn, the mottling is much finer and gives the leaf a uniform, yellowish, speckled appearance. On fruiting canes, the leaves are either coarsely or finely mottled, and reach only about one-half normal size. A portion of the fruit dries and has very little pulp, while that which develops a normal pulp is insipid. Affected suckers often develop laterals the first year, from the axillary buds.

18. All three of the varieties grown commercially in the district are susceptible. However, it is rare to find a percentage of mosiac over 1 per cent in Herberts, except when they are planted adjacent to Cuthberts or Marlboros. The Cuthbert seems to

be slightly more resistant than Marlboro, although the matter of apparent relative susceptibility is probably only an index of the preference of the aphid for that variety as a food plant. Once infected, the plants of the three varieties react similarly.

19. Of the many varieties seen at Ottawa and Geneva, N.Y., only two were found at both places free from mosiac; St. Regis or Ranere, and Sunbeam. No attempt, however, has been made to find immune varieties.

20. In two instances, cases of mixed leaf curl and mosaic infection in the same plants were found. The symptoms of each are often discernible in the same leaflet.

21. Canes are dwarfed by mosaic in one to three years on the average of one foot in height and one-tenth of an inch in diameter.

22. Aphids (*Aphis rubiphila*) are definitely correlated with the spread of mosaic in the field in May and June. From an examination of twelve hundred mosaic and healthy plants, it was shown that the frequency ratio was 100 to 1 in favour of finding aphids on mosaic suckers. The aphid thrives and develops colonies better during these months on the suckers affected by mosaic.

23. Attempts to transmit mosaic to healthy plants by rubbing and aphid transfers have so far failed. Only a few aphid transfers were made when the hot weather interfered with the work.

24. Three experimental control plots were started in August. These plots contained 5 per cent, 12 per cent, and 30 per cent mosaic respectively. All bushes affected by mosaic were removed and carried outside the plantation. The theory of the success of control by eradication, the last of July or in August, is based on two facts: (1) aphids are relatively inactive in hot weather, therefore a larger percentage of infected plants can be identified, after three weeks or more of hot weather, than at any other time of year, and (2) by eradicating the large majority of infected bushes, very few will be left on which aphid eggs will be laid, and from which mosaic can spread by the important spring dispersal of newly-developed young.

Projects 89, 90 and 91.

LEAF CURL AND MOSAIC, OR YELLOWS, OF THE CULTIVATED RED RASPBERRY

In the intensive fruit growing belt in Ontario, along the shore of lake Ontario from the Niagara river to Toronto, the red raspberry is one of the main small fruits grown. Plantings varying from a few rows up to several acres are found on practically every fruit farm. In this entire district, which is about ninety miles long and from one to five miles wide, only three varieties are grown, namely Cuthbert, Marlboro, and Herbert. Of the total acreage about ninety per cent is Cuthbert. Conditions in the district are very favourable for these varieties, and practically no damage is caused by any of the raspberry diseases, except the yellows. This disease, however, is serious and threatens the stand.

The Cuthbert is a rank growing variety. It is grown in solid rows without supports. The green canes grow abundantly, necessitating rigorous thinning of the rows. The roots send out laterals in all directions for three feet or more and canes are sent up at intervals. Frequent cultivation and the use of the "grape hoe" are necessary to keep the rows in shape. Owing to these peculiarities of the Cuthbert many plantings are allowed to form dense wide rows, while others are kept narrow and thinned out. The first year canes grow to six feet or more and are pruned back in the spring to about four and a half feet. In August the second year wood is cut off near the ground and the new wood thinned. The first-year green canes are succulent at first but soon become woody and usually are about three-eighths to a half inch in diameter near the base. When healthy and uninjured they produce leaves only and grow until frost. A bud in the axil of each leaf produces a lateral the second year which grows to the length of a foot or more. Leaves and fruit are borne

on these laterals. Plantings are kept for ten years or more. In most cases the same roots are used through the life of the planting. Other growers take out old roots gradually and allow new ones from neighbouring plants to fill in the spaces. All of these facts regarding the rank growth of the variety and the methods of culture have a direct bearing on the spread and control of both leaf curl and mosaic.

The term, yellows, has been used in literature and by the grower indiscriminately, to refer to two separate diseases, for which the names leaf curl and mosaic are believed to be appropriate. Where leaf curl occurs commonly this name has been used, as well as the name yellows. On the other hand, yellows has been used to refer to mosaic, and the fact that it was a mosaic disease has been apparently overlooked. The original description of the yellows by Stewart in 1902 without much doubt refers only to the mosaic. Melchers (1914) describes leaf curl and apparently was not working with mosaic, or failed to clearly distinguish it from curl. The inclusion of leaf curl under the same name has been of long standing, and in some descriptions of the disease yellows, both are described or only one. This has led to a complete confusion of the symptoms of these two diseases. Doubtless this has been due to the plausible assumption that leaf curl is a more advanced stage of mosaic. Both diseases are apparently co-extensive with the cultivated red raspberry in Canada and northern United States. Little is known of either disease, apparently because no serious attempt has been made to investigate them. Their communicability has never been proved according to the literature, and many have assumed one or another of a wide variety of causes. A closer examination of the literature is hardly necessary since it is mainly descriptive of the symptoms and theoretical as to the possible causes and control. The following discussion of these diseases refers almost entirely to conditions as they exist in the Niagara Peninsula of Ontario. The investigations of leaf curl were begun in 1920, and those on the mosaic in 1921. The main contribution is made to the study of the economic importance of these diseases in the district, their symptoms, seasonal development, relation of aphids to their dissemination and control.

Economic Importance of Leaf Curl

The extent to which leaf curl is present in the Niagara district was determined by actual counts made in a large number of plantations. Some data gathered in 1918, 1919, and 1920, before the present work was begun, are also included. The figures for 1921 are, however, much more accurate and representative. The average percentage prevalence given in the tables below, is directly convertible into per cent loss, because the fruit on a leaf curled plant is worthless, and either is not picked, or the bushes are removed to avoid its being picked. Likewise, the space taken by a leaf curl bush is a direct loss until it is replaced by natural spread of roots or by transplanting a new root. Many growers do not trouble to fill in spaces where leaf curl is removed, and, therefore, the loss accumulates.

A survey of twenty-one plantations in Grantham Township in 1918 showed an average of 6.8 per cent leaf curl. Most of the plantations contained more than one thousand bushes and the percentages ran from 0 to 5 per cent in the majority, with individual cases of 12 per cent (in three plantings), 20 per cent, 25 per cent, and 35 per cent.

In 1919 a similar survey of thirty-four plantings in Grantham and Niagara townships showed an average of 2.5 per cent leaf curl. Not so many plantings with high percentages were found that year, as the year before, and only one was over 10 per cent. Five plantings in Clinton township showed 0.5 per cent, and eleven around Fonthill (Welland county) contained an average of 1.2 per cent leaf curl.

A survey, made in 1920 in Louth, Clinton, Grimsby, and Saltfleet townships, showed that leaf curl was generally present throughout the district and, although absent or of little importance in many plantings, the average loss was close to 5 per cent. The highest individual losses due to leaf curl were 10 per cent, 18 per cent, 19 per cent, 41 per cent, and 71 per cent.

A more accurate survey was conducted in the spring of 1921. Three places were chosen in each plantation, in such a way that the average condition would be ascertained. A tape one hundred feet long was staked in each of these three places and the data taken in the rows on either side. This gave an analysis of three pairs of strips one hundred feet long in each plantation, or six hundred running feet. Owing to the fact that, in a year or two after planting, the rows are usually evenly filled in by the roots, the data were taken not by stools but by feet. The amount of leaf curl, misses, and healthy plants, was determined, and mosaic was also included after the symptoms were distinguishable. At the same time, the following data were taken for each plantation; age, variety, location, soil type, cultivation and care, aphids present or absent on ten leaf curled plants, ten adjacent healthy, and ten distant healthy plants (a few leaves of each were turned over and examined). In all about one hundred and eighty plantations were thus examined from the Niagara river to Oakville. The data obtained from this survey are also used in other parts of this report.

The following table shows the general average amount in per cent of leaf curl and misses in the several districts. These figures are simple averages representing the total number of feet of curl and misses found in the measured rows examined in each township or district. No allowance whatever is made for size of planting (all were commercial), soil type, care, etc. Owing to the fact that plants affected by leaf curl are often dug out or cut back each season, the amount of misses in the row is largely due to curled plants which have been removed. Other causes of misses are relatively negligible and are no doubt compensated for by the rapid filling in from adjacent roots. The survey was made early in the season before any great number of growers are accustomed to remove curled bushes. Therefore, the amount of curl present represents at least one year's spread, and in some cases more. The amount of misses added to the amount of curl is of course a cumulative loss. Since, however, the spaces if not extensive, fill in rapidly due to the extensive root development, it is not believed that it is far wrong to consider the sum of the amount of curl and misses to represent from two to three years cumulative loss in stand from leaf curl. Owing to the fact that mosaic-affected plants have not been removed by growers up to the present time, this disease has not influenced the above interpretation, that misses are largely the cumulative curl loss.

AVERAGE PER CENT OF LEAF CURL IN LINCOLN, WENTWORTH, AND HALTON COUNTIES

	Cuthbert (136)			Marlboro (18)			Herbert (27)		
	Per cent Curl	Per cent Missing	Per cent Loss 2-3 yrs.	Per cent Curl	Per cent Missing	Per cent Loss 2-3 yrs.	Per cent Curl	Per cent Missing	Per cent Loss 2-3 yrs.
Grantham township	3·5	1·4	4·9	.....	.....	.....	0·0	0·8	0·8
Louth township	2·1	4·4	6·5	0·0	0·1	0·1	.....	.....	.....
Clinton township	4·2	6·0	10·2	2·5	1·5	4·0	0·6	5·0	5·6
Grimsby township	6·1	7·6	13·7	.....	.....	.....	1·5	4·8	6·3
Saltfleet township	4·0	5·1	9·1	.....	.....	.....	0·0	1·2	1·2
Nelson township	2·9	8·0	10·9	0·5	4·8	5·3	0·0	2·0	2·0
Trafalgar township	3·8	7·0	10·8	0·2	2·4	2·6	0·0	0·8	0·8
General averages	3·8	5·6	9·4	0·8	2·2	3·0	0·3	2·4	2·8

The amount of leaf curl found in different plantations even in the same locality often varies widely. While the above general averages for the different sections of the Niagara fruit belt show that leaf curl is more destructive in Grimsby, there are many plantations in other districts with high percentages of leaf curl, as well as some with none or very little. A few figures are given below showing the extent of the variability found in Cuthberts in 1921.

—	Leaf Curl				Missing			
	Max. per cent	Over 5 p.c.	Under 5 p.c.	Min. per cent	Max. per cent	Over 5 p.c.	Under 5 p.c.	Min. per cent
Grantham	12·3	1/4	3/4	0·1	7·1	1/10	9/10	0·0
Louth	9·6	1/10	9/10	0·0	23·1	1/4	3/4	0·0
Clinton	27·0	1/3	2/3	0·0	21·0	2/5	3/5	0·0
Grimsby	62·0	1/2	1/2	0·8	15·6	1/2	1/2	1·0
Saltfleet	40·0	1/5	4/5	0·0	20·5	1/3	2/3	0·5
Nelson	62·0	1/2	1/2	0·5	19·0	1/2	1/2	0·5
Trafalgar	23·5	1/6	5/6	0·0	16·0	1/2	1/2	0·0
Average conditions	.....	1/4	3/4	.....	.....	1/3	2/3	.....

In an attempt to determine the relation between age of the plantation and the cumulative loss from leaf curl in Cuthberts, the data obtained in the survey of 1921 were arranged according to age classes for the entire district. The general average per cent leaf curl and misses combined are given below:—

2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years
1·1	4·0	2·8	6·2	13·3	7·9	10·6	17·7	8·6

The fact that there is no regular increase shown by these figures is easily accounted for. While the averages were made from more than ten plantations of each age class, except the two year, it must be remembered that they are scattered over a district about sixty miles long where there is a considerable variation in the prevalence of leaf curl. Also due to the fact that the plantations are so variously treated with regard to removing leaf curled plants and filling in misses, leaf curl is being partially controlled, but the degree of control varies greatly in the different plantations. By pairing the age classes and making simple averages for the entire district, the following comparison is obtained:—

Number of Plantations	Age Class	Per cent Leaf curl	Per cent Misses	Per cent Loss
18	2 — 3	3·1	3·5	6·6
21	4 — 5	1·8	3·3	5·1
21	6 — 7	3·1	5·7	8·8
56	8 — 12	6·3	6·6	12·9

Even here there is no regularity shown except that those over six years show a higher loss, especially in cumulative misses. The amount of leaf curl is practically double for plantations over eight years old as compared with those less than eight years old. On the basis of comparing plantations less than five years old and those six to twelve years old, the following percentages show the increased liability to loss from leaf curl after five years under the present methods of control:—

Number of Plantations	Age Class	Per cent Leaf curl	Per cent Misses	Per cent Loss
39	2 — 5	2·4	3·1	5·5
77	6 — 12	5·4	6·5	11·9

As was seen in other comparisons above, the actual per cent of missing plants varies directly with the amount of leaf curl actually present, and adds weight to the assumption that such percentage is largely due to leaf curl loss. With the present practice of removing leaf curl plants annually, at any time convenient to the grower, and despite the rapid filling in of the spaces, the average loss in stand is 5·5 per cent for plantations under six years old, and 11·9 per cent of those six years and older. Since leaf curl soon makes its appearance in the plantation and slowly spreads, the average annual loss in stand increases yearly until it is around 10 per cent. It is, therefore, seen that the grower loses on the average from leaf curl what amounts to about one entire year's crop during the life time of the plantation.

Symptoms of Leaf Curl

Leaf curl is a systemic disease, in that all of the above-ground growth formed subsequent to infection, is more or less typically affected. The leaves on the first- and second-year wood are much darker green than normal, and the mid-rib arches downward throughout its length. A similar arching of the main lateral veins causes a downward curling of the entire margin of the leaf. The rolling of the tip, however, during periods of rapid growth is seemingly under greater tension, and tightly rolled leaves result. Another characteristic of the affected leaves, which evidently accounts, in part at least, for the curling is the "gathering" of the interveinal tissue along the mid-rib and lateral veins. Also the interveinal tissue is arched between the lateral veins. In fact the abnormal morphology of the leaves on a leaf curl plant is due to the development of more interveinal tissue than the length of the veins will permit without causing curling downward, puckering along the veins, and arching between the veins. These three results of uneven development are more pronounced when the plants are growing rapidly, and the tissues are succulent. Where growth is less rapid and the infection of the plant was recent, the "gathering" along the veins in certain areas may be marked, without much, if any, curling. Not all cases of slight "gathering or puckering" along the veins are, however, attributable to the leaf curl disease. Very slow growth in early spring, insect injuries, and continued hot dry weather, will cause the same effect. In such cases, as soon as these conditions are past, the new growth is normal. In the case of leaf curl, all subsequent growth under good growing conditions is typically curled, and the deformation usually becomes worse, until in the case of first-year canes, the tip is stunted and ends in a few small light yellowish-green, and curled leaves. The symptoms of curl are similar for the three varieties, Cuthbert, Marlboro, and Herbert. In fact, the leaf characters of these varieties, by which they are easily distinguished, are so masked in the curled plant, that it would be difficult to distinguish the variety. All the leaves developed on first-year wood previous to infection remain normal. Those formed subsequent to infection show in the next two or three leaves simply the gathering in spots along the

veins. The next few leaves formed are large, very dark or "blackish" green, and typically curled. Then gradually as growth proceeds the new leaves are smaller, not so dark a green, and more deformed, until the tip ends in very small, yellowish, crumpled leaves. Usually the first-year wood, if infected early in the season, never reaches the normal height. If infected in mid-season or later, the effect of the disease which results in the dwarfed tip is not reached before the normal height is attained. In this way curled first-year wood may or may not reach the normal height, according to the time of infection and the vigour of the plant. The fruiting laterals developed on a diseased second-year cane are short, upright in habit, and the leaves are small, dark green, and more or less typically curled. The fruit which is developed is small, has very little pulp, and is lacking in flavour. In all respects, the effect on the fruit is similar to that produced by mosaic, anthracnose, and other raspberry cane diseases.

Leaf curl. Cuthbert variety plants with fruiting canes and suckers affected.

Curled leaves are developed in four to six weeks after infection. All branches or new suckers developed from the stem or roots after curled leaves are formed at the tip, are typically curled. Likewise all the growth from the root in subsequent years will be curled. Although this disease does not kill, the new canes the year after infection are much shorter than normal. Although individual plants have not been observed for sufficient time it is believed that the canes in two to four years develop only to a height of a few inches, and in this way the disease is finally fatal.

Leaf curl in many respects is similar to potato leaf roll in its effect on the plant. The fundamental foliage symptoms are the same, suggesting inhibition of the translocation of starch, or some disturbance which results in starch accumulation. The staring habit is common to both diseases, as well as the general dwarfing effect. Also both are systemic and the histological studies so far indicate that a necrosis of certain elements of the phloem and pericycle is found in the raspberry, which resembles potato

phloem necrosis. Also both are aphid disseminated. Although two such diseases may be alike in the gross symptoms shown, without there being much in common in regard to their cause, it is at least plausible to suspect that raspberry leaf curl and potato leaf roll both belong to the same group of related diseases and that their causes may be expected to be similar in nature.

Varietal Susceptibility to Leaf Curl

All three of the cultivated varieties of red raspberry grown in this district (Cuthbert, Marlboro, and Herbert) are susceptible to leaf curl. The disease is found in almost every planting of Cuthberts in the district. On the other hand, it is rarely found in Marlboros or Herberts. In the Marlboro, this difference in apparent susceptibility is unexplained. It is certainly not due to the fact that the aphids are not there to transmit it. For in the case of mosaic, which is without much doubt transmitted by the same aphid, the percentage infection in the variety Marlboro is usually higher than in Cuthberts. The Marlboro once infected is as severely affected as a Cuthbert. In the variety Herbert neither leaf curl nor mosaic are found in any great amount. This apparent immunity may be either due to the Herbert being a poor host plant for the aphid, or to a low degree of susceptibility. Since, however, both diseases are found to some extent in Herberts, especially when they are growing very close to high percentages in adjoining Cuthberts, it seems more likely that this variety only escapes infection. This is probably due to the habits of the aphid in its selection of food plants. One case of typical leaf curl in a black raspberry was found. The bush was undoubtedly a pure black raspberry from all cane and leaf characters but it was growing in rows of Cuthberts. Occasionally the wild red raspberry (*Rubus strigosus*) has been found near cultivated plantings, but no leaf curl has been observed. However, there are several reports of leaf curl in the wild red raspberry. Mr. Tucker sent specimens from near Port Arthur where he says it is common on both wild and cultivated red raspberries. Mr. Freeman Weiss, who studied leaf curl in Minnesota, makes the following statement in an unpublished manuscript. "I have observed leaf curl in all parts of Minnesota both in cultivation and in the wild, and in Manitoba it seems to be co-extensive with the distribution of *Rubus strigosus,* certainly, at least, reaching to the north end of Lake Winnipeg. It almost certainly is quite widespread in the Dakotas, Iowa, and Wisconsin, wherever raspberries are cultivated." There is no doubt, therefore, that the wild red raspberry, from which practically all the cultivated red varieties have been derived by selection, is susceptible, and that this disease is common on the wild plant. A common introduced species, *Rubus phœnicolasius* Maxim., the wineberry, was found severely affected by typical leaf curl at the Horticultural Farm, Vineland. Two bushes of five or six were affected, and a third showed the first symptoms.

Effect of Shade on Prevalence of Leaf Curl

The data accumulated for Cuthberts were examined to ascertain the possible effect of growing raspberries under trees on the prevalence of leaf curl. The following table shows the number of plantations for which accurate data were available, and the per cent of leaf curl in these plantations, averaged for each township or district:—

—	Number under trees, rows 18 feet apart	Number in the open, rows about 6 feet apart	Per cent Plantation under trees	Average Per cent Leaf Curl
Grantham township	0	12	0·0	3·5
Louth township	1	20	5·0	2·1
Clinton township	10	15	40·0	4·2
Grimsby township	18	3	85·7	6·1
Saltfleet township	6	20	30·0	4·0
Nelson township	0	5	0·0	2·9
Trafalgar township	0	13	0·0	3·8

Condensing these figures the following comparisons are obtained of the per cent of leaf curl found under trees and in the open:—

—	Per cent Plantation under trees	Average Per cent Leaf Curl
Grantham, Louth	3·0	2·8
Clinton, Grimsby, Saltfleet	47·2	4·8
Nelson, Trafalgar	0·0	3·35

Further condensing these figures for the entire district the averages are:—

—	Per cent Plantation under trees	Average Per cent Leaf Curl
Grantham, Louth, Nelson, Trafalgar	2·0	3·07
Clinton, Grimsby, Saltfleet	47·2	4·77

In order to judge more accurately if shading is the factor largely concerned in the greater prevalence of leaf curl in Clinton, Grimsby and Saltfleet townships, the following table shows the plantations under shade and in the open separated from these three townships and compared with the plantations in the open in the other four townships:—

—	Number of plantations	Average Per cent Leaf Curl
Grantham and Louth, in the open	32	2·8
Clinton, Grimsby and Saltfleet, under trees	34	4·96
Clinton, Grimsby and Saltfleet, in the open	38	3·69
Nelson and Trafalgar, in the open	18	3·3

It seems reasonable to conclude from the above figures, that the practice of growing raspberries under trees, as is almost universal in Grimsby Township and to some extent practised in Saltfleet and Clinton Townships, accounts for the higher percentage of leaf curl found in those districts. Although the average per cent leaf curl in the plantations grown in the open in those three townships is somewhat higher (3.7 per cent as compared with 2.8 per cent to the east and 3.3 per cent west), there is the clear difference of an average of 4·96 per cent leaf curl under trees and 3·69 per cent in the open. This apparent increase in prevalence under trees of about 1.3 per cent on the average is probably due to the more favourable conditions under the trees for aphid activities. Two plantations under trees, one in Grimsby and one in Saltfleet, were omitted from the above averages because of the very high percentage of leaf curl; they averaged 62 per cent and 40 per cent respectively. The three highest percentages (omitting the two above) found in the open were 12 per cent, 14 per cent and 27 per cent, and under trees, 12 per cent, 17 per cent and 27 per cent.

Variability of Soil Type, State of Cultivation, and Leaf Curl Prevalence

Although raspberries are grown upon a variety of types of soil in the Niagara peninsula, there are but few opportunities to observe the effect of heavy, poorly drained soil upon leaf curl prevalence. One plantation of about two acres of both Cuthberts and Herberts, in such heavy and poorly drained soil that many bushes died yearly from drowning, contained three bushes affected by leaf curl. A comparison of the data obtained for Cuthberts was attempted for different types of soil, such as, fine sand, coarse sand, light, heavy and dark sandy loams, gravelly loam, and sandy loam with clay sub-soil. The conclusion was that, other conditions being equal (i.e. under shade or in the open, different states of poor, fair, or good cultivation, and age of plantation), the type of soil seemed to have no influence upon the prevalence of leaf curl.

The amount of care given a Cuthbert plantation in respect of time and frequency of cultivation and thinning, makes a great difference in the density of cane growth and thickness of foliage, since the Cuthbert is such a rank growing bush that it amounts in itself to a weed. Naturally, one would expect that the state of cultivation would markedly affect leaf curl prevalence, owing to the greater amount of shade and high humidity in dense plantations as compared with those kept thinner and more open. No figures were taken this year which would give any conclusive evidence upon density of growth and leaf curl prevalence, but, in general, the state of culture was recorded for each of the plantations as poor, fair or good, or very good. Provided the state of cultivation found at the time of gathering the data was the regular treatment the plantation was receiving, the density of growth would naturally vary with it. An examination of the data respecting the plantations under different states of cultivation did not, however, show any connection between this factor and leaf curl prevalence.

Correlation of Aphids with Leaf Curl in the Field

As a part of the data obtained in the survey of 1921, ten curled plants, ten healthy plants next to curled, and ten healthy plants distant from curled were examined in each plantation for the presence or absence of aphids. A few leaves of each were turned over for examination. During May no aphids were found until about the twentieth of the month. From that date for over a month they were fairly abundant. Although aphids (*Aphis rubiphila*) are never so abundant that they are easily found by examining a few leaves of a curled plant, the following percentages derived from 1,400 plants examined show the evident connection between the aphids and the dissemination of leaf curl in Cuthberts.

Per cent curled plants showing aphids	8·5
Per cent plants adjacent to curled plants showing aphids	8·9
Per cent plants distant from curled plants showing aphids	0·4

The frequency with which aphids were found by such a casual examination on curled canes and healthy bushes next to curled canes was about 20 to 1, as compared with healthy plants selected at random some distance from curled plants. Since it is easier to detect the small aphids on the smooth light green healthy leaves than on the curled and wrinkled, white, downy, diseased leaves, it is believed that more careful determinations would greatly increase the ratio. It is noticeable, however, that aphids are not nearly so easily found or abundant on curled suckers as on mosaic suckers. This may account for the difference in their rate of spread (as indicated by the present prevalence figures), and is probably due to the fact that the leaves of mosaic canes furnish better conditions to the aphid than the curled or healthy plants do. The above remarks apply to only one season's observations, during the months of May and June.

Infection Experiments with Curl Leaf

Several methods of inoculating healthy plants have been used. A special plot was planted to Cuthberts and Marlboros in 1920 for inoculation purposes. This plot did not contain any leaf curl plants, and was several hundred yards distant

from other raspberries. During June and July when the suckers were from a foot to two feet tall and growing rapidly, about one hundred plants were inoculated in various ways with expressed juice from curled leaves. The juice was pressed in the laboratory, from leaves collected the day before, and was taken to the field for use within five hours in test tubes. It was diluted with three or four parts of sterile distilled water. An all glass hypodermic with No. 26 needle was used in making the injections. The same plant was often inoculated in more than one place. The following types of inoculations were made:—

1. Injections into the green cane near the tip and six to eight inches below the tip.
2. Injections into the petioles and mid-ribs of the youngest full grown leaves.
3. Injuring the lower epidermis of the youngest full grown leaves with the needle and leaving drops of the expressed juice on the injured surface.
4. Injuring the unfolding leaves at the tip with the needle and leaving drops of the juice between them.
5. Rubbing the under surface of the youngest full grown leaves with a curled leaf rolled into a ball. The rubbing was continued until the mesophyl tissue was exposed.

The plants were labelled and examined from time to time, but no symptoms of leaf curl developed in any case, therefore more details regarding the inoculations are omitted. The plants were all alive the following spring and producing fruiting laterals, but no leaf curl appeared.

A few insect transfers were made in 1920 to healthy potted suckers in the green house. The insects included aphids (*Aphis rubiphila*), the common spring tail on raspberries, and another unidentified insect. All were collected on leaf curl plants in the field, in a spot where there were strong indications that some one of these insects might be the carrier. The insects were taken from the leaves with a camel's hair brush, and carried to the greenhouse in vials. They were placed on the leaves, and paper bags tied over them. Two plants received several aphids each, two several spring-tails, and one the unidentified insect. Only one plant developed leaf curl, and this was one on which aphids had been placed. The first symptoms were evident in 15 days, and later all subsequent growth showed definite leaf curl.

During the winter Cuthbert plants grown in pots under electric light were inoculated in various ways. These inoculations were made about one month after the suckers started growth, when they were adding two new leaves a week.

1. Two plants inoculated by rubbing the youngest fully grown leaf (all leaflets) on under side until severely damaged with crushed curled leaf.
2. Three plants inoculated by inserting split pieces of the petiole of a curled leaf into a longitudinal slit in the cane just below the youngest fully expanded leaf. The slit was closed and bound with adhesive tape.
3. Two healthy plants, held back in cold room, with suckers four inches tall, were repotted with a curled plant and the roots interwoven.
4. Three healthy plants, one month in warm room under lights, were re-potted with curled plants, the roots being interwoven.

These operations were carried out on March 13, and the plants grew well until May 21 when the experiment was discontinued. Some of the suckers reached three feet in height and the foliage was normal. The internodes were of proper length, but the canes did not attain the normal diameter, due more to the poor soil than anything else. A few fruiting laterals developed, set bloom, and matured fruit in the interval. However, in no case did leaf curl develop.

Aphids were obtained by bringing canes from the open and placing them in the light. The buds soon burst and two stem mother aphids were hatched. These were transferred to two healthy plants. One died but the other produced a colony which was multiplied by transfers to several plants. A few aphids, which were allowed to feed on curled leaves for two days, were transferred to healthy plants, but no infection resulted. Later, a colony was developed on a healthy plant, which became so abundant

that they crowded each other and infested the petioles. One leaflet containing many aphids in the blade and petiole was laid on the top of a curled plant. They migrated to the curled leaves and were allowed to feed for 48 hours. They were then transferred to a healthy plant. Over fifty aphids migrated to the healthy leaves and began feeding. Curl symptoms in the new unfolding leaves were developed after two weeks.

A planting of healthy Cuthbert and Marlboro suckers was set out at Vineland in 1921. These grew well and were used for the following inoculations.

Aphids collected on curled leaves in the field were transferred to two healthy Cuthberts on May 30. Cheese cloth cages were placed over the plants. About 15 to 20 aphids were transferred to each plant. The colonies did not thrive and soon only two or three aphids could be found on each plant. No symptoms of leaf curl developed in either plant.

On June 7 dense and diffuse colonies of aphids, on curled leaves collected in a commercial planting, were transferred to four healthy plants. No cages were used for these. Two plants each received one-half of a vigorous compact colony, part of which was on the petioles. The plants received over 50 aphids each. Definite leaf curl symptoms developed in four weeks, and the plants have since been typically affected with leaf curl. The two other healthy plants, infested with aphids from other curled leaves collected at the same time, did not develop curl. In these cases only fifteen to twenty aphids were transferred to each. These were from diffuse colonies on the blades of the leaflets only. The material for the four transfers was sorted at a point within two feet of plants in the same row, and after four weeks a previously healthy plant, at this point in the row, developed definite leaf curl. The infection had apparently taken place at about the same time as the purposely infested plants, and there is little doubt that aphids migrated from the discarded material to this plant. It was the only case of chance infection in the entire planting of over two hundred plants.

Another set of aphid transfers was made on June 16. Twelve healthy Cuthbert suckers were infested by hanging curled leaves, with from 2 to 10 aphids each, in the axil of the youngest fully developed leaf. Very hot and dry weather began at about this time and continued for four or six weeks. The plants grew very slowly, and aphids were difficult to find. No symptoms of curl developed in any until August 3. One plant, which had received three aphids, then showed definite curl symptoms and has since developed typical curl. The other eleven plants remained healthy.

It had been planned to make other sets of aphid transfers, but the hot weather made this impossible. Even the aphids under cheese cloth cages were nearly all killed. In the open it was difficult to find even single aphids, and no colonies were developed. Conditions remained thus until September, when they became abundant again. By this time the raspberry suckers had attained their normal seasonal growth, and it was too late to expect results from transfers.

Rubbing inoculations were made on three plants in the field on June 7. A curled leaf, rolled into a ball and crushed, was used to severely damage the under epidermis of all five leaflets of the youngest fully expanded leaf. The curled leaf was then rolled up in the tip leaflet and held by a rubber band. In no case did curl develop.

From all the field evidence obtained to date, and the above inoculations, it is proved that *Aphis rubiphila* is an active agent for the dissemination of the leaf curl organism or virus, and so far there is no evidence that infection occurs in any other way than by aphid carriers. Numerous instances were observed this season of infection which had occurred in May or June. In most cases it was impossible to find aphids or their cast skins on the third, fourth or fifth healthy leaf below the first curled leaf. This is the position to be expected, allowing for the variable incubation period.

In all of the cages used to enclose aphids on rapidly growing suckers, a peculiar curling of the leaves was produced. This curling resembled leaf curl except that the leaf was not dwarfed. There seemed to be a normal development of mesophyll tissue, which was wrinkled and puckered due to a fore-shortening of the veins. This type of curl was developed where the leaves were in close contact with the sides of the cheese cloth screen. After the cages were removed, the new growth was normal.

Experiments on the Control of Leaf Curl

Experiments on the effect of rogueing for the control of leaf curl were begun in 1918. Two plots were selected that year and all leaf curl plants removed. The plot of Cuthberts on the farm of Mr. Gale, Louth Township, had been very badly diseased for some time. It had been set out from stock containing a high percentage of leaf curl. The plantation of Herberts had never shown leaf curl although they were directly adjoining the Cuthberts. The following record shows the success with which curl has been eliminated:—

	1918	1919	1920
Cuthberts	48	.....	3
Herberts	0	.....	0

The owner had the opinion, from his experience previous to 1918, that the eradication must be done early (before the plants bloomed) to be successful. He consequently attended to his plantation in 1919 at the time he thought it should be done and there are no figures for that year. His own statements that curl was very severe, and the fact that there is now practically none, indicate, it seems, that early eradication has been successful. Recent observations have added weight to the reason why early eradication should be more successful.

The other Cuthbert plot which was started in 1918 did not contain a high percentage of curl. The eradications were done in June or July, and no care taken to quickly remove the plants. These methods, however, have kept the disease in check, as is shown by the following table:—

NUMBER OF LEAF CURL PLANTS ERADICATED

(rows 350 feet long)

Row	1918	1919	1920	1921
1	2	0	3	4
2	5	0	1	3
3	0	0	0	0
4	1	0	0	2
5	4	1	0	0
6	3	3	2	0
7	0	2	0	0
8	2	2	0	2
9	0	11	4	1
10	7	9	3	1
11	4	4	3	5
12	0	6	2	3
13	0	0	4	3
14	2	6	6	7
Total	30	44	28	31
Per cent diseased	0·95	1·4	0·9	1·0

In 1919 another Cuthbert plantation on the same farm as the above was included, and the figures on this are more complete. The results would have been more successful, we believe, if (1) the eradication had been done at an earlier date, and if (2) the bushes had been quickly removed from the plantation. We did not know, when this work was done, of the connection of the aphids with dissemination, and, therefore, did not take the precautions against their spread. The results, however, indicate a considerable reduction in the amount of curl. The plantation was in such poor condition this year, due to severe hail injury, that the experiment was discontinued. The

following table gives the number and percent diseased bushes removed in the three years:—

RESULTS OF TWO YEARS' ROGUEING FOR LEAF CURL
(rows 340 feet long)

Row	1919		1920		1921	
	Number	Per cent	Number	Per cent	Number	Per cent
1	3	1·3	11	4·9	5	2·2
2	2	0·9	5	2·2	4	1·8
3	9	4·0	1	0·4	1	0·4
4	1	0·4	3	1·3	1	0·4
5	8	3·6	2	0·9	1	0·4
6	3	1·3	6	2·7	4	1·8
7	6	2·7	1	0·4	1	0·4
8	2	0·9	2	0·9	1	0·4
9	5	2·2	3	1·3	1	0·4
10	9	4·0	3	1·3	2	0·9
11	23	10·2	13	5·8	3	1·3
12	8	3·6	4	1·8	2	0·9
13	7	3·1	4	1·8	2	0·9
14	16	7·1	7	3·1	4	1·8
15	9	4·0	5	2·2	2	0·9
16	29	12·9	12	5·3	7	3·1
17	8	3·6	4	1·8	3	1·3
18	12	5·3	7	3·1	1	0·4
19	15	6·7	8	3·6	5	2·2
20	15	6·7	9	4·0	2	0·9
21	26	11·5	9	4·0	0	0·0
22	14	6·2	1	0·4	0	0·0
23	4	1·8	1	0·4	4	1·8
24	5	2·2	4	1·8	1	1·4
Totals for plantation	239	4·4	125	2·3	57	1·0

A summary of the data on this plantation shows that, in more than 74 places where diseased bushes were eradicated in 1919, the disease appeared on adjoining bushes the next year in 43 places. In at least 31 places it did not appear the next year. In 1920 diseased bushes were eradicated in 73 different places, and of these it reappeared in 24, and did not reappear in 49. At the same time the disease appeared in 30 new places. In 1921 the total number of places where bushes were eradicated was 39, and of these 15 were new. During the three years the disease reappeared each season in 11 places. These figures indicate that our methods were only about 50 per cent successful in preventing the healthy bushes next to diseased ones from becoming infected, and that they did not prevent 30 distant infections in 1919, and 15 in 1920. The fact that the disease reappeared in so many places is believed to be due to the late date of eradication, and the number of new places to leaving the bushes in small piles for hours sometimes, and eventually dragging them out in large bundles. The following table gives a summary of results which, despite the above noted faults, may at least be considered good commercial control:—

Time of eradication	Number bushes removed	Number places found	Number places controlled	Number places spread	Number new places	Per cent diseased
1919—June, July, August	239	74	31	43	.....	4·4
1920—July	125	73	49	24	30	2·3
1921—May	57	39	.....	.....	15	1·0
Check	.....	.....	.....	.....	.....	4·7

In the spring of 1921 rogueing experiments were conducted in eight Cuthbert plantations. Five of these were laid out, and the bushes dug and removed May 26-June 4.

This was not as early as it had been planned, but time was consumed in making a careful selection, and adverse weather conditions interfered. As it happened the work was done within a week after aphids became noticeably present, and, therefore, there could not have been much migration. Later in the season five additional plantings were sought in the same districts for late eradication. Only three could be found, however, which were suitable for direct comparison with the early plots. The plots were gone over in September, and the spread noted. Two of the plots (one early and one late) were found unsatisfactory and were discontinued. The final figures on the results of this year's eradication will be obtained next April. The following data, in so far as showing results, are only partial, since the recounts were made only two or three months after the eradication. During this interval the aphids were not abundant. Later in the season they were very numerous, and this fact may greatly change the figures that will be obtained in the spring.

In addition to the dissemination of leaf curl and mosaic by the dispersal of aphids from one plant to another, there is considerable spread, no doubt resulting from cultivation and pruning operations. In the spring when the suckers are growing rapidly, frequent cultivation is necessary to keep the rows in shape. No doubt young suckers and roots are dragged some distance, and the dispersal of aphids from these may start new diseased areas. Likewise in pruning out the old fruiting canes and surplus sucker growth in the autumn, considerable spread may result in the same way. It is especially noticeable that leaf curl is more frequently found at the ends of the rows than inside the planting. This may be due to the dragging of the canes during cultivation and caneing to the ends of the rows where they are piled. It was at least proved by frequent observation in the field that aphids quickly leave an uprooted or broken bush and attempt to find another food plant. In the laboratory they have proved very active and capable of negotiating a considerable distance in a short time over many obstacles. Precautionary measures should be taken to avoid, as far as possible, the dragging and piling of canes within or near the plantation, and thus aid in confining the disease to the established areas.

Economic Importance of Mosaic

Counts were made in 1921 in a large number of commercial plantations to determine the percentage of the stand affected by mosaic. While the disease is found in practically every plantation, a wide variation in the amount present is common in every district. The average figures given below represent the condition in the majority of plantations. A few plantations were found in each district with very high percentages of mosaic.

District	Variety	Number of plantations visited	Per cent Mosaic	Per cent Healthy
Grantham	Cuthbert	12	20	75
	Herbert	2	6	93
Louth	Cuthbert	22	20	74
	Marlboro	3	40	60
Clinton	Cuthbert	26	28	62
Grimsby	Cuthbert	22	27	60
	Herbert	4	1	93
Saltfleet	Cuthbert	22	18	73
	Herbert	2	1	98
Nelson	Cuthbert	5	20	70
	Marlboro	4	40	55
	Herbert	7	1	97
Trafalgar	Cuthbert	13	9	80
	Marlboro	8	20	78
	Herbert	9	0	99

In the districts around Burlington and Oakville, where the most accurate counts on mosaic were made in connection with the leaf curl survey, the following percentages were found:—

District	Variety	Age	Per cent Mosaic
Nelson	Cuthbert	4	25·0
		5	29·0
		8	32·0
		9	10·0
		12	5·0
	Marlboro	3	30·0
		5	24·0
		6	77·0
		8	27·0
Trafalgar	Cuthbert	3	2·0
		3	3·0
		3	3·0
		3	13·5
		3	16·0
		5	9·0
		6	2·5
		7	26·0
		8	8·5
		8	11·5
		10	2·0
		10	3·0
		10	18·0
	Marlboro	2	2·0
		2	18·5
		4	4·5
		6	48·0
		7	13·0
		10	11·0
		10	20·0
		10	46·0

The following notes on the presence of raspberry mosaic in different sections of Ontario show, at least, that this disease is found generally wherever raspberries are grown. It is not an important disease, however, in Norfolk, Middlesex, and Frontenac counties, where representative plantations were seen. The reports from other sections are merely notes, and no careful survey has been made.

Brant County (near Brantford)—
One plantation of Cuthbert, 1 acre, 4 years old, 2 per cent mosaic.
Plantation of Herbert, forty feet away, no mosaic.

Norfolk County (near Waterford)—
Small plantation, Cuthbert, 10 years old, 1 per cent mosaic.
Large plantation, Cuthbert, 9 years old, no mosaic.
Large plantation, Cuthbert, 9 years old, 0·2 per cent mosaic.
Small plantation, Herbert, 9 years old, no mosaic.
Large plantation, Cuthbert, 6 years old, no mosaic.
Small plantation, Cuthbert, 3 years old, no mosaic.
Large plantation, Cuthbert, 8 years old, no mosaic.

Norfolk County (near Simcoe)—
Small plantation, Cuthbert, 3 per cent mosaic.

Middlesex County (near London)—
Large plantation, Marlboro, 5 years old, no mosaic.
Large plantation, Marlboro, 5 years old, 1 per cent mosaic.
Small plantation, Cuthbert, 2 per cent mosaic.
Large plantation, Marlboro, no mosaic.

Kent County (near Blenheim)—
One plantation, Cuthbert, 5 per cent mosaic.

Frontenac County (near Kingston)—
One plantation, Columbia, 3 per cent mosaic.
One plantation, Herbert, no mosaic.
One plantation, Cuthbert, 0·5 per cent mosaic.

Algoma District (near Sault Ste. Marie)—
One plantation, 60-70 per cent mosaic.

Thunder Bay District (near Dorion, Murillo, and Fort William)—
Three plantations, mosaic present.

Symptoms of Mosaic

Mosaic is noticeable in a plantation from a distance because of the dwarfing of the canes, the sparse, yellowish foliage, and thin growth, which contrast markedly with the tall, rich, green, dense foliage and compact growth of the healthy parts of

Mosaic and healthy plants of the Cuthbert variety in the field.

the row. Once mosaic appears in a row it soon spreads in both directions, causing long streaks in which every cane is affected. Where these diseased areas are of three or four years' development and from ten to more feet in length, the canes near the middle are markedly dwarfed, and those near the ends of the spot almost normal in height. The size of the leaves, the density of the foliage, and amount of sucker

growth are also less in the middle of the area than near the ends. The foliage of diseased canes at a distance is lighter green, and soon becomes yellowish as summer advances. It is also more likely to bronze earlier than that on the healthy fruiting canes.

In the Cuthbert plantations over five years old there are usually many short or long strips of mosaic. The fruiting canes near the middle of the long strips (probably diseased for more than three years) are short and very slender. They may be only little more than half as tall as healthy canes, and often less than half the diameter. The laterals developed on these dwarfed canes approach the normal in length, but are spindly. The leaves are not over one-half the size of normal leaves. Many of the leaves show the large, green, blister-like mottling, while others do not show marked mottling. The leaves have a dull green or even yellowish appearance in contrast to the light shiny green of the healthy leaves. The veins are more apparent than normal and appear to be slightly sunken, causing a fine marking of the upper surface. These leaves soon bronze, or turn yellow-green in the summer. The suckers from the roots of such canes are usually shorter than the cane of the preceding year, and show distinct coarse and fine mottling in all the leaves.

The fruit developed on a cane which shows the dwarfing effect is largely worthless. During the present season, which was hot and dry at the time of the maturing of the fruit, much of it on mosaic canes was dry, and did not develop much pulp. That which did develop a pulp was tasteless and even insipid. Where there was a large percentage of mosaic, the quality of the fruit was greatly diminished, even though the dry and seedy berries were not picked. Greatly reduced yields were common in the district this year. The grower naturally attributed this to the season alone, but it was noticeable that the loss due to seedy and small berries was almost entirely confined to canes affected by mosaic. It is not known what the character of the damage to the fruit is in a more normal season. It may be expected that a larger percentage of fruit would develop pulp, but that it would all be tasteless or insipid.

All the symptoms above described for a plant which has been diseased for probably three years or more are also shown, but often to a less degree, in plants which have been affected only one or two years. Fruiting canes and suckers near the ends of diseased areas in the row are nearly as tall and as large in diameter as healthy canes. The leaf symptoms on the fruiting canes are the same, except that there is probably less tendency to bronze and turn yellow. In some cases tall, sturdy, fruiting canes, normal to all appearance, except for the definite leaf mottling, have been noted with suckers normal in height and diameter.

At the ends of the diseased areas there will often be found two stages of the invasion into the healthy plants. There will be some plants, all of the fruiting canes appearing normal, but one or more of the suckers will show marked mosaic symptoms from the oldest leaf to the tip. In other cases, not only is the fruiting cane healthy, but the suckers show no signs of mosaic except in the tip leaves, which may be either finely or coarsely mottled. These two conditions are apparently due to whether infection occurred early in the spring or during late spring and summer. A count made at the end of a diseased area, which was typical, showed, in the four feet adjacent to the last diseased fruiting cane, no mottled fruiting canes, four suckers mottled since early spring, six suckers mottled since mid-summer, and eight suckers showing no mottling. The presumption is that most of the suckers in this four feet will develop laterals with mottled foliage, and mottled suckers next year, and this will mean that the diseased area has spread four feet at the one end in a season.

The leaf symptoms on suckers seem to be the most constant feature of this disease. No difference has been noted between those coming from roots diseased for several years, and those apparently infected in the spring when they started growth. The leaves before the middle of June show large, irregular, green blisters, which arch upward. They are not confined to the arrangements of the veins in any way. The tissue between these blisters is lighter green than normal, or yellowish. Severely blistered leaflets curl downward, while the mid-rib remains straight, forming a longi-

tudinally rolled leaflet. In 1921 very high temperatures and drought conditions prevailed from the middle of June for about six weeks. During this time the suckers grew slowly, making short internodes. The leaves were normal, except that the leaflets were broader, and rolled on the mid-rib so that the tip curled under. A dry corky area was always to be found on the under surface of the mid-rib about one-third of the way from the base of the leaflet. The leaves formed during this period on affected suckers did not show any mottling. During August and September, under normal conditions, the suckers made the usual growth with normal foliage. All suckers, which had shown large blister-like mottling in the spring, now developed a fine, yellowish, speckled mottling, without any rolling of the leaflets. Also, recently infected suckers, which showed no mottling in the spring foliage, developed the fine mottling. In some cases coarse, blister-like mottling was produced on some leaves also, but this was the exception.

Many of the Cuthbert suckers affected by mosaic (probably one-fourth) form from one to six or more laterals from the axil of the leaves. These grow into long, leafy branches, and the axillary buds on them will develop fruiting laterals the next year. Such suckers do not grow to normal height. This condition was common in 1920 also.

There is some difference in the appearance of mosaic on the three varieties grown commercially in the Niagara district. These differences are due more to the varietal characters of the plant, than to any real difference in the symptoms. In the Cuthbert with its flat, thin, light green leaf, the mosaic mottling shows very prominently. In the Marlboro, where the leaves are more or less rolled and fluted, due to an arching of the tissue between the main lateral veins, the mottling is not distinct, except when abundant, and where the yellowish areas are large. The natural dark green of the leaf also seems to mask the finer mottling more than in the Cuthbert. In the Herbert, mosaic seems to show more prominently than in the other two varieties. Even slight mottling results in distinct yellow areas in the dark green leaf. Pronounced mottling in the Herbert results in a distinctly yellow leaf. The character of dwarfing is shown by all three varieties. More Cuthbert suckers showing pronounced mottling are found which are not markedly dwarfed than in the case of the Marlboro and Herbert. In these two varieties the canes are dwarfed severely and uniformly. The difference in dwarfing is apparently due to a time factor. It is believed that the Marlboro and Herbert respond very quickly after infection, and are soon dwarfed, while the Cuthbert is slower to respond, and is not dwarfed until probably two years after infection, when it is as severely dwarfed as the other two varieties.

The final effect of mosaic, if allowed to spread in a plantation, was observed in two plantations near Grimsby in 1921. One was a plantation of Marlboros, more than fifteen years old, and the other of Herberts said to be twenty-five years old. It is admitted that causes other than mosaic may have also helped to bring about the condition in these plantations, yet it appeared that mosaic was the most important. In both cases, the plants were extremely dwarfed. The fruiting canes were about two feet tall, and the suckers in many cases were about one foot. The owners said they had been in this condition for three or four years. Practically every plant showed mosaic symptoms and, doubtless, all were affected. An old plantation of Cuthberts near the Marlboros showed 50 per cent mosaic, and a new three-year-old plantation contained 3 per cent to 5 per cent. Four-year-old Cuthberts near the Herberts showed as high as 70 per cent mosaic in some of the rows.

Varietal Susceptibility to Mosaic

Since probably ninety per cent of the stand of the red raspberries in the Niagara district is composed of the variety Cuthbert, the chances for comparative observations on Marlboro and Herbert were not as abundant as desired. All three varieties are susceptible, and it is presumed that differences shown in the effects of mosaic in a commercial plantation may be largely due to the habits of the aphid on these varieties. Mosaic seems to spread much more rapidly in a planting of Marlboros than in Cuth-

berts, while in Herberts it spreads very slowly or is absent, except where Marlboros or Cuthberts are planted adjacent to them. Mosaic then spreads in Herberts as rapidly as in Cuthberts for a few feet. The percentage mosaic was high in all Marlboro plantations seen, running in some cases to nearly one hundred per cent, while, on the other hand, Herbert plantings have either a very low percentage or are free from mosaic. The fact that individual plants of all three varieties are severely affected, and in about the same degree, leads to the assumption that the apparent difference in susceptibility, as seen in the commercial plantings of the district, may be due to some factor other than real susceptibility. This can be determined after reliable inoculation methods are developed.

Several counts were made where Cuthbert and Herbert plantings were found adjacent, or where rows were planted alternately. These counts illustrate the great difference in apparent susceptibility between these varieties. From present indications it seems that the Herbert could be grown without much loss or trouble due to mosaic. Since also leaf curl is rarely found in Herberts, it is unfortunate that this variety is not a better commercial berry.

The following figures show a comparison of amount of mosaic in Cuthberts and Herberts planted alternately six feet apart in pairs or threes between rows of peach trees. The Cuthberts are four years old, and the Herberts three years, and the rows about 300 feet long:—

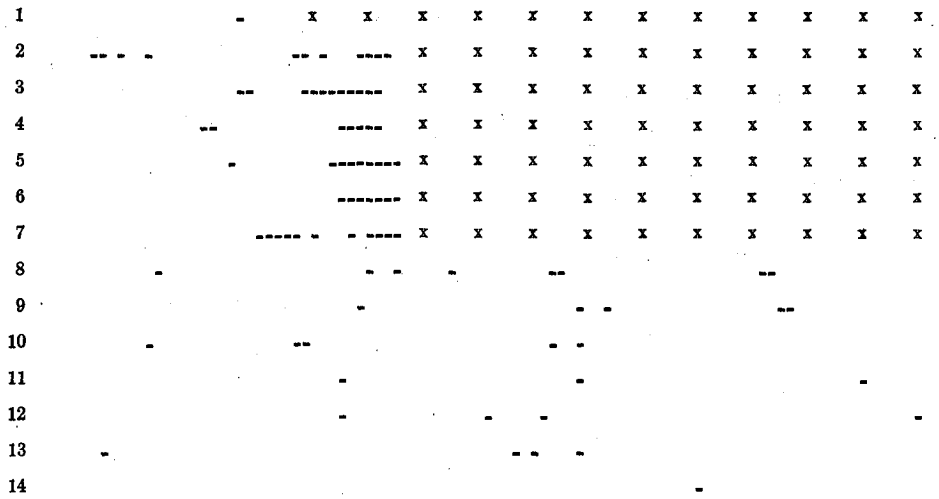
—	Per cent Mosaic	—	Per cent Mosaic
Cuthbert	97·4	Cuthbert	49·2
Cuthbert	94·8	Herbert	1·4
		Cuthbert	13·1
Cuthbert	73·9		
Cuthbert	69·6	Cuthbert	33·6
		Herbert	8·8
Cuthbert	47·8	Cuthbert	35·6
Cuthbert	74·3		
		Cuthbert	44·5
Herbert	1·7	Herbert	9·0
Herbert	1·3	Cuthbert	42·7

In another plantation of two rows (400 feet) of Herberts beside rows of Cuthberts and all rows 6 feet apart, the following counts were made. Both were 6 years old.

	Per cent Mosaic	
Herbert	4·3	
Herbert	7·7	Average, 6·0
Cuthbert	–	
Cuthbert	57·1	
Cuthbert	48·5	
Cuthbert	85·7	Average, 63·8

In another plantation, where the highest percentage of mosaic in Herberts was found, the condition was easily seen to be due to the proximity of badly diseased Cuthberts. In fact, the Cuthberts were dug and burned, a few days before the counts were made, because of the seriousness of mosaic. The amount in the Cuthberts probably ran to fifty per cent or more, or the grower would hardly have destroyed them.

SPREAD OF MOSAIC FROM CUTHBERTS INTO HERBERTS



The part of the block indicated by x was planted with Cuthberts which had a high percentage of mosaic. The remainder of the first seven rows and all of rows 8 to 14 were planted with Herberts of the same age (eight years). Each dash (-) indicates the position of two feet or less of plants affected by mosaic. The amount of mosaic in the Herberts was 6·7 per cent.

In September, the variety plots at the Central Experimental Farm, Ottawa, and the New York Agricultural Experiment Station, Geneva, N.Y., were examined. Mosaic was common in both places. The percentage found in each variety is given in the following tables. Some of the varieties are represented by very short rows, and, therefore, the figures are only approximate, and they should in all cases be taken only to represent the extent to which the disease has spread. The figures are not intended to signify the relative susceptibility of the variety. At Geneva the affected plants are removed occasionally, so that, in cases where none was found, it does not indicate immunity. The main purpose of the tables below is to record the disease on the different varieties.

MOSAIC COUNTS (SEPTEMBER, 1921)

Varieties at Ottawa	Ottawa Per cent	Geneva Per cent
Brighton	8	0
Brighton	16	0
Columbia	8	18
Count	4	0
Cuthbert	26	70
Deacon	0	–
Dr. Reider	24	0
Eaton	8	0
Empire 1st ½ (Lovett 191)	60	14
Empire 2nd ½ (Wardell 191)	60	14
Golden Queen	40	0
Heebner	0	–
Henry	0	–
Herbert	0	4
Herbert (E.F.)	0	4
Herbert (R.B.W.)	0	4
Herbert (Dora)	0	4
Highland Hardy	7	–
Hiram	0	–
Idaho	9	–
Jumbo	0	–
June	30	15
King	16	0
Louboro	26	4
Marlative	27	90 (?)
Minnesota	10	–
Newman 23	8	0
Newman 23	4	0
Newman 24	2	–
Newman 5	0	–
Newman 1	2	–
Newman 1	6	–
Newman 20	0	–
Percy	0	–
Pluma Farmer	0	–
Ranere	0	0
Royal Purple	2	0
Ruby	16	7
Sarah	0	–
Shinn	0	–
Sir John	0	–
St. Regis	6	–
Sunbeam	0	0
Superlative	0	–

Varieties at Geneva	Geneva Per cent	Ottawa Per cent
Abundance (10 ft.)	10	–
Brighton (25 ft.)	0	12
Brilliant (10 ft.)	?	–
Buckeye (15 ft.)	0	–
Columbiana	18	8
Count (30 ft.)	0	4
Cuthbert (50 ft.)	90	26
Cuthbert (15 ft.)	50	26
Cuthbert (15 ft.)	0	26
Donboro (30 ft.)	0	–
Eaton (20 ft.)	0	8
Eaton (18 ft.)	0	8
Eaton (10 ft.)	0	8
Eaton (10 ft.)	0	8
Empire (15 ft.)	14	60
Golden Queen (30 ft.)	0	40
Haymaker (30 ft.)	60	–
Herbert (50 ft.)	4	0
June, Cuthbert (400 ft.)	5	–
June (50 ft.)	20	30
June (100 ft.)	10	30
King (30 ft.)	0	16
Latham (20 ft.)	0	–
Louboro (50 ft.)	4	26
Marlative (25 ft.)	90 (?)	27
Marlboro (10 ft.)	20	–
Marlboro (40 ft.)	10	–
Marldon (10 ft.)	0	–
Marldon	?	–
Miller (10 ft.)	0	–
Minnietonka (35 ft.)	0	–
Newman 23	0	6
Ohta (20 ft.)	0	–
Ohta (25 ft.)	0	–
Ontario (100 ft.)	10	–
Perfection (20 ft.)	0	–
Ranere (18 ft.)	0	0
Red Rose (25 ft.)	0	–
Royal Purple (6 ft.)	0	2
Ruby	7	16
Segrist (20 ft.)	10	–
Sunbeam (50 ft.)	0	0
Surprise (20 ft.)	0	–
Syracuse (10 ft.)	0	–
Twentieth Century (20 ft.)	0	–

VARIETIES AT OTTAWA OR GENEVA SUSCEPTIBLE TO MOSAIC

(Approximate average per cent found)

Abundance	10 (?)
Brighton	10
Brilliant	x
Columbia	10
Count	5
Cuthbert	50
Dr. Reider	25
Eaton	10
Empire	50
Golden Queen	40
Haymaker	60
Herbert	5
Highland Hardy	10
Idaho	10
June	40
King	15
Louboro	25
Marlative	50
Marlboro	50
Marldon	10
Minnesota	10
Newman 23	10
Newman 24	2
Newman 1	5
Ontario	50
Royal Purple	1 (?)
Ruby	10
Segrist	10
St. Regis	5

VARIETIES AT OTTAWA OR GENEVA WHICH DID NOT SHOW MOSAIC

(x, Variety examined but no mosaic found; -, variety not included in the plots)

	Ottawa	Geneva
Buckeye	-	x
Deacon	x	-
Donboro	-	x
Heebner	x	-
Henry	x	-
Hiram	x	-
Jumbo	x	-
Latham	-	x
Miller	-	x
Minnetonka	-	x
Newman 5	x	-
Newman 20	x	-
Ohta	-	x
Percy	x	-
Perfection	-	x
*Ranere (St. Regis)	x	x
Sarah	x	-
Shinn	x	-
Sir John	x	-
*Sunbeam	x	x
Surprise	-	x
Superlative	x	-
Syracuse	-	x
Turner	-	x
Twentieth Century	-	x

*St. Regis or Ranere and Sunbeam were the only varieties seen at both Ottawa and Geneva which were entirely free from mosaic. These and the other varieties above may have escaped, or the affected plants been recently rogued.

Plants Affected by Both Leaf Curl and Mosaic

In only two instances plants have been found affected by both leaf curl and mosaic. In one case, a plant was found consisting of two suckers, over a foot tall, arising from opposite sides of the crown. The last season's cane (the root was one year old) had been cut off at the ground. One sucker showed predominantly leaf curl symptoms, and the other mosaic. This was the condition which first attracted attention. Upon closer examination it was found that definite mosaic symptoms were present in the leaf curled sucker, and definite leaf curl in the mosaic sucker. An analysis of each sucker leaf by leaf shows an interesting gradation of symptoms (leaves numbered from the base):—

SUCKER SHOWING PRONOUNCED LEAF CURL SYMPTOMS WITH STRONG MIXTURE OF MOSAIC

First leaf—practically normal except for "curl" shade of green.

Second leaf—lies flat, slightly arched between veins and puckered along veins—etiolated between veins as in curl, but also slight indication of mosaic puckering—"curl green."

Third leaf—lies flat, arched and puckered like second, several areas of mosaic, puckering, and etiolation—"curl green."

Fourth leaf—slightly rolled down—some curl puckering on veins, pronounced mosaic puckering, and etiolated.

Fifth and sixth leaves—insect (slug) damaged—with curl and mosaic symptoms.

Seventh leaf—end leaflet pronounced curl rolled lengthwise, other leaflets pronounced curl and mosaic.

Eighth leaf—all leaflets mixture of distinct curl and mosaic.

Ninth leaf—distinct curl—slight indication of mosaic, mostly due to "mosaic green" areas, irregularly placed.

Tenth leaf—pronounced and typical curl, with indication of mosaic due to "mosaic green" area.

Eleventh leaf—typically curled with "mosaic green" areas.

Twelfth and thirteenth leaves—young leaves, pronounced curl—no mosaic.

SUCKER SHOWING PRONOUNCED MOSIAC SYMPTOMS WITH SLIGHT MIXTURE OF LEAF CURL

First leaf—small, dwarfed, yellow leaf.

Second leaf—small, dwarfed, yellow leaf, finely mottled, light green or yellow.

Third leaf—small, dwarfed, yellow leaf, finely mottled, light green or yellow.

Fourth leaf—larger, slight mosaic blistering, distinctly mottled with yellow in light green.

Fifth leaf—large, light green, mosaic blistered, distinctly mottled with yellow in light green, rolled longitudinally.

Sixth leaf—like fifth, with slight curl puckering along veins in tip leaflet, and very slight in second pair.

Seventh leaf—same as sixth, with strong indication of curl due to curl puckering along veins, and accompanying "curl green" in these regions, also arching of deep green tissue between veins.

Eighth leaf—definitely curled with strong puckering, curl green, rolled (especially tip leaflets), but mottled with mosaic green, tip leaflet strongest in curl, and basal leaflets least.

Ninth leaf—same as eighth.

Tenth leaf—small leaf, strongly curled, but only rolled longitudinally, otherwise like eighth and ninth.

Extent to which Canes are Dwarfed

As was stated above, observation seems to prove that Cuthberts send up suckers the year after infection, which may or may not be dwarfed. If dwarfed, it is not much more apparent than the "normal" difference between healthy canes. After the second year, however, it is believed that the suckers show severe dwarfing both in height and diameter, and the fruiting laterals are dwarfed in proportion. The leaves on these canes are also only about half the size of normal leaves. In order to accurately follow the extent to which the successive year's growth is dwarfed, measurements were made and the clumps banded for future measuring. Fifty clumps were chosen representing both long standing mosaic and year-old infections. To compare with these, it was intended to band and measure fifty clumps which had become infected in midsummer of this year, but, unfortunately, due to the hot summer, the foliage dropped early in the season, especially the lower leaves. It was then impossible to distinguish between old and new infections. In order to get some comparisons of the extent of dwarfing for this season, the twenty-five healthy clumps nearest to twenty-five of the dwarfed clumps were measured. The following table gives the comparison between the nearest healthy clump and a clump diseased at least for one year. Several or all of the suckers of the clump from one root were measured, and the following are averages:

No. of diseased clump	Mosaic height		Healthy height		Mosaic dia.	Healthy dia.
	feet	inches	feet	inches	inch	inch
7	3	4·6	5	4·2	0·30	0·40
8	3	5·3	4	7·3	0·31	0·38
9	4	7·3	5	0·8	0·34	0·40
10	4	1·3	5	10·7	0·32	0·50
11	4	3·7	6	2·3	0·36	0·44
12	4	6·0	3	10·5	0·36	0·38
13	3	4·2	3	10·8	0·35	0·33
14	3	9·0	5	8·8	0·25	0·47
15	3	9·7	6	1·0	0·35	0·50
16	4	6·5	5	3·8	0·42	0·45
17	4	2·2	6	3·5	0·35	0·50
18	4	6·8	5	9·3	0·33	0·38
19	4	6·7	6	0·3	0·27	0·50
20	5	2·0	5	7·2	0·41	0·40
21	5	3·7	5	8·7	0·34	0·46
22	5	5·5	5	11·3	0·37	0·50
23	5	10·7	5	10·8	0·44	0·44
24	4	10·8	5	11·5	0·33	0·40
25 and 26	5	2·0	6	2·1	0·32	0·50
27	4	9·3	5	2·3	0·31	0·38
28	4	10·5	5	5·0	0·35	0·38
36 and 37	4	6·0	6	3·4	0·34	0·50
38	4	7·4	5	2·8	0·38	0·38
General average	4	6·1	5	6·5	0·34	0·43

Rate of Spread of Mosaic

An excellent chance to study the rate of spread of mosaic was afforded in a plantation set out this year, adjacent to an old plantation which had a high percentage. All the plants showing mosaic were banded and charted. The amount in the plantation this fall, while not large, shows the beginning of many spots which will soon become larger.

Beginning with the row adjacent to the last row of the old plantation, the number of affected plants was as follows (rows 370 feet long):—

Row	Affected when planted	Infected during summer	Total diseased
1	1	7	8
2	1	2	3
3	0	1	1
4	0	0	0
5	1	3	4
6	1	0	1
7	4	2	6
8	1	1	2
9	1	0	1
10	1	0	1
11	2	0	2
12	0	1	1
13	4	3	7
14	0	1	1
15	0	1	1
16	0	0	0
17	0	1	1
18	0	0	0
Total	17	23	40

The amount of mosaic present in September, 1921, was 0.9 per cent; 0.4 per cent of the stock planted was diseased, and 0.5 per cent has become infected during the summer.

Correlation of Aphids with Mosaic in the Field

The first symptoms of mosaic on suckers became evident about May 20. Aphids were very hard to find before this time, but, when mosaic was first showing in several plantations, they became very evident. At this time, it was striking that all suckers showing mosaic contained aphids on several leaves. They seemed to thrive best on these diseased plants, and the more severely affected leaves (with the largest green blisters) were worse infected than the other leaves. At this time it was very difficult to find aphids on healthy plants, and then, only single ones. There seemed to be no question as to two correlations between aphid infestation and mosaic: (1) that the aphid was the inoculating agent, and (2) that the aphid thrived better at this season on the worst mottled leaves, and was not thriving at all on healthy plants. This condition regarding the aphid and its association with mosaic-affected suckers continued until the extremely hot and dry weather in June and July, when they were practically eradicated. They became abundant again in September, and were found equally abundant on healthy, mosaic, and leaf-curled plants. They were especially abundant on the young second crop of suckers which came up in September.

The following figures, gathered during the survey for leaf curl prevalence, show the striking connection between aphid infestation and the dissemination of mosaic. The percentage figures given represent data from 780 healthy plants and 450 mosaic plants:—

Per cent mosaic plants showing aphids	40·2
Per cent healthy plants showing aphids	0·4

It will be seen that the frequency with which aphids could be found, by casual examination, on mosaic suckers was about 100 to 1, as compared with healthy suckers.

Infection Experiments with Mosaic

The evidence in the field pointed unmistakably to the aphid (*Aphis rubiphila* Patch) as the carrier of mosaic from plant to plant. Transfers of aphids to healthy plants in cages and in the open were begun as soon as they became plentiful, but the extremely hot and dry weather practically eliminated the aphids from the middle of June until August. They were plentiful in September, but this was too late to expect results, since the suckers had attained full growth. The following inoculations were made, but all were negative.

Two plants under electric lights in the laboratory were inoculated by rubbing the under surface of several leaflets with a leaf from a mosaic plant. The under epidermis was broken, and juice pressed from the mosaic leaf was rubbed on the injured surface. Inoculation made March 22, the suckers grew normally and showed no mottling on May 21, when the plants were discarded.

A colony of aphids (*Aphis rubiphila*) on a leaf of a sucker affected by mosaic was transferred to a healthy plant in the experimental plot on June 2. There were about ten aphids in the colony. A cheese cloth screen was placed over the plant. The colony did not thrive, and more aphids were placed on it on June 7. This colony failed to thrive also, and no infection resulted. Another colony of the large green raspberry aphids (*Amphorophora Rubi* Kaltenback, determined by Mr. W. A. Ross), about ten in number, was transferred to a healthy plant from a mosaic plant and enclosed by a cheese cloth screen. This colony became very abundant. The leaves, growing tip, petioles, and cane were crowded. Winged forms soon developed, and these were used for the determination of the species. No mosaic symptoms developed. In the case of this plant, however, we had a chance to observe what the effect of large numbers of aphids was on the plant, a condition which rarely happens in the open. All of the leaves, which developed after locating the colony, were infested as they unfolded, and they were in every morphological respect like the leaves which are formed on a plant affected by leaf curl. In July, the entire colony died, due to the high temperature and dry weather. From this time on to the end of the season, the suckers grew to full height and produced normal leaves, proving that the curling of the leaves was due only to the aphids.

On June 7, leaves from mosaic affected suckers were hung on the axils of the last fully expanded leaf of healthy suckers which were some distance from diseased plants. Eight plants were thus infested. The colonies did not thrive, and the hot weather soon checked them completely. No infection resulted.

On June 7, leaves from mosaic affected suckers with aphids on them were hung in the axil of the leaves of two healthy suckers in the experimental plantation. No infection resulted.

On the same day, three healthy suckers were inoculated by rubbing the under surface of the leaflets of one leaf with a rolled-up leaf from a mosaic affected sucker. Rubbing was continued until the epidermis was injured, and then the mosaic leaf was rolled up in the tip leaflet, so that it was tightly held against the injured surface and held with a rubber band. No infection resulted.

On June 16, fifteen healthy suckers were infested with aphids from mosaic affected plants by hanging the infected leaves in the axils of the last fully grown leaf. In each case five or more aphids were on each leaf used. It was a very hot day and the weather continued hot for several weeks. The colonies did not thrive. No infection resulted.

The failure to secure infection is believed to be due to the weather conditions then prevailing. It is doubtful if a sufficient number of the small colonies (2 to 10), then to be found on leaves in the open, migrated successfully to the healthy plant.

No attempt has been made at cross inoculation experiments to determine the possible identity of raspberry mosaic with mosaic diseases of other hosts. So far as known, *Aphis rubiphila* lives on raspberries the year around, and on no other host.

The larger aphid, (*Amphorophora Rubi*), is supposed to have an alternate host which is unknown. This host should be determined as a possible source from which mosaic may be transferred to raspberries.

Experiments on the Control of Mosaic

One of the possible methods of control, for such a disease as raspberry mosaic, is to remove the diseased bushes. Taking all the facts now at hand regarding mosaic, it would seem that a thorough eradiction of all affected bushes the last of July or in August would be more effective than at any other time of year. This year there were two periods when the aphids multiplied rapidly and spread from plant to plant. These periods, if our assumption is correct that aphids are the only, or main agent of dissemination, were, then, the periods of infection. Aphids became numerous on suckers about May 20. They were hatched from eggs laid in the autumn on the fruiting canes. After hatching, they presumably fed on the leaves of the fruiting laterals, and then dispersed (they do not fly) by crawling to the new suckers, where evidently they find better food conditions. Those migrating from fruiting canes affected by mosaic to suckers coming from healthy roots presumably inoculate them. Then, if they should pass to other suckers, they would be inoculated in turn. The details regarding the habits of the raspberry aphid are still to be worked out. A large amount of new infection was noticeable in August and September. Whether under normal conditions there would have been this break between spring and summer infections is not known. At any rate it may be presumed that June and July in this district will be the months most unfavourable for aphid multiplication and migration. This period of inactivity, if it prove to be a regular occurrence, will be a fortunate fact in devising control measures for mosaic. It probably takes one or two weeks for the symptoms to show after the plant is inoculated. Therefore, if there is a break between periods of spread, practically all the affected bushes can be picked out and eradicated. If no such break occurs, then those infections, which have occurred within the two weeks at least before the eradication, would be missed. On the basis of the sequence of weather conditions this season, the first of August was selected as the best time to test the value of eradicating all mosaic affected bushes. Three plantations were selected for the trials. They contained 5 per cent, 12 per cent, and 30 per cent mosaic respectively. Every root which showed even a single sucker affected was dug out. Every five or ten minutes, the bushes dug out were carried to a distance from the plantation for burning. This is an important matter, since very soon after a bush is dug the aphids leave it to seek other food plants. Therefore, if they are left for any time in the rows, there is danger that they will cause further infection immediately. The results of these control experiments should be available in time next year to use as a basis for recommendations to growers. Even if they are successful, it may take two or three more years to ascertain sufficiently well the habits of the aphid in midsummer, in order to determine the best time to carry out the eradication.

The experimental control areas were accurately charted, so that the location of every diseased bush removed is known. In one case a large check was left. The affected bushes at the ends of spots in the check area were banded to define their location.

If the present assumption that both leaf curl and mosaic are disseminated only or very largely by the aphid (*Aphis rubiphila*) be correct, the reduction or elimination of the aphid would be an effective control measure. Such possible control measures as spraying or dusting in the dormant condition, and when the aphids are on the leaves, will be taken up with Mr. W. A. Ross, of the Dominion Entomological Branch, with the hope that co-operative efforts in this direction will be made, if they seem feasible. (W. H. Rankin and J. F. Hockey).

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, SASKATOON, IN CO-OPERATION WITH THE UNIVERSITY OF SASKATCHEWAN, AND THE DOMINION FIELD LABORATORY AT INDIAN HEAD, FOR 1921

(W. P. FRASER, *Plant Pathologist, Officer in Charge*)

The Laboratory work and greenhouse experiments of the Dominion Laboratories at Saskatoon and Indian Head were carried on at Saskatoon in a laboratory and greenhouse provided by the University of Saskatchewan.

The most of the field experiments were carried out at Indian Head through the co-operation of the superintendent, Mr. N. D. Mackenzie. There was no officer in charge at Indian Head, nor regular assistant at Saskatoon, till the season was about over. This hindered seriously the work of the laboratories. Mr. L. D. Hazelton was temporary assistant during the summer, and valuable assistance was given by Mr. H. S. MacLeod during the periods when not actively engaged in potato inspection. Mr. P. M. Simmonds was appointed assistant at Saskatoon in August.

The following is an outline of the experiments carried out and the results obtained during the season:—

FIELD EXPERIMENTS TO DETERMINE THE EFFECT OF STEM RUST ON DIFFERENT VARIETIES OF WHEAT AND EMMER; ALSO TO DETERMINE THE BIOLOGIC FORMS THAT WILL DEVELOP UNDER VARYING CONDITIONS

The experiment was carried out in co-operation with a number of the Dominion Experimental Stations in Western Canada, the Field Husbandry Departments of the Universities of Manitoba, Alberta, and Saskatchewan, and the Provincial School of Agriculture, Vermilion, Alta.

The varieties selected for seeding were those known to have some rust resistance, early maturing varieties, and the principal varieties of commercial importance in the United States and Canada, and such other varieties as are important differential hosts in determining the different biologic forms of stem rust.

The varieties used were as follows:—

Row No.	Variety	C.I. No.	Row No.	Variety	C.I. No.
	Durum—			*Common*—	
1	Border		26—27	Haynes	C.I. 2874
2— 3	Kubanka	C.I. 1440	28—29	Marquis	Ottawa 15
4— 5	"	" 2094	30—31	Power	C.I. 3697
6— 7	"	" 4063	32—33	Ruby	Ottawa 623
8— 9	Arnautka	" 1493	34—35	Kitchener	C.I. 4800
10—11	"	" 4064	36—37	Red Bobs	" 6255
12—13	"	" 6236	38—39	Preston	" 3081
14—15	Mindum	" 5296	40—41	Kota	" 5878
16—17	Acme	" 5284	42—43	Prelude	Ottawa 135
18—19	Monad	" 3420	43a—43b	Early Red Fife	Ottawa 16
20—21	D-5	" 3322		*Winter*—	
22—23	Kahla	" 5529	43c	Kanred	C.I. 5146
24—25	Peliss	" 1584		*Club*—	
25a	Iumillo		44—45	Little Club	C.I. 4066
25b	Purple Durum (Select'n)			*Emmer*—	
25c	Kubanka	Ottawa A	46—47	White Spring	" 3686
			48—49	Khapli	" 4013
			50	Border	

Each variety was seeded in two adjoining rows, 16 feet long, except Iumillo, Purple Durum, Kubanka (Ottawa A), and Kanred. Of these only one row was seeded.

The officer in charge of the laboratory at Saskatoon visited all the stations, and estimated the percentage of rust.

These percentages are given below in tabular form. The rows were examined, and the percentage of rust estimated, a few days before ripening, except at Morden where the rows were in the dead-ripe stage. Sheaves were cut from the rows later at Brandon and Indian Head, when the wheat was in the dead-ripe stage, and forwarded to Saskatoon for examination. At this stage, Iumillo showed a trace of rust, D-5 and Monad about 10 per cent, Acme about 20 per cent, while 30 per cent to 40 per cent of stem rust was present on Kota. The rows at Saskatoon and Rosthern were also examined when dead ripe, and showed a considerable increase in rustiness (about 5 per cent to 10 per cent) in the resistant varieties.

Leaf rust (*Puccinia triticina* Eriks.) was very prevalent throughout Western Canada, appearing early, and killing many of the leaves before the stem rust was prevalent. This probably prevented, to a certain extent, a severe attack of stem rust, as the leaves and sheaths of the wheat were covered with leaf rust, and left only the stem for stem rust infection.

The names of the collaborators, and stations where the experiments were carried out, are as follows. The percentages of stem rust as estimated are given in tabular form.

LIST OF STATIONS AND COLLABORATORS

Dominion Experimental Farm, Morden, Man.	W. R. Leslie, Superintendent.
Manitoba Agricultural College, Winnipeg, Man.	T. J. Harrison, Professor of Field Husbandry; I. L. Conners Plant Pathologist.
Dominion Experimental Farm, Brandon, Man.	W. C. McKillican, Superintendent.
Dominion Experimental Farm, Indian Head, Sask.	N. D. Mackenzie, Superintendent.
University of Saskatchewan (Dominion Laboratory), Saskatoon, Sask.	W. P. Fraser, Officer in Charge.
Dominion Experimental Farm, Rosthern, Sask.	W. A. Munro, Superintendent.
Dominion Experimental Farm, Scott, Sask.	M. J. Tinline, Superintendent.
University of Alberta, Edmonton, Alta.	G. H. Cutler, Professor of Field Husbandry.
Provincial School of Agriculture, Vermilion, Alta.	J. C. McBeath, Principal.
Dominion Experimental Farm, Lacombe, Alta.	F. H. Reed, Superintendent.

RESULTS OF THE EXPERIMENTS AT THE VARIOUS EXPERIMENTAL STATIONS AND UNIVERSITIES, SHOWING THE PERCENTAGES OF STEM RUST INFECTION.

Experimental Stations	Date sown, May, 1921	Date examined, 1921	Kubanka C.I. 1440	Kubanka C.I. 2094	Kubanka C.I. 4063	Arnautka C.I. 1493	Arnautka C.I. 4064	Arnautka C.I. 6236	Mindum C.I. 5296	Acme C.I. 5284	Monad C.I. 3320	D-5, C.I. 3322	Kahla C.I. 5529	Peliss C.I. 1584	Tumillo	Purple Durum	Kubanka, Ottawa A	Haynes C.I. 2874	Marquis, Ottawa 15	Power, C.I. 3697	Ruby, Ottawa 623	Kitchener C.I. 4800	Red Bobs C.I. 6255	Freston C.I. 3081	Kota C.I. 5878	Prelude, Ottawa 135	Early Red Fife, 0-16	Kanred C.I. 5146	Little Club C.I. 4066	White Spring Emmer C.I. 3686	Khapli, C.I. 4013
Morden	13 21	Aug. 3	60	50	70	70	75	75	75	30	25	3	55	30	0	55	55	80	65	75	*	65	*	80	8	*	60	0	40	0	0
Winnipeg	....	Aug. 4	40	35	45	40	55	40	35	4	3	0	40	35	0	40	60	60	90	70	90	90	85	85	3	70	80	0	50	0	0
Brandon	23	Aug. 5	50	60	45	35	40	45	35	3	5	1	30	20	0	25	15	50	70	40	50	45	35	40	5	40	35	0	10	tr	0
Indian Head	13	July 28	3	1	20	15	10	20	5	0	0	0	20	20	0	30	40	80	45	10	60	45	40	35	5	60	40	0	5	0	0
Saskatoon	11	Aug. 9	5	10	20	8	25	20	5	1	tr	tr	10	10	0	10	15	5	60	30	50	70	50	50	0	40	40	0	30	0	0
Rosthern	9	Aug. 12	15	15	25	30	40	25	10	1	1	0	30	20	0	30	40	80	85	80	75	75	60	75	5	50	85	0	85	0	0
Scott	16	Aug. 13	0	0	0	0	tr	0	0	0	0	0	0	0	0	0	0	0	0	tr	0	tr	0	tr	0	0	0	0	0	0	0
Vermilion	8	Aug. 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	tr	tr	0	0	0	0	0	0	0	0
Edmonton	....	Aug. 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lacombe	....	Aug. 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*—Destroyed by sparrows. "tr"—"TRACE".

It will be seen from the table that, of the Durums, Iumillo, D-5, Monad, and Acme showed marked resistance.

Of the common wheats, Kota alone showed resistance. It was nearly ripe before being attacked by stem rust, and though considerable rust developed by the dead ripe stage, the grain was not injured. The straw is weak, and it frequently lodges, but this year it did not lodge as badly as the resistant Durums. It seems worthy of further trial in Western Canada, and should be of value in breeding for rust-resistant varieties.

It will also be seen from the table that rust was prevalent in Manitoba and most of Saskatchewan. At Scott in Saskatchewan, and at the stations in Alberta, practically no rust was present.

(This experiment was carried on in co-operation with Mr. J. A. Clark, Agronomist in charge of Western Wheat Investigations, United States Department of Agriculture.)

Project 97.

STRAINS OF STEM RUST IN WHEAT

(Preliminary Report)

A summary of the work done on rust strains in 1919 and 1920, as far as completed, was given in last year's report. As stated in that report, collections were made in 1920 from the following places:—In Manitoba: from Winnipeg (three collections), Morden, Boissevain, Napinka, Treesbank, Brandon (three collections), Rapid City, Dauphin, and Morris. In Saskatchewan: from Carlyle (two collections), Weyburn, Swift Current, Moose Jaw (two collections), Regina, Indian Head (five collections), Yorkton, Govan, Elbow, Watrous, Rosetown, Saskatoon (two collections), Watson, Rosthern (six collections), Scott, Melfort, Prince Albert, Shellbrook, and Mervin (two collections). In Alberta: from Macleod, Carstairs, Lacombe (two collections), Vermilion, Edmonton (three collections), Stettler (two collections), Camrose, and Vegreville (two collections); fifty-eight collections in all.

The work, as far as carried out, shows the following strains:—

XVII from Boissevain, Brandon, Dauphin, Morris, Morden, Rapid City, Napinka, Treesbank, and Winnipeg, in Manitoba; Carlyle, Govan, Elbow, Mervin, Indian Head, Melfort, Moose Jaw, Rosthern, Prince Albert, Rosetown, Shellbrook, Saskatoon, Swift Current, Yorkton, and Scott, in Saskatchewan; Camrose, Edmonton, Lacombe, Stettler, and Vegreville, in Alberta.

XVIII from Boissevain, Manitoba; Indian Head, Rosthern, Weyburn, and Yorkton, in Saskatchewan; and from Vermilion, Alta.

XI from Winnipeg, Manitoba; Rosthern and Watrous, in Saskatchewan; and Vegreville, Alta.

IX from Winnipeg and Brandon, in Manitoba; Rosthern, Saskatchewan; and Edmonton, Alta.

XII from Indian Head, Saskatchewan.

The work was continued in the season of 1921. Collections of stem rust on wheat were made at the following places:—In Saskatchewan: Alameda, Balcarres (two collections), Carlyle, Grenfell, Indian Head (two collections), Melville, Melfort, McGee, Moose Jaw, Rosthern (two collections), Saskatoon, Scott, and Stoughton. In Manitoba: Brandon, Minto, Morden, Rapid City, and Treesbank. In Alberta: Vermilion.

By the end of the year, the following strains were identified:—

XVII from Balcarres, Saskatoon, Melville, Morden, Rosthern, and Yorkton.

III from Brandon.

IX from Brandon.

XI from Moose Jaw.

XXI from Alameda.

The results show that the strain designated XVII was much more common and more widely distributed in 1919, 1920, and 1921, than any other strain. It was also the first to appear.

Project 96.

WINTERING OVER OF THE UREDOSPORES OF STEM RUST (*Puccinia graminis* Pers.)

It was shown in the early spring of 1919 and 1920 that a few collections of uredospores of stem rust on grasses were still viable. Unfortunately it was not possible, owing to the lack of assistance, to make collections, or test the viability of the uresdospores this season. Some observations were made at the time of the appearance of stem rust, and in every case the rust appeared first on wheat and, apparently, spread to grasses. It would seem that, if the wintering of the uredospores on grasses was general and the spring infection came from that source, in some cases at least rust would develop first on grasses. As far as observations have been made, this is not the case. Stem rust has always been collected first on wheat, and spread later to grasses, except where infection came from the barberry.

Project 99.

FIRST APPEARANCE OF STEM RUST

Not much time could be given to observations on first appearance of rust, and from these to gain information as to how the rust passes the winter, or the origin of spring infection on wheat and cereals.

Stem rust was first reported on Marquis wheat at Emerson, Man., on June 28, by Mr. I. L. Conners. The first collections were made in southern Saskatchewan at Grenfell on July 6. A few pustules could be found with difficulty in most of the wheat fields visited. A field survey was made further south on the 7th and 8th in the vicinity of Carlyle and Weyburn. A few pustules could be collected in most of the wheat fields. None could be found on grasses. A large area seemed to be equally infected. Stem rust was collected the following week at Melville and Yorkton, and soon appeared farther north. In some of these places secondary infection had taken place before collected, so the dates would not be of value. As in previous years, the rust appeared first in the south and later in the north, but sufficient time could not be given to field survey to obtain much data.

TIME OF CUTTING RUSTED GRAIN

Experiments on a small scale were carried on at Winnipeg in 1918 and 1919, and at Indian Head in 1920, to determine the best time to cut heavily rusted grain. The results of these experiments were conflicting so they were not recorded, but on the whole they seemed to indicate that the yield was greater when the grain was allowed to stand until ripe. It was not possible to carry on further experiments this season. The experience of many intelligent farmers, and the observations carried on at the laboratory would, however, indicate that heavily rusted wheat should be cut early. Rusted wheat ripens slowly and never shows the bright golden colour of clean wheat. The straw of heavily rusted wheat soon becomes very brittle and easily breaks down and is difficult in harvest. It is, of course, difficult to decide just what degree of rust severity would justify cutting, but when the upper part of the stem shows a heavy infection, and when rust is developing rapidly under favourable weather conditions, early cutting is probably advisable.

Project 98 (a).

DUST TREATMENT FOR SMUT CONTROL

Mackie and Briggs (Science, N.S. 52:540; 1920. Phytopath. 11:38; 1921) have shown that certain chemical dusts are effective in controlling smut of wheat, more especially dusts of copper carbonate and copper sulphate mixed with lime or calcium carbonate.

As the dusting method is in several ways more satisfactory than the wet treatment with formaldehyde, experiments were carried out to test its effectiveness under Western Canada conditions.

Marquis wheat was shaken in a container with spores of the stinking smuts of wheat (both *Tilletia Tritici* (Bjerk.) Wint. and T. *lævis* Kühn). As much spore material was used as would readily adhere to the grains. Part of this smutted wheat was then dusted with anhydrous copper sulphate and anhydrous copper sulphate mixed with calcium carbonate or lime. Only in plot 2 was hydrated copper sulphate dust used. The dust was applied by shaking the dust and smutted seed in a container.

The experimental plots contained each about 400 square feet. The percentage of smut heads was found by taking one hundred heads from seven different places in the plot, and basing the percentage on the number of smutted heads in the seven hundred thus obtained.

WHEAT (MARQUIS)

—	Fungicide used	Amount used per bushel	Percentage Smut
		Oz.	
Plot 1	Check	.....	13·6
" 2	Copper sulphate (hydrated) powdered	2	2·7
" 3	Copper sulphate (anhydrous)	2	1·28
" 4	" " and lime (1–1)	4	0·65
" 5	" " and lime (1–1)	2	5·88
" 6	" " and calcium carbonate (1–1)	4	0·78
" 7	" " " " "	2	1·1
" 8	Formalin solution (1–320), seed dipped	.....	0·0

A similar experiment was tried with oats. The seed was dusted with smut spores *Ustilago Avenæ* (Pers.) Jens. as in the wheat experiment. The plots were also the same size. As very little smut developed in the treated plots, the total number of smutted heads in each plot were counted except in the case of the check. The following is a summary of the experiment.

OATS

—	Fungicide used	Amount used per bushel	Number of smutted heads in plot	Percentage
		Oz.		
Plot 1	Check (Banner oats)	.....	.....	8·7
" 2	Copper sulphate and lime (1–1)	4	14	0·03 (estimate)
" 3	" " " "	2	117	0·25 "
" 4	Copper sulphate and calcium carbonate (1–1)	4	8	0·02 "
" 5	" " " "	2	115	0·25 "
" 6	Formalin (1-320), dipped	.....	1	0·00 "

It will be seen from the experiments that, though on both wheat and oats the dusts reduced markedly the amount of smut, they did not prove as effective as formaldehyde solution. There was no germination injury to the seed evident in the plots.

It is not easy to account for the large percentage of smut in plot No. 5 as compared with the other treated plots. Two ounces of dust covered the seed completely and seemed to be sufficient. With four ounces there was a considerable waste as all the dust did not adhere. It will be seen, however, that the larger quantity was more effective in controlling smut.

Copper carbonate, which was found effective in the experiments by Mackie & Briggs, was not tested, as it could not readily be obtained at the time of seeding.

Further experiments are desirable, as the method is, in many respects, easier of application than the formalin treatment. It is not recommended for use by farmers until further tested.

Project 92.

EXPERIMENTS ON THE CONTROL OF WESTERN RYE GRASS SMUT

The results of experiments on the control of Western Rye grass smut were reported last year. These experiments showed that the formaldehyde seed treatment, as commonly used for grain, was effective in controlling Western Rye grass smut. Further field experiments were carried out in 1921 at Saskatoon and Indian Head.

Commercial seed was obtained, and part shaken in a container with the spores from smutted plants of Western Rye grass (*Agropyron tenerum* Vasey). Part of this smutted seed was dipped for five minutes in formaldehyde solution of the strength commonly used for seed grain treatment (one part 40 per cent formaldehyde to 320 parts of water). The treated seed was covered for two hours, spread out to dry, and then seeded in rows. Each experimental row was sixteen feet in length.

The results were as follows. Percentage of smut was estimated by head count:—

	Percentage of smut
Saskat on—	
Coommercial seed	0·004
Smutted seed, no treatment	75·7
" treated with formaldehyde solution	0
Indian Head—	
Commercial seed	0·003
Smutted seed, no treatment	80
" formaldehyde solution	0

These results confirm those of the past two years, and show that the ordinary formalin treatment gives effective control.

The smut of Western Rye grass in its morphological characters closely resembles the smut of Brome grasses (*Ustilago bromivora* (Tul.)·Fisch.) To test if they are alike in biological characters, commercial seed of Western Rye grass was heavily dusted with the spores of *Ustilago bromivora* collected on *Bromus ciliatus* L. at Peace River, Alta., and seeded along with the other experiments. There was no heavier smut infection than on the commercial seed. This result indicates that these smuts may be biologically distinct. Further and more complete experiments would be necessary to prove that they are distinct.

Project 98.

SEED TREATMENT OF CEREALS BY THE DRY FORMALIN METHOD FOR SMUT CONTROL

The dry method, as it is called, of seed treatment for smut control, consists in spraying with a strong solution of formalin (one part 40 per cent formalin to one part water) at the rate of one quart of the solution to 50 bushels of grain. The experiments of last year showed that this treatment controlled smut in oats and wheat, but injured seriously the germination of wheat. Further experiments were carried out with wheat this season.

Marquis wheat was smutted artificially with the spores of stinking smut (*Tilletia Tritici* (Bjerk.) Wint. and *T. lævis* Kühn) by shaking together in a container. As much smut was used as would readily adhere to the grain. The grain was

then treated as described below and seeded in plots, each plot being about 400 square feet in area.

		Percentage of smut
Plot 1.	Smutted seed dipped 10 minutes in formalin solution (1-320), then dried	0·
" 2.	Smutted seed sprinkled with formalin solution (1-320), covered 2 hours	0·
" 3.	Smutted seed sprayed with formalin solution (1-1) at rate of 2 quarts to 50 bushels—covered 2 hours	0·
" 4.	Smutted seed sprayed with formalin solution (1-1) at rate of one quart to 50 bushels	0·02
" 5.	Smutted seed, no treatment. (Check)	16·6

There was no evident seed injury. It will be seen that this treatment controlled smut. It is, however, not recommended for wheat, as under certain conditions serious seed injury may result.

EXPERIMENTS TO TEST THE VALUE OF SEED TREATMENT FOR SMUT CONTROL BY THE "GAS GRAIN PICKLER" METHOD

As an apparatus called the "Gas Grain Pickler" is being placed on the market in Western Canada for seed treatment for smut control, it was thought advisable to test experimentally this apparatus and the method recommended. The apparatus consists of a long, perforated pipe, which is to be thrust through a hole bored in the tail board of a grain wagon box. Connected with the pipe is a container for powdered "para-formaldehyde". This is to be heated by an oil lamp protected by a sheet iron case.

Marquis wheat was heavily smutted artificially by shaking in a container with the spores of stinking smut (*T. Tritici* and *T. lævis*). This seed was enclosed in wire netting and placed in the grain box in the positions indicated below, the grain box being then filled with wheat. A small grain box and the apparatus for gas treatment were lent by the Field Husbandry Department of the University of Saskatchewan.

"Para-formaldehyde" powder was placed in the container and heated for one-half hour, as recommended, for one experiment, and one hour for the second. It was intended to test a longer treatment, but at the end of one hour the oil in the lamp, owing to the heat developed in the case, was boiling, and it was deemed dangerous to continue the experiment.

The treated grain was seeded at Indian Head. Each plot contained about 300 square feet. One hundred heads were selected from seven different places in each plot. The percentage is based on the count of these 700 heads from each plot.

An outline of the experiment, and the results, is given below:—

Seed Lot A: (Nos. 1, 2 and 3 treated half hour according to directions of "Gas Grain Pickler Co.")

		Percentage of smut
Plot 1.	Smutted seed near gas pipe	4·0
" 2.	" " near middle of box	7·5
" 3.	" " near top of box	10·5
" 4.	" " no treatment, check	18·5
" 5.	" " ordinary formalin treatment	0·0
Seed Lot B: (Nos. 1 and 2 treated one hour according to directions).		
Plot 1.	Smutted seed near gas pipe	10·5
" 2.	" " near top of box	14·0
" 3.	" " no treatment, check	20·0
" 4.	" " ordinary formalin treatment	0·0

It is evident from these experiments that seed treatment by the "Gas Grain Pickler" method does not effectively control smut of wheat. There was no evidence of injury to the seed, judging from an examination of the plots. A few germination

tests were made using the grain near the openings in the pipe. The germination of this grain was severely injured, but it does not seem that this injury extended far from the place where the gas was escaping or evidence of injury would have been apparent in the plots.

Project 107.

PLANT DISEASES IN SASKATCHEWAN AND ALBERTA IN 1921

No systematic survey was made during the season, but many observations were made by the staff of the Saskatoon Laboratory and others who co-operated in this work. In Alberta, Mr. G. E. DeLong, of the Lacombe Experimental Farm, and Mr. G. B. Sanford, of the University of Alberta, furnished valuable data; also Mr. C. H. Holmes, Dominion Potato Inspector. In Saskatchewan, Dr. Seager Wheeler furnished an interesting report on the Stem Rust of Wheat in the Rosthern district, and Mr. F. J. Greaney, Dominion Potato Inspector, submitted a number of valuable reports.

Weather.—The spring and summer in Saskatchewan were marked by a rainfall much greater than the average. Southern Alberta suffered from a lack of moisture, but in the north there was an average rainfall. The month of August was hot and dry, and this checked the development of the stem rust on the late grain.

WHEAT

STEM RUST (*Puccinia graminis* Pers.).—The first collection of stem rust in Saskatchewan was made at Grenfell in southern Saskatchewan on July 5. At this date a few pustules could be collected here and there over a wide area. A few days later collections were made at Melville and further north. The rust spread rapidly and became severe in southern and eastern Saskatchewan.

It is difficult to estimate the losses due to rust, but in southern Saskatchewan the yield was much below expectation. As this reduction of yield was in the districts where rust was most prevalent, doubtless this was due in a large measure to rust. The leaf rust (*Puccinia triticina* Eriks.), as noted later, appeared very early, and was very severe. This rust was probably also partly responsible for the lessened yield. An unusual feature of the rust attack this season was the patchy nature of infection. Some localities or fields suffered severely, and neighbouring districts, or adjacent fields, suffered little. On the whole, it does not seem an overestimate to place the loss due to rust in southeastern Saskatchewan at 20 per cent; in some districts it was probably much greater.

In northern Saskatchewan, the hot dry weather in August checked the rust, so that little damage was done. Dr. Seager Wheeler's summary of the rust situation in the Rosthern district is true for northern Saskatchewan according to the present writer's observations. He says:—

> "There is no doubt it caused a slight shrinkage of the grain, though I am not sure but that this was due to the hot, dry weather. The stem rust in its action was very erratic this season. Instead of spreading uniformly through the crops, it appeared in small patches of not more than a few feet square, while the surrounding crops were only slightly affected. The rust did not spread owing to the hot, dry weather in August, as there was no rain or dew or fog for about three weeks."

Stem rust was rare at Scott in west Saskatchewan and that region, as the rainfall was less than in most of the province. Only traces of stem rust were found at Vermilion on August 16, and none at Edmonton and Lacombe a few days later. Mr. Sanford reports stem rust in the Edmonton district as very rare, and no damage. Damage due to rust was reported to Mr. Sanford from Lloydminster in Alberta, but he was not able to get time to investigate and verify the reports.

LEAF RUST (*Puccinia triticina* Eriks.)—This rust was very severe in Saskatchewan, and extended in a mild form into Alberta. It was the most severe attack of leaf rust that has occurred in Western Canada for a number of years at least.

STRIPE RUST (*Puccinia glumarum* (Schum.) E. and H.)—No collections were made this season.

LOOSE SMUT (*Ustilago Tritici* (Pers.) Rostr.)—Mr. DeLong reported about 1 per cent in the Lacombe district. Mr. Sanford reported the amount varying from no infection to 5 per cent, many fields almost free. In Saskatchewan, the average infection would be about 1 per cent.

BUNT (*Tilletia lævis* Kühn and *T. Tritici* (Bjerk.) Wint.)—Very little of this smut observed or reported. Seed treatment of wheat is general in the better farming districts. "Noticed in one field about 2 per cent; in another 10 per cent." (Sanford).

SCAB, due to *Fusarium*.—A few collections were made in southern Saskatchewan, and at Saskatoon and Rosthern. It was, however, rare, only a few heads here and there could be found. Not reported from Alberta.

ROOT ROTS.—These were found in some districts in Saskatchewan, probably due to *Helminthosporium*. Also reported from Alberta by Sanford.

GLUME SPOT, due to *Septoria*.—No collections were made.

BASAL GLUME ROT, due to *Bacterium atrofaciens* McCulloch.—This disease was much more common in Saskatchewan than usual throughout the districts where the rainfall was above the average. In some plots it ran as high as ten per cent.

POWDERY MILDEW due to *Erysiphe graminis* D.C.—Collections on wheat were made at Edmonton, Alberta. It did no serious damage.

RYE

LEAF RUST (*Puccinia dispersa* E. et H.)—"Slight to severe in number of fields in Edmonton district; no serious damage." (Sanford).

ERGOT (*Claviceps purpurea* (Fr.) Tul.)—Generally distributed, but not common enough to cause serious injury. "General about Edmonton, but probably less than 1 per cent." (Sanford).

FLAG SMUT (*Urocystis occulta* (Wallr.) Rab.)—About half-a-dozen heads were collected in southern Alberta. There were no other reports of this disease.

OATS

STEM RUST (*Puccinia graminis* Pers.)—Common over the same area as wheat stem rust, in some places doing serious damage.

LEAF RUST (*Puccinia coronata* Cda.)—Present in Saskatchewan, but not severe.

SMUT (*Ustilago levis* (K. & S.) Magn. and *U. Avenae* (Pers.) Jens.).—DeLong reports only about 1/10 of one per cent in the Lacombe district. General, but usually the percentage small, not averaging more than 2 per cent to 3 per cent.

ROOT ROT.—Severe on a small plot at Saskatoon, about 50 per cent due to a *Fusarium*. Reported from the Edmonton district by Sanford.

BARLEY

STEM RUST (*Puccinia graminis* Pers.).—Common over the same area as wheat stem rust, but apparently doing little damage.

STRIPE DISEASE (*Helminthosporium gramineum* Rab.).—This disease was rather common in northern Alberta, but usually percentage was not high. Present, but not severe in Saskatchewan.

SPOT BLOTCH (*Helminthosporium sativum* (P.) K. et B.).—Common in Saskatchewan and in northern Alberta, in some places severe and causing injury.

LOOSE SMUT (*Ustilago nuda* (Jens.) K. et S.).—General. In a few fields very severe, in some as high as 30 per cent.

COVERED SMUT (*Ustilago Hordei* (Pers.) K. et S.).—General, but usually only a small percentage. In some fields 10 per cent.

FLAX

RUST (*Melampsora Lini* (DC.) Tul.).—More or less where flax is grown, but doing little damage. 3 per cent reported in one field in Saskatchewan.

ALFALFA

LEAF SPOT (*Pseudopeziza Medicaginis* (Lib.) Sace.).—More or less present on alfalfa wherever grown, but doing little injury.

TIMOTHY

Puccinia Phlei-pratensis E. et H.)—Collected on timothy late in season in the Edmonton district. Not as common as usual.

SUNFLOWER

RUST (*Puccinia Helianthi* (Schw.).—General on sunflowers in Saskatchewan, but not doing very serious damage.

ROOT ROT, due to *Sclerotinia.*—A few infected plants were found at Edmonton, but the fungus seems distinct from the common *sclerotinia* attacking sunflowers. Not collected elsewhere this season.

WESTERN RYE GRASS

SMUT (*Ustilago Agropyri*).—Not collected this year, except on experimental plots.

PLUM

(*Exoascus Pruni* Fckl.).—Plums at Rosthern were severely attacked by this disease.

BLACK CURRANT

MILDEW (*Sphaerotheca mors-uvae* (Schw.) B. et C.).—This mildew was present at Saskatoon. It did little damage.

LEAF SPOT OF CURRANT (*Mycosphaerella Grossulariae* (Fr.) Lindau).—Quite severe on currants at Scott.

RUST (*Puccinia Pringsheimiana,* Kleb.).—On the fruit of black currants at Scott, rather severe.

RED CURRANTS

ANTHRACNOSE (*Pseudopeziza Ribis,* Kleb.).—Common at Scott, defoliating currants.

GOOSEBERRY

ANTHRACNOSE (*Pseudopeziza Ribis,* Kleb.).—Common at Scott.

RHUBARB

A disease of rhubarb, probably bacterial, was quite destructive at Indian Head, Rosthern, and Scott.

BEAN

BLIGHT, due to *Pseudomonas Phaseoli,* E. F. S.—Bacterial blight was quite severe and widespread, causing heavy losses in some districts.

ANTHRACNOSE (*Colletotrichum Lindemuthianum* (S. et M.) B. et C.).—The bean anthracnose was severe at Rosthern. No other collections were made.

PEA

POWDERY MILDEW, caused by *Erysiphe Polygoni* D.C.—Quite severe on garden peas in some localities in Saskatchewan and Alberta.

SPOT, caused by *Mycosphaerella pinodes* B. et B.—Present, but not severe.

POTATO

EARLY BLIGHT, caused by *Alternaria Solani* (E. et M.) J. et G.—Quite severe in Saskatchewan and Alberta, and caused considerable loss. "Early Blight was worse than in the last four years in the Edmonton district." (Sanford).

RHIZOCTONIA (*Corticium vagum* B. et C.).—Rhizoctonia was, as usual, very severe. This is the most serious disease of potatoes in Western Canada, and causes much reduction in yield.

BLACK LEG (*Bacillus atrosepticus* van Hall).—This bacterial disease was present, but not severe in Saskatchewan. Mr. Greaney reported about 2 per cent in the fields inspected. In the Edmonton district this disease was much more severe.

MOSAIC.—This disease was reported as rather severe in Alberta by Holmes. Other reports from Edmonton and Lacombe state that it was not very common. Mr. Greaney reports about 9 per cent in the Saskatchewan fields inspected.

LEAF ROLL.—In Alberta, leaf roll was reported as scarce. Greaney reports about 2 per cent in Saskatchewan fields.

WILT, due to *Fusarium.*—There were no reports on *fusarium* wilt. It occurs, but is not common.

LATE BLIGHT, due to *Phytophthora infestans* (Mont.) de Bary.—Not reported in Saskatchewan or Alberta. The writer has never observed it in the Prairie Provinces of Western Canada.

POWDERY SCAB (*Spongospora subterranea* (Wallr.) Johns.).—Powdery scab existed at least three years on two plots in Edmonton, badly scabbing the potatoes. It has not spread to my knowledge (Sanford). This is the only report of powdery scab.

COMMON SCAB, due to *Actinomyces scabies* (Thaxter) Güssow.—As usual, very common.

TOMATO

BLOSSOM END ROT.—Present in a few gardens in Saskatchewan.

REPORT OF DOMINION FIELD LABORATORY OF PLANT PATHOLOGY FOR SUMMERLAND, B.C.

(H. R. McLarty, *Plant Pathologist, Officer in charge*)

This year, there has been added to the establishment of the Division of Botany, a field laboratory of plant pathology, on the Experimental Farm at Summerland, British Columbia. During the last ten years the tree fruit industry of British Columbia has developed such proportions that it is now recognized to be one of the chief assets of the province. To meet the needs for the study of fruit diseases in this province this laboratory has been established. Placed as it is in the centre of the Okanagan valley, it commands a most favourable situation, where the problems of fruit culture under irrigation can be investigated.

The officer in charge took up his duties on September 1, and has endeavoured to become acquainted, as rapidly as possible, with the industry as a whole, and the problems of plant disease that present the most urgent need of attention.

It is perhaps premature, at this present time, to go very fully into the prevalence of the different diseases present in the district. Speaking generally, the dryness of the climate is a limiting factor in the presence and spread of fungal disease. Scab, northwestern anthacnose, powdery mildew on the apple, and leaf curl on the peach are, perhaps, the most serious of these. Spraying practices, while general throughout the district are in many cases not sufficiently thorough to get the best results. The importance of spraying at exactly the proper time needs to be more fully appreciated by a large number of the growers. This is especially true in the more southerly districts where powdery mildew is causing an ever-increasing loss of the crop.

Fire blight has been, and still is, by far the most destructive of all the diseases in the district. The growers, although on the whole well acquainted with the recommended means of control, are in certain sections very lax in their winter cutting. The improving of orchard soils by the use of cover crops and fertilizers, causing more luxuriant growth and a greater degree of susceptibility to disease, is necessitating a more vigorous fight on the part of the growers, if the ravages of this disease are to be kept in check.

Collar rot is of quite considerable importance, and already a great number of inquiries have been made by the growers for a satisfactory control of this trouble.

Arid conditions, an improper use of irrigation water, and unsuitable, or poorly kept-up soils are, no doubt, the chief causes of the very marked prevalence of physiological troubles. Stippen, water core, cork, and Jonathan spot cause an important loss to the crop each year.

In outlining plans for next year's work, an effort has been made to consider only those problems, concerning which there has been the most inquiry on the part of the growers. New problems will, of course, come up, and these will be dealt with according to their importance and the time available for their study. While it cannot yet be definitely stated that experimental work will be carried out this next year on all the problems under consideration, it is expected that a commencement will be made.

These problems are:—

1. To determine, if possible, the factors that are most influential in causing physiological disorders in this district.

2. To test out the known methods of control for fire blight, and certain new possibilities that have recently come to light.

3. To test out new sprays for the control of powdery mildew.

4. To demonstrate the feasibility of controlling collar rot by the cutting out and disinfection of cankers.