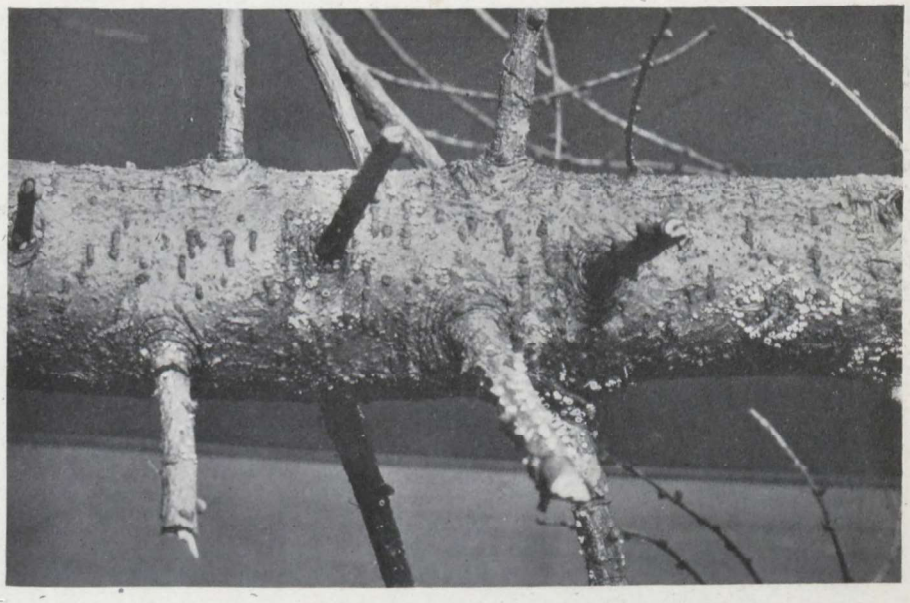
DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF BOTANY

REPORT OF THE DOMINION BOTANIST

H. T. GÜSSOW

FOR THE YEAR 1927



Larch canker showing the fruiting bodies of the causal fungus, *Dasyscypha calycina*, (Schum.) Fuckel. (Photograph, H. T. Güssow, taken in England.)

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TABLE OF CONTENTS

SECTION III—*Concluded* PAGE

SECTION IV

Investigations of the Diseases of Fruits and Vegetables

SECTION IV—*Concluded*

SECTION V

Investigations of the Diseases of Potatoes and Field Crops; Potato Certification Service

SECTION V—*Concluded* PAGE

INTRODUCTION

Since 1910, when the report of the Division of Botany first made its appearance as a separate report of the activities of one of the major divisions of the Central Experimental Farm there has been a synchronous extension in the growth of the Division and of its annual report, with the exception of a brief interlude during the war period, when, for purposes of economy, a drastic reduction in publication work came into force. The growth in size of the report has been due, *inter alia*, to the gradual establishment throughout the Dominion of various field laboratories to meet the varying needs of the agricultural communities as influenced by local geographical factors. Thus the first laboratory was located in the Niagara peninsula at St. Catharines, where the local problems centre mainly around the growing of fruit crops, followed later on by laboratories in the Annapolis valley, at Kentville, N.S., and the Okanagan valley, at Summerland, B.C., where again fruit growing, under widely different geographic and climatic conditions, forms the staple agricultural interest.

So, too, laboratories have been established in the potato-growing districts of Prince Edward Island at Charlottetown, of New Brunswick at Fredericton, and of Quebec at Ste. Anne de la Pocatière; while the cereal crop interests of the Prairie Provinces have been met by the establishment of laboratories in Manitoba (Winnipeg), Saskatchewan (Saskatoon), and Alberta (Edmonton).

Hitherto, it has been my policy, as chief of the division, to treat the activities of each field laboratory as a separate entity, entitled to its own credit. But with the growth in the size of the annual report, other factors have come into play. One concerns the general public, and, stated in brief, amounts to this, that a grower of potatoes, say, has had to turn to different parts of the report for information on his particular problems; and the same thing applies in the case of the wheat grower or orchardist. The other factor is that of cost of issue. While the report, as a whole, retains, we believe, its value as a scientific document, the demand for this could be met by a more limited edition. On the other hand, the needs of the agricultural community can be fully met by the splitting up of the report into "separates," each appealing to a distinct agricultural interest.

With this twofold aim in view, we propose to group subject-matters of the report in future under the following general headings:—

Section 1. General and Economic Botany, Diseases of Ornamentals, Systematic Mycology, Surveys, and Miscellanea.

Section 2. Forest Pathology, and related subjects.

Section 3. Investigations of the Diseases of Cereals and Grasses.

Section 4. Investigations of the Diseases of Fruit and Vegetables.

Section 5. Investigations of the Diseases of Potatoes and Field Crops; Potato Certification Service.

It is intended to have each section reprinted separately, so that anyone interested in any particular phase may inform himself readily of the work carried on throughout the Dominion, and be in a position to follow year after year the progress made in any particular line of investigation.

H. T. GÜSSOW,
Dominion Botanist.

SECTION I.

GENERAL AND ECONOMIC BOTANY; DISEASES OF ORNAMENTALS, SYSTEMATIC MYCOLOGY, SURVEYS, AND MISCELLANEA

GENERAL AND ECONOMIC BOTANY

The inquiries for advice and for samples of seeds related to various groups of plants as in former years. In the group of medicinal plants ginseng received most attention, and there were also a number of inquiries regarding the possibility of peppermint culture in various parts of Canada. Mention may also be made of seneca root, chamomile, anise, belladonna, dandelion, castor oil bean, santonin, and lactucarium.

There were the usual requests for information about feeds suitable for wild ducks; and the propagation of muskrats for their fur appears to be receiving increased attention. The plants included in this group comprise wild rice, wild celery, cat-tail, and muskrat potato as the most important.

Inquiries regarding various plants of economic importance included mustard, chicory, seakale (*Crambe maritima,* L.), caraway, and persimmon.

Miscellaneous items included a variety of subjects such as germination of magnolia seeds, phenological records, marram-grass (*Ammophila arenaria,* Link), edible weeds, native plants as food, sale of wild plants, uses of reindeer moss, uses of *Plantago Psyllium,* L., use of *Carthamus* as a dye-plant, and the collection of resinous substances such as Canada balsam and spruce gum.

In connection with the identification of plants there were requests for literature on ferns, the wild flowers of Ontario and of Canada in general and methods of preserving them, as well as for information on aquatic plants. In relation to these inquiries mention may be made of the publication of Bulletin No. 78 New Series entitled "A Short Guide to Canadian Genera of Seed Plants" which was published during the year. Bulletin No. 58 New Series, entitled "A Survey of Canadian Plants in Relation to their Environment," was reprinted, and also Bulletin No. 36, New Series, on "Medicinal Plants."

The List of Seeds for Exchange, collected in the year 1926, contained the names of 1,291 species and varieties, and was sent to 100 of the leading Botanical Gardens and Botanical Institutions in various countries, and to various private individuals in Canada.

The total number of seeds received in exchange during the year comprised 3,366 packets. Of these, about 150 packets were of seeds collected in China by Mr. J. F. Rock and forwarded through the courtesy of the Director of the Arnold Arboretum. These were sown in spring, and a number of them germinated during the year. Special mention may also be made of 37 packets of various cereals received from the Institute of Applied Botany at Leningrad, U.S.S.R., and of 18 packets of seeds of arctic plants received from the Danish Arctic Station at Disco, Greenland. Through the kindness of a firm in Winnipeg a sample of rice seed was received which had been grown on the high lands of Madagascar. Part of this was distributed among a number of Experimental Farms and Agricultural Colleges in Canada to be tested in the year 1928.

For experimental and breeding work 53 packets of seeds of various species of *Nicotiana* were received for the use of the Tobacco Division of the Experimental Farms Branch.

In exchange for the above there were sent out 4,835 packets of seeds and 175 rooted plants and cuttings. That this exchange service is greatly appreciated by foreign countries is shown by the following figures relating to various botanical institutions: 589 packets were sent to Jalta, Crimea, U.S.S.R.; 322 packets to Warsaw, Poland; 275 packets to the Institute of Applied Botany, Moscow, U.S.S.R.; 153 packets to the Institute of Applied Botany, Leningrad, U.S.S.R.; 165 packets to New York Botanical Garden, U.S.A.; 60 packets to

Sibpur, Calcutta, India; 98 packets to Harvard University and 25 packets to Arnold Arboretum, U.S.A.; 31 packets to Royal Botanic Gardens, Kew, England. In addition to the above, in response to requests for material for experiments, seeds of *Helianthus* were sent to Russia (U.S.S.R.), of *Corylus* to the United States, of sugar maple to England and Australia, etc.

For planting in Canada the usual trial samples of wild rice were sent out; also roots or seeds of peppermint and other medicinal plants; tree seeds were sent to the Quebec Forest Nursery at Berthierville; various roots and seeds of ornamental plants not easily obtainable from nurserymen were sent to a number of private individuals. In addition to the above, 407 packets were sent to the Experimental Station at Morden, Man.

There was little time for work of an experimental nature but, in this connection, a paper entitled "The Germination of the Seeds of some Plants with Fleshy Fruits" was published in the issue of the American Journal of Botany for October, 1927.

SYSTEMATIC BOTANY AND WEED STUDIES

Under this head are comprised a number of services to the public involving considerable routine and time-consuming work, also a major project on weeds, and such lesser services as time permits or occasion demands.

Correspondence relating to weeds, poisonous plants, and wild plants in general, necessarily takes precedence over most other matters, and for several months in the summer, to their exclusion largely. More than 1,200 plant specimens accompanied such letters and required identification, either as the basis for advice, or as botanical information alone.

Inquiries concerning noxious plants were dealt with by means of letters, mimeographed articles, and the department's bulletins. In a few cases field investigations were required. In others meetings of farmers were addressed on weeds in general, or on such weeds as perennial sow thistle in particular. Several days were spent with one weed inspector in a survey of his township, in the course of which quite unexpected weeds, some new to the province, were found established and spreading. As inspectors are appointed under the new Ontario Weed Act it is to be expected that more widespread interest, and resulting uncovering of weed menaces will make increasing demands on those in a position to give counsel.

During the year addresses were given on phases of our work, before the Quebec Society for the Protection of Plants, and the Central Canada Veterinary Association (on poisonous plants). Informal instruction on plant life was also given during brief visits to several Boys' Camps, supplementing similar help extended on different subjects by other specialists.

As in the past, assistance was rendered to other divisions and branches in the identification of plants, botanical analysis of herbage, etc. For the fifth consecutive year examination was made of hay received in the Division of Chemistry from plots at Maple Creek, Sask., where experiments in reclamation of land by irrigation are in progress with quite evident improvement in the quality of the crop. Collections of dry belt plants secured by Dr. S. E. Clarke, Division of Agrostology, in the course of range investigations in the Prairie Provinces, were also examined.

From sources such as these and the regular correspondence, and from recent surveys and trips, in the east, herbarium sheets to the number of several hundred were again prepared.

In the earlier part of the season some lines of experimental work commenced in previous years were resumed with help which proved to be only tem-

porary, and so had to give way soon to other duties. Among the fragmentary results secured may be mentioned the following.

Poison ivy foliage was only slightly injured by salt solutions, but was destroyed quite satisfactorily by careful spraying with a preparation known as Atlas A. The new foliage, soon appearing, showed the plants themselves to be little weakened; and only when the experiment can be carried through repeated applications will it be known how resistant they are. Hand methods of eradication with different tools under varying conditions were further tested.

Salt solutions had little effect on the foliage of field bindweed, but dry salt applied to a roadside infestation at the rate of 18 pounds per square rod and repeated five weeks later, resulted in gradual yellowing and eventually complete dying down of the plants in the centre of the area. That such a stubborn foe should have yielded to these moderate applications of salt may have been due to the previous nature of the road metal through which it grew.

One of the most familiar of door-yard weeds is that known as plantain. It is not so well known that this may be one or the other of two similar species with only such marks of distinction as would escape the unpractised eye. In the course of eradication tests another distinction of practical as well as botanical significance was observed. Common plantain was found to pull up quite readily from sod moistened by rains, but pale or Rugel's plantain, which is ordinarily less robust in appearance and inclined to reddish coloration of the leaf bases, was so well anchored by its clump of fibrous roots, that the tops grasped in the hand usually broke away with a portion of the crown. The difference, though not pointed out in current weed literature, was sufficient to mean success or failure in cleaning up this area by hand, according as one or the other weed predominated.

The Dominion Weed Survey was this year extended through the counties of Quebec north of the St. Lawrence, and into the St. John Lake district, and locally in Quebec and Ontario. In a very general way all Eastern Canada as far west as lake Superior has now been covered. The field notes for the five years since the survey was instituted are being gradually transferred to cards. Those for the Maritime Provinces have been completed, and with cards for records from all other sources, have been arranged for detailed analysis. The number of species to be dealt with in these three provinces is a little over 600. Besides native plants which persist as weeds, and poisonous plants, there are unusual numbers of introduced species, many of which are found nowhere in Canada but in the neighbourhood of these seaport towns. The study of these records, representing anywhere from one to several hundred places in the Maritimes for each species, is bound to be of absorbing interest.

This year, as last year in Prince Edward Island, a somewhat closer survey was made of one area, the rapidly developing Lake St. John-Chicoutimi region of northern Quebec. Records were secured in sixteen townships strung along more than 100 miles of rail and bus line. Excellent agricultural land prevails in a strip of varying width terminating in sandy wastes to the northwest, and broken between Lake St. John and Chicoutimi by typical Laurentian country. Industrial towns springing up within the district provide a local market for all kinds of farm produce.

A list of 165 weedy plants was made to which may be added a couple of dozen others recorded by Frère Marie-Victorin. Of these about fifteen are native wild plants which would not be regarded as weeds but for the fact that they have poisonous properties. A few others are weedy as well as poisonous, and a few introduced plants are poisonous. About 60 per cent of the plants included in the list are introduced species, which seems a surprisingly large proportion for a district which has so recently sprung into prominence, being only a trifle lower than that of old Prince Edward Island. As a matter of fact

some weeds appear to be always right on the heels of the pioneer, and as lumbering, railroad building, agriculture, industry, and commerce follow, the number increases rapidly.

Some of the more important weeds are named below in the order of their observed prevalence, which is not necessarily the order of their importance as weeds.

Yarrow
Canada thistle
Tall buttercup
Tufted vetch
Dandelion
Lamb's quarters
Common wormwood or mugwort
Great willow herb or fireweed
Pearly everlasting
Common horsetail
Common plantain
Canada goldenrod
Couch grass
Pepper grass
Evening primrose
Common knotgrass
Common chickweed
Shepherd's purse
Wild buckwheat
Bladder campion
Curled dock
Tumbling mustard
Common burdock
Wild mustard
Ox-eye daisy
Bull thistle
Hemp nettle
Smartweed
Brake fern or bracken
Lady's thumb
Canadian blue grass
Toadflax
Perennial sow thistle
Meadowsweet
Redroot pigweed
Mouse-ear chickweed
Barnyard grass
Wormseed mustard
Canada fleabane
Sun spurge
Low cudweed
Sweet clover (white)
Blue bur
Upright cinquefoil
Wild barley
Green foxtail
Sheep sorrel

Several other weeds, though less numerous, are equally worthy of notice. Russian pigweed, for more than forty years known in the Prairie Provinces, but seldom eastward, was found, sometimes well established, in half a dozen places from end to end of the district. The western perennial ragweed was a surprising find in one out of the way location. The common and giant ragweed were also seen occasionally. Prairie sage *(Artemisia gnaphalodes)* was found in a couple of patches near Mistassini. A hawk's-beard *(Crepis tectorum)* was plentiful along some miles of road near Chicoutimi. Other weeds, like stinkweed, spurrey, the annual sow thistle, night-flowering catchfly, common groundsel, and wild oats are undesirables, which perhaps have not yet had sufficient opportunity to spread.

With such weeds as perennial sow thistle, Canada thistle, couch grass, and wild mustard infesting field crops, with buttercup and ox-eye daisy in pastures, and with so many of the familiar wayside and farmyard nuisances prevailing, it cannot be said that the weed problem in this somewhat detached community is very essentially different from that of older settled parts. Here, as everywhere, weeds are a limiting factor in crop production, and an occasion of expense that can only be ignored at the cost of increased trouble in the immediate future.

EXAMINATION OF PLANT IMPORTATIONS

The work entailed in the examination for disease of samples taken from foreign shipments of nursery stock, offered for admittance into Canada, was greatly increased this year. From 640 intercepted shipments 2,292 samples were examined, as compared with 413 samples from 261 shipments in 1926.

The various kinds of material examined and the number of samples of each are given in the following lists:—

BULBS, CORMS, RHIZOMES, AND TUBERS OF ORNAMENTAL PLANTS

Name of plant	Number of samples	Name of plant	Number of samples
Aconitum sp. (Aconite)	1	*Iris* spp. (rhizomatous)	6
Anemone spp.	4	*Iris* spp. (bulbous)	28
Begonia spp. (tuberous)	12	*Ixia* sp.	1
Camassia Quamash, Greene	1	*Leucojum* sp. (Snowflake)	1
Canna sp.	1	*Lilium* spp.	5
Chionodoxa Luciliae, Boiss. (Glory-of-the Snow)	2	*Muscari botryoides*, Mill. (Grape hyacinth)	1
Crocus spp.	210	*Narcissus* spp.	67
Cyclamen sp.	1	*Paeonia* spp. (Peony)	16
Dahlia spp.	6	*Scilla* spp.	9
Freesia refracta, Klatt.	10	*Sinningia speciosa*, Benth. et Hook. (Gloxinia)	6
Fritillaria imperialis, L.	1	*Tritonia crocosmaeflora*, Lem. (Montbretia)	8
Galanthus nivalis, L. (Snowdrop)	12	*Tulipa* spp. (Tulip)	308
Gladiolus spp. (Summer-flowering)	1,430	*Watsonia iridifolia*, Ker. (Bugle lily)	1
Gladiolus nanus types (for forcing)	47	*Zantedeschia* sp. (Calla lily)	1
Hyacinthus orientalis, L. (Hyacinth)	58		

ORNAMENTAL PLANTS

Name of plant	Number of samples	Name of plant	Number of samples
Araucaria excelsa, R. Br.	1	*Hydrangea* spp.	3
Aristolochia macrophylla, Lam. (Dutchman's pipe)	1	Orchid	1
Aspidistra elatior, Blume	1	Perennials, mixed	1
Azalea spp.	12	*Phoenix* sp. (Palm)	2
Bambusa sp. (Bamboo)	1	*Rhododendron* sp.	2
Dianthus Caryophyllus, L. (Carnation)	1	*Rosa* sp. (Rose)	1

MISCELLANEOUS PLANTS

Name of plant	Number of samples	Name of plant	Number of samples
Agave sp.—leaves	1	*Phasaeolus vulgaris*, L. (Beans)—pods	1
Castanea sp. (Chestnut)—nuts	1	*Prunus Amygdalus*, Stokes (Almond)—nuts	1
Eleocharis tuberosa, Sch. (Water-chestnut)—tubers	1	*Solanum tuberosum* L. (Potato) tubers	2
Fragaria sp. (Strawberry)—plants	2	*Zingiber officinale*, Roscoe. (Ginger)—roots	1
Lycopersicum esculentum, Mill. (Tomato)—fruit	1		

Of the 640 intercepted for the suspected presence of disease part or all of 99 were refused admission, either because of the presence of diseases which would seriously prejudice the development of these plants, or on account of the complete decay of the material. Gladiolus corms figure most prominently in the rejected material; upwards of 560,000 corms from six different countries were condemned, the material being either returned at the exporter's expense or burned.

STUDIES AND NOTES ON THE DISEASES OF ORNAMENTAL PLANTS

The preliminary work in connection with the study of the unsound bulbs, corms, etc., of ornamental plants found in foreign shipments, together with photographs of some of the types of injury observed, were recorded in the last annual report of the Dominion Botanist. These studies were continued during the past

year, and the information so obtained is being of great value in deciding whether affected shipments should be rejected or admitted. It is now possible to proceed with the preparation of an illustrated guide for the inspectors at the ports of importation, in which the types of injury so far observed will be described and illustrated, the causes given, and the method of handling the shipments so affected. The guide will be prepared in such a way that additional information obtained in subsequent years may be incorporated.

A paper, illustrated with lantern slides, on the condition of bulbs and corms of ornamental plants offered for importation into Canada, was read before the American Phytopathological Society at Nashville, Tenn. An article on common bulb diseases was prepared as a section of Bulletin 95, New Series, Department of Agriculture, Dominion of Canada, on "Some Flowering Bulbs."

Under the headings of the different plants concerned, the results of field and laboratory studies obtained during the year are herewith reported, together with photographs illustrating the more important observations.

Tulip

The most destructive disease of this plant is the so-called fire or grey mould blight, caused by the fungus *Botrytis Tulipae* (Lib.) Hop. It has been well described by Hopkins.[1] Its occurrence in Prince Edward Island and a short description are recorded by Hurst,[2] and an illustrated description of this disease and methods for its control have been published in a departmental bulletin.[3]

The examination of a large number of tulip bulbs taken from foreign shipments reveals the fact that there is a much greater diversity in the appearance of the lesions of this disease on dormant bulbs than one would expect from the descriptions so far published. The presence of sclerotia has always been noted as the symptom which distinguished these lesions from those due to *Penicillium* rot and mechanical injury, but in many instances lesions of various shapes were found which had no sclerotia, but were found to contain living mycelium of *Botrytis Tulipae*. A bulb having dormant mycelium when planted is as much a source of infection to the plant grown from it and to the soil in which it is grown, as a bulb having the characteristic sclerotia. In plate I ten distinct types of lesions are illustrated. In all of these living mycelium has been isolated; those in figs. 1, 6, 7, and 10 have sclerotia, and those in figs. 2, 3, 4, 5, 8, and 9 have no sclerotia. A knowledge of the appearance of these various forms of lesions is of importance in the inspection of imported bulbs and in the elimination of disease from a grower's stock.

There is another destructive disease of the tulip known as grey bulb rot, caused by the fungus *Rhizoctonia Tuliparum* (Kleb.) Whet. et J. M. Arth.[4] Only one case of this disease has been found in the inspection work. The inclusion of affected bulbs in foreign shipments is rare, for, where this disease occurs in the field, the entire plant is usually destroyed.

Several other types of injury in imported tulip bulbs have been investigated. In some of these the cause and importance has not yet been determined, but many have proved to be of no importance in the development of normal plants and flowers. These include surface drying, due to a break or partial removal of the outer papery scale, holes obviously made by some insect or animal, and bruising or cutting. Some of the injuries are due, directly or indirectly, to unfavourable conditions of curing and storage. These may be slight and of no

[1] Hopkins, E. F. The *Botrytis* blight of tulips. Corn. Univ. Agr. Exp. Sta. Memoir 45, 1921.
[2] Hurst, R R. Blight of Tulip, Report of the Dominion Botanist for 1925, page 21.
[3] Drayton, F. L. Common bulb diseases; a section of Bull. 95, New Series, Dominion Experimental Farm, 1928, ut supra.
[4] Whetzel, H. H., and John M. Arthur. Corn. Univ. Agr. Sta. Memoir 89, 1925.

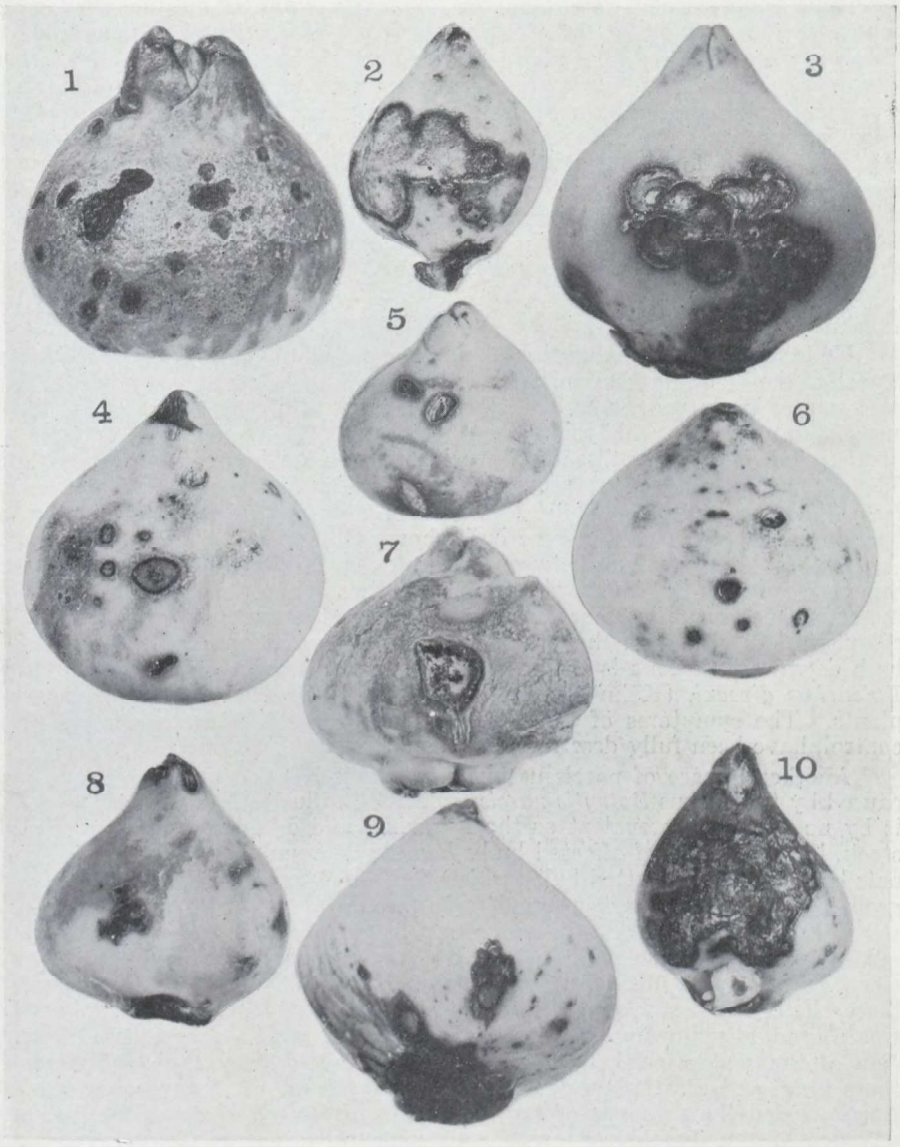

PLATE 1.—Tulip bulbs affected with the fire disease or grey mould blight.

Figs. 1 to 10.—Ten distinct types of lesions caused by the fungus *Botrytis Tulipae,* (Lib.) Hop.

(Photos by F. L. Drayton)

importance, but occasionally they are accompanied by a *Penicillium* decay which may be so extensive as to destroy the bulb either before or after being planted.

Some observations were made in the early summer on the phenomenon known as "breaking" in the Cottage variety Grenadier. The flowers of the "broken" plant exhibited a peculiar variegated or mosaic pattern of the floral coloration, and in a less spectacular way the same peculiarity extended into the leaves, in an indistinct pattern formed by a varying of the intensity of the green colouring matter. There was also a decided dwarfing of the plant as compared with the normal ones of the same variety. This phenomenon was formerly thought to be a genetic reversion and broken bulbs were propagated and sold as individual varieties in the classes of Rembrandts, Bizarres, and Byblooms. Evidence has however been presented by Griffiths[5] which points to the fact that it is probably a virus disease of the mosaic type.

Narcissus

Under this section, attention should be called to a mistake in the annual report of the Dominion Botanist for 1926, page 11—"*Botrytis polyblastis,* Dowson—one of the narcissus ball rots" should read "*Botrytis narcissicola,* Kleb,—one of the narcissus 'bol' rots."

Several destructive diseases have been found on imported narcissus bulbs. The one of most frequent occurrence is a basal decay and bulb rot caused by a *Fusarium* sp. Plate 2, fig. 1, shows the upward progress of this decay, and fig. 2 a cross section of the same bulb showing the extent of the decay and the sheaths of white mycelium between the scale leaves. The bulb decay illustrated in cross section in fig. 4 somewhat resembles that of the *Fusarium* sp., but differs in the absence of an intra-scale mycelial sheath, the more centrally located discoloured tissues, and in the progress of the decay being from the nose of the bulb downwards. This is the so-called "ring" disease caused by the eelworm *Tylenchus dipsaci,* (Kühn) Bast., the most important field disease of narcissus plants. The symptoms of this disease and the methods recommended for its control, have been fully described in a departmental bulletin.[6]

Another disease of narcissus bulbs, which is being investigated, is a decay caused by the fungus *Botrytis narcissicola* Kleb., illustrated in plate 2, fig. 2. It is by no means as prevalent as the *Fusarium* and eelworm decays in imported stock, but a number of affected bulbs have been found, and several correspondents have submitted potted bulbs which had failed to produce either roots or top growth, and this fungus was found to be responsible for the trouble.

Two sterile sclerotium-bearing fungi, illustrated in plate 3 of the report of the Dominion Botanist for 1926, have been repeatedly isolated from dormant stock, and potted bulbs which had produced diseased plants and no bloom. In these plants the root system was normal, the base of the bulb sound, but there was a gradual yellowing and death of the leaves, with a progressive discoloration of the scales from the top downwards, followed by the development of these fungi and a complete destruction of the tissues. A microscopic examination revealed the presence of large numbers of *Rhizoglyphus* mites feeding in advance of the discoloured areas, and some eelworms in the decayed tissue. The leaves showed longitudinal streaks in which the mites were feeding. These observations, coupled with the negative results obtained from an artificial inoculation of sound bulbs with these sclerotium-bearing fungi, seem to indicate that the primary injury is caused by the eelworms, the mites, or both, followed by the development of these fungi on the injured tissue. This point is being

[5] Griffiths, David. U.S. Dept. Agr. Bull. 1082, 1922.

[6] Drayton, F. L. Common bulb diseases; a section of Bull. 95, New Series, Dominion Exp. Farm, 1928.

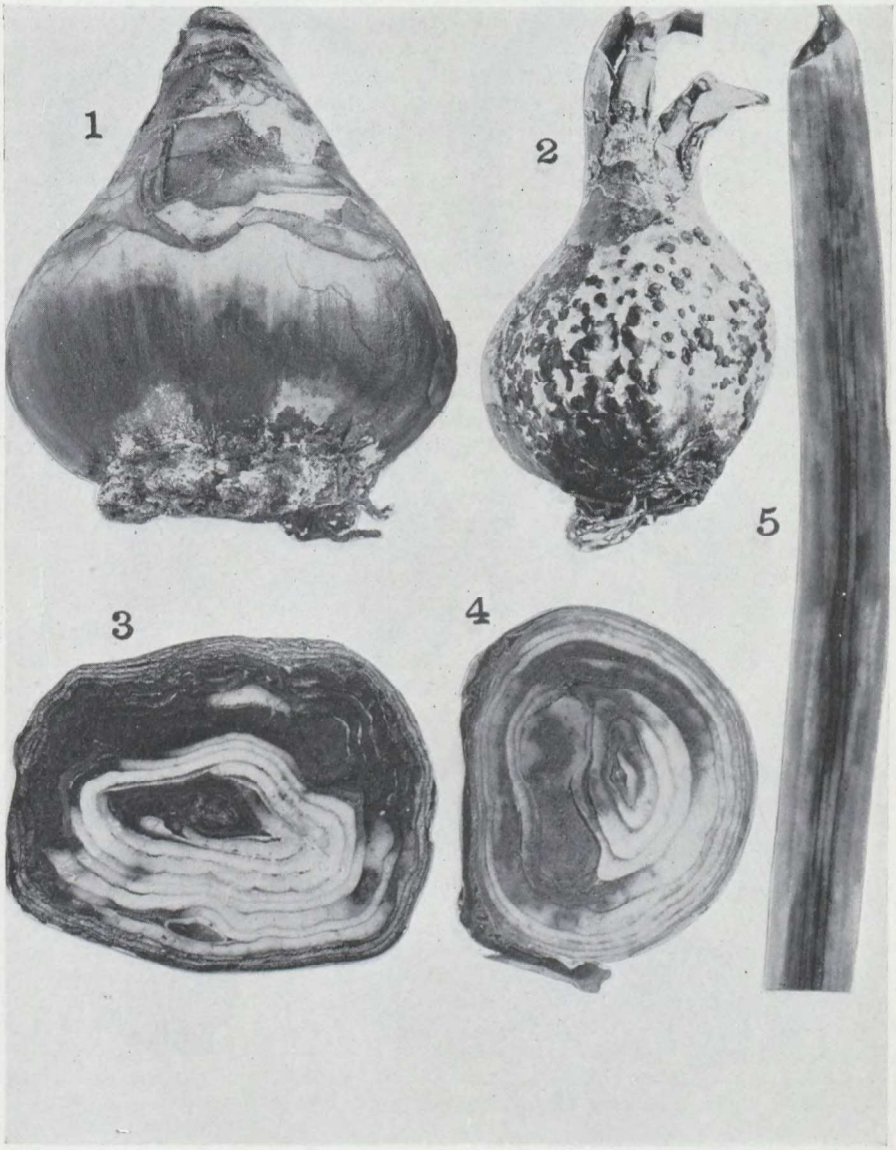

PLATE 2.—Four narcissus diseases.

Figs. 1 and 3.—Surface view and cross section of a bulb affected with a basal decay and bulb rot caused by a *Fusarium* sp.

Fig. 2.—A decay caused by *Botrytis narcissicola,* Kleb.

Fig. 4.—Cross section of a bulb affected with the ring disease caused by the eelworm *Tylenchus dipsaci,* (Kuehn) Bast.

Fig. 5.—A leaf from a plant affected with a mosaic-like disease.

(Photos by F. L. Drayton)

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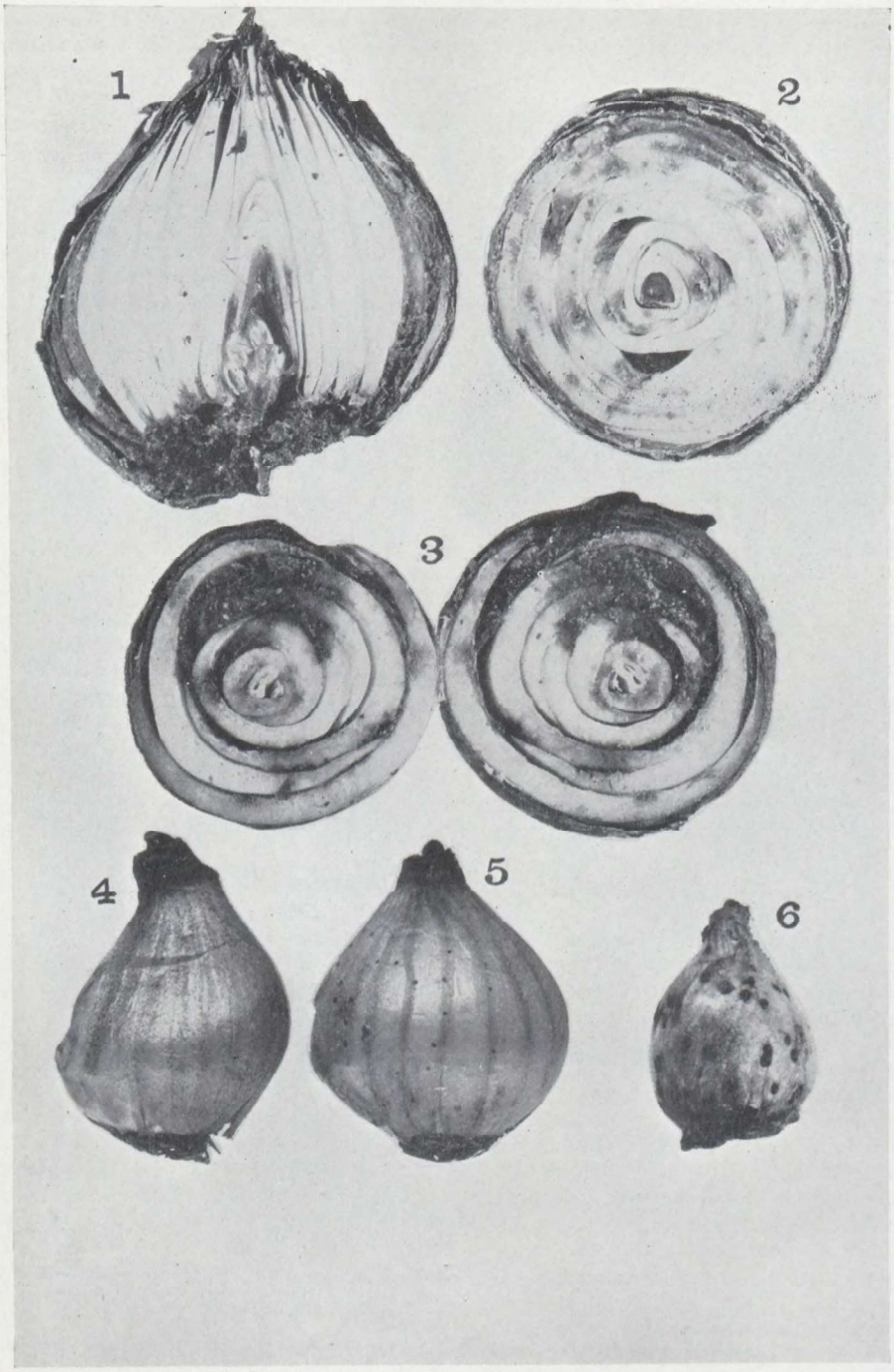

PLATE 3

Figs. 1 and 2.—Hyacinth bulbs affected with the yellow disease *Bacterium Hyacinthi*, [Wakker].
Fig. 3.—A hyacinth bulb cut in two, showing the symptoms of the ring disease caused by the eelworm *Tylenchus dipsaci*, (Kuehn) Bast.
Figs. 4 and 5.—Two snowdrop bulbs affected by two distinct sclerotium-bearing fungi.
Fig. 6.—A Chionodoxa bulb decayed by one of the liliaceous *Botrytis* forms.
(Photos by F. L. Drayton)

further investigated, however, for it is possible that under favourable conditions of curing or storage, these fungi may be responsible for considerable damage.

A mosaic-like disease of the Incomparabilis variety Lucifer has been under observation for the past three years. This is characterized by a dwarfing of the plant, marked mottling of the leaves (plate 2, fig. 5), and imperfect development of the bloom. It has been suggested that these symptoms are the result of the hot water treatment for the control of eelworms, but the recurrence of symptoms for two years after its original appearance, would hardly conform with this explanation.

Hyacinth

The most important disease found in imported hyacinth bulbs is the yellows, caused by *Bacterium Hyacinthi*, Wakker. In advanced infections, it can be detected by a softness of the basal portion of the bulbs, and on cutting the bulb the decayed tissues become evident as shown in plate 3, figs. 1 and 2. In cases of slight infection, it is impossible to detect the presence of this disease without cutting the bulbs, so that it is difficult to estimate the true percentage of infection in a shipment. In the field, an infected plant develops narrow dark stripes near and parallel to the edge of the leaves, the vigour of growth is impaired, the leaf tips turn yellow and roll up, and in an extreme case, in a few days the whole shoot with the inflorescence can be pulled out of the bulb easily. Fortunately this disease does not infect the soil, the bacteria being spread by the splashing of rain and by contact in storage. The only means of control is eradication, by digging up and burning diseased plants, and by submitting newly purchased stock to as careful an examination as possible.

The ring disease, caused by the eelworm *Tylenchus dipsaci*, (Kühn) Bast., is also found in hyacinths. Its injury to the bulb is illustrated in plate 3, fig. 3.

Chionodoxa and Snowdrop

Two sclerotium-bearing fungi have been isolated from snowdrop, and one from chionodoxa bulbs; the latter is one of the liliaceous *Botrytis* forms. These are illustrated in plate 3, figs. 4, 5, and 6. Further study of these will be necessary before an opinion can be expressed as to their importance.

Iris (Bulbous)

These include the so-called Dutch, Spanish, and English irises, which are used principally for greenhouse forcing.

Most of the injuries of these bulbs which have been studied are decays which have followed improper curing, insect holes, or the sucking of aphids. One form of decay of Dutch iris bulbs (*Iris Xiphium hybridum*) has been of interest, for it is caused by a sclerotium-bearing basidiomycetous fungus, identified by Professor H. H. Whetzel as *Sclerotium Delphinii*, Welch, and he says that it constitutes a new record of the presence of this fungus in Holland. The appearance of the decay and the presence of flattened sclerotia between the scales are shown in plate 4, fig. 2.

Iris (Rhizomatous)

This group includes all the so-called garden or Pogoniris varieties.

In imported stock, the only disease so far found has been the rhizome rot caused by *Bacillus carotovorus*, Jones. This is very destructive to the growing plants and has previously been described[7].

[7] Report of the Dominion Botanist for 1922, page 10.

A root rot and die-back disease was prevalent in the iris plantation of the Central Experimental Farm and in several gardens in Ottawa, during the early summer. After making good growth for a month to six weeks, the leaves of these plants turned yellow and then brown and dry, without any of the water-soaked decay typical of the rhizome rot. On digging the plants, a complete death of the roots was observed, each root being reduced to a dry hollow tube. No decay of the rhizomes was evident, but a large number of perithecia were found on their surfaces, particularly on the under sides, and on the roots. This fungus was identified as *Leptosphaeria heterospora,* (de Not.) Niessl., which has been described as present on the rhizomes of iris in Europe[8]. The perithecia of this fungus and the pycnidia of a *Phoma* sp. were found to be constantly associated with die back symptoms, the disease having been observed on 45 different varieties. Pure cultures were made of these fungi and inoculation experiments are now in progress to determine the pathogenicity of these fungi either singly or in combination. Plate 4, fig. 3 illustrates the underside of a rhizome, showing the perithecia and the cut ends of the dead roots.

A rhizome decay, caused by a sclerotium-bearing fungus of the *Botrytis* type, was found in a commercial iris plantation near Ottawa, and is being studied. Plate 4, fig. 1, shows a decayed rhizome bearing the peculiar convoluted sclerotia typical of the causal fungus.

In the experimental plots of the Division of Botany a collection of Iris species has been grown from seed obtained through the seed exchange of world botanical gardens. Some interesting notes were taken on the resistance and susceptibility of these species to the leaf spot disease, caused by *Didymellina Iridis*, (Desm.) Hoehn. This collection is contained in four rows eighty feet long, 18 inch contiguous strips being devoted to each planting, there being in each species several plantings of seed from different countries. In these contiguous strips the chances of infection were uniform, and the differences in susceptibility were very marked. In some of the very susceptible species lesions occurred on the flower stem as well as on the leaves.

In the following table these observations are recorded:—

SUSCEPTIBILITY OF *IRIS* SPECIES TO *DIDYMELLINA IRIDIS*, (DESM.) HOEHN.

Infection—Severe	Infection—Moderate	Infection—Slight	Resistant
I. dichotoma, Pall. *flavissima*, Pall. *germanica*, L. *neglecta*, Parl. *pallida*, Lam. *plicata*, Lam. *prismatica*, Pursh. *pumila*, L. *squalens*, L. *virescens*, (Del.) Red.	*I. aphylla*, L. *biflora*, L. *brachycarpa*, Lodd. *buriensis*, Lem. *Chamaeiris*, Bertol. *coelestina*, Sweet. *coelescens*, Pers. *falcifolia*, Bge. *foetidissima*, L. *Gueldenstaedtiana*, Lep. *livida*, Rooth *lurida*, Ait. *lutescens*, Lam. *sambucina*, L. *setosa*, Pall. *spuria*, L. *tectorum*, Max. *variegata*, L. *xiphioides*, Ehrh. *Xiphium*, L.	*I. arenaria*, Waldst. *Eloudowii*, Ledeb. *ensata*, Thunb. *graminea*, L. *laevigata*, Fisch. *Milesii*, Baker *missouriensis*, Nutt. *sibirica*, L. *Sintenisii*, Jka. *virginica*, L.	*I. aurea*, Lindl. *chrysographes*, Dykes *Delavayi*, Mich. *ensata* var. *pabularia*, Naud. *humilis*, Bieb. *kamaonensis*, Wall. *longipetala*, Herb. *Monnieri*, (DC) Red. *montana*, Dykes *ochroleuca*, L. *ruthenica*, Ait. *speciosa*, Poir. *Swertii alba* *Thunbergii*, Lundstr. *versicolor*, L. *Watsoniana*, Purdy *Wilsoni*, Wright.

[8] Sacc. Syl. Fun. II, page 67.

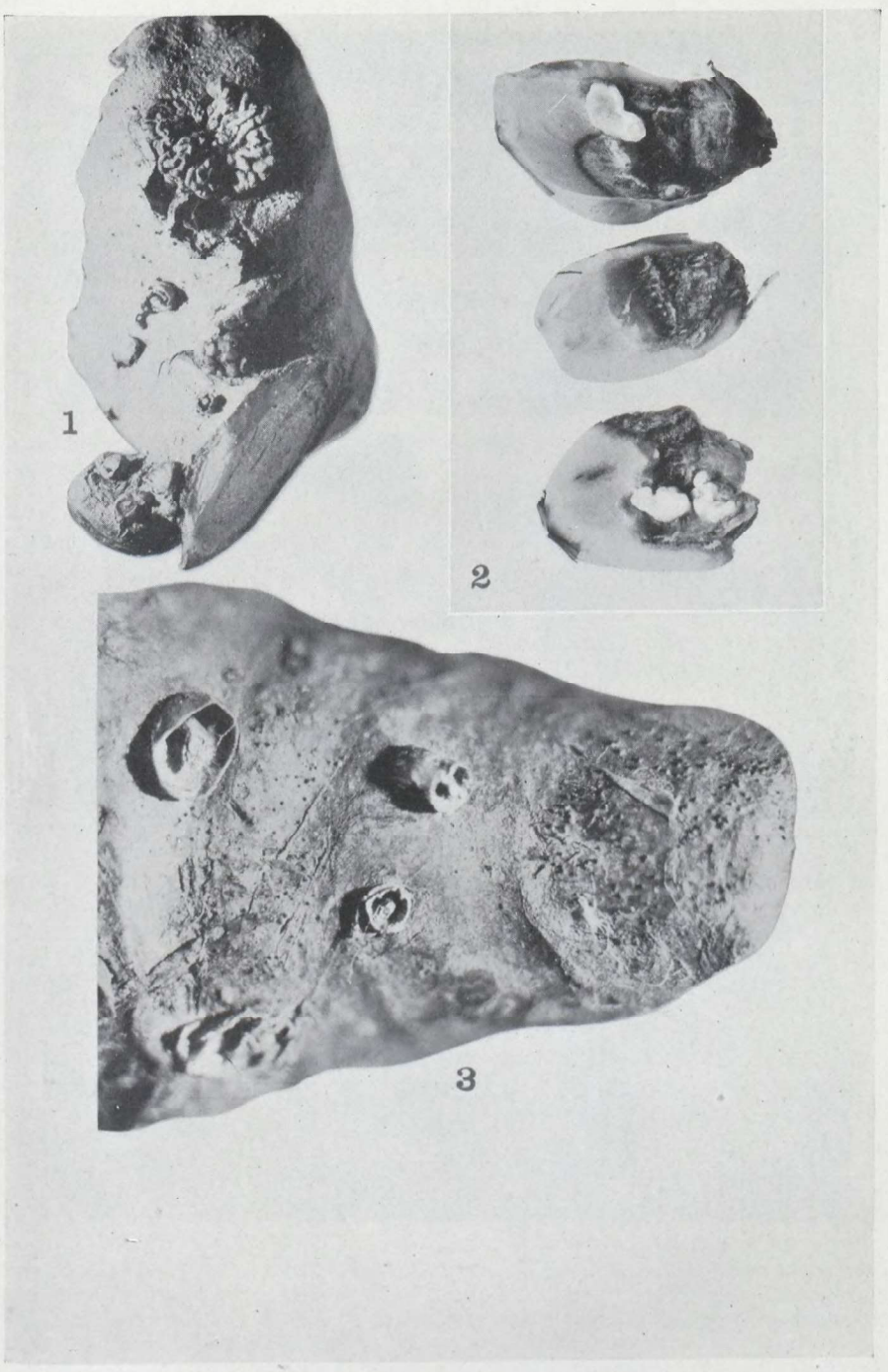

PLATE 4.—Three iris diseases.

Fig. 1.—An iris rhizome decayed by a sclerotium-bearing fungus of the *Botrytis* type.

FIG. 2.—A decayed bulb of *Iris Xiphium hybridum* (Dutch iris) showing the sclerotia of *Sclerotium Delphinii*, Welch. Found in a shipment from Holland.

Fig. 3.—A rhizome from a plant affected with a root rot and die-back disease. Note the cut ends of the dead roots and the perithecia of *Leptosphaeria heterospora*, (de Not.) Niessl. (Photos by F. L. Drayton)

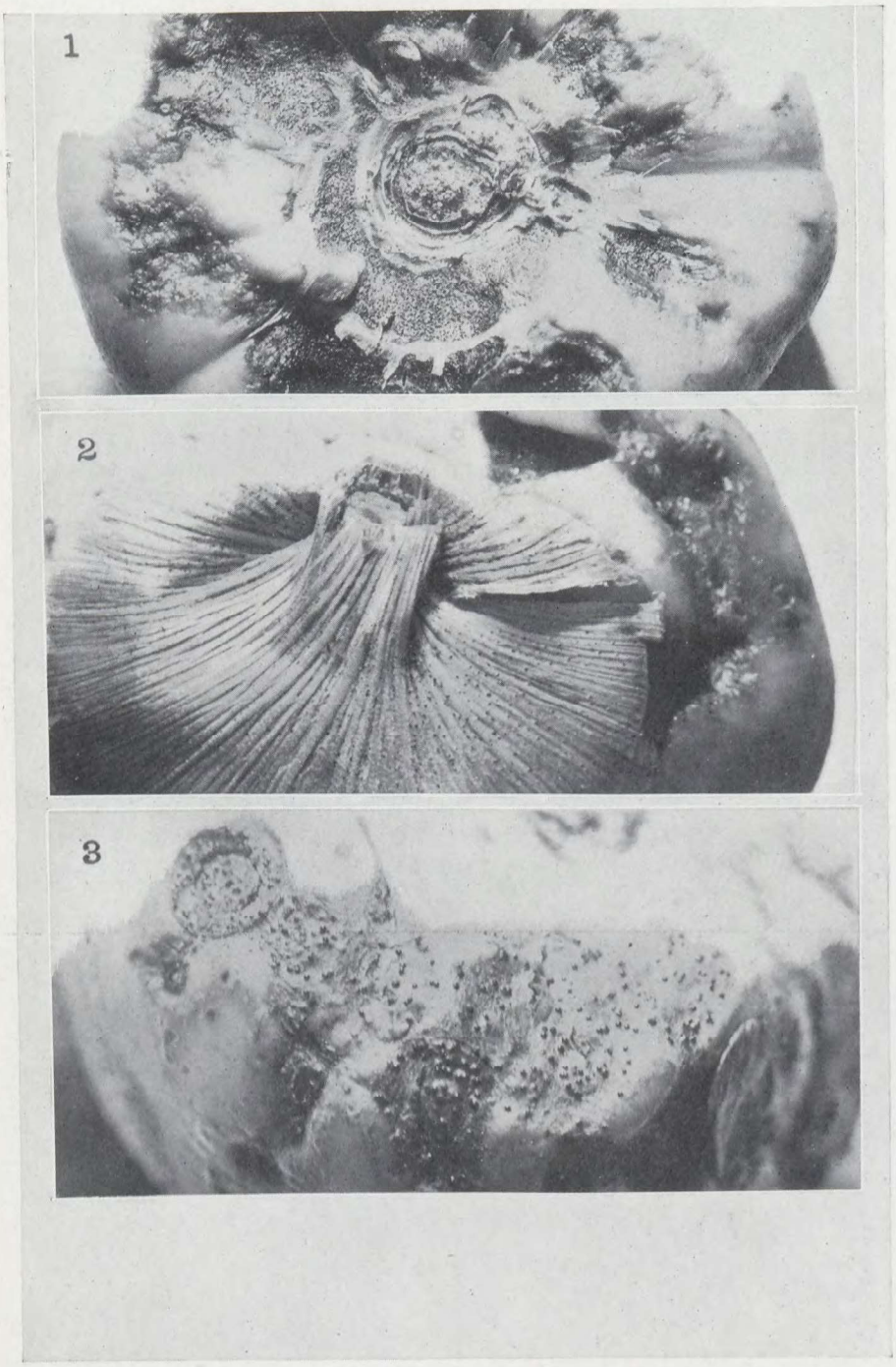

PLATE 5.—Enlarged gladiolus corms of the Nanus type.

Fig. 1.—Sclerotia of the hard rot fungus (*Septoria Gladioli*, Pass.) on corm lesions.
FIG. 2.—Corm lesions of hard rot and sclerotia of *Septoria Gladioli* on the corm scales.
Fig. 3.—Sclerotia of the dry rot fungus (*Sclerotium* sp.) on corm lesions.
(Photos by F. L. Drayton)

GLADIOLUS

Two types of gladioli are imported into Canada; one which includes all the large flowering varieties, and Primulinus hybrids for spring planting, and the other the Nanus types, imported in the fall and used exclusively for greenhouse forcing. In the latter type, the same diseases occur which are found on the former, but with somewhat different symptoms; in addition there is one disease, not yet found on the former type. The results of field and laboratory studies, together with field surveys in connection with this plant, are herewith reported under the separate headings of the diseases concerned.

HARD ROT (*Septoria Gladioli*, Pass.)

The fungus responsible for this disease was described by Passerini in 1874 as the cause of a leaf spot disease, and in 1916 Massey linked up this leaf spot with the well-known disease of the corms.[9] The symptoms on the corms are illustrated in plate 1, fig. 5, of the report of the Dominion Botanist for 1926. In the field survey of commercial gladiolus plantations in Ontario, the leaf spot stage of this disease was found in 27 of the 53 plantations inspected, with infections varying from a trace to 100 per cent in the varieties infected. In one instance this stage was found on plants from planting stock (corms ½ to ¾ inch in diameter), but in every other case only on plants from cormels. The leaf spots bear large numbers of pycnidia, the spores from which spread the leaf infections and are washed into the soil, where they infect the corms and establish the fungus in the soil. Dr. Massey has shown that this fungus may remain active for at least ten years in contaminated soil, even if non-susceptible crops are planted in the intervening years.

One point of interest, which was not observed by Dr. Massey during the course of his studies of this fungus, is the occurrence of sclerotium-like bodies on the corm lesions and on the scales of affected corms.* These were first observed on the imported corms of the Nanus varieties, and are illustrated in plate 5, figs. 1 and 2. They are dark brown to black, round or oval, vary in length from 45·0 to 93·5 μ, and when placed on suitable culture media, grow into typical colonies of the fungus. They have since been found on a few corms of the large flowering varieties in imported stock as well as on the corms harvested from the hard rot experiments conducted at Ottawa.

Corms having hard rot lesions were soaked in a number of different solutions and planted in soil which had never grown gladioli. The corms harvested from those soaked in 1:500 corrosive sublimate for 2 hours were clean, those in 10 per cent Semesan yielded 1·8 per cent of diseased corms, but the corms from the other experiments and the check were from 3·6 to 21·3 per cent diseased. Under garden or commercial field conditions, this loss would not seem great, but the important consideration is the contamination of the soil and the resultant injury to the gladioli grown subsequently in the same area.

DRY ROT (*Sclerotium* sp.)

In the article on this disease published two years ago[10] the sclerotia of the causal fungus were described as occurring on the leaf sheaths below ground and on the corm scales of diseased plants. It is of interest to note that, on several imported corms of the Nanus types affected with this disease, sclerotia were found in addition on the corm lesions. These are illustrated in plate 5, fig. 3. They resemble the ones previously described in colour and shape, but are somewhat larger.

[9] Massey, L. M. Corn. Univ. Agr. Exp. Sta. Bulletin 380, 1916.
[10] Drayton, F. L. The dry rot disease of gladioli, Scientific Agric. VI:6; page 199, 1926.
* Since found to be immature pycnidia. Vide Pape, H., Die Krankheiten und Schädlinge der Gladiole. Aus: Sandhack, Dahlien w. Gladiolen. Berlin, 1927.

This disease occurred in 50 of the 53 Ontario commercial plantations inspected, the average percentage infection of varieties was not high, but the means of spread through the planting of cormels was very apparent. This gave a practical demonstration of the necessity for destroying or segregating diseased plants at digging time, as has been advised for the control of this disease in the mimeographed circular sent to all commercial growers and interested amateurs.

In the field experiments with this disease a number of treatments of affected corms were made prior to planting them in soil which had never grown gladioli, and also field treatments of soil which had previously borne diseased plants and in which sound corms were planted. The following is a summary of the results obtained:

1. With skinned corms having dry rot lesions the best results were obtained with soaks of 10 per cent Uspulun for 1 hour, 5 per cent Semesan for 2 hours, and 1 in 500 corrosive sublimate for 2 hours.

2. With unskinned diseased corms, 10 per cent Uspulun for 1 hour and 10 per cent Semesan for 1 hour succeeded in controlling the disease, the progeny being quite sound.

3. In soil which had borne a diseased crop in 1925 and 1926 various substances were applied in the trenches prior to planting sound corms, viz., hydrated lime, chloride of lime, acid phosphate, powdered copper sulphate, Rectisoil, and ammonium sulphate. All of these substances failed to control the disease, the percentages of infection in the harvested corms varying from 55·3 to 93·3.

4. In an experiment similar to No. 3, except that the soil had borne a diseased crop for one year only, 1926, the same soil treatments yielded percentages of infection ranging from 62·1 to 95·3, but with a somewhat lower average percentage for all the treatments.

In last year's experiments with soil treatments Semesan Jr., Bayer Dust, and sulphur were employed with equally unsuccessful results.

5. An experiment was conducted in 1926 and 1927 to demonstrate the fact that when dry rot diseased corms are planted in soil which had never grown gladioli, good plants and bloom are obtained the first year with a comparatively small percentage of disease in the progeny, but that the danger lies in the release of the fungus into the soil and its effect on subsequent plantings. In 1926 a row 80 feet long was planted with corms from an imported shipment which had 60 per cent of the corms affected with dry rot; only 17·3 per cent of the harvested progeny had dry rot, but when sound corms were planted in the same row in 1927, 71 per cent of the harvested corms were diseased. This shows very conclusively that contaminated soil is a far greater source of infection than the first year planting of diseased corms in uncontaminated soil—the greatest danger of the latter practice being in the resultant establishment of the causal fungus in the soil.

SCAB OR NECK ROT (*Bacterium marginatum*, McC.)

This disease was described and the causal organism named by Miss McCulloch[11]. Its field symptoms are readily distinguishable from those of dry rot in that, in the latter, the progress of the death of the leaves and the decay of the leaf sheaths below the ground is from the outside inwards, while, in scab infections, the third leaf in usually shows the first sign of drying and the decay progresses outwards to form the typical neck rot. This disease was found in 37 of the 53 commercial plantations inspected, although in no case was the infection as serious as those of dry and hard rots.

[11] McCulloch, Lucia. A leaf and corm disease of gladioli caused by *Bacterium marginatum*. Jour. Agr. Res. 29:4; page 159, 1924.

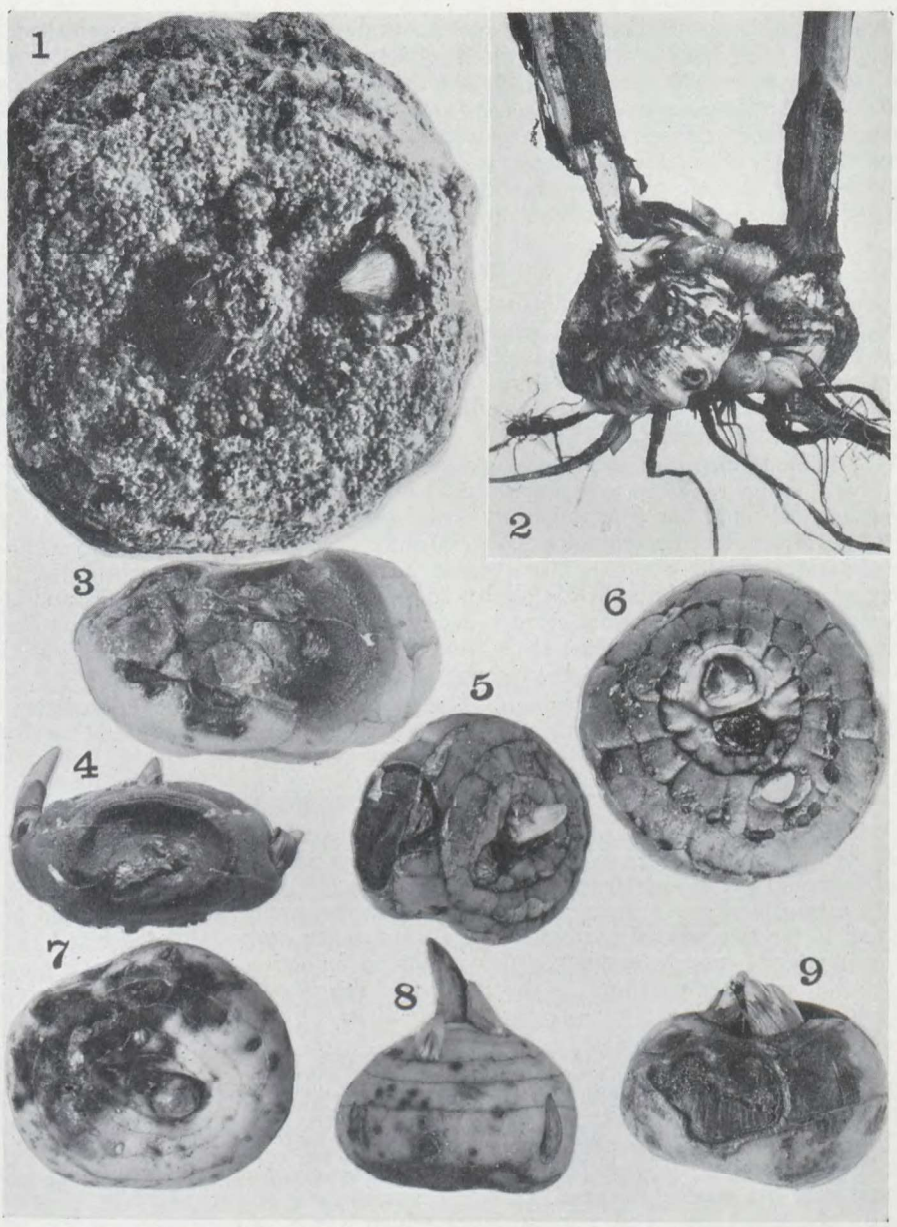

PLATE 6.—Gladiolus and crocus diseases.

Figs. 1, 3 and 4.—A gladiolus storage decay caused by *Penicillium Gladioli*, McC. et Thom, showing the copious production of sclerotia and the lesions on the corms.
Fig. 2.—Injury to a gladiolus plant by a white grub (*Phyllophaga* sp).
Fig. 5.—A gladiolus storage decay caused by a *Botrytis* sp.
Fig. 6.—Scab or neck rot of gladiolus (*Bacterium marginatum*, Mc.C.) showing lesions on the vascular bundle endings.
Fig. 7.—A crocus corm with lesions caused by *Septoria Gladioli*, Pass.
Fig. 8.—Dry rot lesions on a crocus corm caused by the *Sclerotium* sp. responsible for this disease on the gladiolus.
Fig. 9.—A storage decay of the crocus caused by a *Botrytis* sp.

(Photos by F. L. Drayton)

The usual type of corm lesion, which is more or less circular, varnished in appearance, and with a raised margin, is illustrated in the report of the Dominion Botanist for 1926, plate 1, fig. 2, but there is another fairly common manifestation of this disease on the corms in which sunken lesions appear on the vascular bundle endings, shown in plate 6, fig. 6. The causal organism has also been obtained from concentric surface markings of the corm. These atypical lesions are either the result of an infection occurring late in the season, or are caused possibly by a different strain of the organism.

STORAGE DECAYS

Dr. Massey recently described a rot of gladiolus corms, primarily in storage, and named the causal fungus *Fusarium oxysporum Gladioli*.[12] This type of decay has not yet been found during the course of these investigations, but a decay caused by a closely allied *Fusarium* has been found repeatedly in imported corms of the Nanus type. This was illustrated in plate 1, fig. 4 of the report of the Dominion Botanist for 1926.

A *Penicillium* rot of stored corms caused by a sclerotium-bearing *Penicillium* has been found repeatedly in imported stock and in corms harvested from the experimental plots, the fungus having been isolated four years ago (plate 6, figs. 1, 3, and 4). The deeply sunken, almost round lesions are nearly always found on the sides of the corms. This disease has recently been described and the fungus named *Penicillium Gladioli* by Miss McCulloch and Thom[13] and by Machacek.[14] It is a typical storage-decay form: no field symptoms have been observed either in plants the corms from which have ultimately developed the rot, or in plants which have been grown from affected corms.

Another storage decay frequently found in imported corms, caused by a sclerotium-producing fungus of the *Botrytis* type, illustrated in plate 6, fig. 5, is being studied.

BACTERIAL BLIGHT (*Bacterium gummisudans*, McC.)

This disease was described and the causal organism named by Miss McCulloch.[15] It had never been reported as occurring in Canada, but this year it was found in two plantations in Kitchener, Ontario. The infections had apparently arisen from a few corms of a mixed lot in one corner of the field, and had spread to the two adjoining rows. It is a spectacular disease, for the leaf lesions bear a copius gummy exudate. A widespread infection would result in considerable loss, judging from the destruction of the plants in the limited area in which it was found.

A MOSAIC-LIKE DISEASE

A marked deterioration of certain gladiolus varieties has been observed when they have been grown for a number of years. With a complete absence of any of the symptoms of the fungous and bacterial diseases, these varieties produced smaller corms each year until, with no production of cormels, the corms were too small to bloom. This deterioration was accompanied by a dwarfing of the plant, and leaf abnormalities which are of three types, a definite mottling of both leaves and flower buds, yellow longitudinal streaking, and necrotic areas followed by a drying and rusty colour of the leaves. Preliminary inoculations by means of hypodermic injections of juices from affected

[12] Massey, L. M. Fusarium rot of gladiolus corms. Phytopath, 16:8; page 509, 1926.
[13] McCulloch, Lucia, and Chas. Thom. A corm rot of gladiolus caused by a *Penicillium*. Science, New Series 67:1730; page 216, Feb. 24, 1928.
[14] Machacek, J. E. A *Penicillium* rot of gladiolus. Nineteenth Annual Report of the Quebec Society for the Protection of Plants, page 77, distributed on Feb. 28, 1928.
[15] McCulloch, Lucia. A bacterial blight of gladioli. Jour. Agr. Res. 27:4; page 225, 1924.

plants and by transference of aphids found feeding on infected plants, point to the possibility of this being a virus disease of the mosaic type, but further work will be necessary before this is definitely established.

A mosaic disease of the gladiolus has recently been described by Miss Louise Dosdall.[16] The symptoms there described are similar to those mentioned above, but the wartiness of the corms has never been noted in the varieties under observation.

WHITE GRUB INJURY

An interesting observation was made in a commercial plantation where newly broken sod was being employed. Two per cent or more of the plants in this two acre field appeared to be affected with the dry rot disease as shown by the death of the outer leaves. An examination of the affected plants failed to reveal any of the sclerotia typical of the causal fungus, but a number of examinations showed that the larvae of a white grub (*Phyllophaga* sp.) were eating the corm scales and leaf sheaths below ground, in many cases laying bare the corm, without injury to the corm itself. The destruction of these tissues cut off the water supply to the corresponding leaves and resulted in their death. Plate 6, fig. 2, shows this injury and the white grub in situ.

FIELD INSPECTION OF GLADIOLI

Frequent references in the above section on gladiolus diseases have been made to the diseases which were observed during a survey, made in August, of 53 commercial plantations in Ontario. The object of this inspection trip was to get some idea as to the problems confronting the grower, to familiarize him with the disease symptoms in the field, recommend means of control, and determine the feasibility of establishing an inspection and certification service similar to that of seed potatoes. Without exception, the growers were greatly impressed with the possible advantages of such a service. It would be essential to base such certification on field and bin inspections, and it is hoped that it will be possible to establish this as a subsidiary service to the seed potato work.

CROCUS

In plate 4, fig. 3, of the report of the Dominion Botanist for 1926, a disease of crocus corms is illustrated. This is a decay caused by a *Fusarium* species, and is by far the most prevalent and most destructive disease of these corms found in imported stock. The causal fungus has been isolated, and inoculation experiments have proved it to be actively pathogenic. The affected corms are frequently destroyed and, in cases where living tissue remains, the decay is completed after the corm is planted, and no growth takes place.

Some of the injuries encountered during inspection are of no importance. These include surface drying through the removal of the papery scale, holes eaten by insects or animals, and moulding from improper curing and storage.

Certain storage decays are being studied, notably one caused by a sclerotium-producing fungus of the *Botrytis* type (plate 6, fig. 9).

One point of interest which was encountered during the study of the crocus diseases was the fact that these corms are subject to the attacks of two fungi which so far have been described as parasitic on gladiolus corms only, namely *Septoria Gladioli*, Pass., causing the hard rot of gladiolus, and the *Sclerotium* sp. responsible for the dry rot of gladiolus. These diseases as they occur on crocus corms are illustrated in plate 6, figs. 7 and 8. The types of lesions which these fungi produce on the crocus corms are somewhat different from the gladiolus lesions, but a study of the fungi isolated from them established without doubt their identity.

[16] Dosdall, Louise. A Mosaic disease of gladiolus. Phytopathology, 18:2; page 215, 1928.

Peony

Several diseases of this plant are being investigated, including the leaf spots and stem cankers caused by *Botrytis Paeoniae,* Oud. and *Septoria Paeoniae,* West var. *berolinensis,* Allesch., a ring spot of unknown cause, and the destructive malady, probably of the virus type, known as "Lemoine's Disease."

On July 23 word was received from a grower of peonies on an extensive scale in Montreal that a serious decay had started in some 100,000 peony blooms which were being held in cold storage. A visit was paid to the cold storage plant of the Montreal Harbour Commission, and a careful investigation was made of the conditions to which these blooms had been subjected both before and during their storage.

The flower buds were cut in June just as they were commencing to show colour, and it happened that, during most of this period, there was considerable rainfall, so that the leaves, stems, and buds were quite moist when brought to the cold storage plant. Here they were packed tightly into galvanized iron buckets with water and without removal of any leaves. The buckets were arranged on the floor of a large cold storage room which had no air circulation. A record showed that the temperature, five feet from the floor, was held at 33° F., and the humidity readings at about the same height showed 86 to 89 per cent relative humidity. There is no doubt that, if these readings had been taken between the buckets of bloom, they would have been higher, because of congestion of leaves and bloom in the buckets and the water present in the buckets and between the leaves. Copious fungous growth was found on many of the blooms, producing a rapid decay of 3 to 5 per cent of them. (Plate 7.) A visit was paid to the fields where these blooms had been grown, and it was found that, in certain areas, there was much leaf and stem injury due to the fungus *Botrytis Paeoniae,* Oud. On returning to Ottawa the decayed flowers were cultured and, in every isolation, pure cultures of the fungus *Botrytis Paeoniae* were obtained, which pointed conclusively to the fact that the infection was brought into the cold storage room on the cut flowers. This fungus is capable of rapid development at a comparatively low temperature; and, with the conditions of stagnant moist air and congested packing, an ideal environment was provided for its development and the consequent decay of the flowers.

The following routine for keeping peonies in cold storage has proved to be eminently successful in other cold storage plants which have been under observation:—

1. When the blooms are cut and brought to the cold storage plant, they should be placed loosely in dry containers on tables in the well ventilated corridors which usually link up the various cold rooms, and should be left there long enough to rid the leaves and blooms of adhering moisture.
2. Part of the leaves should then be taken off and the blooms packed moderately loosely in slatted flower boxes with paper, and labelled with the name of the variety.
3. The boxes should then be placed in the cold room, stacked with strips of wood between them, a temperature of 34° F. and humidity of 75 to 80 per cent maintained, and continuous ventilation supplied.

From previous experience we feel sure that, under these conditions, the blooms can be held successfully for at least 90 days; in addition, it overcomes a serious difficulty in the system adopted in Montreal, namely, that the stripping of the leaves and packing of the blooms have to be done by workmen under trying conditions in the cold room at the end of the storage period, when the flowers are more susceptible to injury. Moreover the cold storage area required under the routine recommended would be very materially decreased with an obvious saving in the cost of storage.

PLATE 7.—Pæony flowers decayed in cold storage by *Botrytis Pæoniae* Oud.
(Photo by J. B. MacCurry)

THE USE OF RECTISOIL AS A SOIL FUNGICIDE

Several inquiries were received by the division relative to the use of this preparation for the control of soil diseases, particularly aster wilt. It is manufactured by Messrs. Hawker and Botwood, Ltd., Essex, England, and is claimed to be capable of exterminating soil pests, correcting acidity, and rendering fertilizers more efficient.

Experiments were conducted with this substance for the control of soil diseases of gladioli and asters. The results were as follows:—

Gladioli

1. Rectisoil was broadcast, at the rate of 13 ounces per 14 feet of trench, in soil which had never grown gladioli but in which skinned corms affected with the dry rot disease were planted.

The harvested corms had a percentage of 13·1 of disease as compared with 30·7 in the check.

2. As in 1, but planted with unskinned corms affected with dry rot.
Harvested corms, 21·7—check, 62·7 per cent of disease.

3. As in 1 but planted with skinned corms affected with hard rot.
Harvested corms, 21·1 diseased—check, 12·8 per cent of disease.

4. Soil which had borne a dry-rot-diseased crop for two years—Rectisoil applied at the rate of 2 pounds per 40 feet of trench and sound corms planted.
Harvested corms, 87·7—check, 80·9 per cent of disease.

5. Soil which had borne a dry-rot-diseased crop for one year—Rectisoil applied at the rate of 1½ pounds per 30 feet of trench and sound corms planted.
Harvested corms 72·8—check 69·0 per cent of disease.

China Asters

A piece of land was used which has been contaminated with the aster wilt fungus *Fusarium conglutinans Callistephi*, Beach, for a number of years. This was divided into 8 plots, Rectisoil was broadcast and harrowed in and the following results obtained.

4 plots untreated—75 per cent of the plants wilted.

3 plots with 27 ounces of Rectisoil per 60 square feet—81·2 per cent of the plants wilted.

1 plot with 20 ounces of Rectisoil per 60 square feet—87·5 per cent of the plants wilted.

Mixed varieties of asters were employed.

From the above results of one trial with the two diseases of gladioli and the one of asters it is obvious that there was little or no fungicidal action on these soil-contaminating fungi.

FLESHY FUNGI OF KENTVILLE, N.S., 1927

(K. A. Harrison, Assistant Plant Pathologist.)

Part I

The season of 1927 was very favourable for the development of the sporophores of the various fleshy fungi and the following, with the exception of *Coprinus atramentarius, C. comatus,* and *Pholiota adiposa,* were collected on the Experimental Station; a few from the lawns and open fields, but the majority from the groves or the wooded ravine that occupy one side of the farm.

The list would have been several times the present length if it had been possible to identify positively all the species collected.

Nyctalis asterophora, Fr.—On what appeared to be a *Lactarius* sp.
Amanita muscaria, (L.) Fr.—Abundant on sandy lawns.
Amanita phalloides, (Vaill.) Fr.—Only a few specimens of brownish form. Glossy white form very abundant in September.
Amanita solitaria, Fr.—Two specimens only on border of woods.
Amanita rubescens, (Pers.) Fr.—Abundant in mixed woods.
Amanitopsis vaginata, (Bull.) Roze—Only a few specimens collected, in mixed woods.
Lepiota procera, (Scop.) Fr.—Three specimens on road side.
Armillaria mellea, (Vahl.) Fr.—In tremendous quantities on old stumps and dying trees during latter part of September.
Tricholoma rutilans, (Schaeff.) Fr.—Found on two occasions on stumps.
Cantharellus aurantiacus, (Wulf.) Fr.—Common, and on two occasions observed in the form of "Fairy Rings" in coniferous woods.
Cantharellus floccosus, Schw.—A few specimens from coniferous woods.
Lactarius piperatus, (Scop.) Fr.—Common through summer and fall in mixed woods.
Lactarius scrobiculatus, (Scop.) Fr.—Three or four specimens only.
Lactarius deliciosus, (L.) Fr.—Only a few scattered specimens.
Lactarius subdulcis, (Pers.) Fr.—Common.
Lactarius hygrophoroides, B. et C.—Scattered. Only a few found.
Lactarius volemus, Fr.—Found several times in deciduous woods.
Russula delica, Fr.—Collected several times with *Lactarius piperatus.*
Russula foetens, (Pers.) Fr.—Very abundant in early September in coniferous woods.
Pleurotus ostreatus, (Jacq.) Fr.—Only observed on one dead beech.
Collybia radicata, (Relh.) Berk.—Common. Scattered in woods.
Omphalia campanella, (Batsch) Fr.—Large numbers around an old stump.
Marasmius oreades, (Bolt.) Fr.—Common on lawns.
Panus strigosus, B. et C.—Two specimens on maple stub on November 26.
Panus stipticus, (Bull.) Fr.—On dead beech.
Pholiota adiposa, Fr.—On living apple tree. Also observed there in 1926.
Pholiota spectabilis, Fr.—Three specimens from a fir tree.
Paxillus involutus. (Batsch) Fr.—A few specimens during middle of October near shrubbery.
Hypholoma sublateritium, (Schaeff.) Fr.—Very common around old stumps.
Psalliota campestris, (L.) Fr.—Not very common.
Psalliota silvicola, (Vitt.) Fr.—A few specimens only.
Psalliota arvensis, (Schaeff.) Fr.—Common.
Psalliota haemorrhoidaria, Kalchbr.—Common through August and September in coniferous woods.
Coprinus atramentarius, (Bull.) Fr.—Found on lawns in Kentville.
Coprinus comatus, (Fl. Dan.) Fr.—Found on lawns in Kentville.
Schizophyllum commune, Fr.—Common on dead beech.
Boletus edulis, (Bull.) Fr.—A few seen in mixed woods.
Boletus granulatus, (L.) Fr.—Very common in wind break.
Boletus retipes, B. et C.—Very common in wind break.
Boletus scaber, (Bull.) Fr.—Collected on several occasions.
Boletinus pictus, Pk.—Very abundant through August.
Polyporus sulphureus, (Bull.) Fr.—Noticed on one stump.
Ganoderma lucidum, (Leyss.) Karst.—Common on hemlock stumps.
Hydnum repandum, (L.) Fr.—Common in ravine.
Hydnum caput-ursi, Fr.—Three specimens collected.

Clavaria stricta, (Pers.) Fr.—Very common in woods.
Clavaria cristata, (Holmsk.) Fr.—Common.
Clavaria vermicularis, (Scop.) Fr.—Collected on different occasions.
Clavaria corniculata, (Schaeff.) Fr. (*C. muscoides,* Fr.)—Found only once on edge of ravine.
Clavaria aurea, (Schaeff.) Fr.—Collected twice.
Clavaria cinerea, (Bull.) Fr.—Collected on several occasions.
Clavaria coronata, Schw.—Collected once on rotting log.
Clavaria fusiformis, (Sowerby) Fr.—Collected several times.
Clavaria ligula, (Schaeff.) Fr.—Very abundant in several areas of from five to ten feet in diameter.
Clavaria fistulosa, (Holmsk.) Fr.—Five specimens were found growing from one buried limb.
Hypomyces lactifluorum, (Schw.) Fr.—Common in woods.
Geoglossum hirsutum, (Pers.) Fr.—Collected from ravine on several occasions.
Leotia lubrica (Pers.) Fr.—Common in ravine.
Spathularia velutipes, Cooke et Farlow—Common in woods.
Mitrula vitellina, Sacc. var. *irregularis,* Pk.—Common.

The above species were identified, to our own satisfaction at the time of collecting, using

Atkinson, Geo. F.—Mushrooms, Edible, Poisonous, etc. 1911.
Hard, M. E.—Mushrooms Edible and Otherwise, 1908.
Marshall, Nina L.—The Mushroom Book, 1905.
The specimens of *Geoglossaceae* were identified by using
Massee, Geo.—A Monograph of the *Geoglosseae,* Ann. of Bot. 11:225-306, 1897.

Later in the season more authoritative information was available and, wherever possible, the above determinations have been checked with

Kauffman, C. H.—The *Agaricaceae* of Michigan, 1918.
Overholts, L. O.—A Monograph of the Genus *Pholiota* in the United States, Ann. Mis. Bot. Gard. 14:87-210. April, 1927.
Burt, E. A.—The North American Species of *Clavaria* with Illustrations of the Type Specimens. Ann. Mis. Bot. Gard. 9:1-78. Feb., 1922.
Güssow, H. T. and W. S. Odell.—Mushrooms and Toadstools. The King's Printer, Ottawa. Price, $1. 1927.

Part II

The following were identified at the same time as the above, but the more authoritative information, that became available later, mentions points of distinction that were not noted at the time of collecting. This list, also, includes several species which resemble very closely species that were not collected, and with which they could be confused.

A number were tentatively identified, but some one point, such as a peculiar habitat or growing out of season coupled with the very general description, made it desirable that they should be studied further, and these are not included.

Amanita Frostiana, Pk.—Common.
Amanita mappa, (Batsch) Fr.—On two or three occasions.
Lactarius trivialis, Fr.—Common.
Lactarius lignyotus, Fr.—Collected several times.
Lactarius cinereus, Pk.—Collected several times.
Lactarius chrysorrheus, Fr.—Collected several times.
Boletus subaureus, Pk.—Common.

Boletus versipellis, Fr.—Common.
Polyporus frondosus, (Fl. Dan.) Fr.—One large specimen.
Hydnum imbricatum, (L.) Fr.—Common.
Tremellodon gelatinosum, (Scop.) Pers.—Collected twice.
Craterellus cornucopioides (L.) Fr.—Common.
Clavaria fusiformis, (Sowerby) Fr.—Common.
Lycoperdon gemmatum, Batsch—Common.
Scleroderma aurantium, Pers.—Common.
Calvatia cyathiformis, (Bosc.) Morgan—Collected several times.
Cyathus olla, (Batsch) Pers.—Common.
Ithyphallus impudicus, (L.) Fr.—Collected specimens.
Peziza aurantia, Pers.—Large numbers on hard earth on and near a little used road.

HOLLYHOCK RUST CONTROL

AT CHARLOTTETOWN, P.E.I.

(R. R. Hurst, Officer in Charge, Charlottetown, P.E.I.)

The following five fungicides were employed in this experiment:—

1. Bordeaux liquid spray (4-4-40).
2. Lime sulphur spray (1 gal. commercial to 20 gals. water).
3. Potassium permanganate spray (3 tablespoonfuls saturated solution in 1 quart of water).
4. "Pota" dust.
5. Bordeaux dust.

These were applied at 10 day intervals from the time the plants were six inches in height, making 10 applications, the last being made August 25.

Evidence of control was afforded in the use of "Pota" dust and Bordeaux dust. In both cases rust development was slight, while the untreated checks showed heavy infection. Even though the sprays were applied carefully and the plants well covered, rust development was not arrested. Dew on the plants in the morning, when the dusts were applied, afforded an ideal medium for the fine particles comprising these fungicides, with the result that the entire surface of the plants carried a coating of chemical throughout the season. Control was no doubt influenced by this factor. In future experiments a resin sticker will be combined with sprays, as it was apparent that these did not adhere to the leaf surfaces.

GINSENG DISEASES

(G. H. Berkeley, Sr. Pathologist in Charge, St. Catharines, Ont.)

Early in September badly rotted ginseng roots from Waterford were sent to us for diagnosis. Examination showed the presence of mycelium and countless bacteria in the root tissue. This trouble had every appearance of soft rot. Other roots bore small scabby or rust areas which, upon microscopic examination, showed the presence of copious mycelium. Isolations were made from all material, and cultures of *Bacteria, Fusaria* spp., and *Ramularia* spp. were obtained.

Early in October a visit was made to Waterford to investigate the trouble. It was found that there were apparently two troubles, each in separate gardens of three to four acres. In one garden were found only rusted roots with no signs whatever of soft rot. In the other garden the trouble was almost entirely soft rot, although slight indications of rust were noticeable. The rusted roots were two years old and the rotted roots four years old. Whether or not these

two troubles are different manifestations of the same disease, or are two distinct diseases, has yet to be ascertained. Investigations are now under way in an attempt to find the cause or causes of the trouble and to work out satisfactory control measures. Mr. Hellyer, the owner of the ginseng gardens, has wholeheartedly co-operated with us by supplying us with ginseng material, land, and necessary help for the experiments at Waterford.

An examination of freehand sections of roots of both troubles revealed the presence of mycelium. However, mycelium was far more abundant in the tissues of the rust affected roots than in the tissues of the rotted roots. In the latter case mycelium was very scarce and, when present, could be found only in the outermost tissues of the roots.

From the rusted roots and underground parts of stems, several organisms were isolated, namely, *Ramularia* spp., *Fusarium* and *Macrosporium* spp., and *Bacteria*. From the rotted roots, *Bacteria* and *Fusaria* spp. only were isolated. These organisms were similar to the corresponding ones isolated from the rusted roots.

Numerous plates were poured from soil dilutions of both rot- and rust-infected soils. Several organisms were isolated most of which were *Penicillium* spp., *Aspergillus* spp., and *Bacteria*. In the rot-infected soil a *Ramularia* sp. was isolated once.

Several experiments are being carried on in Waterford on the Hellyer plantation, and in St. Catharines, the results of which will not be available before next summer. A complete series of inoculation experiments, using as inoculum the various organisms isolated, is now under way.

Healthy and rusted roots were transplanted in ordinary soil, sterilized soil, rust- and rot-infected soils, to ascertain whether or not both troubles are carried in the soil.

Treated and untreated seed and roots from healthy as well as from diseased plants were planted in healthy and diseased soils. The object of this experiment was to see whether the diseases were carried through the seed and if they could be prevented by various seed and root treatments.

Investigations are under way to ascertain whether or not plants can be protected by simply spraying the soil with chemicals after it has been seeded.

Is soil reaction a factor in this connection? Several demonstrations, planned to throw some light on this point, have been started at Waterford.

At present we are unable to say which of the various organisms above mentioned may be the primary cause of these diseases. It may be the case that the rot is the advanced stage of the rust, but this is a mere hypothesis, no definite facts being available as yet to prove this statement. However, since a ginseng rust has already been reported by several workers in the United States who have attributed the disease to *Ramularia*, we are inclined to believe that the rust found in Waterford may also be caused by a *Ramularia* sp.

SECTION II.

FOREST PATHOLOGY AND RELATED SUBJECTS

FOREST PATHOLOGY

White Pine Blister Rust

No field work in connection with this disease has been done this year. As pointed out in the last annual report, the salient facts concerning it are now well known and it becomes a question for pine owners to adopt the recommended control measures for the protection of their trees. The illustrated circular[1] issued by the department, in which the symptoms and methods of control are fully described, has been widely distributed, and it is believed that much good has been done through this medium, in acquainting pine owners with the existence and serious nature of blister rust, and with the proper methods of control.

Larch Canker

Larch canker, caused by *Dasyscypha calycina,* (Schum.) Fuckel, (see frontispiece) has long been known in European countries as a serious parasite of larch and other conifers. While young trees may be killed outright by this fungus, large trees usually survive, but in severe attacks the stems are so deformed by the cankers as to render infected trees worthless for lumber. In April, 1927, this disease was found for the first time in America, when it was observed on European larch in Massachusetts. Since then it has been found at several additional places in the same general vicinity, and it is probable that intensive examination of larch plantations will show that it is more widely distributed.

As far as is known now larch canker is not present in Canada, but such negative evidence is not at all conclusive. Its presence here may become known at any time. If only larch were affected by this fungus the matter would not be of much significance as, on account of the depredations of the larch sawfly, this species is not nearly as important as it once was. In addition to European larch *(Larix europaea),* however, the following species were found diseased in Massachusetts: Japanese larch *(Larix leptolepis),* tamarack *(Larix laricina),* Douglas fir *(Pseudotsuga mucronata),* pitch pine *(Pinus rigida),* and Scotch pine *(Pinus sylvestris).* In Europe it is also known to attack these species: *Larix occidentalis, Larix sibirica, Picea excelsa, Picea sitchensis, Pinus nigra austriaca, Pinus Cembra, Pinus Laricio, Pinus pumilio,* and *Abies pectinata.*[2] Some of these trees are native to Canada while other have been introduced. The most valuable tree, as far as this country is concerned, in this list of susceptible species, is the Douglas fir.

It is very important that we know as soon as possible if this disease is present in this country, and to this end, all those who have an opportunity to do so are urged to inspect plantations of European larch especially, and to send in for examination any specimens which suggest the larch canker. The fruiting bodies of the fungus are characteristic and may be readily recognized. They occur either on recently killed branches or on cankers on the main stem. They are cup-shaped and each has a short stalk. This stalk and the outside of the cup are white, while the inside of the cup is bright orange or yellow. The cups are much contracted in dry weather, while in wet weather they expand and the cup becomes shallow.

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[1] Circular No. 48, New Series.

[2] Spaulding, Perley, and Paul V. Siggers. The European Larch Canker in America. Science 66: (1716): 480-481, 1927.

Decay in Balsam Fir

During the field season of 1927 a study of decay in balsam fir, similar in nature to those which have previously been reported upon, was carried out in Gaspé on the limits of the Howard Smith Paper Mills, Limited. The same decays as had been found previously in this species were again encountered in Gaspé, i.e., red heart rot caused by *Stereum sanguinolentum*, brown butt rot caused by *Polyporus balsameus*, and feather rot caused by *Poria subacida*. It would seem that in Eastern Canada there is no other decay of importance which affects balsam fir. These three decays are not always present in a given region —for instance, brown butt rot was not found in the course of work done in 1923 on the Shipshaw River in the Lake St. John country. The variation in habit, from one region to another, of wood-destroying fungi is of interest. During the past summer *Trametes Pini* was found only twice fruiting upon dead balsam fir. In the Adirondack region this fungus is reported[3] as occurring commonly on balsam fir, both living and dead. In the course of several years' work in the province of Quebec only one living tree has been found which showed the decay caused by *Trametes Pini*. The occurrence of *Fomes pinicola* in living balsam fir, referred to subsequently, is another example of this kind.

One of the important results expected from this study was evidence as to whether or not the budworm outbreak had been an important contributing factor towards the present serious condition of balsam fir in regard to decay. Gaspé peninsula is really the only extensive tract of country in eastern Canada which has not been affected by the budworm. A comparison, then, of the amount of damage occurring in Gaspé and that found in the other two areas would give some indication as to whether the budworm had a significant influence in inducing decay. As yet, the statistical data obtained from this study have not been fully analyzed, but the indications are that there is as much as, if not more, loss from decay in Gaspé than in the other two districts.

Red-brown Rot

Fomes pinicola, the cause of this decay, is the commonest polypore occurring in the forests of eastern Canada. It fruits abundantly upon stumps, stubs, and fallen trees. Either the sapwood or the heartwood or both may be affected. Briefly, the decayed wood is characterized by the destruction of the cellulose, which causes it to become darker in colour and to check. The rotted wood is generally reddish brown in colour. The checks in the wood soon become filled with white mycelium which subsequently forms tough, felted mats. The wood itself is at first of a cheesy consistency, and later can be easily pulverized between the fingers.

This fungus occurs upon many different hosts, both coniferous and hardwoods. In the United States it is generally regarded as an enemy of living trees and has been so recorded by numerous investigators. While it is much more frequently found on dead wood yet it seems commonly to attack the wood of living trees. During the past summer in Gaspé this decay was found once in a living balsam fir. As far as the writer is aware, this is the first record of its occurrence in this country as an enemy of green timber. The tree in question was a large, healthy looking balsam fir with no large wounds or areas of dead wood. At the base of the tree there was a fresh fruiting body of *Fomes pinicola* and the remains of an old one. The tree was cut about two feet from the ground and typical *Fomes pinicola* rot was found there. At that point it was confined to the heart wood. The decay extended up for about four feet above ground

[3] Schrenk, Hermann von. Some diseases of New England conifers. U.S. Dept. Agric., Div. Veg. Phy. and Path. Bull. 25: 1-56. 15 pl., 3 figs. 1900.

altogether. The diameter of the decayed area increased towards the roots, and in the stump thick sheets of white mycelium appeared in semicircles between the annual rings. The fungus had apparently entered the tree by way of a small side root.

It may well be that, in time, as our work in forest pathology is extended and districts now unknown from a pathological point of view are explored, we shall find, among other things, that this plant occurs more frequently in the manner just described than we now surmise. At present, however, the indications are that *Fomes pinicola* in eastern Canada is confined almost exclusively to dead wood. Nevertheless, it is a fungus of considerable economic importance. It quickly attacks much of the fallen timber in a forest and is of great benefit in assisting in reducing such wood to humus. In advanced decay this wood is dangerous since, on account of its punky nature, it will retain fire for a long time. Structures of logs built in the forest, such as cabins, logging camps, and dams are often destroyed in a very few years, mostly by *Fomes pinicola*.

CULTURAL STUDIES OF WOOD-DESTROYING FUNGI

Stock Cultures of Wood-destroying Fungi

In the report of the Dominion Botanist, 1926, a list was given of the different species of wood-destroying and wood-inhabiting fungi included in the collection of stock cultures at Ottawa. Seven new species have been added during the year, namely:—

Cryptoporus volvatus (Peck) Shear.
Daedalea unicolor (Bull.) Fr.
Fomes graveolens (Schw.) Cooke.
Polyporus balsameus Peck.
Polyporus cuticularis (Bull.) Fr.
Polyporus resinosus (Schrad.) Fr.
Trametes suaveolens (L.) Fr.

Many new cultures of species already included in the collection have been obtained from new hosts, new localities, or both. The majority however came from the Timagami Forest Reserve, Ontario, and from the Gaspé region, Quebec. A large number of valuable specimens of wood-destroying fungi and of the rots which they cause have been added to the herbarium. We are indebted to Mr. E. J. Eliason, New York State College of Forestry, for cultures and a sporophore of *Fomes pinicola* var. *marginatus* from Sweden.

Heterothallism in *Fomes pinicola*, (Sw.) Cooke

For the last two years notes on a study of sexuality in *Fomes pinicola* have been included in this report, and the study has been continued. For this work 143 monosporous mycelia from the following sources have been available:

Culture No.		
158.	Sporophore from old hemlock (?) stump, Bond Lake, Ont.	2
285A.	" " *Picea mariana*, Timagami, Ont.	28
285B.	" " same tree as No. 285A, Timagami, Ont.	14
283.	" " *Picea mariana*, Timagami, Ont.	23
5770.	" " *Picea* sp., Guelph, Ont.	15
5778.	" " *Prunus serotina*, York Mills, Ont.	16
586.	Culture of sporophore of *F. pinicola* var. *marginatus*, isolated and determined by M. Jean Dufrénoy, France.	26
562C.	Sporophore from *Tsuga heterophylla*, Vancouver, B.C.	19
		143

In every case a series of all possible pairings of monosporous mycelia from one sporophore has shown that this fungus is heterothallic and bisexual. The spores from a single fruit-body fall into two groups; clamp-connections are formed only when a member of one group is paired with a member of the opposite group. For example table 2 shows the results obtained when all possible pairings of ten monosporous mycelia from fruit-body 285A were made. The plus sign (+) indicates the presence of clamp-connections on paired mycelia, the minus sign (—) their absence. The mycelia have been rearranged so that those which behave alike are grouped together.

5778 × 586

	11	12	15	16	9
8	+	+	+	+	+
9	+	+	+	+	+
10	+	+	+	+	+
11	+	+	+	+	+
12	+	+	+	+	+

TABLE 1

285A

	1	2	4	6	7	8	3	5	9	10
1	—	—	—	—	—	—	+	+	+	+
2	—	—	—	—	—	—	+	+	+	+
4	—	—	—	—	—	—	+	+	+	+
6	—	—	—	—	—	—	+	+	+	+
7	—	—	—	—	—	—	+	+	+	+
8	—	—	—	—	—	—	+	+	+	+
3	+	+	+	+	+	+	—	—	—	—
5	+	+	+	+	+	+	—	—	—	—
9	+	+	+	+	+	+	—	—	—	—
10	+	+	+	+	+	+	—	—	—	—

TABLE 2

283 × 562C

	1	9	11	15	16
12	—	—	—	—	—
13	—	—	—	—	—
14	—	—	—	—	—
15	—	—	—	—	—
1	—	—	—	—	—

TABLE 3

Next, five monosporous mycelia from each source (except 562C) were selected at random and paired with five monosporous mycelia from every other source, making over four hundred pairings in all. With a single exception, clamp-connections were obtained in every pairing. Thus it was shown that the monosporous mycelia from each group belonged to different geographical races, or sexual strains, which were perfectly cross fertile. Table 1 is typical of this series.

Recently a sporophore was obtained in a culture (562C) from western hemlock (Tsuga heterophylla), and nineteen monosporous mycelia isolated. All possible pairings of ten of these monosporous mycelia gave results similar to those in table 2. Then five monosporous mycelia chosen at random were paired with five monosporous mycelia from each of the other sources. With the exception of 562C x 586 no clamp-connections were formed in any pairing, and table 3 is typical of all the series. In the pairings of 562C x 586 nine pairings out of the twenty-five developed clamp-connections. These results are particularly interesting at this time since they duplicate in part results obtained by Vandendries, in his most recent work with *Coprinus micaceus*.[4]

HETEROTHALLISM IN *Cryptoporus volvatus*, (Peck) Shear

This interesting polypore, unique in that it has its pores almost completely enclosed in a volva, is common on the bark of conifers both in eastern and western Canada. It has been reported by Zeller,[5] on *Pseudotsuga taxifolia, Tsuga heterophylla,* and *Abies grandis;* by House,[6] on *Pinus rigida;* by von

[4] Vandendries, René. Nouvelles recherches expérimentales sur le comportement sexuel de *Coprinus micaceus*. Mem. Acad. Roy. Belg. t. IX, 1927.

[5] Zeller, S. M. Notes on *Cryptoporus volvatus* Myc. VII:3. 120-125, 1915.

[6] House, H. D. Origin of the volva aperture in *Cryptoporus volvatus* (Peck) Hubbard. Myc. VI: 4, 217-218, 1914.

Schrenk,[7] on *Picea rubens;* by Weir,[8] on *Pinus ponderosa, P. contorta,* and *Picea Engelmanni;* by Boyce,[9] on *Libocedrus decurrens;* and has been collected by Dr. J. H. Faull on *Picea canadensis, P. mariana,* and *Pinus resinosus.* From field observations on western yellow pine slash Schmitz[10] concluded that this fungus was probably weakly parasitic.

The development of the sporophore from the small resin-covered button stage to the mature sporophore with cavity, ostiole, and pores has been described and well illustrated by Zeller (loc. cit.). He made tissue cultures of the fungus and described the formation of conidia and sporophore rudiments in culture.

Tissue cultures of this fungus were obtained from sporophores collected on dead *Pseudotsuga taxifolia* in British Columbia. Two weeks after inoculation on prune agar slants pored surfaces developed and shed spores. Twenty-four monosporous mycelia were isolated on dextrose-lactose gelatine. As noted by Zeller (loc. cit.) clamp-connections were frequent on the mycelium obtained from tissue cultures. Since no clamp-connections developed on any monosporous mycelium, a series of pairings of these mycelia was made on malt agar plates as follows:

737

	4	9	10	12	11	13	5	7	6	8
4	−	−	−	−	−	−	−	+	−	+
9	−	−	−	−	−	−	−	+	−	−
10	−	−	−	−	−	−	−	+	−	−
12	−	−	−	−	−	−	−	+	−	−
11	−	−	−	−	−	−	−	−	+	−
13	−	−	−	−	−	−	−	−	+	−
5	−	−	−	−	−	−	−	+	+	−
7	+	+	+	+	−	−	+	−	−	−
6	−	−	−	−	+	+	+	−	−	+
8	+	−	−	−	−	−	−	−	+	−

TABLE 4

737

	14	19	23	7	15	18	22	24	20	17
14	−	−	−	+	+	+	+	+	−	−
19	−	−	−	+	+	+	+	+	+	−
23	−	−	−	+	+	+	+	+	+	−
7	+	+	+	−	−	−	−	−	−	−
15	+	+	+	−	−	−	−	−	−	−
18	+	+	+	−	−	−	−	−	−	−
22	+	+	+	−	−	−	−	−	−	−
24	+	+	+	−	−	−	−	−	−	−
20	−	+	+	−	−	−	−	−	−	−
17	−	−	−	−	−	−	−	−	−	−

TABLE 5

As before, the plus (+) sign indicates the presence of clamp-connections in paired cultures, the minus sign (−) their absence. From tables 4 and 5 it is obvious that *Cryptoporus volvatus* is heterothallic, but it is not possible to arrange the mycelia in either two or four groups in which all members behave alike. The results shown in table 5 suggest that this fungus is bisexual. The fact that it was not possible to make pairings until six months after the monosporous mycelia had been isolated probably accounts, in part at least, for the lack of uniform behaviour.

Collybia velutipes, (Curt.) Fr. as a Wound Parasite

Collybia velutipes grows in dense clusters on decaying wood and can be recognized by its tawny, sticky cap, and its dark, velvety stem. It is well illustrated in " Mushrooms and Toadstools ",[11] and by Stewart.[12]

[7] von Schrenk, Hermann. Some diseases of New England conifers. U.S. Dept. Agr. Bull. 25, 13-14, 1900.

[8] Weir, James R. Montana forest tree fungi. Myc. IX:3, 133, 1917.

[9] Boyce, J. S. The dry rot of incense cedar. U.S. Dept. Agr. Bull. 871, 1920.

[10] Schmitz, Henry. Note concerning the decay of western yellow pine slash caused by *Polyporus volvatus,* Peck. Phytopath: 12:494-496, 1922.

[11] Güssow, H. T., and W. S. Odell. Mushrooms and Toadstools. Dept. of Agr., Ottawa, 1927.

[12] Stewart, F. C. *Collybia velutipes*—the velvet-stemmed Collybia—a wild winter mushroom. N.Y. Agr. Expt. Sta. Bull. 448, 1918.

This fungus has been reported by Massee[13] on trunks of living alder, beech, birch, elm, horse-chestnut, lime, oak, poplar, and willow. Rhoads[14] found it to be a serious wound-parasite causing wide-spread destruction of the arborescent shrub *Lupinus arboreus*.

Sporophores of *C. velutipes* have been found repeatedly on the trunks of crabapple, mountain ash, and basswood trees in the Arboretum. In one instance a section from the decayed trunk of a mountain ash tree blown down in a storm was brought into the laboratory. The wood showed typical advanced stage of *C. velutipes* rot, and some weeks later clumps of sporophores of that fungus developed from the base of the block.

During the last two years two of the group of basswood trees in the Arboretum have died, large branches have died and been removed from two others, and the remaining trees look decidedly unhealthy. Clumps of imperfect sporophores of *C. velutipes* were found on four of these trees, and advanced *C. velutipes* rot at the base of both branches which were removed. Cultures made from the branches yielded mycelium of *C. velutipes*, which later produced rudimentary sporophores with typical dark brown velvety stipes. No inoculations of healthy trees have been made, but the presence of sporophores on the trees and the isolation of the mycelium of *C. velutipes* from the decayed wood have led to the conclusion that this fungus is responsible for the damage.

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[13] Massee, George. Diseases of cultivated plants and trees. p. 363. Macmillan, 1914.

[14] Rhoads, Arthur S. The pathology of *Lupinus arboreus*, with special reference to the decays caused by two wound-parasites—*Collybia velutipes* and *Pleurotus ostreatus*. Phytopath. 11:389-404, 1921.

SECTION III.

INVESTIGATIONS OF THE DISEASES OF CEREALS AND GRASSES

REPORT OF THE DOMINION RUST RESEARCH LABORATORY. WINNIPEG, MAN.

(D. L. Bailey, Officer in Charge)

RUST EPIDEMIOLOGY

(J. H. Craigie and Wm. Popp)

(A) FIELD STUDIES

The year 1927 will be remembered as a bad rust year. Rust developed in epidemic form in most parts of Manitoba and Saskatchewan. In Alberta it was less severe and did not do any very appreciable damage, although as high as 60 per cent of infection in some localities was observed. On account of the excessive precipitation during the month of May seeding was retarded from two to four weeks. Lighter soils could be cultivated earlier than heavier soils, so that it frequently occurred that, in even the same districts, there was little uniformity in the maturing of the grain: by the time some fields were approaching ripeness others were in the shot blade, while still others were less far advanced.

Moreover, although the total amount of precipitation for Manitoba during July was not excessive, yet rain fell frequently, and, when there was no rain, heavy dews fell at night. As a consequence, the standing grain was covered with a film of moisture much of the time, thus affording optimum conditions for the germination of the spores and the infection of the plants. On account of the dull cool weather, however, the development of the organism in the plants was retarded, so that only a very moderate amount of rust was evident in Manitoba and Saskatchewan until the first week of August.

The first traces of rust were discovered at Winnipeg and at Morden, Man., in the experimental plots on the same day, July 6. By July 18 a light infection was general in Manitoba as far north as Winnipeg, and throughout southeastern Saskatchewan. Little change was evident in the amount of rust in the fields until towards the last of July. Several days of hot weather, from July 23 to July 27, evidently stimulated the development of the organism in the plants, for infections became considerably more common by the first of August, and this increase in the expression of the disease is reflected in the sudden increase of inoculum, as indicated by the number of spores on the stationary slides. By this time, also, epidemic conditions had developed in the wheat-growing States across the border, and, doubtless, spores, blown in from those States, played no small part in bringing about the sudden increase just noted. The first eight days of August were cool, and both wheat and rust made slow progress during that time, although heavy dews made conditions favourable for infection of the plants.

The temperature for the week beginning August 9 was hot and imparted a decided stimulus to the development of the rust mycelia in the wheat plants, so that by August 16 the situation was decidedly alarming. Following that date, the progress of the rust proceeded apace, with the result that Western Canada suffered one of the worst rust epidemics in its history.

Alberta, as always in respect to rust, escaped severe infection. As high as 60 per cent infection occurred around Camrose, where some shrinking of the kernels was noticed, but in general the loss due to rust was negligible. The

good fortune of Alberta is evidently attributable, not to lack of conditions favourable for rust development, for there was abundant rainfall this year, but to the failure of spores to arrive early enough and in sufficiently large numbers to initiate an epidemic, a circumstance corroborated by the data from slide exposures mentioned elsewhere in this report. Before spores were present in any abundance, the grain was too far advanced to suffer much damage. The late arrival of spores in Alberta seems to be due, partly to the great distance they have to travel, and partly to the opposition their spreading encounters from the prevailing winds, which usually blow from some other quarter than east or south east. However, more rust was present in Alberta this year than ever before, for the unusual amount of precipitation delayed the early maturing of the grain, and gave the earlier arriving spores an opportunity of becoming established. Rust was found, moreover, farther north than in any previous year, occurring at Beaver Lodge for the first time on record.

Stem rust of oats, which has not been very prevalent in the Western Provinces in recent years, appeared this year in epidemic form. Its first appearance, its development and spread, and its severity, except perhaps in Alberta, paralleled those features in the wheat stem rust. Owing to the lateness of the spring, a much larger acreage than usual was sown to oats. A great deal of the oat seeding was done very late, so that, with the weather behaving as it did throughout the growing period, the optimum conditions for rust development were furnished, and an epidemic of first dimensions resulted. Oats, however, in southwestern Saskatchewan did not suffer very severely from rust, and in Alberta the infection was very light and no damage was done.

Leaf rust of wheat (*Puccinia triticina*) appeared in southern Manitoba and southeastern Saskatchewan during the third week of June, more than two weeks earlier than stem rust. Its spread and development were rapid, so that, by the middle of July, it had become fairly abundant and was obviously beginning to do a good deal of harm. It is impossible to determine how much damage, taken separately, is attributable to either of the rusts, but it is certain that in combination they wrought in many places the maximum havoc.

Crown rust of oats (*Puccinia coronata*) was also prevalent in intensive form, and contributed in no small degree to the sum total of damage done to oats this year by rusts. As early as July 15, it was abundant throughout southern Manitoba. In previous years, infection by crown rust was fairly definitely confined to a limited area in the immediate neighbourhood of buckthorn hedges. This year, however, it broke all bounds and vied in its severity and spread with the stem rust.

Two other rusts, dwarf leaf rust of barley (*Puccinia anomala*), and yellow stripe rust (*Puccinia glumarum*), were also present in Western Canada this year. The former was found in a number of localities in southern Manitoba, and at Indian Head in Saskatchewan. Traces of the latter were found in Alberta, from Edmonton as far south as the boundary, and at Robsart in Saskatchewan. In no previous year is there any record of such frequent occurrences of either of these two rusts.

An estimate of the damage caused by the various rusts this year, either separately or collectively, is difficult to make. A number of other diseases took their toll, especially root-rots. Moreover, the weather prevented normal development and maturing of the crop. An idea, however, of the tremendous loss sustained from all causes may be gained from data kindly given by Mr. A. Cairns, Statistician for the Canadian Co-operative Wheat Producers Limited. These data are identical with those compiled by the Winnipeg Grain Exchange. He states: " Out of 152,210 cars of wheat inspected in the Western

Division up to December 11, only 35 per cent grades No. 3 Northern or above, as compared with 55 per cent so graded last year. Of the total cars, 1·5 per cent graded No. 1 Northern, 9·8 per cent No. 2 Northern, 24 per cent No. 3 Northern, 13 per cent No. 4 Northern, 37 per cent no grade, and 14·7 per cent of other grades." The "no grade" wheat embraces wheat with excessive moisture, and some of it would ordinarily have been grades Nos. 1, 2, and 3, had the season been dry.

(B) Stationary Slide Exposures

(Co-operative experiment between the Dominion Plant Pathological Laboratory at Saskatoon, Sask., and the Dominion Rust Research Laboratory, Winnipeg, Man.)

What starts rust epidemics in western Canada, is an oft repeated question. That urediniospores and mycelia of rust may overwinter in western Canada and serve as infection centres the following year is a theoretical possibility, but the evidences of their doing so are, up to the present, all negative. Moreover, the barberry as a possible source is of little significance. The remaining possibility is wind-borne urediniospores and aeciospores which may be carried to the wheat field from the south and east. During the last three years, the two laboratories have been carrying on a study of this possibility. A brief statement of this phase of the work is given below.

The methods of preparation and exposure of the slides were identical with those outlined in the Dominion Botanist's Report for 1926. Slides were exposed during the latter part of May and the month of June at four new stations in the southern part of Manitoba and Saskatchewan, in order to increase the possibility of detecting the earliest arrival of rust spores. As the exposures at some of the stations were discontinued at the end of June, and others begun at more northerly and westerly points in July, the data are presented in two separate tables. Table 6 has to do with the earlier, and table 7 with the later exposures. The data for the exposures made in the second half of August and in early September will not be discussed in this report. The figures in the tables represent the number of spores found in an area of a little less than one and a half square inches on the surface of a vaselined microscope slide.

TABLE 6.—STATIONS AT WHICH STATIONARY SLIDES WERE EXPOSED, WITH THE DATE AND NUMBER OF SPORES FOR EACH EXPOSURE BETWEEN MAY 28 AND JULY 14, 1927.

Date	Morden, Man.	Killarney	Winnipeg	Carnduff, Sask.	North Portal	Frobisher	Estevan	Indian Head	Saskatoon
May 28									
" 29					1				
" 30				6					
" 31			1						
June 1			5			3			
" 2			6						
" 3			20						
" 4									
" 5				4					
" 6									
" 7							1		
" 8			2						
" 9			4	2					
" 10			9						
" 11									
" 12									
" 13			1	2		1			
" 14			2						
" 15						2			
" 16				1					
" 17						1	6		5
" 18					2				17
" 19						2	1	2	
" 20									
" 21		4		1					
" 22			2		3				
" 23		3							
" 24			3		1				
" 25	6		43	2			1		
" 26									
" 27			26	2					
" 28	12				2				
" 29			4	7		2			
" 30					3			1	
July 1		5		3		3	5		
" 2								2	1
" 3		9		8					
" 4	18		70						48
" 5			29	2	4				
" 6									2
" 7	7		15						
" 8		48	7						
" 9				5	16				
" 10	8								
" 11			3						
" 12			1						2
" 13				3					
" 14	5		3						

It will be seen from table 6 that a few urediniospores were caught during the last three days of May and the early part of June. Traces of spores appear somewhat irregularly at all the stations throughout the month of June. A light shower of spores apparently fell in southeastern Saskatchewan about the middle of the month, and again over that area and southern Manitoba towards the end of the month.

The presence of urediniospores (no aeciospores are recorded) of wheat rust in the atmosphere over southern Manitoba and Saskatchewan has considerable significance. The fact that spores were caught on so many of the slides and on such a small area is indicative that spores were distributed fairly generally over this region, and in quite sufficient numbers to be responsible for our initial rust

infections. That no rust was found in the fields in Canada until July 6, although a sharp outlook was kept for its first appearance, seems fairly conclusive evidence that these earlier spores were directly responsible for our first rust infections. That these rust spores originated elsewhere than in Canada is likewise evident.

TABLE 7.—STATIONS AT WHICH STATIONARY SLIDES WERE EXPOSED, WITH THE DATE AND NUMBER OF SPORES FOR EACH EXPOSURE BETWEEN JULY 15 AND AUGUST 16, 1927

Date	Morden	Brandon	Winnipeg	North Portal	Indian Head	Saskatoon	Swift Current	Spedding ton	Vermilion	Edmonton	Olds	Lethbridge	Beaver Lodge
July 15		30	0	90			9	0	0	0	0	0	
" 16	7		5			0							
" 17		7			1		5	0	0	0	0	0	
" 18	0		6	28		0							
" 19		3	350		19								
" 20	12		84			0	12	0	0	0	0	0	
" 21		2	3	5	61								0
" 22	0		360			0							
" 23		5	15		3		0	2	0	0	0	0	
" 24	48			424		2							
" 25		3	13		33								
" 26	60		141			32	0	0	0	0	0	0	
" 27		60	183	1414	40								
" 28	1500		321			126							6
" 29	120	15	194		227		126	4	4	0	110	0	
" 30			487		18065		182						
" 31		84	178		14								
Aug. 1	1600		34			14	184	36	34	0	278	0	
" 2		22	350	2422									
" 3	1400		48		138	63							0
" 4		31	2709				1036	32	9	9	354	0	
" 5	5000		1900	19600	270	728							
" 6		96											
" 7			7200		168	588	1834	140	16	8	1284	0	
" 8		0	340	178795									
" 9			846		139	186							
" 10	7660	162	31				2646	294	24	0	98	0	0
" 11			205	155925	728	231							
" 12		480	240										
" 13	5940				1680	2673	4620	1540	254	30	2925	3	
" 14		1890	36	420750									
" 15	6320				4494	1298							
" 16		45					5200	230	196	58	1428	2	155

On July 6, two or three rust pustules were found both at Morden and Winnipeg, and by July 18 there was a light general primary infection over Manitoba as far north as Winnipeg. On that date also primary infections of stem rust were becoming somewhat common in southeastern Saskatchewan. An examination of the two tables will show that, up to that date, the spore content of the air did not increase very noticeably, but that, shortly after that date, there was quite a decided increase in the number of spores. This increase can be attributed, in part at least, to spores originating north of the international boundary, as can also the enormous increase in the number of spores during the latter part of July and the first two weeks of August, and in the later period not given in the tables; also, in part, to spores blown in from the Dakotas and Minnesota, where a severe rust epidemic had developed by this time.

In Alberta, at none of the five stations were spores found until the last few days of July. During the first half of August spores in greater or less abundance were found at Vermilion, Edmonton, and Olds, at which place they were most numerous. It was not, however, until the middle of August that field

infections were found in the vicinity of Edmonton, and field observations showed that, during the last week of August, there was little over a trace of rust in the territory lying between Calgary and Lethbridge. The scarcity of rust in this region seems to be directly attributable to the lack of inoculum, as indicated by an almost complete absence of spores on the slides up to August 16. Drought conditions could not be responsible, for rain, amounting to a total of nearly two inches at that station, fell on nine different days during the month.

A point worthy of special attention is the presence of stem rust spores on slides at Beaver Lodge. At this station, each slide was exposed for seven days. The slide exposed during the week ending July 28 had 6 stem rust spores. No more spores were found the next two weeks, but, with the week ending August 18, the slide showed 155 spores, and the slide for the following week, 52 spores. The slide collected September 10, on which date the exposures were discontinued, had 54 stem rust spores. Correlated with the presence of spores in the air at Beaver Lodge is the fact that pustules of stem rust were this year found in the fields. The extent of the infection was not more than a trace, but in no previous year has stem rust in the fields been recorded in that district. As shown above, primary infections were only showing up at Edmonton about the second week of August, and it seems a reasonable inference that at least the six spores found about the end of July and the 155 spores found about the middle of August at Beaver Lodge did not originate in that vicinity, (although the date of the first field infections is not definitely known), but that their place of origin was most probably as far east as Saskatchewan.

The data here presented emphasize again the important role which wind-borne spores almost unquestionably play in the dissemination of the rust organism throughout western Canada.

(C) Aeroplane Experiments

As the exposures were confined to routine flights, the data presented are necessarily fragmentary, but sufficient to be somewhat indicative of what may be of more or less general application.

From stationary slide exposures and field observation it is definitely known that rust spores were present in the air over the southern part of Manitoba and Saskatchewan during the latter part of June, and that a general primary infection on about 25 per cent of the wheat plants was present in Manitoba, as far north as Winnipeg, by the 16th of July; also, that from that date up to August 1 there was only a limited increase in the amount of infection, but that, between August 1 and August 9, a somewhat alarming increase in the expression of the disease was manifest, and that by August 16 a general epidemic was well under way in Manitoba and Saskatchewan.

TABLE 8.—TABULATED DATA OF SLIDE EXPOSURES MADE DURING FLIGHTS AT LAC DU BONNET, NORWAY HOUSE, AND CORMORANT LAKE

Date	Station	Wind direction	Altitude	Duration	Number of spores
July 7	Norway House	S.W.	4,800	15 mins.	0
" 17	Cormorant Lake	W.N.W.	3,000	15 "	0
" 19	Lac du Bonnet	S. by W.	5,000	10 "	24*a*
" 22	" "	S. by W.	5,000	15 "	35
" 23	Cormorant Lake	S.W.	3,000	15 "	0
" 29	"	S.W.	5,000	15 "	0
Aug. 9	Lac du Bonnet	N.	4,500	15 "	3
" 11	Cormorant Lake	W.	5,000	15 "	36
" 12	"	S.E.	3,000	5 "	240
" 12	"	S.E.	4,000	5 "	123
" 12	"	S.E.	5,000	5 "	5
" 17	Lac du Bonnet	N.E.	4,200	15 "	0
" 22	Norway House	N.	5,000	15 "	0
" 24	Cormorant Lake	W.	4,500	10 "	0
" 31	"	S.S.W.	3,500	15 "	300
Sept. 6	Lac du Bonnet	S.W.	5,000	15 "	1,327
" 8	Cormorant Lake	S.W.	3,500	15 "	720
" 12	"	S.E.	5,000	15 "	864
" 16	"	S.W.	5,000	15 "	28
" 16	Norway House	W.	5,000	5 "	0
" 16	"	W.	4,000	5 "	24
" 16	"	W.	3,000	5 "	1
" 24	"	N.W.	5,000	5 "	6
" 24	"	N.W.	4,000	5 "	20
" 24	"	N.W.	3,000	5 "	5
" 26	"	S.W.	5,000	12 "	2

a The numbers represent spores on both slides of the exposure.

To what extent the spores collected on the later-exposed slides were of local origin, it is impossible to say, but it seems clear that the spores caught in the vicinity of Fort Alexander (Lac du Bonnet), on July 19 and July 22 (see table 8), must have originated at least as far south as Winnipeg, a distance of approximately 65 miles. That spores were not detected by the two earlier flights, at Norway House and Cormorant Lake, is not surprising, as, owing to excessive precipitation, the atmosphere during the first half of July must have been practically washed free of spores. (Rain fell on twelve out of the first eighteen days of July at Winnipeg, Dauphin, and Lac du Bonnet, a condition which seems to have been more or less general over northern Manitoba, at least.) Why the two exposures at Cormorant Lake, on July 23 and 29, failed to record any spores may quite possibly be explained by the limited amount of rust in, and the greater distance of the exposures from the place of origin of the spores, together with the frequent drenching of the rusted area by rain.

The number of spores caught on the slides at Lac du Bonnet and Cormorant Lake during the second week of August can be correlated with a combination of circumstances. In the first place, during the first week of August, as noted above, there was a very pronounced increase of rust infection in the fields, resulting in the production and dissemination of a greatly augmented number of rust spores. The amount of rainfall in the wheat-growing area of Manitoba in the first two weeks of August was but slight. These two conditions would favour the accumulation of a high concentration of rust spores in the air. Moreover, on August 12, the date on which the greatest number of spores for this month was recorded, the wind blew from the southeast, and, on the previous day, August 11, directly from the south, so that undoubtedly there was a northward movement of spores at that time.

During August 15, 16, and 17, and again on August 21 and 22, rain fell fairly generally over Manitoba, and, as a consequence, one would not expect to

find any considerable number of spores in the air. This condition is reflected in the absence of spores on the slides exposed on August 17, 22, and 24. Another period of general precipitation occurred over Manitoba on August 26, 27, and 28, but a southerly wind blew during the last three days of August, with no precipitation on the 29th and 30th, and, as the epidemic was at its height at this time, a large number of spores were to be expected on the slide exposed at Cormorant Lake on August 31, as indeed happened.

Although rain fell somewhat locally during the first eleven days of September, the amount was not excessive, and the slides exposed on September 6 and 8 are indicative of the high concentration of spores in the air for that period. On September 12, an extremely heavy rain occurred in many parts of Manitoba, but the exposure at Cormorant Lake on that date was made under conditions of "good visibility, cumulus clouds." This exposure was evidently made somewhat previous to an excessively heavy fall of rain on that date, which amounted to 1·14 inches at that station.

A period of general precipitation around the southern part of the lake region set in on September 12 and extended on to September 26. During those fifteen days rain fell at Winnipeg on ten days; at Dauphin on eight days; and at Lac du Bonnet on eleven days. Most of the spores must have been washed out of the air during that part of the month, as in indicated by the small number of spores caught on the slides during that period.

The data of this year emphasize the marked effect that periods of continuous rain-fall have on clearing the atmosphere of rust spores. Throughout the greater part of August and the first half of September, epidemic conditions prevailed in the wheat-growing areas of Manitoba and Saskatchewan, but, except for short periods, the spore concentration in the air at these northerly points where exposures were made was comparatively low.

PHYSIOLOGIC FORMS OF WHEAT STEM RUST IN CANADA

(M. Newton, T. Johnson, and A. M. Brown.)

The work of determining the number, characteristics, and geographical distribution of all physiologic forms of wheat stem rust in Canada was continued in the greenhouses in 1926 and 1927. [For previous work on physiologic specialization in wheat stem rust in Canada see footnotes (1), (2), (3)].

Until 1926, extensive collections of rust were made only in the three western provinces, Manitoba, Saskatchewan, and Alberta. That year the rust survey was extended to include the whole of Canada, and collections were made in every province but British Columbia. With the greater prevalence of stem rust of wheat in the West this year, collections were made not only in all the provinces, but also in many parts of northern Alberta, Saskatchewan, and Manitoba, where rust has seldom or never been found, such as at Smith and Beaver Lodge in the Peace River district, Eldred and St. Walburg in Saskatchewan, and Mile 311, situated about two-thirds of the distance from the Pas to Port Nelson. One of the most difficult problems in this physiologic form study has been to trace the direction and rate of spread of each form throughout the length and breadth of the land. This year, with the very widespread occurrence of rust in Western Canada, a greater opportunity has been provided for this study than in any year since 1916.

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[1] Fraser, W. P. Reports of the Dom. Field Lab. of Plant Pathology, Saskatoon, Sask., in Reports of Dom. Botanist, Canada, for year ending March 31, 1922, p. 64; for year 1922 (1923), p. 45; for year 1923 (1924), p. 40.

[2] Newton, M. Studies in Wheat Stem Rust, *Puccinia graminis Tritici*. Trans. Roy. Soc. of Can. 16:153-210, 1922.

[3] Newton, M., and T. Johnson. Physiologic Forms of Wheat Stem Rust in Western Canada. Sci. Agr. 7:158-161, 1927.

Some evidence has been found suggesting a possible relationship between the varieties of wheat grown and the distribution of physiologic forms of rust. In the eastern collections of wheat stem rust last year, there were more Marquis resistant forms than in those from the West. Two hundred and eighty-six collections were made in the West; of these only five contained a Marquis resistant form. In the East, one hundred and eight collections were made; to twenty of these was Marquis resistant. That is, Marquis was resistant to eighteen per cent of the eastern collections, and to less than two per cent of the western collections. The reason for this was not absolutely clear. We do know, however, that, while in the past Marquis has been grown almost exclusively in the West, a greater variety of wheats has been grown in the East. This year, due to the unusually late spring, durum wheats and varieties other than Marquis were planted in many localities. The question naturally arose, would the introduction of these new wheats bring about an appreciable change in the number or kinds of forms present in the West? So far the results would seem to suggest that there has been a slight change in the kinds of forms, since sixteen Marquis resistant forms, most of which were collected on durum and winter wheats and *Hordeum jubatum*, have already been identified this season from the West, instead of five as in 1926, and none as in all the previous years but 1919, when but one was isolated. The results are suggestive, but the work has not been carried on for a sufficient length of time to show whether there is a direct correlation between the varieties grown in a certain locality and the forms isolated there.

TABLE 9.—ANNUAL OCCURRENCE OF PHYSIOLOGIC FORMS OF *Puccinia graminis Tritici* IN CANADA FROM 1919 TO 1926, WITH A RECORD OF THE NUMBER OF TIMES EACH FORM WAS COLLECTED ANNUALLY

Year	Number of times form was collected							
	1919	1920	1921	1922	1923	1924	1925	1926
Form 1	2	1						
2					1			
3		4	3	10	10	16		
9	4	6	2	3				1
11	2	5	2	3	5	9		
12		2				5		
14								2
15	1							2
17	9	31	27	16	10	1		2
18	4	7	3	2				
19	1							1
21	4		4	24		1	44	86
24	1		1					
29		17	1				13	29
30		1					1	7
32		4	1				3	12
34				1	3	7	1	4
36				2			113	217
A								2
B								3
C								19
D								1
Total number of forms	9	10	9	8	5	6	6	15
Total number of collections made in year	28	78	44	61	29	39	175	388

From table 9 it will be seen that in addition to the regular forms identified, there have been six new forms. These are different from any of those included in Dr. Stakman's key. The total number of forms in Canada is thus slowly increasing, but it is as yet but slightly more than one-half the number of those isolated in the United States by Stakman and his colleagues.

In addition to these new forms of *Puccinia graminis*, several interesting cases of colour mutations have appeared during the year. An article including all the details of the early work on these colour mutations will be found in Phytopath. 17: 711-725. 1927.

Ever since physiologic forms of *Puccinia graminis Tritici* were discovered by Stakman and his co-workers in 1916, workers in all parts of the world have been seeking for some explanation of the origin of these forms. A complete explanation is not yet apparent, but the sudden change of a normal red rust to an orange form is at least indicative of one way in which physiologic forms may have arisen—that is by mutation. If rusts can mutate for colour and become weaker parasites, may they not change completely in their pathogenicity and become absolutely new forms?

Later work on colour mutations in rust has shown that these greyish-brown forms are of more common occurrence than was at first suspected. In the spring of 1927, thirty-three separate cultures of aeciospores from barberries, all but one of which had been artificially inoculated, were transferred to wheat plants in the greenhouse. In fourteen of these wheat cultures, some greyish-brown pustules appeared. These were all obtained in pure culture, and, as in the earlier case, they have remained constant in colour, producing only greyish-brown ureedinia. For most of these barberry infections, the telia from *Hordeum jubatum* have been used as a source of inoculum, as these telia appeared to give better germination than did those on wheat straw. There seemed but two explanations for these greyish-brown rusts, either that a greyish-brown rust was present in the fields on *Hordeum jubatum* and that we had failed to observe it, or that some change had taken place in the rust while passing through the barberry. A special effort was made, therefore, to find the grey form in the field.

Forty-three collections of rust were made on *Hordeum jubatum* in all parts of the country from Ontario to the Peace River district. Collections were even made in the same chicken yard in which the original *Hordeum* used to infect the barberries had been grown. But all to no avail. Not a single greyish-brown pustule appeared in any culture. It would seem, therefore, that these greyish-brown forms originated on the barberry. This work is being continued and further results will be published later.

As will be seen in table 9, different physiologic forms predominate in different years. From 1919-1921 form 17 was the predominating one, and form 21 occurred only rarely; from 1921-1925, the reverse has been true. Form 17 has almost disappeared and form 21 has become one of the most prevalent forms. In the same way, a form, for example form 1, may appear for a season or two, and then disappear for a series of years; or again, as with form 3, it may appear so consistently, year after year, as to be looked upon as a permanent form, and then, without any apparent cause, it may suddenly disappear.

TABLE 10.—DISTRIBUTION BY PROVINCES OF THE PHYSIOLOGIC FORMS OF *P. graminis Tritici* IN CANADA IN 1927*

——	9	14	15	16	17	21	29	30	32	34	36	B	C	D	E	F
Prince Edward Island	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Nova Scotia	....	....	....	....	....	3	....	1	....	....	3	....	4	....	....	....
New Brunswick	....	....	....	....	....	....	....	....	....	....	1	....	2	....	....	....
Quebec	....	....	....	....	1	5	....	....	....	....	7	....	....	....	....	....
Ontario	....	1	....	....	2	7	....	1	....	1	7	....	1	....	....	....
Manitoba	3	6	3	....	8	50	1	4	2	7	78	4	5	6	1	....
Saskatchewan	2	....	2	....	7	50	1	2	....	4	83	2	3	....	....	1
Alberta	....	1	1	1	2	23	....	....	....	....	45	2	....	....	....	....
British Columbia	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....
Total	5	8	6	1	20	139	2	8	2	12	225	8	15	6	1	1

Total number of forms, 16.
Total number of collections, 459.
* This table is incomplete, representing only rust collections identified up to Jan. 31, 1928.

Twenty-five physiologic forms have been isolated in Canada during the period 1919-1927 (tables 9 and 10). Of the collections made during the past year, 459 have so far been identified (table 10). It will be noted that there is a close correlation between the results of 1925, 1926, and 1927. The same two physiologic forms, 36 and 21, predominated in approximately the same proportion in the three years, and were the most widely distributed of all the forms isolated.

PHYSIOLOGIC FORMS OF OAT STEM RUST

(W. L. Gordon)

This project has been continued from 1925, and has been considerably enlarged. One hundred and ninety-two collections of oat stem rust were obtained from various localities in Canada, and identified in the greenhouse. The majority of these were from Manitoba and Saskatchewan, but collections were obtained from all the provinces except Alberta and British Columbia. Comparatively little damage resulted from oat stem rust infection in 1926 in Western Canada.

The predominating physiologic forms were 2 and 5. These comprised more than 95 per cent of the total number of forms isolated. Form 1 was isolated infrequently.

Physiologic forms, more virulent than 1, 2, and 5, occurred again this season. Form 4 was isolated from collections made at Weyburn, Sask., Pine River, Man., and Winchester, Ont. The physiologic form first collected at Paskwegin, Sask., in 1925, which differed from all forms reported, was present this year in a collection from McCreary, Man. It is capable of infecting heavily all the differential hosts, so it is considered to be a new form and has been named physiologic form 6.

Field tests, in the rust nursery, of more than 180 varieties or strains showed clearly the extreme virulence of forms 4 and 6. All the varieties ordinarily resistant appeared quite susceptible. Their susceptibility was shown later to be due to the above forms, by collections being taken from them in the field and identified in the greenhouse. Additional varieties will be tested for rust resistance in the near future.

The origin of the various collections, and the forms isolated from them are summarized in Table 11. In table 12 is shown the distribution of the physiologic forms isolated.

TABLE 11.—PHYSIOLOGIC FORMS OF *Puccinia graminis Avenae*. IDENTIFIED IN 1925-26. TOTAL NUMBER OF COLLECTIONS—192.

Origin of collections	Physiologic forms present	Origin of collections	Physiologic forms present
Manitoba		*Manitoba*—Continued	
Arnes	5	Dauphin (2)	5
Ashville	5	Deloraine	5
Birds Hill	5	Dufrost	2 and 5
Boissevain	5	Elm Creek	2 and 5
Brandon (4)	2 and 5	Emerson	5
Broomhill	2	Ethelbert	5
Carman	5	Gilbert Plains	5
Clear Lake	2 and 5	Gimli	5
Coulter	5	Glenboro'	5
Crystal City (2)	2 and 5	Goodlands	5
Cypress River	5	Grandview (2)	2 and 5
Darlingford	2 and 5	Hartney (2)	2 and 5

TABLE 11.—PHYSIOLOGIC FORMS OF *Puccinia graminis Avenae*. IDENTIFIED IN 1925-26. TOTAL NUMBER OF COLLECTIONS—192.

Origin of collections	Physiologic forms present
Manitoba—Concluded	
Headingly	5
Homewood	5
Ile des Chenes	5
Kane	2
Kelwood	2
Macdonald	2 and 5
Manitou	2 and 5
McCreary (2)	1, 5, 6
Melita	5
Methven	2
Minnedosa	2 and 5
Morden (7)	2 and 5
Neepawa	2 and 5
Newdale	5
Oak Bluff	5
Ochre River	2
Pembina Mts	1 and 5
Pine River	2, 4, 5
Poplar Point (2)	2 and 5
Portage la Prairie (2)	2 and 5
Rathwell	5
Reston	2
Ridgeville	5
Riding Mt	2
Sanford	5
Sanger	5
Selkirk	2
Souris	5
Starbuck	2
Stonewall	5
Stoney Mt	2 and 5
St. Claude	5
Ste. Rose (2)	5
Swan River	5
Teulon	5
Thornhill	5
Tolstoi	2
Virden	5
Waskada	2
Wawanesa	5
Westbourne	5
Winnipeg (6)	2 and 5
Saskatchewan	
Arcola	2
Benson	5
Carlyle	5
Carnduff	2
Cloan	2
Cory	5
Cullen	2 and 5
D'Arcy	2 and 5
Delisle	5
Duck Lake	2 and 5
Dundurn	5
Duro (2)	5
Estevan (2)	2 and 5
Guernsey (3)	2 and 5
Handel	2
Harris	2 and 5
Saskatchewan—Concluded	
Hepburn	5
Holbein	1
Humboldt	5
Indian Head (5)	2 and 5
Kelfield	5
Kipling	2
Langenburg	5
Laura	5
Leipzig	5
Macdowall	2
Midale	3
Moosomin	5
North Battleford	5
Parkside	5
Plenty	2 and 5
Prince Albert	2
Prud'homme	5
Richard	2
Saskatoon (5)	2 and 5
Shell Brook	2
Stranraer	2
Tessier	2 and 5
Vanscoy	2
Vonda	2 and 5
Waldheim	5
Wapella (2)	2 and 5
Watrous	5
Weyburn (4)	2, 4, 5
Wilkie (2)	2 and 5
Young	2
Zealandia	5
Ontario	
Kapuskasing (3)	2 and 5
Kenora	5
Mountain	2 and 5
Ottawa (2)	2 and 5
Port Arthur	2
Sault Ste. Marie	2 and 5
Williamstown	5
Winchester	4 and 5
Quebec	
Lachute (2)	5
Macdonald College	2
Ste. Anne de la Pocatière (6)	2 and 5
New Brunswick	
Fredericton (10)	2 and 5
Nova Scotia	
Kentville (4)	5
Merigomish	5
P. E. Island	
Charlottetown (5)	5

TABLE 12.—DISTRIBUTION OF PHYSIOLOGIC FORMS OF *Puccinia graminis Avenae* IDENTIFIED FROM 1926 COLLECTIONS

Physiologic Form	Provinces									Total number of isolations of each form
	B.C.	Alta.	Sask.	Man.	Ont.	P.Q.	N.B.	N.S.	P.E.I.	
1	.....	.....	1	2	.....	.....	.....	.....	.....	3
2	.....	.....	31	35	5	4	4	.....	.....	79
4	.....	.....	1	1	1	.....	.....	.....	.....	3
5	.....	.....	45	66	8	6	9	5	5	144
6	.....	.....	.....	1	.....	.....	.....	.....	.....	1

SEXUAL BEHAVIOUR OF THE STEM RUST ORGANISM
(Puccinia graminis Tritici)

(J. H. Craigie, Plant Pathologist, Winnipeg)

INTRODUCTION

Up to the year 1916, *Puccinia graminis Tritici* was considered to be a simple variety. From that time to the present, it has been shown that this variety really consists of somewhat more than forty different pathogenic strains, commonly called physiologic forms. These forms are similar in appearance but differ markedly in their pathogenic reaction on certain varieties of wheat. A wheat variety may be resistant to one form and susceptible to another, and vice versa.

When an investigation of stem rust was begun at the Rust Research Laboratory, the question naturally presented itself, may not physiologic forms other than those already present arise, and, if so, by what means? The bearing which such a possibility had on the breeding of rust resistant varieties of wheat, as well as of oats, does not require much comment here. Such a possibility would seriously complicate the plant breeders' task.

There are three possible ways in which new forms might arise: (1) by adaptation of an existing form, (2) by a mutation in an existing form, and (3) by hybridization on the barberry of two existing forms. This report has to do with an investigation of the latter method.

NUCLEAR BEHAVIOUR

A brief statement concerning the behaviour of the nuclei of stem rust will help to clarify the subsequent discussion. When the black stage of rust develops in the autumn, each cell of the black spores contains two nuclei. Before germination of these spores takes place in the spring, the two nuclei of each cell fuse, so that, when these spores germinate, the fused nucleus passes out of the cell into a tube-like process, called the promycelium, in which it divides. This division is followed by a division of the two daughter nuclei, so that four nuclei come to lie in the promycelium. These soon become separated by cell-walls and each cell so formed produces a spore, called a sporidium, into which the nucleus of the cell passes. The sporidia infect the barberry and produce on its leaves pustules, the mycelia of which have uninucleate cells. These pustules give rise to uninucleate spore-forms *(pycnospores)* which develop in vase-shaped organs *(pycnia)*, usually on the upper surface of the pustules. The pycnospores are exuded from the pycnia in a honey-like fluid, called nectar. Several days after the pycnospores appear, a second sporeform *(aeciospore)* develops on the under side of the pustules in cup-shaped structures, called aecia. This sporeform is binucleate and arises through fusion of certain cells of the uninucleate mycelia.

Until the present work was undertaken, the regular appearance of aeciospores in every pustule was considered to be the normal course of development. But, as will be shown subsequently, this spore-form only develops under certain circumstances.

Discussion of Results

Experimentation during the last two years has shown quite clearly that the uninucleate sporidia are of two sexes, (+) and (—). When two sporidia of opposite sex alight close together on a barberry leaf and infect it, the mycelia arising from these two infections intermingle; cell fusions occur; and, as a result, the binucleate aeciospores develop.

Fig. 1.—Under side of barberry leaf. Pustules on the right of midrib had nectar transferred from one to the other. The nectar of pustules on the left of midrib was not transferred. Aeciospores developed in the pustules on the right within six days after the transference, but not in the pustules on the left.

There is, therefore, the possibility that (+) sporidia of one form of stem rust may infect the barberry and produce pustules, the mycelia of which will intermingle and fuse with the mycelia of pustules arising from infections by (—) sporidia of another form, and, as a result of such fusions, aeciospores bearing characteristics of both forms may appear. In other words, there is the possibility that hybridization may take place between existing forms and thereby a new form of rust arise.

In addition, it has been demonstrated that, when a single sporidium, whether (+) or (—), infects a leaf, a pustule with uninucleate mycelium develops, but only rarely, if at all, do such pustules ever develop aeciospores. Pycnia with abundant pycnospores are produced, but aeciospore development is lacking.

On the other hand, however, if the nectar of a pustule derived from a (+) sporidium is transferred to the upper surface of a pustule derived from a (—) sporidium, or vice versa, binucleate aeciospores develop within a definite number of days in those pustules to which the nectar is transferred (fig. 1). This discovery opens up a second way by which hybridization of rust forms may be effected.

Experiments have shown that flies are active agents in bringing about this transfer of nectar. Observations on infections occurring out-of-doors furnish additional evidence of the important part flies play in transferring the nectar of one pustule to another, and leave little doubt that, through their agency, hybridization of rust forms can take place.

From the foregoing it is evident that the barberry is a much more dangerous enemy to the farmer than has been supposed. Its importance in initiating early infections of rust in cereal crops has long been recognized, but now its presence in any cereal-growing area must be considered as a double menace.

Parallel experiments with the sunflower rust (*Puccinia Helianthi*) have yielded results similar to those with stem rust. This rust does not infect barberry or wheat, but it resembles stem rust in its life history, and the results obtained from it confirm the work done with *P. graminis Tritici*.

Another point of great interest, particularly to mycologists, has been brought to light and experimentally proved by this investigation. For upwards of seventy-five years, the pycnia of rusts have usually been considered as serving no useful purpose in the life history of the organism. The pycnospores were commonly held to be male elements which, in the evolutionary progress of the rusts, had ceased to perform any serviceable function. This long-held view must be abandoned. A function has now been definitely established for the pycnia of at least two rusts.

To summarize briefly, the phenomenon of sex has been experimentally demonstrated in these two rusts; and the possibility that hybridization of forms may occur in at least two different ways has been opened up; in addition, the commonly accepted theory regarding the pycnia of rusts has been disproved.

An account of this investigation will be found also in "Nature," Vol. 120, Nos. 3012 and 3030, 1927.

UNIFORM RUST NURSERIES IN CANADA

(Margaret Newton and D. L. Bailey.)

Since 1921, a number of standard and of especially selected varieties of wheat and oats have been grown in rod rows for a rust resistance test at various experimental farms, stations, and universities. These plots, known as the uniform rust nurseries, have been carried on as a co-operative project between these stations and the Dominion Rust Laboratory.

These rust nurseries have assisted in the work of both the plant breeder and the plant pathologist. In these rows has the plant breeder been able to compare the relative rust resistance of promising new wheat and oat varieties, of early maturing varieties, and of varieties of commercial importance in the United States and Canada. On these same varieties, too, the plant pathologist has year after year been able to collect new and unusual physiologic forms of rust, forms which do not attack Marquis or the more commonly grown wheats

TABLE 13.—PERCENTAGE OF STEM RUST ON 18 VARIETIES OF OATS GROWN IN UNIFORM RUST NURSERIES AT 21 STATIONS IN CANADA IN 1927

Percentage infection of stem rust

Oat Varieties	Charlottetown, P.E.I.	Kentville, N.S.	Nappan, N.S.	Fredericton, N.B.	Ste. Anne de la Pocatière, Que.	Ottawa, Ont.	Guelph, Ont.	Kapuskasing, Ont.	Winnipeg, Man.	Brandon, Man.	Morden, Man.	Saskatoon, Sask.	Indian Head, Sask.	Swift Current, Sask.	Rosthern, Sask.	Scott, Sask.	Lethbridge, Alta.	Lacombe, Alta.	Edmonton, Alta.	Beaver Lodge, Alta.	Summerland, B.C.
Victory	......	5	tr.	0	tr.	tr.	40	55	31	45	80	45	8	3	28	25	tr.	tr.	tr.	0	0
Gold Rain	tr.	5	......	0	tr.	10	20	50	30	40	80	48	6	3	25	10	tr.	tr.	tr.	0	0
*Richland	......	0	0	0	0	tr.	0	tr.	tr.	0	0	10	0	0	5	25	0	0	tr.	0	0
Alaska	tr.	tr.	tr.	0	5	5	tr.	65	26	45	50	50	40	5	20	22	0	tr.	tr.	0	0
Red Rustproof	......	10	0	0	tr.	tr.	40	70	20	30	70	20	2	tr.	55	45	0	0	tr.	0	0
*Monarch Strain	......	0	0	0	0	0	tr.	tr.	2	0	5	10	0	0	5	5	0	0	0	0	0
Joanette	5	0	0	0	0	tr.	0	10	15	30	60	25	tr.	tr.	15	15	0	0	tr.	0	0
*White Tartar	......	0	0	0	0	0	tr.	3	tr.	0	10	25	tr.	0	5	5	0	0	tr.	0	0
Ruakura	tr.	30	tr.	0	tr.	7	tr.	60	32	45	10	40	5	2	15	15	tr.	0	tr.	0	0
*Minota x White Tartar	......	0	0	0	0	0	tr.	5	tr.	0	0	10	tr.	tr.	5	5	0	0	0	0	0
*Green Mountain	......	0	0	0	0	0	tr.	10	tr.	0	0	15	tr.	0	8	7	0	0	tr.	0	0
*Heigira Strain	......	tr.	0	0	0	tr.	0	3	tr.	0	0	10	0	0	5	5	0	0	0	0	0
Banner	tr.	20	0	0	tr.	5	25	40	20	40	80	50	7	7	28	29	0	tr.	tr.	0	0
*Victory x White Tartar	......	0	0	0	0	0	tr.	20	tr.	0	0	15	5	3	6	5	0	0	0	0	0
O.A.C. No. 72	tr.	10	0	0	0	1	45	40	16	40	70	45	8	3	27	26	0	tr.	tr.	0	0
Iowar	......	0	0	0	0	tr.	......	......	12	35	30	45	6	3	27	27	0	tr.	tr.	0	0
Iogold	tr.	tr.	0	0	0	0	......	......	tr.	0	10	12	tr.	tr.	5	6	0	tr.	0	0	0
Iowa 444	......	......	0	0	0	tr.	0	......	8	35	10	45	25	6	8	8	0	0	0	0	0
Physiologic forms isolated																					
	4	2 5	2 5	2 5	2 5	2 5	2 5	2 5	2 5	2 5	2 5	2 5	2 4 5	2 5	2 5	2 5	2 5	5 ...	2 5	0	0 ......

*The pustules on these varieties were consistently small.
Prepared by M. Newton, T. Johnson, and W. L. Gordon.
The rust percentages were estimated by the scale devised by the Office of Cereal Crops and Diseases, U.S.D.A.

TABLE 14.—PERCENTAGE OF STEM RUST ON 25 VARIETIES OF WHEAT GROWN IN UNIFORM RUST NURSERIES AT 21 STATIONS IN CANADA IN 1927

Percentage infection of stem rust (1)

Wheat Varieties	Charlottetown, P.E.I.	Kentville, N.S.	Nappan, N.S.	Fredericton, N.B.	Ste. Anne de la Pocatière, Que.	Ottawa, Ont.	Guelph, Ont.	Kapuskasing, Ont.	Winnipeg, Man.	Brandon, Man.	Morden, Man.	Saskatoon, Sask.	Indian Head, Sask.	Swift Current, Sask.	Rosthern, Sask.	Scott, Sask.	Lethbridge, Alta.	Lacombe, Alta.	Edmonton, Alta.	Beaver Lodge, Alta.	Summerland, B.C.
Border	10	20	30	40	25	60	30	75	65	60	65	65	58	55	72	60	3	10	25	0	0
Kubanka, 1440	tr.	tr.	tr.	tr.	tr.	20	15	15	50	20	20	54	42	10	38	36	0	3	3	0	0
Kubanka, 2094	tr.	0	tr.	tr.	tr.	45	8	5	52	15	15	52	42	9	35	38	0	tr.	tr.	0	0
Arnautka, 1493	tr.	tr.	tr.	tr.	tr.	50	35	15	50	19	18	55	51	9	38	40	0	tr.	tr.	0	0
*Iumillo	.....	0	0	0	0	0	tr.	tr.	tr.	0	2	tr.	tr.	10	20	2	0	0	0	0	0
Mindum, 5296	tr.	tr.	tr.	1	1	30	30	10	40	15	17	60	20	20	40	40	0	0	tr.	0	0
*Acme, 5284	tr.	0	0	0	0	tr.	tr.	tr.	15	tr.	3	10	5	tr.	30	8	0	0	0	0	0
Axminster	tr.	tr.	tr.	2	3	5	8	30	63	59	63	63	20	40	70	50	3	tr.	4	0	0
White Russian	tr.	0	tr.	1	1	1	45	30	63	58	61	65	35	40	85	55	2	tr.	tr.	0	0
*Ceres, 6900	.....	0	0	tr.	10	tr.	2	30	37	25	48	55	25	40	85	60	tr.	tr.	2	0	0
Garnet	10	10	40	40	2	60	20	75	65	65	70	65	65	60	60	48	tr.	8	3	tr.	0
Huron	tr.	tr.	tr.	2	12	8	25	30	60	58	50	65	55	45	85	52	4	tr.	2	tr.	0
Kota, 5878	tr.	0	tr.	tr.	tr.	tr.	2	15	20	28	45	55	10	40	65	68	tr.	tr.	tr.	tr.	0
Marquillo	.....	0	0	0	tr.	tr.	3	5	5	5	8	40	10	20	50	40	tr.	0	tr.	0	0
Marquis, Ott. 15	tr.	tr.	tr.	1	3	tr.	45	65	65	60	63	68	40	50	70	65	10	tr.	2	tr.	0
Reliance, 7370	tr.	tr.	tr.	tr.	1	tr.	45	65	65	58	60	65	35	50	70	65	5	tr.	tr.	0	0
*Ma. x KO. 1656	tr.	0	0	0	tr.	tr.	2	10	35	20	40	55	15	35	72	48	tr.	tr.	tr.	0	0
*Ma. x KO. 1656-81	.....	.....	0	0	.....	.....	.....	tr.	25	20	40	45	10	38	.....	48	.....	.....	.....	.....	.....
Reward	.....	tr.	.....	.....	3	tr.	15	.....	55	.....	.....	.....	.....	.....	70	.....	3	2	tr.	tr.	0
Parker's	tr.	tr.	tr.	tr.	tr.	tr.	15	15	40	58	59	55	20	43	68	58	3	tr.	tr.	0	0
Webster, 3780	.....	tr.	0	0	0	0	15	15	55	10	6	55	20	42	78	42	tr.	0	tr.	0	0
*McFadden's Emmer (H-44-24)	.....	0	0	0	0	0	tr.	tr.	tr.	0	4	18	25	3	10	tr.	0	0	tr.	0	0
Little Club, 4066	5	30	tr.	30	30	tr.	30	80	66	55	60	55	40	40	92	68	4	tr.	tr.	0	0
*Khapli, 4013	.....	.....	0	0	tr.	0	.....	tr.	20	0	2	25	20	20	12	30	tr.	3	tr.	0	0
*Vernal, 3686	0	0	0	0	0	0	tr.	0	0	0	0	tr.	0	0	5	10	0	0	tr.	0	0
Einkorn, 2433	0	0	0	0	tr.	tr.	tr.	tr.	10	0	10	20	3	5	5	5	0	2	tr.	0	0
*Physiologic forms isolated**																					
	36	21	21	36	17	14	17	21	9	21	15	17	21	21	15	36	36	21	21	36	
	.....	30	36	C	21	21	21	34	17	36	21	21	36	36	17	.....	.....	36	36	.....	.....
	.....	36	.....	.....	36	.....	30	36	21	B	36	29	C	.....	21	.....	.....	.....	B	.....	.....
	.....	C	.....	.....	.....	.....	36	.....	30	D	.....	36	.....	.....	36	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	32	.....	.....	C	.....	.....	.....	.....	.....	.....	.....	.....	.....

(1) Manitoba and Western Nurseries read by Margaret Newton.
Eastern Nurseries read by Dr. H. B. Humphrey, U.S. Dept. of Agric., and D. L. Bailey.
Results summarized by M. Newton and T. Johnson.

*The pustules on these varieties were consistently small.

The rust percentages were estimated by the scale devised by the Office of Cereal Crops and Diseases, U.S.D.A.

*Forms 34, 36, B, C, D, E, & F were also found at Winnipeg. Forms B, C, D, E, & F are physiologic forms isolated at this laboratory, which differ from all of those reported by Stakman & Levine, and which have not yet been assigned a number by them.

of Canada, and yet forms which the plant breeder must know, if he is to develop a wheat or oat resistant to all the common physiologic forms.

In epidemiology studies also these nurseries have played a significant role. The extreme northern limit for stem rust has never been clearly defined. This year an attempt was made to study this question, and a rust nursery was placed at Beaver Lodge in the Peace River district. A subsequent examination of the varieties in this nursery revealed stem rust on five wheat varieties there, although no trace of rust could be discovered in any of the nearby fields. Had this nursery of late sown varieties not been placed there, it would not yet be known that viable rust spores could be carried as far north as the Peace River district, and there cause infection.

In tables 13 and 14 are summarized the percentages of stem rust on 18 varieties of oats and 25 varieties of wheat grown in the uniform rust nurseries at 21 stations in Canada in 1927, with a record of the physiologic forms isolated at each. The very resistant varieties are marked by an asterisk.

DUSTING WITH SULPHUR FOR THE CONTROL OF LEAF AND STEM RUST OF WHEAT IN MANITOBA

(D. L. Bailey and F. J. Greaney.)

Winnipeg Fortieth-Acre Plot Experiments

The experiments of this type, which have been carried on during the last two years here, have established[1] the effectiveness of sulphur dust in controlling leaf and stem rust of wheat, and have told us something as to the limits of the effectiveness of this method of rust control under the conditions of the experiments. However, the feasibility of sulphur dusting as a practical method of controlling rust depends partly on whether comparable results can be obtained by the same procedure in different years. For this reason the fortieth-acre plot experiments, dealing with the effectiveness of various rates and frequencies of dusting, were extended and repeated this year. Additional experiments were included to determine the influence of (1) the time at which dusting was begun, in relation to the stage of development of the rust epidemic, and (2) the addition of an oxidizing agent to the sulphur dust.

EXPERIMENTAL METHODS

A field of heavy clay loam, on which corn was grown last year, was sown with Marquis wheat on June 10. About a month after sowing, the field was divided into fortieth-acre plots, which were separated from each other by three-foot pathways. The plots were laid out in long narrow rectangles, 136 feet by 8 feet, and this made it possible to dust them thoroughly from the pathways without injuring the stand.

The dusting was all done with a hand duster of the blower-gun type (fig. 2). With such a duster it was not possible to apply a specific rate of application, such as 15 or 20 pounds of dust per acre, with absolute accuracy, but it was found that a satisfactory approximation to any desired rate could be obtained. The Niagara Sprayer Company's Kolo-dust was used throughout the experiments.

Dusting was begun on July 18, at which time only a light scattered infection of leaf and stem rust was to be found. Final data on leaf rust infection were taken on August 24, and the percentage of stem rust infection was read on September 13. In each case the percentages of infection were determined by Dr. Margaret Newton and Mr. T. Johnson, without their knowing the treatment which had been given to the various plots.

[1] See Report of Dominion Botanist for the years 1925 and 1926.

Soil moisture was abundant throughout the season, and a rank, succulent growth developed. Extremely heavy epidemics of both leaf and stem rust occurred, and this combined with the lateness of the crop to make the test unusually exacting.

Eight undusted check plots were scattered through the 40 plots in such a way that each plot was touching a check at least on one corner.

Yield results were secured by harvesting and threshing 3 rod-rows selected at random from each plot. The weight per bushel was determined, as well as the yield per acre, and the threshed samples were graded for quality according to the Dominion Government standards by Prof. T. J. Harrison.

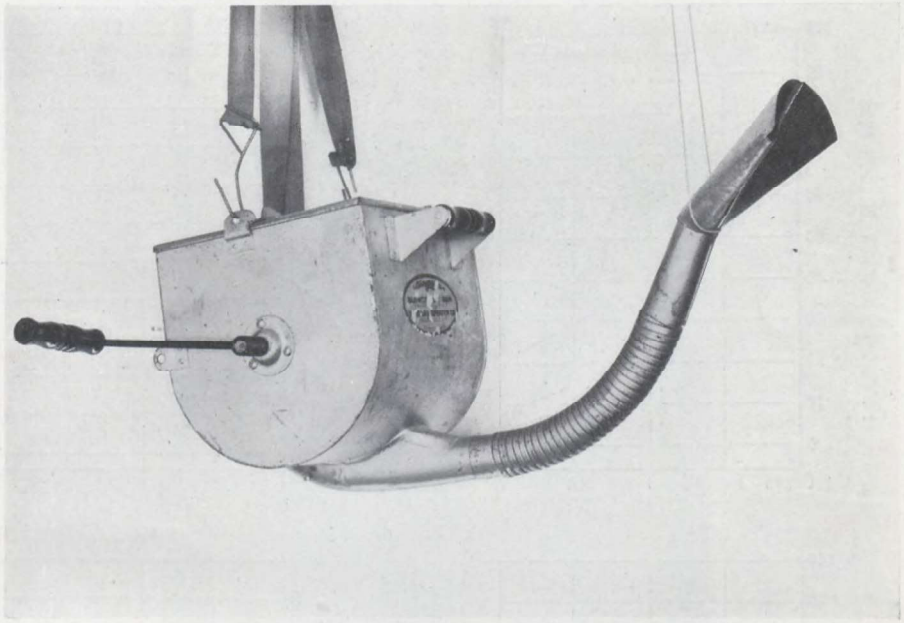

FIG. 2.—The type of hand-duster (Niagara Blower Dust Gun No. 42) used in the small plot sulphur dusting experiments. The duster is suspended by cross straps from the shoulders of the operator. The fan is rotated by means of a crank.

TABLE 15.—RESULTS OF DUSTING WHEAT WITH SULPHUR. INFLUENCE OF THE RATE AND FREQUENCY OF APPLICATIONS ON RUST INFECTION, YIELD, AND QUALITY OF GRAIN

Applications of sulphur dust			Percentage infection			Yield and quality results			
Rate lb. per acre	Frequency number per week	Total number	Leaf rust	Stem rust		Yield of grain per rod row	Weight per measured bushel	Canadian Government grade	Yield per acre in bushels
			Average	Range	Average				
						grammes	lb.		
Checks (a)	0	0	62	60–95	87	62·9	45	Feed	12·2
15	Fortnightly	4	42	50–85	75	79·6	46	Feed	15·4
15	1	8	32	25–45	35	173·6	54	5	33·4
15	2	16	22	20–45	30	172·0	56	4	33·3
15	3	24	21	10–30	20	207·3	60	3N	39·2
Checks (a)	0	0	62	60–95	87	62·9	45	Feed	12·2
30	Fortnightly	4	53	40–75	65	80·6	48	Feed	15·5
30	1	8	30	20–60	35	106·6	54	5	20·6
30	2	16	20	5–20	15	157·3	53	5	30·5
30	3	24	20	tr–15	8	220·0	54	5	42·6
Checks (a)	0	0	62	60–95	87	62·9	45	Feed	12·2
45	Fortnightly	4	30	30–70	50	124·6	51	6	24·7
45	1	8	25	25–50	35	124·3	55	5	25·0
45	2	16	25	5–15	10	172·6	53	6	33·4
45	3	24	15	tr–8	4	252·3	56	5	48·9

(a) Average of eight undusted plots ....

EXPERIMENTAL RESULTS

I. Relative Efficiency of Different Rates and Frequencies of Dusting

Four plots were dusted with 15 pounds of Kolo dust per acre, one at each of the following frequencies—once every two weeks, and once, twice, and three times per week. Four other plots were dusted at the same intervals but at the rate of 30 pounds Kolo dust per acre, instead of at 15. A third series was dusted with the same frequencies, but at the rate of 45 pounds Kolo dust per acre. Dusting was commenced on all three series on July 18, and was continued until September 9, when the crop was practically mature.

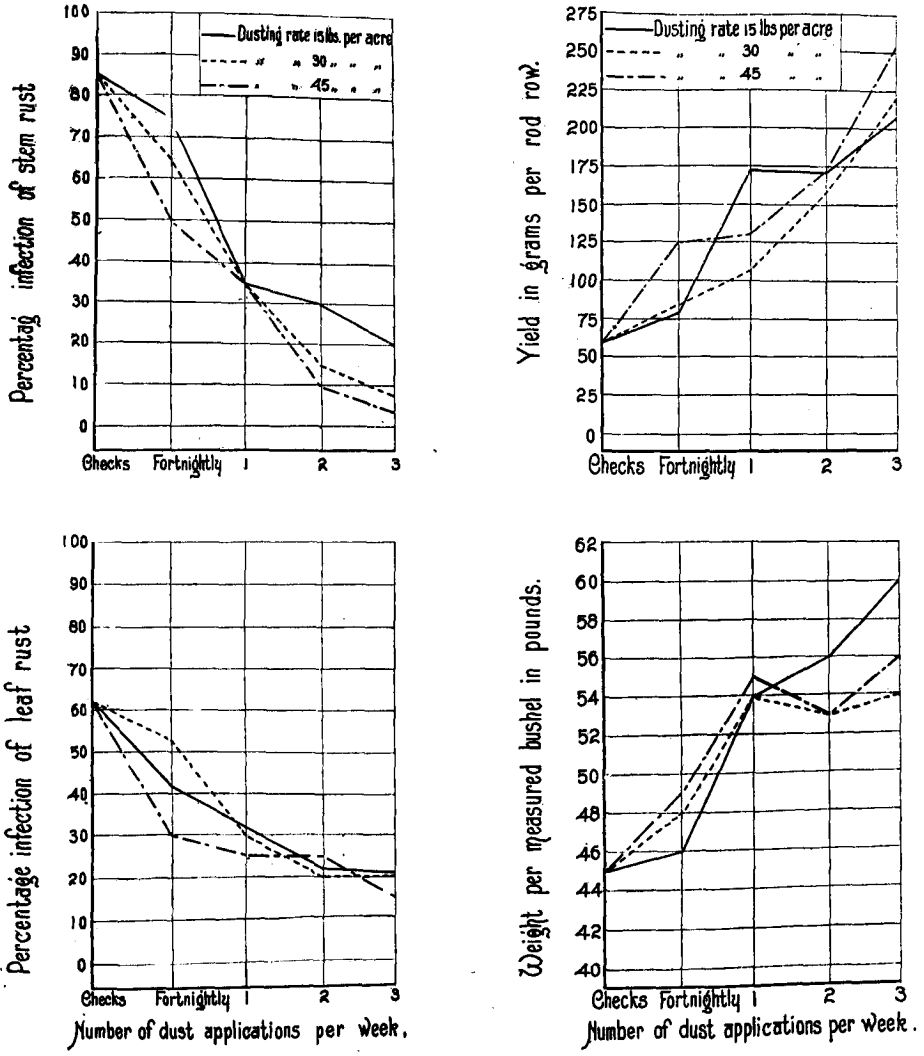

FIG. 3.—The relation between the rate and frequency of application of sulphur dust and (1) the percentage infection of stem rust, (2) the percentage infection of leaf rust, (3) the average yield of one rod-row from each plot, and (4) the weight per measured bushel of the threshed grain of each plot.

The results of this experiment are summarized in table 15 and presented graphically in fig. 3 (1-4). Taken as a whole, these results are a striking confirmation of those obtained previously, and indicate conclusively that, if sulphur is applied in sufficient amounts and with sufficient frequency, it can be relied on to control effectively both leaf and stem rust of wheat, even under the most favourable conditions for rust attack.

The most perfect control was achieved by the heaviest application at the greatest frequency, i.e., by 45 pounds per acre applied three times per week. The stem rust infection in this case was 4 per cent as compared with 87 per cent, which was the average of eight undusted plots. Leaf rust was likewise controlled to a remarkable extent by this treatment. The degree of leaf and stem rust control is clearly indicated in figs. 1 and 2. It will be noticed further that, with each particular rate of application, the effectiveness of the control achieved increased with the increased number of applications.

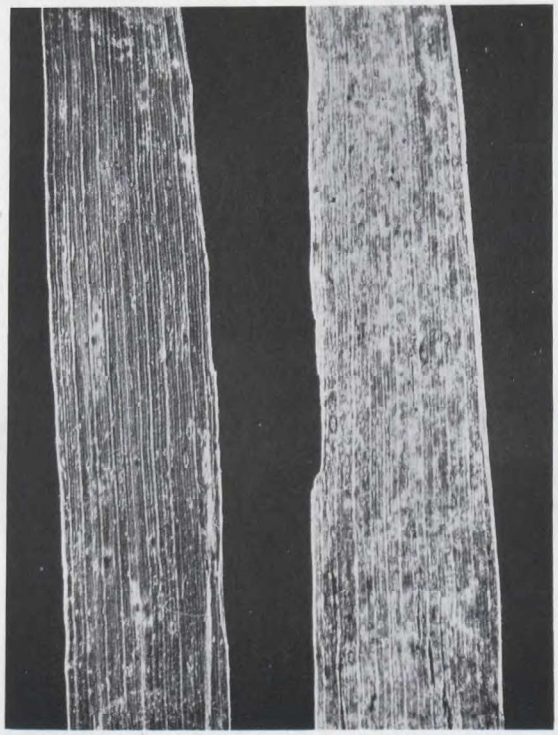

FIG. 4.—The effectiveness of sulphur dust in controlling leaf rust of wheat, *Puccinia triticina*, under conditions of a natural epidemic in 1927. (Left) Leaf from plot of Marquis wheat dusted tri-weekly at the rate of 30 lb. of sulphur per acre. (Right) Leaf from plot of Marquis wheat grown under similar conditions, but which remained undusted.

The only fortnightly application which was significantly effective was the 45 pounds per acre one. This decreased the percentage infection of stem rust, as compared with the checks, from 87 to 50 per cent and increased the yield from 12 to 24 bushels per acre. The results from this treatment compare favourably with the weekly applications (except the 15 pounds per acre one) in yield, but not in the reduction in percentage infection.

Weekly applications gave consistent results and were surprisingly effective in controlling rust and increasing yield. The yield in the case of the 15 pounds per acre application (33·4 bushels per acre) has almost certainly been exaggerated by some factor other than rust control. Judging from the percentage infection among the weekly applications, 15 pounds per acre is as effective as the heavier ones. However, since this plot was located between plots which received frequent heavy applications, some of the result may be due to its position. Hence it does not seem wise to base conclusions on this result.

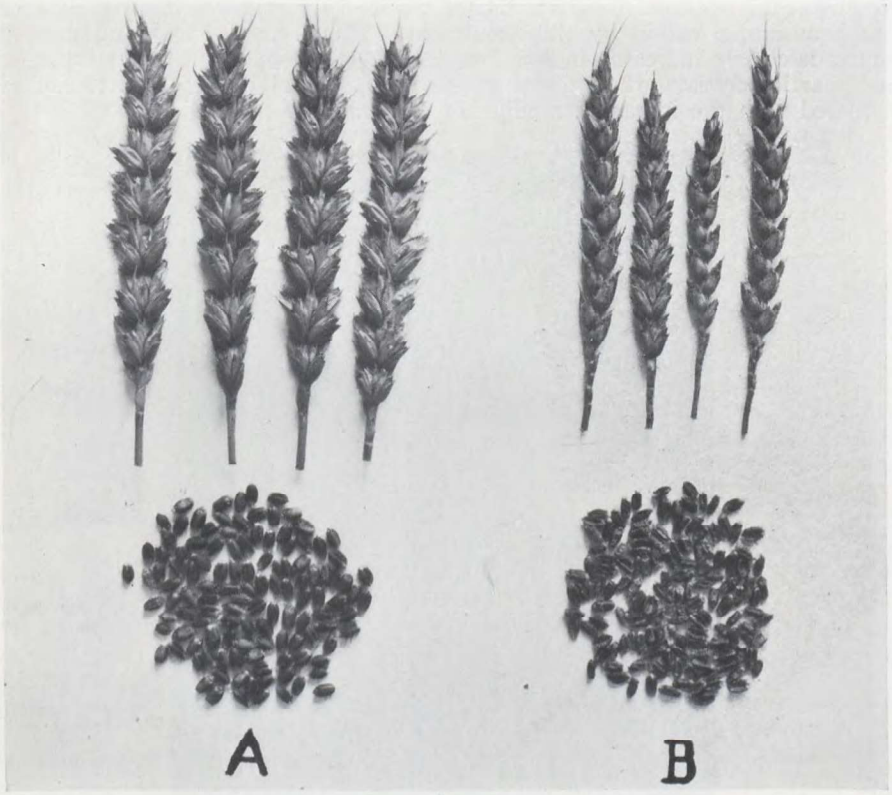

FIG. 5.—The effect of controlling rust by sulphur dusting on the size and plumpness of heads and kernels of Marquis wheat plants grown in 1927. A—Heads and kernels of Marquis wheat plants dusted tri-weekly at the rate of 30 lb. per acre. B—Heads and kernels of Marquis wheat plants grown under the same conditions, but which were not dusted.

Bi-weekly applications at the heavier rates (30 and 45 pounds per acre) significantly decreased infection and increased yields, as compared with the weekly applications. At 15 pounds per acre there was little difference in rust infection between the weekly and bi-weekly applications.

Tri-weekly applications at each rate caused a sharp decrease in rust infection and a marked increase in yield, as compared with the bi-weekly ones. As pointed out previously, it was with three applications per week at 45 pounds sulphur dust per acre that the most perfect rust control and the greatest increase in yield were secured. Therefore, if the most perfect control of rust is the objective, this is the best treatment of all those tried.

From a practical standpoint, however, the objective is not the most perfect control of rust, but rather that degree of rust control which, considering the cost of achieving it, gives the greatest net return from the operation. It is interesting to look at the results from that point of view and to attempt to choose the treatment which promises the best practical results. In comparing these results, wherever the yield is inconsistent with the percentage infection, the rust reaction should be considered in preference to yield, since the plots were not replicated. The cost of carrying out any treatment, requiring three applications of dust per week for a period which in Manitoba will probably average five or six weeks, will certainly be prohibitive. Two applications per week might possibly be applied, but they are to be considered only if the results obtained thereby are decidedly better than those obtained by one application per week. This matter cannot be decided definitely from the available data, and in general use may perhaps have to be decided in each case by the means employed to apply the dust and the environmental conditions which prevail. For a bad rust year like 1927, it would seem from these data that two applications per week at the rate of 30 pounds per acre should be applied if possible and, if one application per week is being used, the rate should be increased to 45 pounds per acre. It is obvious, however, that a great deal more work must be done before we can generalize on what constitutes the optimum rate and frequency for the most effective practical control. It may even be that this can only be stated in terms of a particular season, and that satisfactory generalizations can never be made.

The Influence of the Time at Which Dusting is Commenced on the Control Achieved

In the experiments already described, dealing with the effect on rust control of different rates of application and different frequencies of dusting, the first application was made on July 18, at which time only a very light scattered trace of rust had appeared. Further experiments were undertaken to determine whether equally satisfactory control could be achieved, if dusting were commenced at various stages later in the development of the rust attack. Accordingly, dusting was commenced on July 25 on a series of three plots, which were dusted subsequently at the rate of 15 pounds of dust per acre, once, twice, and three times per week respectively, until September 9. At this time 40 per cent of the plants were carrying an infection ranging from a trace to 5 per cent. A second similar series was dusted first on August 8, when 90 per cent of the plants were infected with from a trace to 20 per cent infection. On August 15 another series of three plots was dusted at the rate of 45 pounds per acre. From August 15 to September 9, these three plots were dusted at the following frequencies, fortnightly, weekly, and bi-weekly. By August 15 practically all the plants were infected in undusted plots. Stem rust infection ranged from 30 to 45 per cent, while that of leaf rust was from 50 to 55 per cent.

The results of these experiments are summarized in table 16, and presented graphically in fig. 6, (5-8). It will be noticed that the earliest series, which was dusted first on July 18, gave very much better results throughout all the different frequencies of dusting and rates of application than did any of the later series. Even in the second series, in which dusting was started only a week later than the first, it required three applications per week to achieve the same measure of control as was achieved by weekly applications in the earlier series. In the very late series, which was dusted first on August 8, the application of 45 pounds sulphur dust twice per week failed to produce significant results.

These results emphasize the importance of making the first application of dust as soon as possible after rust first appears. Apparently early dusting prevents the accumulation of large amounts of inoculum, and makes the control

TABLE 16.—RESULTS OF DUSTING WHEAT WITH SULPHUR. INFLUENCE OF TIME OF INITIAL APPLICATION ON LEAF AND STEM RUST INFECTION, YIELD, AND QUALITY OF GRAIN

Date of initial application	Dusting period—July 18th-September 9th			Percentage infection			Yield and quality results			
	Rate of application	Frequency of application. Number per week	Total number of applications	Leaf rust	Stem rust		Weight in grammes per rod row	Weight per measured bushel	Canadian Government grade	Yield per acre in bushels
				Average	Range	Average				
							grammes	lb.		
July 18	15	1	8	35	25–45	35	173·6	54	5	33·4
July 25	15	1	7	45	40–80	65	136·0	51	6	26·4
Aug. 8	15	1	5	40	40–70	65	92·6	49	Feed	17·9
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2
July 18	15	2	16	22	20–45	30	172·0	56	4	33·3
July 25	15	2	14	45	35–60	45	127·0	54	5	24·6
Aug. 8	15	2	10	60	36–75	60	69·6	47	Feed	13·5
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2
July 18	15	3	24	21	10–30	20	220·0	60	3N	39·2
July 25	15	3	21	45	20–40	30	164·3	57	4	31·8
Aug. 8	15	3	15	45	25–60	40	169·3	54	6	32·8
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2
July 18	45	Fortnightly	4	30	30–70	50	124·6	51	6	24·1
Aug. 15	45	Fortnightly	2	62	40–80	65	81·3	45	Feed	15·8
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2
July 18	45	1	8	25	28–50	35	129·3	56	5	25·0
Aug. 15	45	1	4	65	40–75	65	69·6	44	Feed	13·5
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2
July 18	45	2	16	25	5–15	10	172·6	53	6	33·4
Aug. 15	45	2	8	60	40–90	65	73·6	46	Feed	14·3
Checks (a)	0	0	0	63	50–95	87	62·9	45	Feed	12·2

(a) average of 8 untreated check plots.

of rust subsequently relatively easy. The time at which dusting can be discontinued safely will likewise depend on the amount of rust present in the dusted crop and the weather conditions which prevail. In most cases it will be advisable to continue dusting almost to the time when the crop matures.

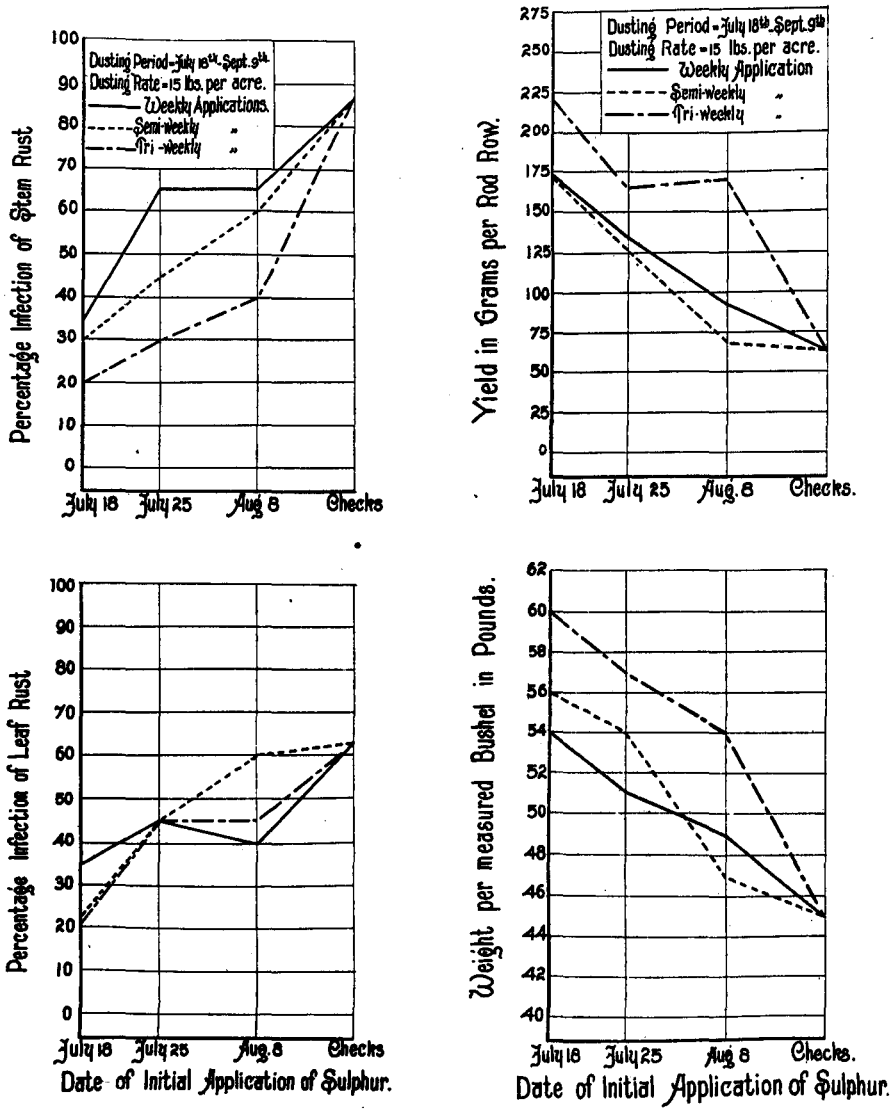

FIG. 6.—Influence of the time of initial application of sulphur dust at the rate of 15 pounds per acre, and at different frequencies, on (5) the percentage infection of stem rust of wheat, (6) the percentage infection of leaf rust of wheat, (7) the average yield of one rod-row from each plot, and (8) the weight per measured bushel of the threshed grain of each plot.

The Influence on Rust Control of the Addition of an Oxidizing Agent to Sulphur

It has been reported by Lee and Martin (Science N.S. LXVI, 1703, p. 178, Aug. 19, 1927), that the addition of oxidizing agents to sulphur greatly increased its effectiveness in controlling eye-spot of sugar cane in Hawaii. To see whether a similar result could be obtained when using sulphur for rust control, two fortieth-acre plots were dusted weekly from July 18 to September 9, at the rate of 15 pounds per acre with sulphur dust to which one per cent of potassium permanganate was added. These plots were compared with adjacent plots dusted at the same times and at the same rates with Kolo-dust.

Slightly better control was achieved by the addition of the potassium permanganate but the difference was not striking. Further experiments along this line are desirable.

FIELD TRIALS

A. Horse Drawn Dusters

Some preliminary experiments on field dusting with a horse-drawn duster for the control of stem rust were conducted in Manitoba in 1926. Although very little rust developed, the results obtained from these trials indicated the possibility of applying sulphur dust thoroughly and practically by means of horse-drawn dusters. This phase of the sulphur dusting investigations was continued this year using two power dusters, which were loaned for that purpose by the Niagara Sprayer Company, of Middleport, New York.

Field trials were carried out in 1927 on the Manitoba Agricultural College farm at Winnipeg, and at Graysville, Manitoba, on the farm of Mr. Alex. Murray. Kolo dust, which is produced by the Niagara Sprayer Co., was used in all the experiments.

The writers wish to express their appreciation to the Niagara Sprayer Co. for the loan of the machines, and to Mr. Alex. Murray for his splendid co-operation and for his helpful advice and criticism throughout the experiments at Graysville.

Winnipeg Field Trials

METHODS

The Winnipeg field was located on the Agricultural College farm, and was a heavy clay loam which had grown corn the previous year. This field was sown with Marquis wheat on June 10, and the initial stand and subsequent development appeared quite uniform over the entire area. The field was divided into four acre-plots separated from each other by seven-foot roadways. Dusting was done from these roadways to avoid tramping down any grain during the operation.

Dusting was begun on July 18 and was continued for eight weeks, the last application being made on September 8. An effort was made to determine the effect of the frequency and rate of application of Kolo dust on the control of leaf and stem rusts. One plot was dusted twice per week during the whole eight weeks at the rate of 15 pounds per acre. Another plot received eight weekly applications at the rate of 30 pounds per acre. Dusting was not begun on the third plot until August 15, four weeks later than in the previous ones. It was dusted at the rate of 45 pounds to the acre, and received subsequently three weekly applications at the same rate. The fourth plot was undusted as a check.

When dusting was begun on July 18, rust was just beginning to show up in the field. By August 15, when the third plot was first dusted, practically all the plants in undusted plots were infected. The stem rust infection ranged from

30 to 45 per cent, while that of leaf rust was from 50 to 55 per cent. Rust developed rapidly during the early part of August, and before the end of the growing season severe epidemics of both leaf and stem rust had occurred.

The Kolo dust was applied with the same horse-drawn traction duster which was used last year. Fig. 7 shows this machine in operation.

The particular combination of circumstances at Winnipeg made these trials a severe test of the efficiency of this method of rust control. Rust appeared before the wheat was headed out and developed quickly in epidemic form. Therefore the late crop had to be protected from a heavy rust attack throughout the greater part of its growing period.

Rust infection was estimated as usual on the percentage basis. Final data on leaf rust were taken on August 23, and those on stem rust on September 13.

Yield data were obtained by harvesting twenty rod-rows from each plot. The average of these twenty samples was used in calculating the yield of each plot in bushels per acre.

FIG. 7.—Horse-drawn traction dusting machine (Niagara Traction Crop Duster C-26-P) in operation. A cloud of dust is discharged through a flexible delivery tube, 5 inches in diameter.

RESULTS

The results of the Winnipeg experiments are summarized in table 15. The cost of the various treatments in relation to the results obtained therefrom is given in table 18.

Fifteen-pounds-per-acre applications of sulphur dust, applied twice per week for eight weeks, resulted in a marked reduction in both leaf and stem rust and a decided improvement in yield and grade, as compared with the undusted check plot. The increase in yield was 18·7 bushels per acre, and the grade was No. 4 as compared with feed wheat. The low grade of the dusted plot is somewhat disappointing, but is due largely to factors other than rust. The weather in late August and early September was cold and wet, and altogether unsuitable for finishing off this late piece of wheat. Frost caused considerable shrinking, and the wet weather spoiled the colour of the sample.

The plot dusted weekly for eight weeks at the rate of 30 pounds per acre yielded as well as the plot dusted twice as often at 15 pounds per acre. Even the plot which received only four weekly applications at the rate of 45 pounds

per acre yielded 11 bushels per acre more than the check. In this instance, however, there was little improvement over the check in the quality of the threshed sample.

From the standpoint of net returns the weekly applications at 30 pounds per acre proved the most profitable, the net increase in value per acre due to dusting being $15.28. This result seems to indicate that heavy enough applications of sulphur dust can be applied to ensure the effective control of stem rust, even under conditions unusually favourable to its development, without sacrificing the practicability of the treatment.

GRAYSVILLE FIELD TRIALS

Methods

This trial was carried out on the farm of Mr. Alex. Murray, who sowed a nine-acre field with Marquis wheat specially for the experiment. The field was one half-mile long by nine and a half rods wide. Across one end of the field an area slightly less than an acre was left undusted as a check.

The remaining eight acres were dusted six times at the rate of 25 pounds to the acre. The first dusting was done on July 21, at which time only about 60 per cent of the wheat was headed, and leaf and stem rust were easily found. By July 29 about 50 per cent of the plants were lightly infected with stem rust. Dust was applied twice per week from July 21 to August 13. During this period conditions were most favourable for rust, and a severe epidemic of both leaf and stem rust developed.

The dust was applied by a Niagara "Aero Duster" specially modified for cereal dusting. This duster was mounted on a platform on two high wheels, and the outfit was equipped with a 5 h.-p. New Way engine. The dust was discharged through a five-inch blower pipe which oscillated from side to side and distributed the dust, as the machine was drawn through the crop by a team of horses. Ordinarily this machine dusted effectively a swath thirty feet wide, and, if the air were calm, a forty-foot strip could be covered satisfactorily.

The percentage infection in the dusted and undusted areas was determined on August 25. Yield data were obtained through the courtesy of Mr. Murray, who harvested and threshed separately the dusted and undusted parts of the field. The threshed samples were graded by the local elevator operator.

Results

The results of this experiment are summarized in table 17. The cost of the treatment in relation to the results obtained is given in table 18. The average infection of stem rust in the dusted area was 35 per cent as compared with 85 per cent in the undusted area. Dusting increased the yield by 12 bushels per acre and the grade from No. 5 to 3 Northern. This represented a net increase in crop value per acre of $11.87, due to the control of rust through dusting with sulphur. The cost data are based on current labour costs and the time which Mr. Murray spent in making the six applications. The result would have been even better had the crop ripened more quickly, or if another application of dust had been applied. The last dusting on August 13 was followed on August 14 by a heavy rain. Unfortunately the supply of dust was exhausted by this time, and further applications were impossible. The crop was not cut until September 6, and between August 10 and September 6 the rust developed considerably.

DISCUSSION

The results obtained in the control of wheat stem rust through the application of sulphur dust with horse-drawn dusters are a convincing demonstration of the practical possibilities of this method of rust control. The Graysville results of a trial which was carried out by a farmer on his own farm

TABLE 17.—RESULTS OF SULPHUR-DUSTING WHEAT WITH HORSE-DRAWN DUSTERS FOR THE CONTROL OF LEAF AND STEM RUSTS

District	Treatment	Size of plot in acres	Applications of sulphur dust			Percentage infection			Yield and quality results		
			Rate—lb. per acre	Frequency number per week	Total number	Leaf rust	Stem rust		Weight in lb. per measured bush.	Canadian Government grade	Yield per acre in bush.
						Average	Range	Average			
Graysville, Man.....	Dusted.....	8	25	2	6	60	15–55	35	60	3	22·6
	Undusted.....	1·1	0	0	0	65	65–90	85	53	5	10·3
Winnipeg, Man.....	Dusted.....	1	15	2	15	50	10–50	35	58	4	29·5
	Dusted.....	1	30	1	8	60	20–50	40	56	4	30·2
	Dusted.....	1	45	1	4	63	45–65	55	51	6	21·8
	Undusted.....	1	0	0	0	70	65–95	90	44	Feed	10·8

TABLE 18.—AN ANALYSIS OF THE COST OF VARIOUS TREATMENTS IN RELATION TO THE RESULTING INCREASE IN YIELD

District	Treatment	Size of plot in acres	Applications of sulphur dust			Yield in bushels per acre	Canadian Government grade	Value per bushel (a)	Per acre				
			Rate—lb. per acre	Frequency—number per week	Total number				Value of crop	Cost of sulphur used	Cost of applying sulphur (b)	Net value of crop	Increase over checks
								$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Graysville, Man....	Dusted.....	8	25	2	6	22·6	3	1 26	28 48	5 25	0 75	22 48	11 87
	Undusted.....	1·1	0	0	0	10·3	5	1 03	10 61	0 00	0 00	10 61	0 00
Winnipeg, Man.....	Dusted.....	1	15	2	15	29·5	4	1 14	33 63	7 85	3 75	22 03	13 28
	Dusted.....	1	30	1	8	30·2	4	1 14	34 43	8 40	2 00	24 03	15 28
	Dusted.....	1	45	1	4	21·8	6	0 92	20 06	6 30	1 00	12 76	4 01
	Undusted.....	1	0	0	0	10·8	Feed	0 81	8 75	0 00	0 00	8 75	0 00

(a) Winnipeg cash prices, Oct. 20th, 1927.

(b) The depreciation of dusting machine is not included.

are especially convincing. It seems certain that this method of rust control will be widely introduced and extensively used as soon as a thoroughly satisfactory cereal duster is developed.

The duster used this year at Graysville, while it is the best that is available and is a satisfactory machine in many respects, is not well suited to large-scale, cereal dusting. The distribution was not sufficiently uniform and the swath effectively dusted was too narrow.

Field results this year indicated that the crop has to be thoroughly covered with sulphur each time it is dusted, if rust is to be satisfactorily controlled. This was evident both at Graysville and at Winnipeg. At Winnipeg, where the acre-plots were dusted from roadways, which went all around each

FIG. 8.—Dusted and undusted sections of a field of Marquis wheat at Graysville, Manitoba, Sept. 13th, 1927. A—Section of field dusted semi-weekly for a period of three weeks at the rate of 25 lb. of sulphur per acre. Note the erectness of the dusted plants, and also the size and plumpness of heads. B—A strip of the same field not dusted. Note the small, unfilled heads, and the characteristic breaking of the heavily rusted straw. A yielded 12 bushels per acre more than B, and the grades were 3 Northern and 5 respectively.

plot, the central part of one plot was a little beyond reach of the duster. This central strip rusted heavily, although on the rest of the plot rust was satisfactorily controlled. At Graysville the first swath was laid down thirty feet into the field from the outside edge. This left a strip about twelve feet wide on the outside which was beyond the effective reach of the machine. This strip rusted just as heavily as the completely undusted check plot (see fig. 8).

The ideal duster, therefore, must dust uniformly a swath at least 50 feet wide, and must be so built that a minimum of mechanical injury is done to the standing crop during dusting operations. A tractor duster with narrow high wheels, and equipped with a high-power duster attachment, appears most desirable, if it can be produced at a reasonable cost. With the effectiveness of the treatment no longer in doubt, the solution of the mechanical difficulties incidental to the development of a satisfactory duster for cereal dusting should be easily surmounted.

FIG. 9.—The Huff-Daland plane used for sulphur dusting operations. The dust hopper is immediately in front of the cockpit from which the machine is controlled.

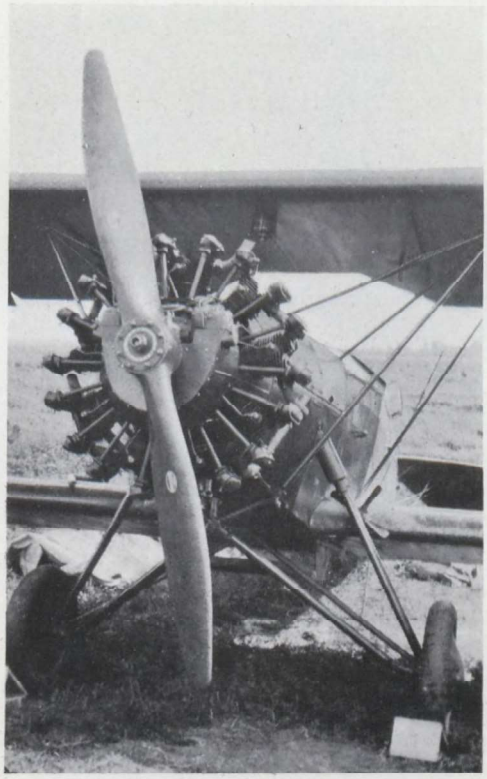

FIG. 10.—Huff-Daland plane. The distributer through which the dust is discharged is shown projecting below fusilage. Dust delivery is controlled by the pilot. The small propeller turns the agitator inside of the hopper.

Aeroplane Dusting

The success which has attended aeroplane dusting for boll weevil control suggested aeroplane dusting as a feasible method of using sulphur for controlling rust over large acreages.

Accordingly aeroplane sulphur dusting was undertaken this year in Manitoba in a series of co-operative experiments between the Royal Canadian Air Force and the Dominion Rust Research Laboratory. The Air Force supplied for these experiments a new Huff-Daland dusting plane, similar to those recommended in the cotton dusting work.[1] This plane was under the very able direction of Flying Officer T. M. Shields. Areas of approximately 250 acres each were chosen for dusting at each of the following localities, Graysville, Portage, and Morden.

Fig. 11.—Loading the dusting plane with sulphur. Hopper capacity 600 lb.

EXPERIMENTAL METHODS

In Manitoba, due to the extremely wet and late spring of 1927, the acreage of common spring wheat was greatly reduced. The task of locating large fields of late-maturing, common wheats, suitable for aeroplane dusting experiments, and in close proximity to a satisfactory landing base, was a difficult one. It was necessary to divide each district into three or four dusting areas. In this way it was possible to select fields of Marquis wheat for dusting purposes, and to have in close proximity to them fields of the same variety, growing under similar conditions, which could be left undusted for controls. In each dusting area the check field was either a portion of the field under experiment which was left undusted, or an adjoining field of the same variety, very similar in stage of maturity and type of growth, and subject to the same environment.

All of the dusting was done with the same plane, the Huff-Daland duster mentioned above. This machine had a hopper capacity of 600 pounds but the agitator did not work properly if more than 400 pounds were used at a time. The dust was released at heights of 15 to 25 feet over the crop depending on the

[1] Post, G. B. Boll Weevil Control by Airplane. Georgia State College of Agr. Bull 301, 1924.

atmospheric conditions. The average speed of the plane while dusting was around 100 miles per hour. Evening was found to be the most satisfactory time for dusting, because, as a rule, there was no wind then, and the dust settled uniformly and with very little drifting. Very unsatisfactory results were obtained if a wind of ten miles per hour or over were moving. The actual time

FIG. 12.—Dusting plane approaching the camera, showing the downward trend of the dust cloud.

of releasing the dust was the shortest part of the operation, most of the time being consumed turning at the ends of fields and coming down for new loads.

Field results on dusted and undusted areas were taken from the yield of 20 rod-rows chosen at random throughout the field. The yields which were actually obtained from field threshing were also secured.

All threshed samples were graded for quality according to the Dominion Government grades.

Experimental Results

MORDEN DISTRICT

Six fields of Marquis wheat comprising an area of 220 acres were dusted in this district. The first application was made on July 13, at which time a light trace of stem rust was general, and leaf rust was well established.

Area I

In this area two fields, one of 20 acres and the other of 70 acres, were dusted. The first of these received five applications six days apart, while the second was dusted four times at weekly intervals. On the 20-acre field the rate of application was approximately 15 pounds of sulphur per acre, and on the 70-acre one, about 12 pounds per acre were used. An eleven-acre strip of the 70-acre field was used as a check in the one case, while an adjoining 30-acre field was used for comparison with the 20-acre field.

Neither the yield nor the grade of the 70-acre field were influenced by dusting, although rust was slightly less severe than in the check. The 20-acre field yielded 8 bushels per acre more than its check, weighed 4½ pounds per bushel more, and graded 4 as compared with 5 for the check.

Area II

This area was made up of three adjoining fields of 40, 40, and 30 acres. While this gave a continuous stretch of over a mile, it was not altogether satisfactory since a road allowance with telegraph poles, and scrub growing along a fence made some difficulty in finishing the ends of two of the fields. These fields were dusted four times at weekly intervals, and at the rate of 12 pounds of sulphur to the acre. One field was given one additional application.

Area III

This consisted of a late 20-acre piece of Marquis, which was dusted only twice, relatively late in the season. The first application was made on July 29, and the second on August 9, and approximately 20 pounds per acre were applied each time. Four acres of the same field were so located that they could be left undusted as a check.

The two dustings carried out here had very little influence on the final rust infection or on the yield, though they may have slightly influenced the grade of the sample.

Table 19.—Results of Dusting Marquis Wheat with Sulphur by Aeroplane for the Control of Stem Rust at Morden, Man.

Area	Treatment	Acres	Dusting Period, July 13–August 9			Percentage infection of stem rust		Yield and quality results			
			Rate of application lb. per acre	Interval between applications in days	Total number of applications	Range	Average	Weight per measured bushel lb.	Canadian Government grade	Yield per acre in bush.	Field results (a) yield per acre in bush.
1	Dusted	20	15	6	5	30–75	60	60	4	20·6	18
	Undusted	30	0	0	0	65–85	80	55·5	5	9·7	10
	Dusted	70	12	7	4	60–85	75	58	4	18·8	17
	Undueted	11	0	0	0	60–95	85	56	4	18·1	17
2	Dusted	40	12	7	5	20–85	55	61	3	17·1	17
	Dusted	40	12	7	4	10–65	45	63	3	35·6	20
	Dusted	30	12	7	4	25–75	55	61	3	28·8	16
	Undusted	14	0	0	0	40–80	60	60	3	20·3	17
3	Dusted	20	20	10	2	20–80	45	59	2	19·7	19
	Undusted	4	0	0	0	30–85	45	56	3	16·2	18

(a) Yields obtained from actual field threshing operations.

Conclusion

The results for this district are summarized in table 19. They emphasize the difficulty of obtaining reliable check plots for such experiments. It is practically impossible to leave a part of a field undusted, except where the acreage is large and continuous. With small acreages a certain amount of sulphur inevitably drifts over the check and it is impossible to judge the feed of the sulphur within a few feet when travelling at 100 miles per hour. An adjoining field may be altogether unsuitable for a check. To obtain a further check on the results, therefore, an average yield for the whole district was estimated from a survey at threshing time, and from information obtained from local elevator operators. This average was between eleven and twelve bushels per acre, and practically none of the wheat from the district graded above 3 Northern. As compared with this average, all of the dusted fields showed considerable improvement both in yield and grade.

Taken as a whole, however, the results in the Morden district were disappointing. This was due in part to the unfortunate weather conditions that prevailed when some of the applications were made, and to heavy showers following closely after applications, and thus cutting down their effectiveness. In addition, the rate of application was not heavy enough. While 10 to 15 pounds of sulphur per acre seemed to give satisfactory coverage, it is evident that from 20 to 30 pounds per acre would be necessary to secure results in a season like the past one.

PORTAGE DISTRICT

Approximately 245 acres in four different fields were dusted in this district. One of these was a 110-acre field of Quality. This received four 12-pound-per-acre applications, seven days apart. Rust was well established in the field when dusting was commenced, and field evidence suggested strongly that rust development was satisfactorily checked. The part of this field which was left for a check, however, was thoroughly dusted by mistake, and no satisfactory check was available. A small 10-acre field of Quality situated about a mile from the field yielded about the same as the dusted field, but no conclusion can fairly be drawn from this.

A 45-acre piece of Marquis was dusted only twice, two weeks elapsing between dustings. The rate of application was 15 pounds to the acre. A 20-acre piece was dusted three times, with a seven-day interval between applications, at the same rate. These were dusted for the first time on July 18, at which time only about 40 per cent of the heads had broken through the boot. Following the final dusting, which took place on August 9, weather conditions were favourable to rust development, and were quite unsuitable for finishing off the slowly maturing crop. Therefore, while the rust seemed to be held in check satisfactorily while the dusting was continued, subsequently it developed sufficiently to wipe out the differences between the dusted and undusted areas.

Four applications were made also on a very late 70-acre field of Marquis, which was just beginning to head on July 18 when it was first dusted. The last application was made on August 9, and four weeks elapsed subsequently before the field was cut. By that time rust infection was just as heavy as on the check.

The results for the district are summarized in table 20. That they are negative is not surprising under the circumstances. The crop was late, dusting was stopped before the crop was out of danger of attack, heavy rains followed within a day after two of the applications, and a third was done during a wind. These results indicate quite clearly that dusting must be continued until the crop begins to mature, if positive results are to be secured. They further indicate that heavier applications are essential.

TABLE 20.—RESULTS OF DUSTING WHEAT WITH SULPHUR BY AEROPLANE FOR THE CONTROL OF STEM RUST AT PORTAGE LA PRAIRIE, MAN.

Area	Variety	Treatment	Acres	Dusting period, July 18th–Aug. 9th			The percentage infection of stem rust		Weight per measured bushel	Canadian Government grade	Yield per acre in bushels	Field results[a] Yield per acre in bushels
				Rate of application lb. per acre	Interval between applications	Total number of applications	Range	Average				
					Days				lb.			
1	Marquis.....	Dusted.....	45	15	14	2	60–90	75	58	3N	21·1	23
		Undusted.....	40	0	0	0	60–90	80	58	3N	20·8	20
2	Quality.....	Dusted.....	110	12	7	4	25–80	60	59	3N	34·0	19
		Undusted.....	10	0	0	0	30–90	60	59	3N	32·6	19
3	Marquis.....	Dusted.....	20	15	7	3	50–80	65	57	4	22·1	14
		Undusted.....	30	0	0	0	60–85	75	55	4	14·5	11
4	Marquis.....	Dusted.....	70	15	7	4	30–95	85	54	5	14·3	19
		Undusted.....	12	0	0	0	70–95	85	54	5	15·2	19

[a] Yields obtained from actual field threshing operations.

GRAYSVILLE DISTRICT

Approximately 156 acres of wheat were dusted in this district. Weather conditions were ideal each time dusting was done, and the lay-out of the fields was the most suitable for aeroplane dusting of any of the areas worked with.

Area I

Two fields of Marquis, 75 and 30 acres in extent, were dusted, and 20 acres left undusted for a check. Four 15-pound-per-acre applications were applied at seven day intervals.

The control in this instance was thoroughly satisfactory. The rust infection was 35 and 45 per cent in the dusted fields as compared with 75 in the check. The yields were 22 and 28 bushels of No. 2 and No. 1 Northern wheat, as compared with 13 bushels per acre of No. 5 in the check. If we look at the financial side of this particular instance, we find in one case a difference in yield of 15 bushels per acre and an improvement in grade from No. 5 to 1 Northern through controlling rust. Figuring this out at Winnipeg prices, quoted October 20, 1927, this represents a $42 per acre increase in value through dusting. About 60 pounds of sulphur per acre were used, which would cost not more than $2.50. This leaves surely an ample margin for any reasonable cost of application which is effective.

Area II

A 14-acre piece of Marquis was dusted three times, at weekly intervals, at the rate of 20 pounds per acre, and was compared with an adjoining 30 acres for a check.

The control achieved in this instance was not quite so satisfactory as in Area I, so far as yield was concerned. The dusted field yielded 16 bushels per acre as compared with 12 for the check and the grade was 3 Northern as compared with 6.

Area III

A 37-acre piece of Ruby was dusted twice, with a 7-day interval between the applications, and the first one on July 15. One week after the second application it was obvious that the field was ripening well ahead of the rust, and that further applications were unnecessary.

A nearby piece of Ruby comparable in maturity and stand was used as a check. The dusted field carried an average rust infection of 50 per cent and yielded 23 bushels per acre of 2 Northern wheat. The check was somewhat more heavily rusted and yielded 17 bushels per acre of 3 Northern.

The results from the Graysville district are summarized in table 21. Taken as a whole they are an interesting demonstration of the possibilities of aeroplane dusting, and a sufficient reason for continuing the experiments.

DISCUSSION

The results of these experiments can be evaluated accurately only if they are considered in relation to the season in which they were accumulated. This was truly unusual in several significant respects. In the first place, a very heavy rust epidemic, comparable only with those of 1916 and 1923, occurred and made the test as severe as possible from that standpoint. Also, the rainfall during the months of May, June, July, and August was greatly in excess of the ten-year average for those months, and heavy, dashing rains, usually so uncommon in Manitoba, were frequent. The crop on the whole was very much later than usual, and there was the greatest variation in maturity in

TABLE 21.—RESULTS OF DUSTING WHEAT WITH SULPHUR BY AEROPLANE FOR THE CONTROL OF STEM RUST AT GRAYSVILLE, MAN.

Area	Variety	Treatment	Acres	Dusting period, July 14th–Aug. 3rd			The percentage infection of stem rust		Weight per measured bushel	Canadian Government grade	Yield per acre in bushels	Field results[a] Yield per acre in bushels
				Rate of application lb. per acre	Interval between applications Days	Total number of applications	Range	Average	lb.			
1	Marquis.....	Dusted.....	75	15	7	4	20–70	45	61	2N	33·8	22
		Dusted.....	30	15	7	4	20–65	35	63	1N	40·7	28
		Undusted.....	20	0	0	0	40–95	75	59	5	20·8	13
2	Marquis.....	Dusted.....	14	20	7	3	40–80	65	60·5	3N	29·2	16
		Undusted.....	30	0	0	0	45–95	85	54	6	18·2	12
3	Ruby.....	Dusted.....	37	20	7	2	30–75	50	62	2N	29·0	23
		Undusted.....	18	0	0	0	40–80	65	60	3N	19·2	17

[a]Yields obtained from actual field threshing operations.

any given district. All of these circumstances were conducive to heavy rust infection, and at the same time militated against the success of a dust treatment. The test must, therefore, be considered unusually exacting and severe. There is also the further consideration that the season was definitely unfavourable to finishing off the wheat crop, the yields in the absence of rust were disappointing, and hence the control of rust in many cases did not result in the striking gain in yield which would ordinarily have been expected.

Considering the season and the fact that this was the first season's work on an entirely new venture, the results were distinctly encouraging. The Graysville results were outstanding, those at Morden were not convincing, while the Portage la Prairie ones were disappointing. In every case, with the one pos-

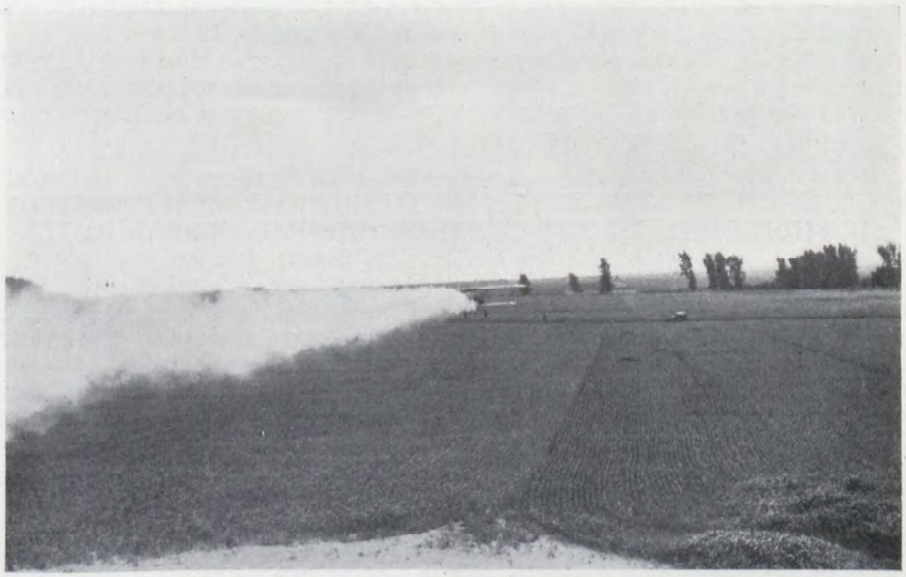

FIG. 13.—Dusting plane in operation, showing the spiral travel of dust caused by rotational flow of air from the propeller. The plane is flying about 20 feet above the wheat plants.

sible exception of the very late field at Portage, however, the dusted fields were significantly better in yield and weight per bushel than the general average of the immediate district in which they were located. The variability in the results emphasizes the importance of four factors, namely, the time of application, thoroughness of application, the rate of application, and the weather conditions following the application. Judging from the Graysville results, if dusting is started in advance of the rust attack, if relatively heavy applications are used, and if no heavy dashing rains occur between dustings, aeroplane sulphur-dusting can be counted on to control rust and to greatly increase the yield. From the negative results at Portage, it is evident that, if it is to be effective, dusting must be continued until the crop begins to mature, and the effectiveness of an application is at an end as soon as a heavy rain occurs. From all of the results it is evident that a heavier application than was used is desirable for aeroplane dusting.

Perhaps the most satisfying feature of the year's results was the convincing demonstration that the aeroplane is so well suited to this work. The rapidity and thoroughness with which large areas can be covered leave nothing to be

desired. Since there is as much flying involved in manoeuvring at the ends of the fields as in the actual dusting, the method is suited essentially to large continuous acreages. It seems probable that the cost of application would be prohibitive on small acreages and, at the speed the plane is travelling, it is next to impossible, in such cases, to govern the flow of dust so as to avoid waste and at the same time ensure proper coverage. Since repeated rust losses have forced a considerable degree of diversification in agriculture in Manitoba, one is apt to find the wheat acreage broken up into blocks of 20 to 50 acres, and this fact may limit the usefulness of aeroplane dusting in certain districts.

The cost of applying the sulphur has not been computed for this season's work, because it would have been of very little significance in relation to the economic possibilities of the method. It seems certain that a three year dusting program at least will be necessary to give this method a fair trial and determine its practicability.

The results obtained already justify the continuance of this work. Profiting by the experience obtained this year, another season's experiments should go a long way toward indicating both the limits of effectiveness and the practical possibilities of aeroplane dusting.

STUDIES ON THE TOXICITY AND FUNGICIDAL EFFICIENCY OF SULPHUR DUSTS IN THE CONTROL OF SOME CEREAL RUSTS

(F. J. Greaney)

Experiments with sulphur dust carried on at this laboratory for the last two years have thoroughly established the effectiveness of sulphur dust in controlling leaf and stem rust of wheat. The application of sulphur dust has given promise of being of considerable practical importance in the control of these diseases. Laboratory and greenhouse studies were carried out to determine some of the factors influencing the efficiency of sulphur dusts in the control of some cereal rusts.

Influence of Sulphur Dust on Spore Germination

A comparative study was made of the inhibitory effects of two forms of sulphur dust on the germination of urediniospores of *Puccinia graminis*. Kolodust and Sulfodust, two sulphur fungicides manufactured by the Niagara Sprayer Company, Middleport, N.Y., were used in these trials. Spores, uniformly matured from cultures of *Puccinia graminis Tritici*, f. 21, and *Puccinia graminis* Avenae, f. 3, were used in all the germination tests. These wheat and oat strains of *Puccinia graminis* were collected in Western Canada and are very constant in their reaction on their differential hosts.

Table 22.—Influence of Sulphur Dusts on the Germination of Urediniospores of *Puccinia graminis Tritici* and *Puccinia graminis Avenae*

Organism	Form of sulphur dust	Tests[1]						Average
		1	2	3	4	5	6	
P. gr. Tritici, f. 21	Kolodust	2	3	2	1	1	2	1·8
	Sulfodust	5	10	10	7	3	10	7·5
	Without sulphur dust	56	85	89	87	91	85	82·1
P. gr. Avenae, f. 3	Kolodust	10	6	9	2	2	1	5·0
	Sulfodust	24	18	21	10	24	11	18·0
	Without sulphur dust	83	68	91	93	91	90	86·0

[1] Each test from actual counts of 1,200 spores.

Preliminary germination tests resulted in slight irregularities in urediniospore germination. However, a sufficiently large number of germination tests were made with each strain to give an adequate test of the viability of the strain under the various conditions. Six tests were made at six different times. In each test 1,200 spores were counted from the six dusted cultures. The same number of spores were counted from the six undusted cultures. Only those spores possessing germ tubes longer than the width of the spores were considered as having germinated.

Kolodust and Sulfodust were examined under the microscope to determine the fineness of the sulphur particles. Kolodust was more finely divided than Sulfodust, being colloidal in nature. Under the conditions of the experiment, both forms of sulphur were extremely toxic to urediniospores of *P. gr. Tritici* and *P. gr. Avenae*, but, as the results presented in table 22 show, Kolodust was more toxic than Sulfodust. These results agree with those of other workers, who found that the toxicity of sulphur increased in proportion to the fineness of its particles.

FACTORS INFLUENCING THE EFFICIENCY OF SULPHUR IN CONTROLLING RUST

(a) Free Moisture

Infection studies were made to determine what influence free moisture before and after inoculation had on the effectiveness of Kolodust and Sulfodust in controlling stem rust.

Large numbers of Marquis wheat seedlings were grown in five inch pots, ten to twelve plants in each pot. Ten days after planting, when the leaves were from 8-10 cm. long, the plants were divided into two series.

One series was dusted, inoculated, and grown under very humid conditions. The plants were inoculated with *P. gr. Tritici*, f. 21, by the ordinary needle method, that is, by moistening the lower leaf of each seedling and applying the urediniospores from uniform stock cultures. The second series of plants was dusted, inoculated by the dry needle method, and grown under relatively dry conditions. Both series of plants were grown at ordinary greenhouse temperatures. Final data on the percentage infection in each series were obtained fourteen days after inoculation.

The fungicidal effectiveness of Kolodust and Sulfodust was greatly reduced when free moisture was abundant before and after inoculation. Under these conditions considerable infection occurred when only one day elapsed between the time of dust application and inoculation. When the plants were treated and grown under relatively dry conditions, i.e., if the plants were not sprinkled, and were incubated for only 24 hours, both sulphur dusts were effective for long periods. Under these conditions, a very small percentage of the plants was infected, even when twelve days elapsed between the dust application and inoculation. Kolodust proved to be slightly more effective than Sulfodust. Photographs of dusted and undusted wheat plants inoculated with *P. gr. Tritici*, and *Puccinia triticina* respectively, are shown in plate 8.

A comparison was made also of the effectiveness of the two sulphur dusts in controlling rust when the dusted plants were subjected to a shower of water for various periods and then inoculated.

Under the conditions of the experiment fifteen minutes exposure to a shower of water reduced markedly the effectiveness of sulphur in controlling stem rust of wheat. Again, Kolodust afforded the plants slightly greater protection than did Sulfodust.

(b) Physical factors.

A number of inert dusts of approximately the same fineness as sulphur dust were used in comparison with Kolodust and Sulfodust in spore germination and infection studies. The inert dusts were not toxic to the growth of urediniо-

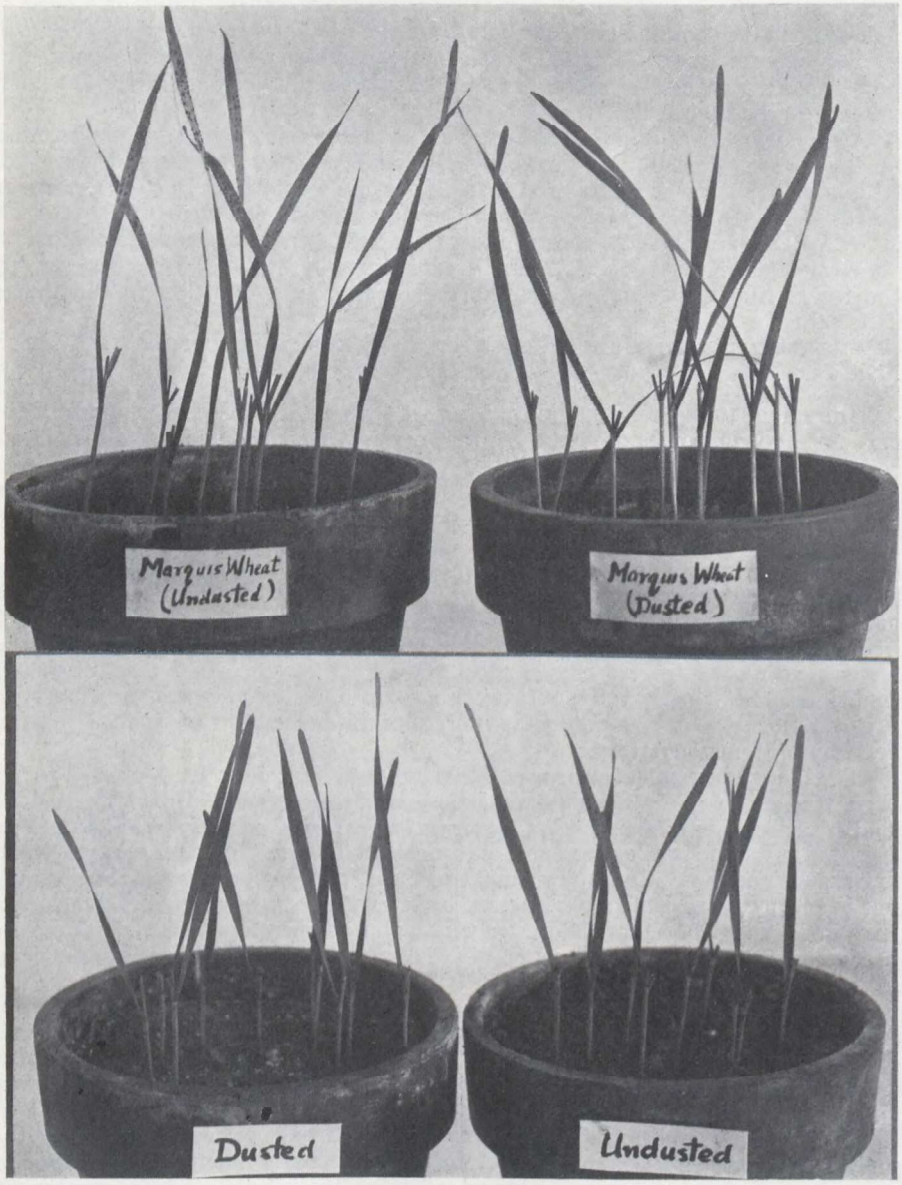

PLATE 8.—Fig. 1.—Effectiveness of sulphur dust in controlling stem rust of wheat. *P. gr. Tritici.* Marquis wheat plants 12 days after inoculation. (Left) Undusted plants. (Right) Dusted plants. Fig. 2.—Effectiveness of sulphur in controlling leaf rust of wheat, *Puccinia triticina.* Little Club wheat 12 days after inoculation. (Left) Dusted plants. (Right) Undusted plants.

spores, whereas both forms of sulphur were extremely toxic. Infection studies indicated that these inert dusts were ineffective in reducing the amount of infection caused by the stem and leaf rust organisms. However, when sulphur dust was used a very marked reduction in the amount of infection was obtained.

These studies indicated that the effectiveness of sulphur in reducing rust infection is due to the toxicity of some of its oxidation products, and that it is not significantly influenced by the physical changes which are brought about by the presence of the finely divided dust material on the foliage.

(*c*) *Temperature.*

An attempt was made to ascertain whether temperature had any appreciable influence in the fungicidal effectiveness of sulphur.

Soil temperature tanks were arranged to serve as efficient moist chambers. One set of chambers was maintained at a temperature of 10°-12° C. A second set was held at from 22°-25° C. A large number of Marquis wheat plants were inoculated with *P. gr. Tritici*, f. 21. One half of the inoculated plants were dusted with Kolodust, while the remaining plants were left undusted, as controls. The dusted and undusted plants were divided into two series. One series comprising half of the dusted plants and half of the undusted ones was incubated at the lower temperature, while the remaining plants were held at the higher temperature. After 48 hours, all of the plants were placed in sections of the greenhouse where approximately the temperatures at which incubation took place were maintained during the entire period of the experiment.

A second experiment was performed which was exactly like the one already described except that the plants were dusted just before inoculation instead of immediately after.

Under the conditions of the experiment, there was no indication that temperature greatly influenced the fungicidal value of sulphur. It seems evident that a temperature of as low as 12° C. has very slight, if any, influence on the effectiveness of sulphur dust in controlling stem rust.

(*d*) *Influence on infection of the interval between inoculation and dusting when conditions are optimum for rust development.*

Experiments were carried out to determine how soon after inoculation sulphur had to be applied in order to control rust effectively.

TABLE 23.—PERCENTAGE OF PLANTS INFECTED WHEN DIFFERENT INTERVALS ELAPSED BETWEEN THE TIME OF INOCULATION AND OF SULPHUR DUST APPLICATION

Time elapsing between inoculation and sulphur dust application	Host and Pathogene			
	Marquis wheat—*P. gr. Tritici*		Victory oats—*P. gr. Avenae*	
Hours	Percentage of plants infected[1]	Degree of infection[2]	Percentage of plants infected[1]	Degree of infection[2]
	per cent		per cent	
0	1	Tip	0	0
1	3	Tip to light	8	Tip to light
3	3	Tip to light	16	Tip to light
6	14	Tip to moderate	23	Tip to moderate
12	85	Light to heavy	74	Tip to moderate
18	89	Moderate to heavy	86	Moderate
24	92	Moderate to heavy	100	Heavy
48	97	Heavy	99	Heavy
Check (Undusted)	100	Heavy	100	Heavy

[1] Average of two tests run at different times. Fifty or more than fifty plants were inoculated in each test.

[2] Symbols for degree of infection:—
Tip-Pustules only at tip of leaf.
Light-Pustules scattered, light infection.
Moderate-Pustules numerous, general infection.
Heavy-Pustules very abundant, heavy infection.

A large number of Marquis wheat seedlings were inoculated with *P. gr. Tritici*, f. 21, and were placed at once in moist chambers for 48 hours. Fifty plants were dusted immediately after inoculation with Kolodust. The same number of plants was dusted subsequently at intervals varying from 1 to 48 hours after inoculation. Fifty inoculated plants remained untreated for controls. The plants were taken from the incubation chambers and held under uniform conditions of light and humidity in the greenhouse. Final data on the percentage of plants infected were recorded 15 days after inoculation.

This experiment was repeated using Victory oats and *P. gr. Avenae*, f. 3, instead of Marquis wheat and *P. gr. Tritici*, f. 21. Two tests of each experiment were made at two different times.

The results of these trials are summarized in table 23. Rust was satisfactorily controlled when the sulphur was applied within six hours following inoculation. However, when an interval of twelve hours, or more, was allowed to elapse between the time of inoculation and the dust application, sulphur was quite ineffective. Consequently it would seem that when conditions for the germination of rust spores are ideal, penetration into the plants can be accomplished within twelve hours, and the rust organism is then beyond the influence of the fungicide.

DISCUSSION

The preceding greenhouse and laboratory studies have yielded data of considerable practical importance. They have indicated the importance of using finely divided sulphur for the most effective control of stem rust. The commercial sulphur dusts used in these experiments were efficient fungicides for long periods under relatively dry atmospheric conditions. The period of effectiveness was greatly reduced if humid conditions prevailed. It is evident that in practical use the time of application and the number of applications necessary will be governed largely by weather conditions. Temperature influenced the fungicidal effectiveness of sulphur dust less than did humidity.

The results obtained from repeated infection studies indicated that one of the most important factors in the control of rust by the use of sulphur is the time of application. Dusting should be done before inoculation occurs. When plants were dusted after inoculation the results were not satisfactory. Field evidence of the last two years has also indicated the desirability of making the initial application of sulphur dust very early. Every attempt should be made to have the plants dusted before rust appears in the field.

These experiments have clearly demonstrated that dusting with sulphur constitutes an effective means of controlling rust diseases of cereals. Although many practical difficulties incidental to applying the dust are still to be solved, this method of rust control should prove most beneficial in experimental plot work, where protection from rust injury is essential for securing vigorous seed lots, and also where seed is grown for registration.

An article including all the details of these experiments and the results obtained will be found in the issue of "Scientific Agriculture," published January, 1928.

THE OCCURRENCE OF YELLOW STRIPE RUST IN WESTERN CANADA

(T. Johnson and M. Newton)

Stripe rust *(Puccinia glumarum)* was discovered at Edmonton, Alberta, in 1918, on *Hordeum jubatum* by Prof. W. P. Fraser of the University of Saskatchewan. Since then it has occurred annually in certain localities in Alberta, chiefly on *Hordeum jubatum*. On barley it has been found once only. On wheat it was first observed in 1926 at Olds, Alberta, by Dr. G. B. Sanford. In 1927

it was again found on wheat at Olds, and likewise to a considerable extent in the neighbourhood of Cardston, Alberta. Other hosts on which it has been collected in Alberta are *Agropyron Smithii* and *Agropyron tenerum*. The area in which stripe rust has been found in Western Canada now includes scattered localities from Edmonton down to the international boundary, as well as the southwestern corner of Saskatchewan.

An attempt was made to determine whether the rust on *H. jubatum* and that on wheat were one and the same form, or whether they were two distinct specialized forms. A great deal of difficulty was experienced in establishing greenhouse cultures of the rust. In most cases the spores from the field collections failed to infect susceptible hosts in the greenhouse, probably through lack of germination. Finally, however, two cultures were established, one from wheat, the other from *H. jubatum*. Both of these proved to belong to the *Puccinia glumarum Tritici* form. Although this does not prove that only that form exists in Canada, it shows that the rust on *H. jubatum* may under favourable conditions affect wheat.

Owing to difficulties in obtaining artificial infection in the greenhouse an attempt was made to determine optimum conditions for germination of fresh urediniospores produced in the greenhouse. Various methods were used at 10° C., 15° C., 17° C., 19° C., and 23° C., but, under all conditions tried, spore germination remained low and irregular. The best germination was obtained at 10° C. and 15° C., the average germination being only about 8 per cent in each case.

SMUT EXPERIMENTS

(I. L. Conners)

The smut investigations conducted this year were concerned largely with the application of copper carbonate dust to wheat seed, and the control of bunt in wheat and covered smut in common oats by using copper carbonate and other fungicides in comparison with formalin.

The Application of Copper Carbonate

The efficiency of the copper carbonate dust treatment depends to a marked degree on the thoroughness with which the dust is applied to the seed. For several years a small drum duster has been used successfully. This duster consists of a wooden drum about 2 feet long and 1½ feet in diameter. The drum is mounted horizontally like that of a cement mixer so that it may be rotated about its natural axis. A slide door is provided in the side of the drum for filling and emptying. To increase the fall of the grain as the drum is rotated three baffle boards are spaced at equal intervals around the inside of the drum. The duster is filled not more than one-quarter full with seed. The grain is levelled off and the required amount of dust is then sprinkled over the grain. The door is closed and the duster is turned for three minutes at 40 revolutions per minute. The manner of handling the duster was arrived at empirically, and it was thought advisable, in view of the increasing use of the dust treatment, to analyze the various factors influencing the proper application of the dust, and thus to arrive at the underlying principles. Experiments were, therefore, conducted at the Dominion Experimental Station at Morden, Man., where a supply of grain was made available for such a study.

The dusters used in the experiments were the small drum duster mentioned above, and the barrel and diagonal box dusters that were described in Dominion Department of Agriculture Bulletin 81, new series. The essential measurements of the dusters are as follows:—The small duster is 16·5 inches in diameter,

51·8 inches in circumference and has a cubical content of 4,706 cubic inches; the barrel duster, diameter from 20 to 23 inches, circumference at greatest diameter 72·3 inches, a cubic content of 13,438 cubic inches; the box duster is a cubical box measuring 24 inches to a side and with a cubic content of 13,824 cubic inches.

The capacity of these dusters was determined by treating different amounts of seed in the dusters and observing the ease of operation and the rapidity with which the seed became dusted. It was found that one bushel could be conveniently treated at one time in the barrel or box duster, while one-third of a bushel worked well in the drum. As a bushel occupies 2,218·2 cubic inches, the capacity of these dusters is approximately one-sixth of their cubic content. One and a half bushels could be treated in the larger dusters, but they are much more difficult to turn. A heavy fly-wheel added to the shaft would probably make it possible.

In the barrel and drum dusters the grain should be levelled off and the dust not dumped near the centre of the duster, but sprinkled evenly over the grain; otherwise the time required to get an even coating of dust is excessively prolonged. In the box duster no precaution is necessary in adding the dust to the grain.

In dusting operations another important consideration is the speed at which the duster is operated. Most effective mixing occurs when the centrifugal force generated is sufficient to carry the grain almost to the top of the duster and yet there is time for it to slip off each baffle in turn and fall to the bottom of the duster. The best speed was determined experimentally, and the centrifugal force developed was calculated from the formula,

$$F = \frac{m4\pi^2n^2r}{g}$$

Where n=revolutions per second, r=radius of the drum, and g=the acceleration to gravity. The value of g is approximately 32 feet per second.

TABLE 24.—THE CENTRIFUGAL FORCE DEVELOPED BY THE DRUM AND BARREL DUSTERS AT DIFFERENT SPEEDS

Revolutions per minute	n	n^2	Centrifugal force (when m = 1)	
			Drum	Barrel
80	1·33	1·77	1·51	2·10
60	1·00	1·00	0·85	1·18
50	0·83	0·69	0·59	0·82
40	0·67	0·45	0·38	0·53
30	0·50	0·25	0·21	0·30
20	0·33	0·11	0·09	0·13

As m was taken to equal 1 pound, the centrifugal force, F, equals the force of gravity when F=1. Therefore, when F is greater than 1, the grain is carried right around, but when F is less than 1, the grain falls. It was found experimentally that when the centrifugal force is about one-third the force of gravity the dusters worked most effectively. From table 24 it will be seen that the drum duster should be turned at about 40 revolutions per minute and the barrel at 30. The box duster was also found to work best at 30 revolutions per minute. The most effective speed for any duster of this type is readily found by turning the drum at different speeds and observing the movement of the grain. The proper speed is reached when the grain is heard falling in a series of rapid, but clear cut splashes to the bottom of the duster. The larger the circumference of the drum the more slowly it must be turned.

In all experiments which were conducted to test factors in the application of copper carbonate dust other than the rate of turning, each duster was rotated at the speed which was found to be most suitable for the particular duster.

After an extensive series of trials it appears that 60 revolutions is sufficient to ensure a good coating of dust on the seed, where the grain is not visibly contaminated with bunt spores. However, the dust is not so readily distributed when the seed is visibly contaminated, and, in such case, 90 revolutions of the drum are recommended to ensure proper coverage.

While the above experiments were in progress, it was noted that the bulk of the seed was increased by dusting it with copper carbonate. Before dusting, a sample of wheat of good quality is smooth to the touch, and appears to compact readily when compressed in the hand. After dusting, however, the grain feels like fine gravel and resists compacting. The bulk was increased one-thirteenth, or 7·7 per cent, by dusting the seed with copper carbonate.

As is well known, the size of the seed influences greatly the rate at which the seed runs through a grain drill. Crops with small seeds require a fine setting of the drill, those with large seeds, a coarse one. An experiment was, therefore, conducted to determine whether dusting wheat seed with copper carbonate, and thereby increasing its bulk, would affect the rate at which the seed would flow through the drill. Working with an ordinary seed drill, duplicate determinations were made on the amount of seed sown, using (1) undusted, and (2) dusted seed, with the drill set to sow 1·5 bushels per acre, and (3) dusted seed with the drill set at 1·75 bushels per acre. The two determinations were averaged and the result expressed in bushels per acre. Each determination was made as follows:—

One half of the seed box of an ordinary grain drill was filled to a depth of about 3 inches with seed. One wheel was jacked up and given a preliminary turn until seed was running freely from all the spouts. A canvas was then spread below the spouts, the wheel was turned through 40 complete revolutions, and the amount of seed on the canvas weighed. As the experimental error was small, the results from each pair of determinations were averaged and the average only is reported. The results are given in table 25.

TABLE 25.—THE EFFECT OF DUSTING WHEAT SEED WITH COPPER CARBONATE ON THE FLOW OF THE SEED THROUGH A GRAIN DRILL

Drill setting, bushels per acre	Actual rate of sowing, bushels per acre		Actual rate expressed as a percentage of the theoretical rate	
	Undusted	Dusted	Undusted	Dusted
1·5	1·96	1·70	130·7	113·1
1·75	.....	1·97	.....	112·6
Average	.....	.....	.....	112·9

This experiment demonstrates that dusting the seed with copper carbonate slows up the flow of the seed through the drill. When the drill was set to sow 1·5 bushels per acre the undusted seed passed through the drill at the rate of 1·96 bushels per acre or 130·7 per cent of the theoretical 1·5 bushels. When, however, the seed was dusted, it was sown at the rate of 1·70 bushels per acre or 113·1 per cent of the theoretical. Dusting the seed reduced the rate of sowing 0·26 bushels per acre or 17·6 per cent. Without knowing the drill setting, we could say that only 1·70 bushels of dusted seed were sown for every 1·97 bushels of undusted seed, or 86·7 per cent of the undusted.

CONTROL OF WHEAT BUNT BY SEED TREATMENT

Co-operative experiments were conducted this year with the Experimental Farms at Brandon, Man., Indian Head and Scott, Sask. The seed was treated at the laboratory and then sent out to the Farms to be sown. The unsown seed was returned to determine the actual amount of seed sown of each treatment. An estimate of the smut was made by a member of the laboratory. The care of the plots and the collection of all other data were done by the Experimental Farm Staff at each place.

Naturally smutted wheat from an elevator at Fort William, Ont., was used as seed in the experiments. An examination of twenty-five bunted heads from the resulting crop showed that the crop was infected with both bunt species, 64 per cent of the bunted heads being destroyed by *Tilletia Tritici* and 36 per cent by *T. laevis*.

As the experiments at these places were conducted for different purposes each experiment will be discussed separately.

At Indian Head the effectiveness of six brands of copper carbonate in controlling bunt was compared with that of formalin. The trade names and manufacturers of these brands are as follows: Mococo, Mountain Chemical Co., San Francisco, Cal.; Deloro, Deloro Chemical Co., Toronto, Ont.; Corona Coppercarb, Corona Chemical Division, Pittsburgh Plate Glass Co., Milwaukee, Wis.; Beaver, manufactured for The Beaver Soap and Chemical Co., Winnipeg, Man.; Trinco, Triangle Chemical Co., New Westminster, B.C., and Cuprojabonite, Geo. C. Gordon Chemical Co., Kansas City, Mo. The Mococo brand is the only one tested containing 50 per cent copper, the other brands containing only 20 per cent. These brands of copper carbonate were applied to the seed at the rate of two ounces per bushel using the drum tester described in the previous section.

The formalin was manufactured by the Standard Chemical Co., Montreal, and was tested by the Chemistry Department, Manitoba Agricultural College, just before using. This formalin was used to make up a formalin solution of the proper strength, 1-320. The seed was steeped in this solution for 5 minutes, drained, covered for an hour, and then spread out to dry.

The amount of bunt was estimated by counting 100 heads in 10 different places in the two one-fortieth acre plots sown to each treatment, five from each plot. The number of smutted heads was based on the number of bunted heads in 1,000. When no heads were found in the counts, a search was made for bunt and, if bunt was found, it was reported as a trace.

TABLE 26.—CONTROL OF WHEAT BUNT BY SEED TREATMENT AT INDIAN HEAD, SASK., 1927

Treatment	Percentage of bunt	Amount of seed sown		Percentage of seed sown
		lb.	oz.	
Formalin dip	0	5	11	84·3
Untreated	2·4	6	12	*100·0*
Mococo copper carbonate	·1	6	1½	90·3
Deloro copper carbonate	tr.	5	15½	88·5
Corona copper carbonate	0	6	0	88·9
Beaver copper carbonate	·1	6	0	88·9
Trinco copper carbonate	0	5	15	88·0
Cuprojabonite copper carbonate	tr.	6	2½	91·2

So little bunt developed in the untreated plots that the treatments are only indicative. However, taken in conjunction with last year's results, it appears that the brands of copper carbonate offered to the public in western Canada are of high quality. The results of rod-row tests made at Brandon this year confirm these results.

Table 26 also shows that treated seed is sown less rapidly by the grain drill than the untreated. Although there is some variation in the effect of the different copper carbonates on the sowing rate, the average rate for seed dusted with copper carbonate was 11 per cent less than that for the untreated. The formalin treatment also results in a reduction of the percentage of seed sown, due to the swelling of the seed and the roughening of the seed coat.

In the previous year's tests certain organic mercury dusts gave satisfactory control of wheat bunt. Accordingly four organic mercury dusts were tested this year at Scott, Sask. These were Semesan, and DuPont dust No. 12, manufactured by I. E. du Pont de Nemours Co. Inc., Wilmington, Del., Bayer dust, by Bayer Co. Inc., New York City, Segetan Trockenbeize by Deutsche Gesellschaft für Schädlingsbekämpfung, Frankfurt a.M., Germany. Semesan was also applied as a wet treatment, the seed being soaked in 0·25 per cent solution of Semesan for 1 hour, after which the seed was spread out to dry. For comparison, seed treated with formalin by the dip method, and with copper carbonate was also included.

Table 27 contains a detailed analysis of this experiment. Although the percentage of bunt in the check is not large, it is evident that we can never expect quite as good control by dust treatments as with the wet. Every one of the dust treatments shows traces of bunt, while the wet treatments appear entirely free.

As in the experiment at Indian Head the amount of seed sown was determined by measuring the plots after the seed had emerged. It appears, however, that this precaution is unnecessary if the sowing is carefully done.

A careful estimate of the stand was made by counting the number of seedlings emerging in an area of a square yard at 20 places in the four one one-hundredth acre plots of each treatment, 5 counts being in each plot. The number of seedlings was significantly less in the plots where the seed had been treated with formalin, Semesan solution, or copper carbonate, than in those sown with untreated seed. The number of seedlings in the other treatments was not significantly different from those in the check.

By determining the amount of seed sown and the percentage stand, it was possible to calculate the percentage of the seed which germinated. It would seem that treated seed germinated about as well as the untreated, except that treated with copper carbonate. The vigour of the plants was estimated on a scale of 1 to 10, the maximum vigour being recorded as 10. Taking into consideration both vigour and percentage germination, the formalin treatment gave the poorest result, copper carbonate was next, and the organic mercury dusts were best.

The yields of the plots were so uniform that those of the plots sown with treated seed were not significantly different from the yields of the untreated plots. It may be concluded, however, that, if the organic mercury compounds are found to reduce the damage from root rots in heavily infected soil, no other treatment of the seed is necessary, for these compounds will control wheat bunt at the same time.

As a dusting machine is necessary for applying copper carbonate to the seed, the experiment at Brandon, Man., was planned to test three dusters now offered to the farmers in Western Canada. These machines and their manufacturers are (1) Calkins, C. C. Calkins Co., Spokane, Wash.; (2) Koverall, Western Implements, Ltd., Regina, Sask.; (3) Wonder, American Grain Separator Co., Minneapolis, Minn. The experiment was a failure due to absence of bunt in the untreated plots. Some observations were made, however, on the effectiveness of these machines in producing a satisfactory coating of dust on the seed. The Calkins machine is essentially a revolving drum with an opening at each end through which the grain is respectively introduced into and dis-

TABLE 27.—CONTROL OF WHEAT BUNT BY SEED TREATMENT—SCOTT, SASK.

Treatment	Percentage of bunt	Amount seed sown in oz.	Percentage seed sown	Area sown in sq. yds.	Percentage seed sown corrected for area	Average number of seedlings per sq. yd.	Percentage stand	Percentage germination	Vigour of plants	Yield, bushels per acre
Formalin dip	0	97·5	91·5	282·2	92·1	242·3±5·0	93·1	101·1	8·75	18·87±·72
Semesan soak	0	87·0	81·7	283·5	82·0	236·4±4·8	90·8	110·7	9·0	19·87±·75
Untreated	5·7	106·5	*100·0*	283·6	*100·0*	260·3±5·3	*100·0*	*100·0*	9·75	17·00±·65
Deloro copper carbonate	0·10	98·0	92·0	283·8	92·1	230·8±4·7	88·7	96·3	9·75	18·70±·71
Bayer dust	0·15	110·0	103·3	285·1	103·2	279·7±5·7	107·5	104·2	9·75	18·20±·69
Semesan dust	0·10	104·5	98·1	284·5	97·9	267·5±5·5	102·7	104·9	9·75	18·37±·70
Du Pont No. 12 dust	0·15	104·0	97·7	283·7	97·9	256·4±5·3	98·5	100·6	9·37	18·62±·71
Segetan Trockenbeize	0·05	108·5	101·9	282·4	102·6	273·6±5·6	105·1	102·4	9·75	18·37±·70

The average number of seedlings per sq. yd. is significantly less in the Standard formalin, Semesan soak, and Deloro $CuCO_3$, than in the check plots. The average number of seedlings in the other treatments are not significantly different from the check.

The yields of plots sown with treated seed were not significantly different from that of the check plot.

charged from the chamber. Seed dusted with copper carbonate by this machine appears to have a very uniform coat, and previous experiments have shown that it was slightly more effective than the small drum duster.

In the Koverall duster the mixing chamber is stationary, and a screw agitates the seed to a certain degree while conveying it through the chamber. It was found that the crease in the seed frequently remained undusted, and the dust sifted through the seed, collected at the bottom of chamber, and then was pushed out by the grain, as the latter was carried forward by the screw.

The Wonder duster consists of a series of concave discs, which are attached alternately to a vertical revolving shaft and to the stationary wall of the chamber. The dust and seed feed through the machine by gravity, the movable discs are revolved rapidly causing the grain and dust to be thrown forcibly against the wall of the chamber. The seed appears to be well coated.

Control of Covered Smut of Oats

The success of the copper carbonate dust treatment for the control of wheat bunt has led to a demand for a dust treatment for the control of oat smuts. Although copper carbonate dust satisfactorily controls covered smut in hulless oats, it has not given consistent results in our experiments in controlling this smut in the common varieties of oats. In some years copper carbonate has given very satisfactory control, while in others it failed to hold the smut in check.

Several new dusts, either tested by other workers or suggested by their work, were, therefore, included in this year's experiments, which were conducted in co-operation with the Dominion Experimental Farms at Brandon, Man., Lacombe, Alta., and Rosthern and Indian Head, Sask. The seed was Longfellow oats grown in 1926, and known to be heavily infected with covered smut.

The methods of estimating the smut and other details of the experiments are similar to those for wheat bunt. In the dust treatments, the dust was applied at the rate of 3 ounces per bushel, using the small hand duster. The formalin treatments were carried out as described in previous experiments.

Table 28.—Control of Covered Smut in Common Oats

Treatment	Percentage of smut			
	Indian Head	Brandon	Rosthern	Lacombe
Formalin sprinkle	0·2	.....	0·3	
Formalin dip	0·3	.....	.....	1·1
Formalin spray	.....	0	0·2	
Deloro copper carbonate	1·7	0·2	.....	4·2
Mococo copper carbonate	0·8	0·1	1·4	3·1
Kolo sulphur dust	3·0	0·1	.....	7·0
Monohydrate copper sulphate dust	0·2	0·1	.....	
Mococo copper carbonate, 300 revolutions[1]	0·8	0·1	.....	
Copper acetate	1·8	.....	0·15	
Copper acetate + mercuric chloride 1:1	0	.....	0·4	
Copper acetate + mercuric chloride 1:2	0	.....	1·5	
Mococo copper carbonate + mercuric chloride 1:2	0·7	0	0·4	
Mococo copper carbonate + common salt 2:1	0·3	.....	.....	
Monohydrate copper sulphate + common salt 2·1	0·3	.....	.....	
Untreated	20·1	4·1	28·3	29·2

[1] The duster was turned for 300 revolutions instead of the usual 120 in applying the dust.

In table 28 are given the percentages of smut that developed in the plots. The difficulty of controlling oat smut is emphasized by the poor control obtained at Lacombe. In view of these results copper carbonate cannot be recommended, but it seems likely that continued use of this dust would rapidly eliminate the smut in some sections of the country. At the places where the new treatments were tested, they do not appear strikingly more effective than copper carbonate. These treatments, however, must be repeated several times before definite conclusions may be drawn.

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, SASKATOON, SASK., IN CO-OPERATION WITH THE UNIVERSITY OF SASKATCHEWAN

(P. M. Simmonds, Acting Officer in charge)

Introduction

The major projects under investigation at this Laboratory deal with the root diseases of cereals. The following report is of the progress made during the past year. Besides this work, co-operation is given in connection with certain rust investigation projects, such as Barberry and Buckthorn surveys, and Stem Rust Epidemiology studies, all of which are directed from the Dominion Rust Research Laboratory at Winnipeg. In the epidemiology studies arrangements were made for placing thirteen spore traps, covering Saskatchewan and Alberta. These were exposed throughout the rust season, the slides being examined at proper intervals. The notes were compiled and forwarded to the Rust Research Laboratory to be incorporated with similar notes obtained there. The stem rust survey in Southern Saskatchewan occupied most of the time of Mr. B. J. Sallans. The trips made for rust, root and crown diseases, and general plant disease surveys, were sufficient to cover possible barberry and buckthorn locations. It is becoming apparent from preliminary surveys that a definite outline will have to be followed in surveys on root and crown diseases. Only one disease of this type, the take-all disease, lends itself readily to diagnosis in the field, and some records have been obtained. These will be reported under the proper heading. Every member of the staff assisted in all the surveys. There was a severe infestation of rust in Saskatchewan this season; the collections and notes obtained were sent to the Rust Research Laboratory for summarization. The plant disease survey notes were sent direct to Ottawa. The fungous flora project necessitated considerable routine isolation work, much of which was done by Mr. W. G. Sallans. Field experiments on root and crown diseases were run at Indian Head and Saskatoon, as well as some co-operative tests with farmers; these and the related laboratory work are reported below.

Fusarium Studies

The work reported last year dealt chiefly with a study of *Fusarium culmorum*, (W. G. Smith) Sacc. These investigations were continued, special attention being given to the pathological histology of the seedling blight disease of oats. Some of the *Fusaria* commonly isolated from cereals were tested for their pathogenicity in greenhouse tests. The writer wishes to acknowledge with thanks the kind attention which Dr. H. W. Wollenweber, Berlin, has given to our correspondence regarding *Fusarium* studies. Fifteen cultures were determined by Dr. Wollenweber. Nine of these are tabulated, along with the rate of disease produced in our greenhouse tests. The methods of inoculation and recording data were the same as those explained in previous reports. The results are given in table 29.

These represent species of six sections of the genus *Fusarium*. All are fairly pathogenic when this type of disease is considered. It is intended to use the cultures which have been determined for further comparative tests, and also as a foundation for future taxonomic work.

Sixteen cultures, isolated previous to 1926, are being carried for study. Sixty-eight isolations were obtained from the fungous flora project work this summer. These will be studied as time permits.

TABLE 29.—A COMPARISON OF SOME *Fusaria* IN PRODUCING PRE-EMERGENCE AND SEEDLING BLIGHT OF OATS, WHEAT, AND BARLEY IN GREENHOUSE TESTS

Name	Date isolated	Host	Locality	Disease rate on		
				Oats	Wheat	Barley
F. cereale, (Cke.) Sacc.	1925	Wheat scab	Saskatoon	75·7	25·5	47·7
F. culmorum, (W. G. Smith) Sacc. v. *leteius*, Sherb.	1922	*Bromus maximus* heads	Manitoba	7·2	8·2	16·2
F. culmorum, (W. G. Smith) Sacc.	1922	Wheat scab		28·0	11·0	26·7
F. sporotrichioides, Sherb.	1924	Wheat stalk	Saskatoon	26·0	18·5	29·7
F. sambucinum, Fkl. v. *caespitosum*, Wr.	1921	Wheat		18·7	5·5	27·7
F. acuminatum, (Ell. et Ev.) Wr.	1925	Wheat foot	Indian Head	22·0	7·2	14·5
F. bullatum, Sherb.	1925	Wheat foot	Belbeck	22·5	7·0	16·0
F. orthoceras, App. et Wr. v. *longius*, Sherb.	1925	Wheat foot	Wolseley	38·0	12·0	20·0
F. sambucinum, Fkl. v. *caespitosum*, Wr.	1925	Oat foot	Goose Lake	12·2	8·0	14·2

Helminthosporium STUDIES

Relative virulence of strains of Helminthosporium sativum.—Thirty-six strains of this fungus were tested in the greenhouse for relative virulence on Marquis wheat, Victory oats, and Hannchen barley. The term "strain" is used to designate a monospore culture of the fungus isolated from diseased wheat found in a definite section of the Western Provinces.

One hundred and fifty grains of wheat, oats, and barely were used to test each strain. Twenty grammes of inoculum grown on oat hulls were mixed with the soil at seed level. The soil was not sterilized, but an adequate number of check pots were run, so that any natural infection arising from the greenhouse soil could be detected. About two weeks after seeding the plants were examined, and the infection percentage rate expressed according to McKinney's formula (Jour. Agr. Research 26: 5; p. 199), giving numerical ratings of 5, 4, 2, and 1 for non-emergence, seedling blight, severe, and slight coleoptile lesions, respectively.

In table 30 the results are recorded. The infection expressed for each strain is the infection rate of the inoculated series minus that of the checks. This was done to illustrate, as closely as was possible under the conditions of the tests, the actual damage caused by the fungus.

TABLE 30.—THE RELATIVE VIRULENCE OF THIRTY-SIX STRAINS OF *Helminthosporium sativum* AS INDICATED BY THE PERCENTAGE INFECTION ON MAROUIS WHEAT, VICTORY OATS, AND HANNCHEN BARLEY

Strain	Date isolated	Locality	Host	% infection rate		
				Wheat	Oats	Barley
1	1924	Davidson, Sask.	Wheat seedling	33·9	5·5	16·6
2	1925	Indian Head, Sask.	" "	54·7	28·0	55·0
3	1925	Belle Plains, Sask.	" "	49·5	17·6	37·0
4	1925	Alsask, Sask.	" "	56·4	20·1	46·8
5	1922	Saskatoon, Sask.	" kernel	53·8	11·4	50·5
6	1923	Saskatoon, Sask.	" "	65·5	0	47·1
7	1923	Saskatoon, Sask.	" "	23·8	10·6	23·6
8	1924	Bulyea, Sask.	" seedling	44·5	0	23·6
9	1921	Saskatoon, Sask.	" node	10·6	26·3	38·7
10	1926	St. Paul, Minn.	Corn leaf	82·0	36·5	62·9
11	1926	Langham, Sask.	Wheat	40·9	20·7	38·8
12	1926	Swift Current, Sask.	" seedling	62·4	4·4	46·1
13	1926	Humboldt, Sask.	"	29·4	0	13·7
14	1926	Daylesford, Sask.	"	59·9	4·8	38·6
15	1926	Prince Albert	"	55·3	·5	52·2
16	1926	Beaverlodge, Alta.	"	60·2	32·8	30·3
17	1926	Lumsden, Sask.	"	32·4	41·9	7·6
18	1926	Blaine Lake, Sask.	"	36·7	2·6	15·5
19	1926	Battleford, Sask.	"	73·1	31·4	43·7
20	1926	Wadena, Sask.	"	86·7	39·2	61·0
21	1926	Indian Head, Sask.	"	49·4	3·9	7·5
22	1926	Clair, Sask.	"	44·1	0	12·2
23	1926	Stettler, Alta.	"	79·9	31·7	51·8
24	1926	Moose Lake, Sask.	"	83·3	33·6	57·2
25	1926	Shellbrook, Sask.	"	82·3	24·0	59·0
26	1926	Denholm, Sask.	"	28·0	6·1	5·5
27	1926	Lake Lenore, Sask.	"	85·9	22·4	48·5
28	1926	Rama, Sask.	"	30·9	8·2	20·2
29	1926	Invermay, Sask.	"	42·8	6·9	33·0
30	1926	Margo, Sask.	"	36·0	0	15·3
31	1926	Battleford, Sask.	"	68·0	22·9	49·3
32	1926	Blackfalds, Alta.	"	75·0	19·3	40·9
33	1926	Mirror, Alta.	"	73·1	15·4	19·9
34	1926	Red Deer, Alta.	"	81·0	17·3	13·1
35	1926	Dorenlee, Alta.	"	68·8	24·4	40·5
36	....	Headingley, Man.	"	66·6	36·7	22·2

From an examination of the above table the different strains of *Helminthosporium sativum* tested, with the exception of strains 2, 9, and 17, proved most virulent on wheat and least on oats. There is a very marked difference in infection rating of the strains on the three cereals; wheat ranges from 10·6 to 86·7, oats from 0 to 41·9, and barley from 5·5 to 62·9 per cent. These differences point out the advisability of selecting a virulent strain of this fungus before testing cereal varieties for resistance. Furthermore, such a wide variation in virulence shows the importance of a morphological study of the fungus to try and detect wherein lies the cause of this variation. Strains 10 and 20 may be said to be virulent on the three cereals. Strain 34 is strongly pathogenic on wheat and mildly pathogenic on oats and barley. Future investigations at this laboratory will revolve around the solutions of such problems as are suggested by the results of the above tests.

Parallel field tests were undertaken during the summer on wheat and barley. Due to the lack of pronounced infection it is thought unwise to draw conclusions.

Infection Phenomena on Wheat.—Histological studies of a preliminary nature, dealing with the method of infection of *Helminthosporium sativum* on wheat, were commenced. Wheat was germinated under aseptic conditions, and the coleoptile inoculated with spores of the fungus. The spores germinated readily. The germ tube grew rapidly. At certain places where the mycelium came in contact with the surface of the coleoptile a swelling was noticed. In the centre of each swelling a small bright point could be detected as if a minute hole had been pierced in the cell of the wheat. Viewed laterally this bright

point appeared to be the place where the mycelium entered the host plant. Further studies will be undertaken with the hope of gaining some information regarding the method and rate of infection of a virulent strain of *Helminthosporium* compared with a non-virulent strain, and the reaction of these strains on different varieties of wheat.

Seed Treatments.—Greenhouse tests were run to determine the effect of seed treatments on Marquis wheat and Hannchen barley against artificial inoculations of *Helminthosporium sativum,* and against natural infections from unsterilized soil.

The following wet treatments were used; Semesan, Germisan, Uspulun, Tillantin, and formalin. In the first four the seeds were soaked for one hour in an 0·3 per cent solution, then allowed to dry over-night before sowing. The formalin solution was made up to the usual strength for such seed treatments (1:320). The seeds were soaked for five minutes, then covered for 15 minutes, and air dried.

Eight dust treatments were used: Segetan, Urania, Dupont Nos. 12, 46, 49, 57, sulphur (flowers), and copper carbonate. In applying the dusts a small amount was shaken up with the seed until it was well coated. To avoid an excess of dust, forceps were used to pick out the seed before planting.

Three hundred seeds were used for each treatment in both series. Twelve hundred seeds were planted as checks. Five-inch pots were used, each pot containing fifty seeds. The pots were arranged on the greenhouse bench, with the checks coming at intervals between the treatments, thus allowing for the influence of temperature variations. The soil was unsterilized, and consisted of 5 parts ordinary greenhouse soil to 1 part of river sand. The inoculum consisted of a culture of *Helminthosporium sativum,* known to be pathogenic to wheat and barley, grown on ground oat hulls. About 20 grammes of this inoculum was added to the soil at seed level in all pots where inoculation was necessary.

In most cases notes were taken two weeks after sowing. The emergence and seedling blight were recorded, and from these an infection rate was determined. Generally speaking, the difference in infection rates for artificial inoculations and natural infections would indicate the influence of inoculations. Isolations were made from a representative number of plants in each series to give some assurance in the interpretation of results. Table 31 shows the effect of seed treatments on Marquis wheat.

(G. A. Scott)

TABLE 31.—SEED TREATMENTS OF MARQUIS WHEAT IN GREENHOUSE TESTS, AS A PROTECTION AGAINST ARTIFICIAL INOCULATIONS OF *Helminthosporium sativum* AND AGAINST NATURAL INFECTIONS FROM UNSTERILIZED SOIL.

Treatment	Number of seeds sown	Seed treated Soil uninoculated			Seed treated Soil inoculated		
		Per cent Emergence	Per cent Seedling blight	Per cent Infection rating	Per cent Emergence	Per cent Seedling blight	Per cent Infection rating
Check	1,200	94·2	0·3	6·0	36·8	6·2	67·3
Semesan	300	99·0	0	1·0	88·6	3·3	14·8
Germisan	300	95·0	0	5·0	87·3	5·3	16·9
Uspulun	300	96·6	0·3	3·6	91·0	4·6	12·7
Tillantin	300	96·6	0	3·4	74·3	5·0	29·7
Formalin	300	73·6	0·3	26·4	21·6	4·6	82·0
Segetan	300	82·3	1·0	18·5	64·6	6·3	40·4
Urania	300	88·3	0	11·7	82·3	6·3	22·7
Dupont 12	300	96·3	0·3	3·9	87·0	7·3	18·8
" 46	300	96·0	0·6	4·4	60·6	7·6	45·4
" 49	300	97·0	0·3	3·2	41·0	8·0	55·4
" 57	300	93·6	1·0	7·4	55·3	6·3	49·7
Sulphur	300	94·0	0·3	6·2	10·6	5·0	93·4
Copper carbonate	300	91·0	0	9·0	57·6	5·0	46·4

In the uninoculated soil it will be seen that the emergence of the checks is normal and very little infection is expressed as seedling blight. When non-emergence is considered a fair amount of natural infection is shown. In comparing the infection rates: Semesan, Uspulun, Tillantin, Dupont Nos. 12 and

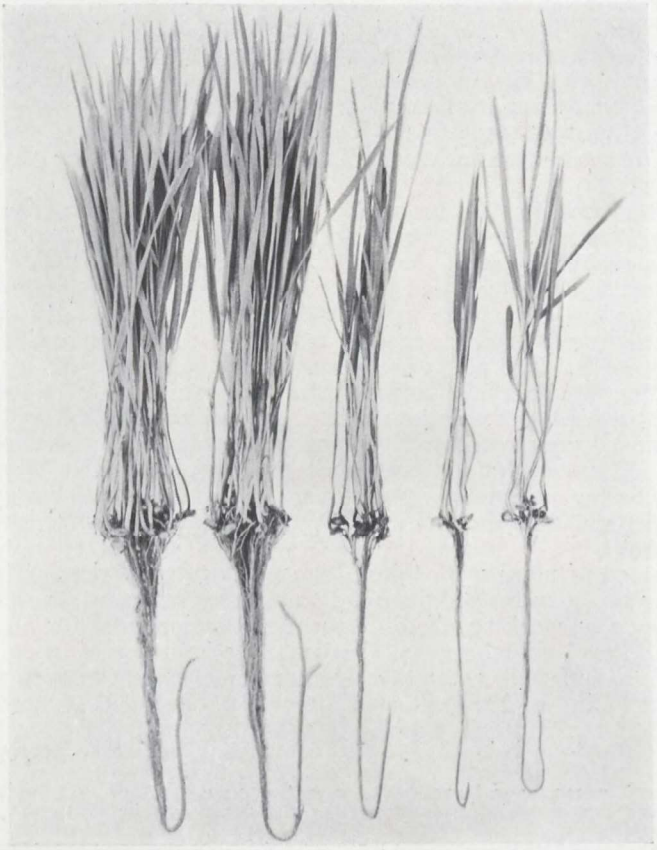

FIG. 14.—Seed treatments of wheat. Fifty seeds were sown to a pot and the treatments were: (1) Dupont dust No. 12, (2) Germisan, (3) check, (4) sulphur, and (5) formalin. Twenty grammes of a ground, oat-hull culture of *Helminthosporium sativum* were added to each pot at seed level.

49 have a comparatively low infection rate. This is due to the increase in emergence. It is possible that these treatments protected the germinating seed from natural infections. Sulphur and copper carbonate did not offer any protection, while formalin, Segetan, and Urania either caused seed injury, or exposed the germinating seed to infection. (See figs. 14 and 15.)

In the inoculated series the checks show a high rate of infection, proving that the artificial inoculation was a success. The variation in the percentage of emergence is very great, and demonstrates the severe injury this fungus can cause to germinating seed. When the high rate of infection is considered the

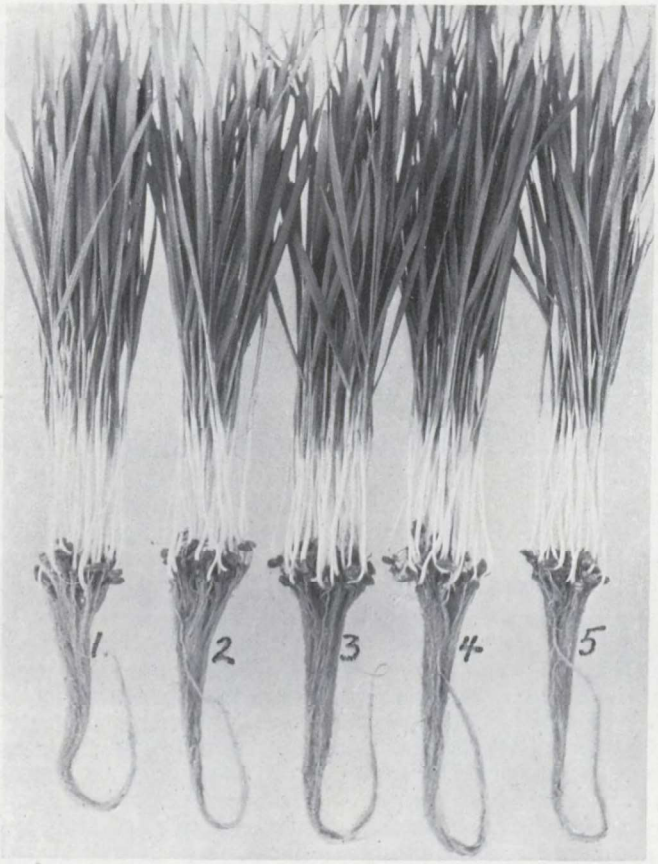

FIG. 15.—Seed treatments of wheat. Fifty seeds were sown to a pot but soil was not inoculated. The treatments are in the same order as for Fig. 14.

control offered by Semesan, Uspulun, and Dupont 12 appears to be significant. On the other hand formalin, Segetan, Dupont Nos. 49 and 57, sulphur, and copper carbonate did not serve as protectors to the seed. The seed treated with formalin and sulphur respectively revealed more disease than the checks.

Similar tests were carried on with Hannchen barley. The results are tabulated in table 32.

TABLE 32.—SEED TREATMENTS OF HANNCHEN BARJEY IN GREENHOUSE TESTS, AS A PROTECTION AGAINST ARTIFICIAL INOCUIATIONS OF *Helminthosporium sativum* AND AGAINST NATURAL INFECTIONS FROM UNSTERILIZED SOIL.

Treatment	Number of seeds sown	Seed treated Soil uninoculated			Seed treated Soil inoculated		
		Per cent Emergence	Per cent Seedling blight	Per cent Infection rating	Per cent Emergence	Per cent Seedling blight	Per cent Infection rating
Check	1,200	94·9	0·4	5·3	54·3	5·3	49·2
Semesan	300	97·6	0	2·4	97·3	1·6	3·7
Germisan	300	98·3	0	1·7	96|9	2·6	4·7
Uspulun	300	99·3	0	0·7	95·6	1·6	5·4
Tillantin	300	98·6	0	1·4	96·9	2·3	4·9
Formalin	300	87·3	1·6	13·9	38·9	5·6	65·5
Segetan	300	95·9	0	4·1	92·6	0·9	8·1
Urania	300	98·3	0	1·7	97·9	0·3	2·3
Dupont 12	300	95·3	0	4·7	97·0	0·6	3·4
" 46	300	97·3	0·3	2·9	71·3	5·9	33·4
" 49	300	95·3	0·6	5·1	51·6	4·3	44·9
" 57	300	98·0	0·	2·0	89·6	4·3	13·8
Sulphur	300	93·0	0·9	7·7	56·6	8·6	20·2
Copper carbonate	300	96·6	0·6	3·8	87·9	3·6	14·9

From a study of table 32 it will be seen that the results tally very closely with those of table 31.

In the inoculated series the checks show a high rate of disease. Semesan, Germisan, Uspulun, Tillantin, Segetan, Urania, and Dupont 12 gave very satisfactory control; Dupont No. 57, and copper carbonate showed some measure of control, while sulphur, and formalin were very unsatisfactory.

Some miscellaneous commercial preparations, as well as some chemical compounds, were tested as possible seed treatments or stimulants. The tests were conducted with wheat only, against artificial inoculations of *Helminthosporium sativum*. None of the treatments gave satisfactory protection against inoculation. The influence of some of them on emergence may be worthy of mention. Chlorophol and Bayer's Dipdust in solutions of ·3 per cent, and cupric jabonite, Seed-o-san, nickel specials Nos. 1, 2, 3, used as dusts, did not cause any decrease in emergence. Dupont No. 42, however, caused severe seed injury. Seed soaked for ten minutes in concentrated solutions of sodium nitrate, potassium acid phosphate, and sodium biphosphate, then allowed to dry before planting, showed that these chemicals caused some injury to the seed. Commercial sulphuric acid, 1 part to 160 of water,—the seed being soaked for half an hour, then air dried,—caused seed injury. Copper sulphide and copper oxide used as dusts did not cause seed injury, while arsenite, used in the same way, injured the seed.

Field tests, using some of the treatments which were found to offer some protection to the seed in the greenhouse tests, were carried on during the summer. Due to the lack of success in obtaining sufficient infection in the check plots it is not thought wise to attempt conclusions. Most of the treatments which gave protection in the greenhouse gave similar indications in the field. The many factors attendant upon field experimentation of this kind necessitate years of observation and study. (G. A. Scott.)

Take-all Studies

The investigation of the take-all problem has been continued throughout the past year. The wheat variety tests and the study of the longevity of the mycelium were nearly completed, and several new phases were taken up. The work done may be roughly divided under the following headings: cultural studies, greenhouse experiments, and field experiments and field survey.

CULTURAL STUDIES

Six different isolations of *Ophiobolus graminis,* Sacc. were studied for evidence of heterothallism, but so far none was observed. Also a study was made of the amount of acid which this organism will tolerate in potato dextrose agar, with a view to facilitating the isolation of *O. graminis* from field material by acidifying the medium to check bacterial growth. Some difficulty has been experienced in isolating this organism even from greenhouse material. The attempt to produce perithecia in artificial culture was continued, but without success.

GREENHOUSE EXPERIMENTS

Wheat Variety Tests.—During the year the testing of 75 varieties was brought to completion. These seventy-five varieties include at least one representative of each of the eight subspecies of wheats. Each variety has been tested three times under as nearly identical conditions as was feasible. In each test four six-inch pots were sown to each variety of wheat. One of these pots was kept as a check and the other three were inoculated with six grammes each of a pure culture of *O. graminis* grown on ground oat hulls. Eighteen seeds were sown per pot so that in each test about fifty inoculated seedlings were dealt with, or one hundred and fifty in all three tests.

Each test ran for a period of five weeks so as to carry the wheat through the seedling stage. As a rule the seedlings attained a height of two or three inches before showing evidence of disease. Then they became limp and gradually withered and died. Throughout these tests from 20 to 90 per cent of the seedlings of each variety were killed inside of five weeks. At two weeks notes were taken of the emergence and condition of the seedlings. At the end of five weeks notes were taken showing the average height of the checks of each variety compared with the average height of the diseased plants, the number of apparently healthy plants, the number of sickly ones, and the number of dead ones in each variety.

The results on the whole were remarkably consistent. Co-efficients of correlation were worked out between the different tests to get a mathematical indication of the value of the results obtained in the experiment. The correlation between the percentage of each variety which died in the first test and the percentage of the same varieties which died in the second test was $0{\cdot}5197 \pm 0{\cdot}0568$. The correlation coefficient for the first and third tests was $0{\cdot}5213 \pm 0{\cdot}0567$; and that for the second and third tests was $0{\cdot}7861 \pm 0{\cdot}0299$.

While differences in varietal susceptibility to *O. graminis* appear to exist, it seems very doubtful if the resistance shown by any of these varieties is great enough to justify one in recommending them for use in fields infested with take-all, or for plant breeding purposes.

The detailed results of the experiment cannot be given here, but they are available in our records.

Oats, Barley, and Rye Variety Tests.—Twenty-five varieties of oats, eighteen varieties of barley, and seven varieties of rye were tested in the seedling stage for differences in varietal suceptibility to *O. graminis.*

As in the wheat variety tests, four pots were sown to each variety, but the test was not repeated, so just about fifty plants of each variety were inoculated. Briefly, the oats did not appear to be affected by the presence of the organism, although their roots were covered with mycelium. No lesioning or decay of the roots was noticeable. The barley varieties showed root and stem lesions, and they were quite noticeably diseased, but, with the exception of Gatami, none of them appeared to be nearly as susceptible as wheat. (See figs. 16 and 17.) The rye varieties were affected, but not quite as much as the barley varieties.

FIG. 16.—Gatami barley inoculated with *O. graminis.* Eighteen seeds were sown to each pot, the centre pot serving as a check.

Longevity of Mycelium in Soil.—This experiment was divided into three parts, two of which were run in 6-inch pots in the greenhouse, and one in 9-inch pots out of doors. The first two parts ran for one year, and they are completed. The other part is to run for three years and is only partially completed.

The experiment was undertaken to show how long the mycelium of *O. graminis* will remain viable in bare soil kept under the conditions of the experiment, and produce disease on wheat sown in the pots subsequently.

Ninety pots were used in the first part of the experiment (L_1). These were divided into fifteen groups of six pots each. Three pots in each group were filled with a mixture of ordinary field soil and sand, and three were filled with a soil mixture containing a great deal of humus. Two pots of each group were kept as checks, and the remaining four were inoculated at a depth of $1\frac{1}{2}$ inches with 5 grammes of oat-hull inoculum. At the beginning of each month for one year a group of six pots was sown to wheat. In most cases notes were taken and the pots discarded five weeks after being sown, but in a few cases the wheat was matured.

The infection fell off greatly during the first two months. After the fourth month no seedlings died of take-all during the five-week period. The mycelium remained viable in certain pots for the full twelve months and produced typical symptoms of take-all on certain plants before maturity. In most cases the infection in the pots, sown after lying for four months or more, was not noticeable to the naked eye when the plants were five weeks old. When pulled, however, lesions were noticeable on base and roots, and, with the aid of a microscope, considerable *Ophiobolus* mycelium could be found on these parts. When kept to maturity, typical take-all developed on certain plants.

FIG. 17.—Canadian Thorpe barley inoculated with *O. graminis*. Eighteen seeds were sown to each pot, the centre pot serving as a check. Notice the difference in infection as compared with Gatami.

The second part of the experiment, (L_2) was very similar to (L_1), but was approached in the opposite direction; that is, at the beginning of each month a group of six pots was inoculated, and at the end of the year all were sown at the same time. The results obtained were very similar to those of (L_1).

The third part of the experiment, (L_3), being carried on out of doors, is still in progress. Take-all developed in the pots sown in 1926, and also in those sown in 1927.

The technique of Applying Inoculum.—Several experiments were conducted in order to find the most convenient and efficient method of applying the inoculum in these studies. The relative effect of different amounts of inoculum per pot was also studied. About 5 grammes of inoculum per 6-inch pot, applied at seed level when the seed is sown, prove very satisfactory when a heavy infection is desired.

Depth of Seeding and Compacting the Soil.—A study is being made of the effect which these factors have upon the severity of infection, but the work has not progressed far enough to report any of the results.

FIELD EXPERIMENTS AND FIELD SURVEY

Field Experiments.—Two experimental plots of about one acre in extent have been secured on private farms, one near Humboldt, Sask., and the other near Melfort, Sask.

This year one hundred varieties of wheat, five varieties of oats, five varieties of barley, and two of rye were sown in five-foot rows replicated three times. Two rows of each variety were inoculated with a pure culture of *O. graminis* grown on ground oat-hulls, and two rows were retained as checks. The bulk of the plot was sown to Ruby wheat and inoculated by mixing inoculum with the seed, just before it was sown, and passing the mixture through the seed drill.

The infection in the wheat rows on the Humboldt plot was quite heavy. Shortly before the checks were mature, final notes were taken on the experiment. The inoculated rows were stunted at least 50 per cent, and an average of about 75 per cent of the plants in them were dead. The common barley varieties were stunted over 40 per cent in height, and over 33 per cent of the plants were dead. In the case of Gatami, the stunting amounted to over 50 per cent, and 83 per cent of the plants died. The inoculated oat rows were slightly stunted compared with the checks, but the percentage dead was less than in the check rows. The inoculated rows appeared quite normal and produced a good crop of grain. The two rye varieties appeared to be slightly affected.

The main plot sown to Ruby wheat showed a very light infection. This was probably due to two main causes. Being sown with a seed drill, the inoculum was not in such close contact with the seed as in the rows sown by hand, and the proportion of inoculum to seed was much less. It is perhaps advisable to sow the main plot to wheat, and inoculate it again in order to get the land more heavily infected, before laying it out in small plots for rotation studies. The duplicate experiment at Melfort showed no signs of infection either in the rows or the main plot. It was sown three weeks later than the Humboldt plot, but the real explanation of the absence of take-all is probably because the inoculum heated on the way out to Melfort. This was discovered on the evening of our arrival, and the inoculum was at once cooled down, but apparently the damage had been done.

Field Survey.—This was divided into two phases, a general survey of various parts of Saskatchewan, in which every member of the staff assisted, to determine the prevalence and importance of the disease, and a continuation of the annual systematic survey of twenty-six fields in the Humboldt and Melfort districts. The field survey brought out four main points; (1) summer-fallowing of infested fields, or sowing them to oats for one year, appear to greatly reduce the amount of disease in the following crop of wheat; (2) *O. graminis* is more widely distributed in Saskatchewan than was known heretofore; (3) take-all was much more prevalent in northeastern Saskatchewan than in 1926; (4) very little evidence of seedling blight due to *O. graminis* was seen.

Table 33 gives a summary of the annual study of the twenty-six fields mentioned above.

Fields 1-3 and parts of fields 4 and 8 have been sown to wheat every year for the past three years. These fields and field 26, which was broken in 1925 and produced its second crop of wheat this year, are the only ones which showed more than 1 per cent infection with take-all this year. The average injury to the crops in these fields was 10-15 per cent by estimate. Fields 5-11 show the beneficial effect of one crop of oats or one year's summer-fallow applied to infected fields. The remaining fields were either summer-fallowed or sown to coarse grains this year, and showed no take-all. When one considers the condition of all these fields in 1925 and the condition of fields 1-4 this season, these results speak very forcibly of the value of simple crop rotation in combating take-all. (R. C. Russell.)

TABLE 33.—SUMMARY OF SYSTEMATIC TAKE-ALL SURVEY

Field			1925		1926		1927	
No.	Acreage	Age	Crop	Per cent Infection	Crop	Per cent Infection	Crop	Per cent Infection
		years						
1	75	4	Wheat	?	Wheat	?	Wheat	30
2	2	5	"	10–30	"	2–10	"	10–30
3	25	4	"	2–10	"	1	"	2–10
4	50	5	"	2–10	"	2–10	Wheat	10–30
							Oats	0
							Summerfallow	–
5	45	7 & 8	"	10–30	Oats	0	Summerfallow	–
							Wheat	trace
6	20	6	"	10–30	"	0	Wheat	"
7	20	4	"	2–10	"	0	Wheat	0
8	15	4	"	2–10	Oats	0	Wheat	1
					Wheat	1	Wheat	10–30
9	16	5	"	10–30	Summerfallow		Wheat	trace
10	25	5	"	10–30	"		"	"
11	8	5	"	2–10	"		"	"
12	3	6	"	10–30	Wheat	1	Summerfallow	
13	50	5	"	10–30	"	2–10	Oats	0
14	30	5	"	10–30	"	2–10	"	0
15	40	5	"	10–30	Barley and oats	0	Barley	0
16	10	7	"	10–30	Oats	0	Oats	0
17	20	5	"	10–30	"	0	Summerfallow	
* 18	40	10+	"	10–30	Brome-grass	?	"	
19	18	4	"	2–10	Wheat	1	Oats	0
20	8	4	"	2–10	"	1	Barley and oats	0
21	3	3	"	2–10				
	8	4	"	2–10	Wheat	2–10	Oats	0
22	23	7	"	2–10	Oats	0	"	0
23	5	6	"	2–10	Wheat	1	Summerfallow	
24	8	3	"	1	"	1	Oats	0
25	10	5	"	1	"	1	Summerfallow	
26	15	2	Breaking		"	trace	Wheat	2–10

* This field was broken years ago, and raised brome grass for several years previous to 1924, when it was broken again.

RESISTANCE OF WHEAT VARIETIES TO *Helminthosporium sativum* and *Fusarium culmorum*

The same twenty varieties of wheat (see this report for 1926) were tested out in the field this year for resistance to *Helminthosporium sativum* and *Fusarium culmorum*. The field work was done in co-operation with Dr. J. B. Harrington of the University Department of Field Husbandry.

The planting plan, methods of inoculation, and inoculum used were exactly similar to the 1926 test. During the period of the experiments careful isolations were made from the diseased basal parts of plants from each variety to determine whether the lesions present were caused by the pathogens under study. With few exceptions the isolations gave positive results.

Table 34 contains a summary of the two years' test.

TABLE 34.—THE RESISTANCE TO *Helminthosporium sativum* AND *Fusarium culmorum* OF TWENTY VARIETIES OF WHEAT AS INDICATED BY INFECTION EXPRESSED IN PERCENTAGE. FIELD AND GREENHOUSE TESTS MADE IN 1926 AND 1927.

Variety	*Helminthosporium sativum*			*Fusarium culmorum*		
	Greenhouse	Field		Greenhouse	Field	
	1926 %	1926 %	1927 %	1926 %	1926 %	1927 %
Garnet	64·7	56·3	45·1	84·2	32·6	37·8
Ruby	69·7	46·5	60·1	80·7	27·7	39·2
Quality	74·5	27·5	49·1	90·0	18·5	41·8
Federation	75·7	39·3	63·9	81·7	26·2	46·3
Red Bobs	78·0	45·2	54·0	87·5	18·0	36·3
Marquillo	52·7	36·1	62·0	77·0	8·7	36·9
Marquis	56·0	35·2	61·8	76·2	11·2	45·5
Ceres	63·5	23·4	62·5	71·0	9·4	43·8
Kota	61·0	37·7	57·2	75·0	16·7	43·1
Early Red Fife	67·2	31·6	52·8	68·7	15·6	42·0
Kitchener	61·2	45·1	53·7	70·0	16·4	37·8
Red Fife	27·2	29·1	63·6	49·2	23·0	53·3
Little Club	75·5	55·8	66·1	81·8	21·5	54·4
Spelt	28·0	24·1	27·3	69·0	13·0	37·8
Emmer	53·0	33·4	47·7	76·0	19·8	30·0
Polish	44·7	42·8	55·9	76·7	30·5	49·8
Peliss	61·5	47·0	46·9	72·0	23·7	32·4
Acme	51·5	31·2	53·7	57·7	19·7	30·2
Kubanka	41·5	51·6	40·9	51·7	35·5	54·7
Mindum	64·8	58·7	60·6	81·0	28·0	60·6

The above table reveals the fact that more severe infection occurred in the field test of 1927 than the previous year. It does not show, however, any specific indication of resistance, when the results of the two years are compared.

INVESTIGATIONS ON CONTROL METHODS FOR ROOT ROTS

Although studies are made in connection with each specific pathogen towards control methods, yet the general root disease condition, as it occurs in the field, can be considered as a particular problem. Such a problem takes in cultural methods, fertilizers, seed treatments, and so forth. Seed treatments are considered here. In the above accounts the effects of seed treatments are considered in relation to specific organisms in the greenhouse and field. In 1926 arrangements were made with farmers to carry on seed treatment tests on their farms. Fields were selected which had presumably a complex root disease infestation. The method was to obtain seed from the farmer, make the treatments, and return the seed. This was sown at the same time as general seeding, consequently the field in general served as a check. The plots were usually about three rods long and the width of the seeder. This gave a fair sized plot, the seed source being the same as the general field, the time of sowing the same, and, in general, all conditions similar, which gave the test a natural setting. For the first season three farms were included in the investigation, two in the Indian Head district, and one at Grenfell. Three treatments were tried: Semesan soak, Dupont 12, and Segetan dust. The two Indian Head co-operators believed that there was a more uniform emergence in the plots. Prior to harvest, however, no outstanding differences were noticed. There was very little evidence of root disease in the fields. In 1927 the same three farmers co-operated, and the same treatments were tried. In addition, two farms were selected in northern Saskatchewan, one at Borden, and one at Maidstone. The material was sent to the farmers with instructions as to the method of treatment. On one, four dust treatments were tried: Segetan, Dupont 12, sulphur, and Wa-wa; on

the other, Semesan, formalin, Segetan, Dupont 12, copper carbonate, and sulphur. All locations were visited at intervals throughout the season and notes obtained. The two Indian Head fields suffered from heavy rain and hail, so that significant notes could not be obtained. The Grenfell field was very good for observation. Here when the general field was just heading out, the Dupont 12 plot was about three or four days in advance. This was very noticeable at this stage; later, however, the difference was not so marked. Segetan was next in earliness, whereas, the emergence on the Semesan plot, which was sown while too damp, was very irregular. The difference did not seem to warrant the taking of yields. There was no evidence of much root disease in the field. In the Borden field no comparative difference could be noted. At Maidstone, the plots were distinctly behind the general field which had been treated with formalin. No explanation of these results can be offered. It is intended to carry on such tests so as to obtain results over a period of years, hoping to get a comparison under a severe natural infection.

Fungous Flora of Wheat Crowns and Roots

It is believed that fungi, such as *Helminthosporium sativum* and *Fusarium* spp., may vary in their occurrence throughout the season, as well as in different regions. Isolations from crowns and roots of Marquis wheat were made from June to October in 1926 at Saskatoon. The results were reported in last year's reports. For this year a project was outlined to take in five districts, namely, Morden, and Winnipeg, in Manitoba; Indian Head, Saskatoon, and Swift Current, in Saskatchewan. Members of the Experimental Farms kindly co-operated, making this investigation possible. We wish to acknowledge with thanks this sincere co-operation.

Marquis and Kubanka wheats were used and were distributed to various places in time to be sown when general seeding commenced. At monthly periods, starting with the seedling stage and extending until after harvest, fifty plants of each variety were taken for isolations. Twenty-five pieces from the roots, and fifty crowns from each lot were plated on potato dextrose agar. Before surface sterilization, the crowns and roots were carefully washed, and pruned down until only the main tiller was left. These were surface-sterilized in bichloride of mercury (1-1000) for 10 minutes, then washed three times in sterile water, after which the excess parts were cut away with sterile scissors until the portion to be plated was exposed. The plates were incubated at room temperature. As soon as possible counts and determinations were made, particular attention being given to the appearance of the two fungous types mentioned above. Many cultures were carried in tubes for some time before identification was possible. It was impossible to determine some of the growths. Detailed records cannot be given here, so the results have been summarized for each region, giving the totals in percentage of isolations made from crowns and roots for the entire season. (Table 35.)

Table 35.—Summary of Isolations from Marquis and Kubanka Wheat collected at Various Points during the Summer of 1927

Station	Marquis				Kubanka			
	Pieces plated	Per cent total fungi	Per cent *Helminthosporium*	Per cent *Fusarium*	Pieces plated	Per cent total fungi	Per cent *Helminthosporium*	Per cent *Fusarium*
Morden	200	43·5	5	10·5	200	64·5	9·5	31·0
Winnipeg	250	49·6	2	12·0	300	60·3	7·0	24·0
Indian Head	300	46·0	12·6	9·6	300	50·0	7·0	16·3
Saskatoon	298	41·6	13·7	19·4	300	58·3	7·3	44·0
Swift Current	300	51·3	24·0	9·3	300	56·6	28·3	10·6

From one season's work it is perhaps not desirable to draw conclusions. When the regions are compared, however, it is seen that the Swift Current samples showed the most *Helminthosporia* while Saskatoon leads with *Fusarium* spp. For the total fungi of all kinds at each place was nearly the same. It may be said that seasonal variations did occur, but they will not be discussed until a comparison can be made with other years. Mention should be made of some other types of fungi revealed by the isolations. A *Rhizoctonia* type was isolated from the Winnipeg, Indian Head, and Saskatoon samples; a sclerotial fungus, somewhat like *Sclerotinia sclerotiorum,* was obtained from the Saskatoon lot, and a *Pythium*-like organism from Indian Head, and Morden. Some *Alternaria* were isolated. The undetermined included both the black and white mycelium types, the former predominating.

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY FOR ALBERTA

(G. B. Sanford, Pathologist)

A plant pathological laboratory was established late this year at Lacombe, and preliminary work was begun, August 13, with an extensive plant disease survey of the province.

The 1927 crop season was very unusual, the spring being very late and wet. Although there were excellent mid-summer conditions for growth, the ripening season was such that late sown grains matured very slowly. The Peace River crop was harvested two weeks before that of Central Alberta, and still earlier than that of the extreme south, where cutting was general September 21, and many fields still green at that date. In spite of these conditions, Alberta harvested the greatest wheat crop in her history.

Practically all the arable territory from Sangudo, Westlock, Athabasca, and the Saskatchewan River, on the north, south to the International Boundary was surveyed. This is the first systematic plant disease survey in Alberta, and, therefore, the following observations are of interest.

Stem Rust of Wheat
(Puccinia graminis Tritici)

This is the first year that shrinkage of wheat from stem rust has been recorded from Alberta. It has been difficult to find more than a trace of rust since 1916, when slight infections occurred, but no damage. By August 13, this year, rust began to appear in the general Edmonton-Wetaskiwin-Vegreville area, and eastward, with more in the immediate Camrose district than elsewhere. In very few places did the severity at this time exceed more than a slight infection, and in many fields it was difficult to find. There was a very noticeable decrease eastward toward the boundary, a fact possibly associated with the lighter type of soil, less rainfall, and, therefore, thinner seeding used than in the blacksoil, and greater precipitation area further west. By August 25, representative points as far south as Lethbridge and Macleod had been visited, and, with the exception of a rather severe local outbreak on some experimental plots at Olds and Lacombe, rust infection decreased very sharply from the general Camrose area, and at this date it was not found as far south as Lethbridge. At this time, also, it did not seem possible that noticeable shrinkage could occur even in the Camrose district, unless on very late-maturing wheat. However, a re-survey of the Edmonton-Camrose-Vegreville area by September 15, when cutting was well advanced, showed that shrinkage to the extent of lowering the quality by one or two grades had occurred in a number of fields in the Camrose district. In many of these cases, however, the shrinkage was complicated with diseased

roots, a fact which would be overlooked by the casual observer. By September 15, when cutting was 75 per cent completed, a trace of rust was noted in fields from Edmonton to the Sangudo district, and northward to Westlock and Athabasca, a point about one hundred miles north of Edmonton. By September 27, rust was found in every field from the northern limits of the survey to the Montana boundary. Slight infections were recorded on four varieties in a late-sown rust nursery at the Experimental Station at Beaver Lodge.

Stem Rust of Oats

(Puccinia graminis Avenae)

The distribution of stem rust of oats was roughly similar to that of wheat, with the exception that it was not found south of Lethbridge, and only about as far north as Edmonton. This rust was more common eastward from Vegreville toward Saskatchewan than elsewhere. No damage was noted, the infection usually not being more than a trace.

Leaf Rust of Wheat

(Puccinia triticina)

Leaf rust of wheat was very prevalent, being similar in distribution to that of stem rust. This rust was heavy enough to appear to be causing injury.

Stripe Rust

(Puccinia glumarum)

On my 1926 survey, stripe rust was collected on August 17 from the leaves of a number of wheat varieties in a plot at the School of Agriculture at Olds, and also from *Hordeum jubatum*, which grew nearby. This is the first record of this rust being observed on wheat in Western Canada. This rust was observed again this year on August 20, on both leaves and glumes of a number of varieties of wheat growing in a plot in practically the same location as the plot in which the infection occurred last year. The *H. jubatum* nearby was also, again, infected with stripe rust, so that over-wintering of the inoculum is suggested. On September 20, stripe rust was observed only on the leaves in eleven wheat fields from Cardston, southeast, toward the Montana boundary, and also on *H. jubatum*. Only two cases of severe infection were seen.

Smuts of Wheat

(Tilletia spp. and *Ustilago Tritici)*, Oats and Barley *(Ustilago* spp.*)*

These smuts were, on the whole, relatively scarce, especially in the older settled, and better farmed districts, where seed treatment is generally practised. But even here, one too frequently finds fields of wheat with a serious amount of bunt, and of oats, with a large amount of covered or loose smut. Loose smut of barley scarcely ever exceeded one per cent, but, being rather common, the aggregate loss is important.

Glume Blotch of Wheat

(Septoria glumarum)

Glume blotch of wheat was exceptionally prevalent throughout the entire area surveyed. It was most severe in the general High River-Nanton-Vulcan-Claresholm area. This severity seemed to have been increased by hail damage.

Basal Glume Rot

(Bacterium atrofaciens)

Basal glume rot was observed in many fields, but never more than a trace, it being usually confined to one spikelet per head, here and there, throughout the field. In view of the moist season which prevailed, it would seem that other factors were lacking for a serious development of this disease.

Black Chaff of Wheat

(Bacterium translucens)

A trace of black chaff was collected at such widely separated points as Westlock, Lacombe, Youngstown, and Claresholm. It was easiest to find in what proved to be one of the driest parts of the crop area.

Barley Stripe

(Helminthosporium gramineum)

This was common and, at times, severe, as was also foot rot and spot blotch *(H. sativum)*.

Ergot of Grains and Grasses

(Claviceps purpurea)

Rather severe cases of this disease were frequently observed throughout the area surveyed on species of *Bromus* and *Agropyron*, and also on common rye.

Foot and Root Rots of Wheat

(Ophiobolus graminis, Helminthosporium sativum, and *Fusarium* spp.*)*

The foot and root rots of wheat present the outstanding plant disease problem of Alberta, as determined by the preliminary survey of 1926, and the more extensive one this year. The data show what appears to be a very close correlation between severity of the disease and the soil type, under the conditions existing this year. The different soil type areas have been located in a general way by the Department of Soils of the University of Alberta, and classified as (1) Podsol, or wooded; (2) Black soil (high organic content); (3) Transition soils; (4) Prairie or brown soil. In the transition area, the black soils naturally predominate near the definitely black areas, as do the brown soils, near the prairie areas. The black soils comprise a large part of Alberta's most productive wheat area. The distribution and relative severity of foot and root rots of wheat in 1927 are shown on the accompanying map (fig. 18), where a close correlation between the black soil type and greatest prevalence of the disease is indicated. The severity of the take-all disease was unquestionably much greater in the black soil areas, and distinctly decreased as the brown prairie types were encountered; in fact, no appreciable amount of root-rot injury was observed in the strictly brown soils. From data obtained from several hundred wheat fields, the average loss this year from foot- and root-rots of wheat, principally take-all, is placed at about ten per cent. Where infection occurred, losses ranged from one per cent to a few exceptional cases of ninety per cent. If this average of ten per cent is applied to one-third of the total yield, the loss from this source would approximate 7,000,000 bushels, a figure believed to be very conservative.

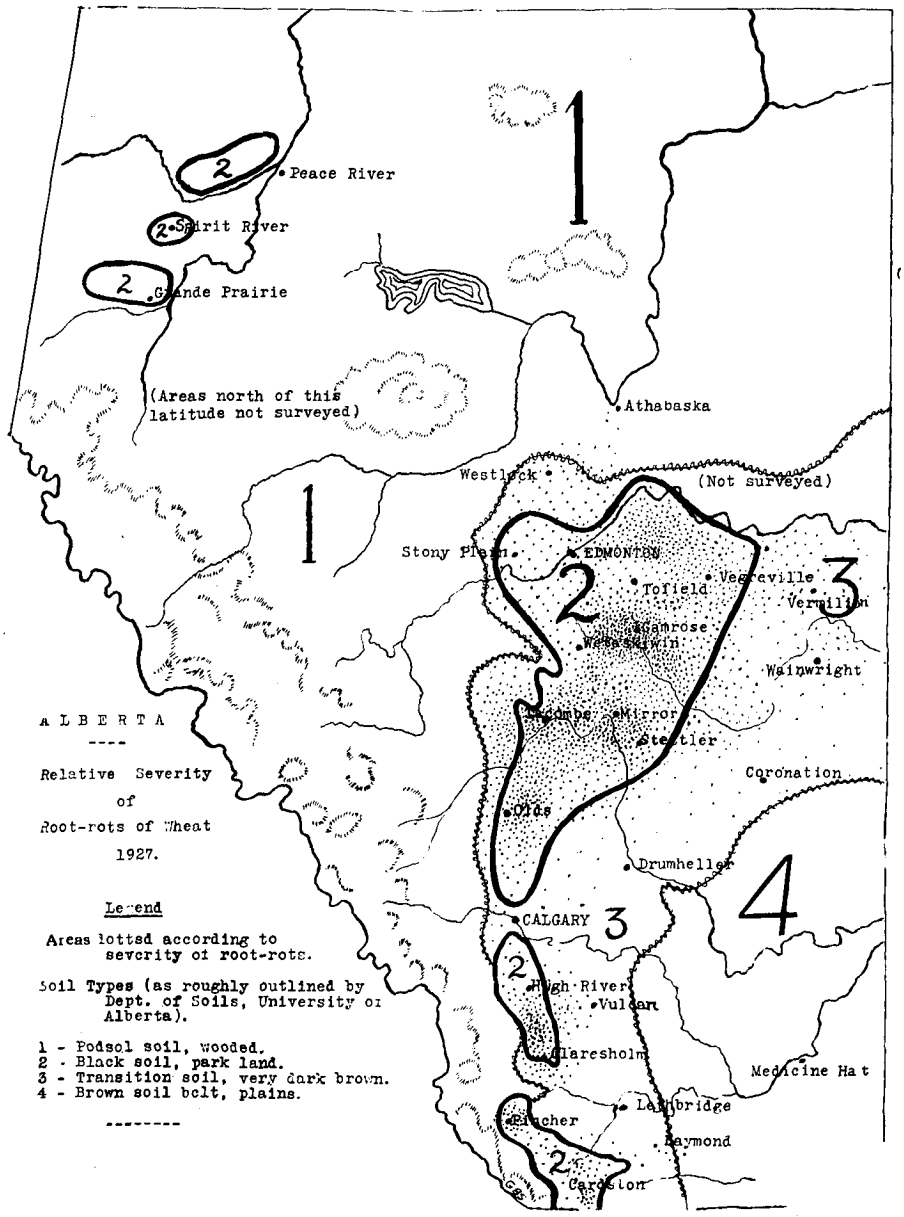

FIG. 18.—The distribution and relative severity of foot- and root-rots of wheat in the different soil types of Alberta in 1927.

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CONTROL OF WHEAT SMUT (*Ustilago Tritici*, (Pers.) Jens.) IN THE HURON VARIETY, AT CHARLOTTETOWN, P.E.I.

(R. R. Hurst, Officer in Charge)

The modified hot water treatment as applied by the Experimental Station at Charlottetown has failed to control smut on Huron wheat. Accordingly, a preliminary project was undertaken to obtain an indication of the reason for this failure. With a belief that Huron wheat grains are more resistant to hot water treatment because of certain characters and textures of its hulls, a plan was devised to test the ability of grains of the Huron variety to resist higher temperatures than those practised and recommended in the past. The inference was that, if grains of this variety will survive the higher temperatures necessary to control smut, variations of the modified treatment could be recommended in accordance with our findings.

The following plan was adopted: Huron wheat from rotation "B," and Early Red Fife were treated simultaneously, the latter as a check against the former. The modified hot water treatment practised at the Experimental Station in the past was tried out as follows:

1. Presoak in water at 20° C. for 3 hours.
2. Intermediate soak at 43° C. for 20 minutes.
3. Final soak at 52° C. for 10 minutes.

Subsequent treatments were modifications of this as follows:

TABLE 36.—RESULTS OF THE MODIFIED HOT WATER TREATMENT

Presoak	Intermediate soak	Final soak
1. 20° C. for 3 hours	43° C. for 20 minutes	52° C. for 15, 20, 25, 30 minutes
2. 20° C. " 3 "	43° C. " 20 "	53° C. " 15, 20, 25, 30 "
3. 20° C. " 3 "	43° C. " 20 "	54° C. " 15, 20, 25, 30 "
4. 20° C. " 4 "	43° C. " 20 "	52° C. " 15, 20, 25, 30 "
5. 20° C. " 4 "	43° C. " 20 "	53° C. " 15, 20, 25, 30 "
6. 20° C. " 4 "	43° C. " 20 "	54° C. " 15, 20, 25, 30 "

Each treatment was made in duplicate, the samples of grain weighing 120 grammes. Constant temperatures were obtained by placing the containers in electric incubators adjusted to provide the required temperature.

Duplicate germination tests were made in the laboratory from each lot. Material was also saved from each treatment and seeded in quadruplicate rod-rows. Table 37 gives the results of the germination tests.

TABLE 37.—RESULTS OF GERMINATION TESTS OF SEED GRAIN TREATED BY HOT WATER METHOD

Presoak in hours at 20° C.	Intermediate soak in mins. at 43° C.	Final soak temperature	Average per cent germination (minutes in final soak)					
			Variety	Check	15	20	25	30
No treatment.			Huron	100				
			Fife	100				
3	20	52° C.	Huron		98	98	81	77
			Fife		98	96	80	78
3	20	53° C.	Huron		100	98	82	70
			Fife		98	96	89	65
3	20	54° C.	Huron		99	93	88	67
			Fife		96	90	70	40
4	20	53° C.	Huron		96	94	78	68
			Fife		97	90	80	60
4	20	54° C.	Huron		81	60	56	57
			Fife		90	81	29	40

Inasmuch as seed viability in the Huron variety was not seriously impaired when soaked for 20 minutes at 54° C. with a presoak of 3 hours at 20° C., it was deemed advisable to adopt this method at the Experimental Station. Samples of grain treated in this manner were included in the field experiment, along with untreated checks of Huron and Red Fife.

On the rotations seeded with Huron grain presoaked 3 hours, then held at 54° C. for 20 minutes, smut incidence was less than one per cent. In the rod-rows 6 per cent of smut developed in the checks (no treatment), and 3 per cent in Huron grain treated as in previous years. Smut was not found in the grain presoaked for 4 hours and held at 54° C. for 20 minutes.

It would appear that, on a basis of one year's test, successful treatment of Huron seed grain may be accomplished when the following method is employed:—

1. Presoak in water at 20° C. for 3 hours.
2. Intermediate soak at 43° C. for 20 minutes.
3. Final soak at 54° C. for 20 minutes.

SECTION IV.

INVESTIGATION OF THE DISEASES OF FRUITS AND VEGETABLES

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, ST. CATHARINES, ONTARIO

(G. H. Berkeley, Sr. Pathologist in Charge.)

The season of 1927 was particularly favourable for the development of fungous diseases and insect pests. Apple scab was more prevalent than during the last four years. An epidemic of cherry leaf spot, *Coccomyces hiemalis*, caused serious defoliation particularly in unsprayed orchards. Rosy and green apple aphids were particularly severe, causing serious loss in many orchards. "Aphid apples" were far too plentiful this year. Grape dead arm continues to be the outstanding disease of grapes, although grape mildews were fairly general this year.

The long felt need for land and greenhouse space has at last been satisfied by the purchase of a thirty-acre farm for the work of this laboratory. When present plans are completed the new St. Catharines Plant Research Laboratories will be splendidly equipped for all phases of plant pathological research.

Spray Service

The season of 1927 was a severe test for the spray service, since fungous diseases and insect pests were more prevalent than usual. At the same time, however, the results obtained have demonstrated that, even in a bad year, spray service methods are best. The results obtained during the past three years have conclusively shown (1), that a properly organized spray service can be successfully operated; (2), that such a service is of great value to the fruit grower; (3), that fruit from spray service orchards is invariably of the better quality; (4), that crop protection has been considerably improved. Comparisons made again this year tell the same story as in previous years, namely, that orchards which received all the sprays recommended by the spray service produced much cleaner and better fruit than orchards which did not receive the recommended sprays, whether these orchards were in the spray service or not. This was particularly noticeable with leaf spot on sour cherries. Cherry orchards, which received the recommended sprays on time, were very slightly affected indeed; in fact, in three such orchards hardly a yellow leaf could be found. On the other hand orchards which did not receive these sprays were almost entirely defoliated. Two such orchards on the mountain, south of Beamsville, showed over seventy-five per cent defoliation two weeks after the disease hit the orchard. Under Ontario conditions cherry leaf spot generally attacks only the leaves; but this year, however, the fruit and particularly the fruit pedicels (stems) were severely attacked. White tufts of mycelium with conidiophores and canker-like depressions were readily apparent to the naked eye (fig. 19).

The membership this year was about the same as last, namely, slightly over two hundred. Eighteen circulars with information regarding the sprays to be applied were sent to each member. The first of these was issued on March 10 and the last on August 17. The spraying information concerning the pink spray on apples was relayed by telephone, since weather conditions did not allow of sufficient time for sending out a circular letter.

The spray service was again this year under the supervision of Mr. G. C. Chamberlain, Assistant Pathologist, who was assisted by Mr. J. H. Johnson. Mr. Johnson was stationed at Grimsby, and covered the territory from Vineland west to Winona. Mr. Chamberlain, who was located at St. Catharines,

not only had charge of the territory from Vineland to the Niagara river, but had, as well, general supervision of the entire territory and service. Mr. Wm. Ross, entomologist, again kindly acted as consulting entomologist.

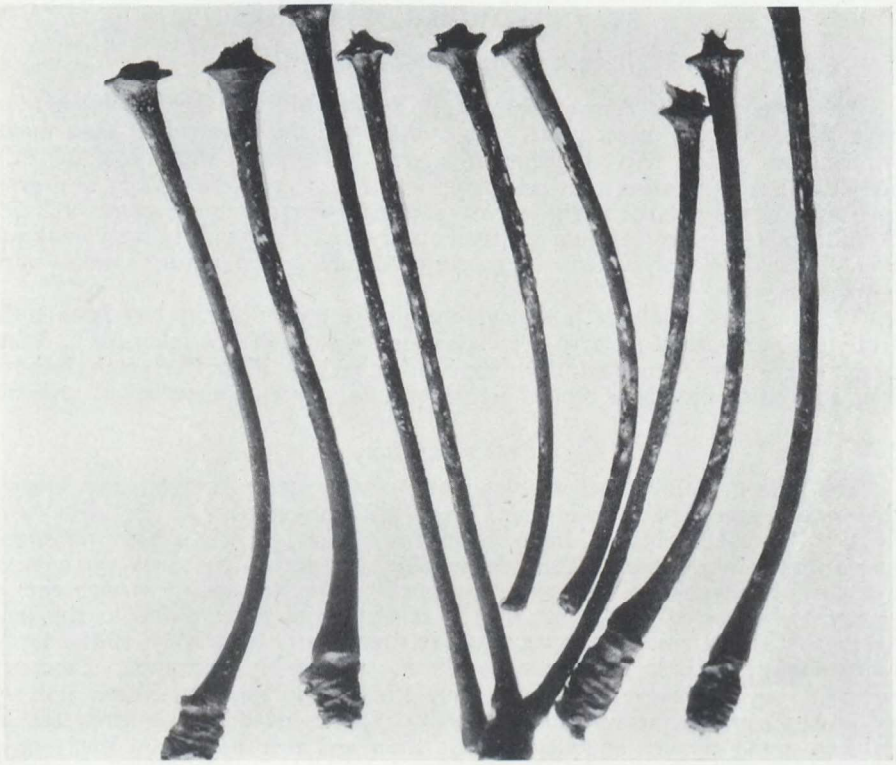

FIG. 19.—Conidiophores of the leaf spot fungus on cherry stems (fruit pedicels).

BORDEAUX MIXTURE ON SOUR CHERRIES

The results obtained this year correspond to those of last year in that the difference in size between lime-sulphur-sprayed and bordeaux-sprayed cherries was not so pronounced as in 1925. The reason for this lack of difference is again put down to a light crop on the trees. In 1924 when the cherry crop was heavy, demonstrations showed that cherries from bordeaux-sprayed trees were considerably smaller in size than cherries from lime-sulphur-sprayed trees. The results obtained this year are as follows:—

TABLE 38.—RESULTS OF SPRAYING WITH BORDEAUX MIXTURE

—	Average weight 1,000 cherries	Six trees crop in 11 qt. baskets	Average diameter per cherry in 1/32"
Lime-sulphur	7 lb. 7 oz.	15¼	23·8
Bordeaux	7 lb.	12½	22·7
Difference	7 oz.	2¾	1·1

These results bear out those obtained in 1925 and 1926, namely, that cherries on bordeaux-sprayed trees are smaller in size than cherries from lime-sulphur-sprayed trees.

Blossom Blight on Peaches

In last year's report it was pointed out that brown-rot blighted blossoms not only initiated peach cankers but were the cause of die-back of affected twigs as well. In addition, cankers so formed produced an abundance of brown rot conidia the following season, thereby increasing the sources of primary infection in the spring. The necessity of blossom blight prevention is, therefore, apparent. In order to find out the value of a pre-blossom spray in controlling blossom blight, two rows of Admiral Dewey peaches were sprayed with wettable sulphur when the blossom buds were showing pink, and two rows were left as checks. The season was favourable for blossom blight and so the experiment was carried out under favourable conditions. Observations and counts were made at different times during the season. The sprayed rows were almost entirely free from blossom blight and die-back. The unsprayed rows showed considerable blossom blight and die-back. Comparison of the two plots demonstrated that a pre-blosom spray was very efficacious in controlling blossom blight, since the sprayed rows showed seventy-five per cent more freedom from blossom blight and die-back than did the unsprayed rows.

Growers would be well advised to apply a pre-blossom spray of wettable sulphur, self-boiled lime-sulphur, or sulphur dust, on all peaches, but particularly on those varieties that are especially susceptible to blossom blight.

Raspberry Mosaic and Certified Raspberry Stock

The raspberry inspection and certification service was again a major part of our year's work. Some four hundred and twenty-five inspections were made by the inspectors throughout Ontario. Again over fifty acres of certified stock have been made available. A special effort was made this year to clean up the nurseries. Our inspectors assisted with roguing in the nursery row, and also in commercial plantations with less than one per cent mosaic. Five special requests were received from nurseries for assistance with roguing of nursery stock.

As in former years mosaic was found to be widespread and, in far too many cases, seriously affecting the yield. The symptoms of the disease were of a more severe type than usual. Leaf curl was again quite prevalent. During the last two years leaf curl has appeared to be on the uphill climb again.

The London and Waterford districts still continue to be relatively free from mosaic.

Much certified stock was again purchased by New York growers. Erie County growers, Buffalo, N.Y., purchased 100,000 plants of the new variety Adams 87. No mosaic has yet been found in commercial plantings of this variety. In four plantings of this variety set out by Mr. Bridgeman, Winona, there was not one single case of mosaic or leaf curl.

Mr. Coombs, Rochester, has again kindly sent me the results of the 1927 inspection of Ontario certified stock planted in the Rochester district.

TABLE 39.—ONTARIO CERTIFIED STOCK IN NEW YORK STATE

Year set out	Amount of stock	Number of plants mosaic rogued	Mosaic 1927
			%
1924	2,000	17	0·85
1925	17,350	153	0·88
1926	250	7	0·28
1927	4,250	30	0·71

It is very encouraging to know that our Ontario certified stock is doing so well in New York State.

PRODUCTION OF MOSAIC RASPBERRY PLANTS

The following table gives the results obtained from the third year's picking of an experimental plot of thirty bushes each of healthy and diseased bushes.

TABLE 40

Date of picking	Healthy		Diseased	
	Weight in ounces	Number of berries	Weight in ounces	Number of berries
July 16	1¾	36	8¾	225
" 20	7¾	213	19¾	556
" 26	57	1,219	68½	1,809
" 29	102	2,058	81	1,895
Aug. 2	143	3,232	84	2,261
" 5	86½	2,256	52½	1,522
" 9	80½	2,167	48	1,423
" 12	47	1,421	22	745
" 16	30½	884	13½	452
Totals	556	13,486	398	10,888

The healthy plot produced 13,486 berries or 556 ounces, whereas the mosaic plot produced 10,888 berries or 398 ounces,—a difference of 2,598 berries or 158 ounces.

It was demonstrated again this year that the mosaic bushes produced earlier berries than healthy bushes. This has been borne out by the first three pickings each year for the last four years. Two facts are, therefore, apparent: (1), that mosaic causes considerable decrease in quantity and quality of crop, and (2), that mosaic bushes are slightly earlier in season than healthy bushes. The degree of earliness is, however, extremely slight and is of no commercial value.

The following table gives for comparison, the results of three years' pickings of the above plot.

TABLE 41

—	Number of berries		Number of ounces		Difference between healthy and mosaic	
	Healthy	Mosaic	Healthy	Mosaic		
					berries	oz.
1925	24,517	18,664	1,203¾	895¼	5,853	308½
1926	20,960	19,107	1,058	913	1,853	145
1927	13,486	10,888	556	398	2,598	158

NOTE.—The 1927 crop was very light compared with those of 1925 and 1926.

Production of Healthy and Mosaic Cuthbert (Plot 2)

The production of Plot 2 is based upon fifty healthy and fifty mosaic Cuthbert bushes three years of age.

Table 42

Date of picking	Healthy		Diseased	
	Number of berries	Pints	Number of berries	Pints
July 20	855	4	1,0'0	5
" 25	3,422	17	2,430	11
Aug. 1	5,560	25	4,750	17
" 4	1,215	5	1,106	5
" 8	1,796	7	1,505	6½
" 12	715	3	532	2
	13,563	61	11,333	46½

The healthy bushes in this plot produced 13,563 berries or 61 pints, whereas the mosaic bushes produced only 11,333 berries or 46½ pints, a difference in favour of the healthy bushes of 2,230 berries or 14½ pints. In the same plot last year, the first bearing year, the difference in the mosaic bushes was only 5⅓ pints less than in the healthy bushes.

Variety Plot

In a variety plantation of eleven varieties the following crops were harvested. The figures are based upon fifty three-year-old plants in each case. For certain varieties the production of an equal number of mosaic plants is also given.

Table 43

Variety	Healthy		Diseased	
	Number of berries	Pints	Number of berries	Pints
Adams 87	17,963	115	.....	.....
Newman 23	20,205	112	.....	.....
Herbert	14,239	79½	.....	.....
Brighton	17,547	77	7,033	25
Owasco	15,196	74	.....	.....
Count	16,249	71½	.....	.....
Marlboro	14,125	65	5,400	27
Cuthbert	13,563	61	11,333	46½
Cayuga	12,790	60	12,350	60
Viking	9,415	50	6,605	32½
King	8,370	40	3,130	11⅔

Rate of Spread

The following figures give the spread of mosaic during 1925-1927. Percentage figures are based on total spread from time set out, 1924, till fall of 1927. The figures in the table below, with the exception of the last column, give the number of plants in each case.

TABLE 44

	1925		1926		1927		% Spread
	Healthy	Mosaic	Healthy	Mosaic	Healthy	Mosaic	
Herbert	20	0	20	0	20	0	0
Marlboro	20	0	14	6	5	15	75
Viking	20	0	17	3	8	12	60
Adams 87	10	0	10	0	10	0	0
King	10	0	9	1	5	5	50
Newman	5	0	5	0	5	0	0
Count	10	0	10	0	10	0	0
Brighton	10	0	10	0	9	1	10
Cuthbert	20	0	17	3	15	5	25

It is apparent from the above table that the greatest spread has taken place in Marlboro, Viking, and King varieties in the order given. It is very interesting to note that, in Herbert, Adams 87, Newman 23, and Count varieties, no spread whatever has taken place during the last three years. All these varieties were grown on the same location and under identical cultural practices.

Winter-killing has been severe in raspberries during the past two winters. Winter injury was especially severe during 1926-27 on the following varieties; —Viking, King, Marlboro, Herbert, Cuthbert. The Viking and King varieties showed the greatest amount of winter injury in our experimental plots at Port Dalhousie. This fact, no doubt, accounts in part for the low yield given by these varieties this year.

LEAF CURL

Leaf curl was more prevalent this year than last. Infection showed up early and, in mid-season, a second period of spread appeared with particularly pronounced symptoms. Leaf curl, particularly in the Niagara peninsula, has been on a steady decline until the last two years, when it has been more prevalent than usual. However, rigid inspection and roguing should take care of this situation successfully.

STRAWBERRY ROOT ROT

We were able to continue, during the past year, the work which was started three years ago with strawberry root rot. Mr. A. R. Walker, Plant Disease Investigator, worked full time on this problem during the summer season. Mr. Walker reports as follows:—

"The work on this strawberry trouble was commenced about the middle of May. Strawberry patches were observed in several different parts of the Niagara peninsula. However, the malady which had been so pronounced during the previous seasons had not put in an appearance in any well marked degree at that time.

"The last week in May some evidence was noted, and by the first week in June the trouble had become quite pronounced. A few diseased plants could then be found in almost any strawberry patch which I visited. These early appearances of the trouble were most marked in an old patch. From the third week to the end of June the strawberry patches seemed to suffer most; even young patches suffered a heavy toll.

"Diseased and healthy stems from the patch at the back of the laboratory were hand sectioned and mounted in glycerine jelly so that comparisons could be made when desired.

"Diseased plants from various patches were brought in and isolations were made from them. This was continued from the first appearance of the trouble up through the height of the disease. A large number of different organisms, including both bacteria and fungi, were thus obtained in culture.

"Some thirty-nine different types of organisms were isolated, but the great majority of these were found rarely, or perhaps only once. Many of these were no doubt only secondary parasites or possibly contaminations from the soil. Such organisms were not used for inoculation experiments. However, these contaminations could not always be avoided, because the surface of the stem could not be completely sterilized without danger of killing organisms in the outer layers of tissue. Since the sections of diseased crowns showed that these outer portions were most likely the real seat of trouble, such extreme sterilization had to be avoided.

"The great bulk of the isolations yielded organisms of one of three types; (a), *Bacteria,* (b), *Fusarium* and *Ramularia,* (c), sterile mycelium of the *Rhizoctonia* type.

"The fungi used for inoculation were of the *Fusarium* and *Ramularia* group, or what appeared to be of the *Rhizoctonia* type; but, since no spores were found at the time, single spore cultures were not obtained, and I had no assurance that the cultures were pure strains. In fact microscopic examination indicated that these were mixed cultures. Old cultures of this inoculum kept since summer have since developed spores of the *Fusarium* and *Ramularia* types. Inoculations were effected by inserting in slits in the crown of the plant pieces of mycelium of the fungus. The only plots which showed ill effects, as a result of the inoculations, were those which had been inoculated with the organism consisting of what appeared to be at the time, a sterile mycelium. Further inoculations with the *Fusaria* and *Ramularia* cultures are now under way.

"Re-isolations were made from these diseased plots and, in five cases, cultures of a type of mycelium like that used for inoculum were obtained. In the crown of the plant from which the first re-isolation was made a distinct diseased area could be traced, which extended into the crown tangentially like a wedge from the point of inoculation. Of the eleven inoculated plants in one of these plots only three remained on August 29. These appeared quite healthy. Thus, of the eight diseased plants removed, positive re-isolations were obtained in five cases.

"Because of the possibility that these experimental plants might have been infected by a soil organism, it was decided to grow plants in sterile soil. Pots of soil were sterilized and placed in the field close to plants which were producing runners. Young runners which had not 'set' in the soil and had not as yet come in contact with the soil were trained over these pots so that they might 'set' in the sterile soil. In this manner a number of young plants were obtained and brought into the laboratory for experimental work. Some of these were inoculated with the so-called sterile mycelium of the culture which gave positive results in the field experiments. Others were left to grow in the laboratory so that they could be inoculated in a similar manner later. The mother plants from which these runner plants were obtained were all staked in the field so that a check might be kept on the health of the stock.

"It was observed, as mentioned above, that this disease was more prevalent and more severe at about the time of fruiting, or a little earlier. Moreover, experiments which yielded positive results were those set up about fruiting time. Hence there seems to be a possibility that the pathogen is not sufficiently virulent to destroy a strawberry plant at other times. It was with a view to testing this possibility, that some of the plants in sterile pots were left to be inoculated at the fruiting period."

This problem will be continued in 1928.

Strawberry Mosaic

In the spring of 1925 a strawberry plantation with pronounced mosaic-like symptoms was brought to our attention. The plantation had been set out in the spring of 1924 with stock obtained from Michigan, and made exceptionally good growth that season, and, according to the grower, the plants were quite healthy when they entered the dormant state in the fall of 1924. However, in the spring of 1925 the Eaton variety showed pronounced yellowing and mosaic-like mottling (about 100 per cent), whereas the Cooper and Premier varieties lying alongside were still healthy. Mr. B. M. Davis of the Horticultural Division, Ottawa, by letter has the following to say about the Eaton variety.

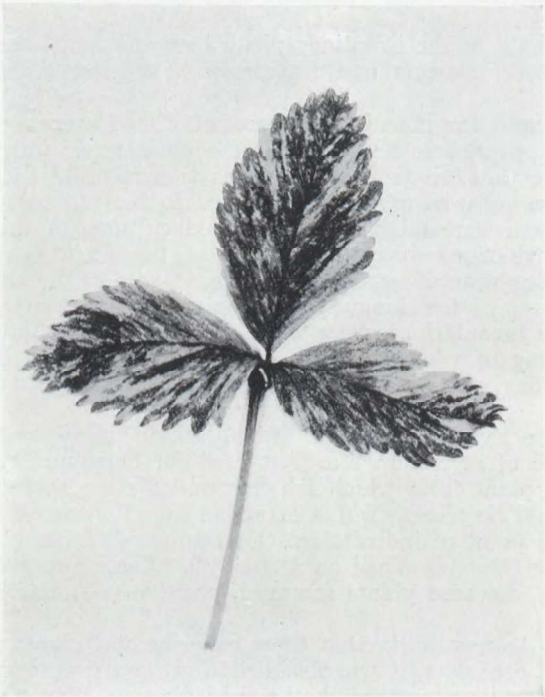

Fig. 20.—Strawberry mosaic?

"This year (1927) mosaic has developed on the Eaton variety. This variety when it came here appeared to be perfectly healthy, and my notes show it was healthy at the beginning of winter; and this year it shows one hundred per cent type 1 (mosaic mottling)."

Mr. Davis also informs me that this same trouble has been observed on Grand Prize and Minnesota No. 3. In 1926 this same mosaic-like trouble was observed at Hamilton, Ontario, on Waites Everbearer as well as on the Eaton variety. This spring (1927) another plantation of Eaton with over 90 per cent mosaic came under our observation.

The fact that this disease has so far been found on several new seedlings (both at Vineland and Ottawa Experimental Farms), and on the newer varieties mentioned above, but has not as yet been found on the older commercial varieties, is suggestive that this trouble may be genetic in character. The fact, also, that the trouble does not spread to adjacent varieties in the same planta-

tion could be explained on this basis. On the other hand, if the trouble is a pure genetic one, it is hard to account for the fact that certain Eaton plants, during 1924, 1925, and 1926, remained healthy and only showed the trouble in 1927 after being inoculated. Experience so far has demonstrated that this trouble has shown up the second year after planting. Most likely, however, the plants were affected when set out but the mottling was not apparent, since it is characteristic of this trouble that the mottling almost entirely disappears with the warmer weather of July and August.

Observations made in the field have shown the following: (1), that this trouble is systemic in that, once a plant becomes infected, the plant as a whole and all runner plants therefrom become diseased; (2), no plant has been observed to recover from the disease; (3), the mosaic symptoms are much more

FIG. 21.—Diseased strawberry (mosaic?) left. Healthy. right.

pronounced in early spring; during the hot weather of July and August the mosaic symptoms becomes less distinct; (4), this trouble has been observed on both drained and undrained land, and on all grades of soil from light sandy to heavy clay.

Symptoms.—The most general and conspicuous symptoms of the disease are (1), a yellowing of unfolding leaves; (2), definite yellowish-green to green mottling of the streak type, with older leaves taking on greyish-white areas, particularly around the margin (fig. 20); (3), puckering and lengthwise curling of leaf tissue is generally present; (4), leaves are often unevenly formed, that is, one of the lateral leaf lobes is greatly reduced in size in comparison with the other; (5), pronounced dwarfing of leaves, leaf pedicel, and fruit pedicel, —i.e., general stunting of all parts of plant; (6), with the Eaton variety a reduction in number of blossoms; (7), badly diseased plants of the Waites Perfection give practically no crop: such a reduction in yield has not been observed with the Eaton variety, since diseased plants of this variety produce fair crops; (8), all runner plants from diseased plants are similarly diseased; (9),

effect of mosaic on a plant in its first year may be very slight, but, from our observations, particularly with Waites Perfection, stunting may be so pronounced by the end of the second year as to make the plant useless from the standpoint of crop production. In one plantation of Waites Everbearer fifty per cent of the plants became useless from a production standpoint after three years time (fig. 21).

Experimental.—In 1925 some one hundred mosaic Eaton strawberry plants were transplanted to an experimental garden plot. Fifteen plants, apparently healthy, and of the same variety were specially selected from the same plantation. During 1925 and 1926 these plants were examined regularly and notes taken as to the progress of the disease. In all cases the mosaic plants remained mosaic, and all runner plants therefrom were likewise mosaic. The healthy plants remained healthy and at no time gave any indications whatever of mosaic symptoms. In the late summer of 1926 one hundred and fifty inoculations were made into the healthy plants by means of aphid transfer from mosaic leaves. By the time the plants went into winter conditions four plants showed a slight mottling. However, in the spring of 1927 all inoculated plants showed the definite mosaic mottling similar to the original mosaic plants.

Due to lack of room in the greenhouse the check plants which had been kept in pots were frozen early in December and so no definite check is at the present time available for the above inoculations. Since the plants, previous to inoculation, were healthy during 1925 and 1926, and since they all showed the mosaic symptoms with the very earliest growth of 1927, it does appear as though the inoculations were successful, and that we have here another virus disease of strawberries. However, to be certain of this, another series of inoculations was carried out this year, and will be reported on in next year's report.

EFFECT OF MOSAIC ON EATON AND WAITES EVERBEARER

The following measurements were made during full bloom:—

TABLE 45

	Average length of leaf pedicel	Average size of leaves		Number of leaves	Number of blossoms
		Length	Width		
		Waites Everbearer Variety			
Severe Mosaic					
1	3·7	2·3	3·8	37	56
2	2·5	1·5	2·8	31	14
3	4·2	2·3	4·2	27	37
4	3·5	2·3	4·2	31	14
5	3·6	2·1	3·9	37	22
Recently Mosaic					
1	7·0	3·2	5·8	40	94
2	5·7	3·0	5·5	48	72
3	6·2	3·5	6·0	30	46
4	6·8	3·7	6·5	15	44
5	6·8	3·0	5·4	43	57
Healthy					
1	9·6	4·8	8·6	30	136
2	13·3	6·4	10·8	41	174
3	10·7	5·6	9·8	37	108
4	10·4	5·5	9·8	42	89
5	11·7	5·5	9·5	49	106
		Eaton Variety			
Mosaic					
1	8·0	4·2	8·0	5	5
2	11·0	5·2	8·8	7	6
3	4·7	3·8	7·0	7	14
4	7·0	4·0	8·0	4	11
Healthy					
1	11·5	8·0	14·0	7	25
2	8·8	6·0	8·7	5	17
3	10·2	7·0	11·3	4	14
4	9·0	6·0	10·5	4	13

Winter Killing on Peach Trees

There was a severe killing of peach trees during the winter of 1926-1927. The heavy fall rains had the effect of producing late vegetative growth resulting in immature tissues, which succumbed during the following winter months. In the greater percentage of cases the injury was confined to the crown, as a crown injury ranging from 6″ to 8″ below the ground line to 4″ or 5″ above. The roots below this depth were healthy (fig. 22). In some cases, in addition to the crown injury, twig and branch die-back were also quite pronounced.

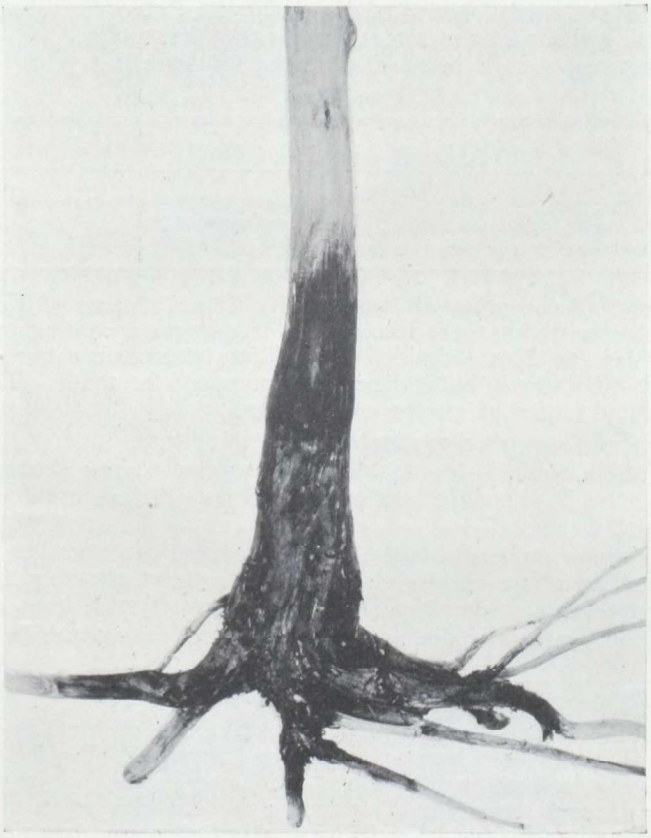

Fig. 22.—Crown injury on peaches caused by winter injury.

No extensive survey of the injury was made, but, from reports sent in to us as well as from the observations made by the field men, we would surmise that an average loss of around twenty-five or thirty per cent would be a very conservative estimate. The following ten cases are authentic.

(1) 10 per cent in 2 and 3 year old orchard.
(2) 25 per cent in 5 year old orchard.
(3) 75 per cent in 2 year old orchard.
(4) 30 per cent in 3 year old orchard.
(5) 85 per cent in 5 and 7 year old orchard.
(6) 25 per cent in 1 year old orchard.
(7) 3 per cent in 5 and 6 year old orchard.
(8) 8 per cent in 4 and 5 year old orchard.
(9) 10 per cent in 5 year old orchard.
(10) 35 per cent in 15 year old orchard.

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From a post card questionnaire sent to over two hundred growers, sixty-seven were returned reporting 7,642 peach trees killed; of these 5,802 were on undrained soil, while 1,840 were on underdrained soil; 5,846 trees were 5 years old or under, while 1,796 were over 5 years. In other words the greatest loss was incurred in young orchards on undrained soil.

Verticillium

In the last annual report (1926) results of studies on the *Verticillium* problem were given. These studies were chiefly concerned with the culture and taxonomy of about thirty strains of *Verticillium*. Pathogenic studies are now to be reported, although these are still somewhat incomplete.

Three new strains have been added to the list since last year, as follows:—

TABLE 46

Number of strain	Host	Place of origin	Date isolated
67	Apricot	St. Catharines	Aug., 1926
68	Snapdragon	"	Oct., 1927
69	Chrysanthemum	"	Oct., 1927

On account of the great abundance of different strains of *Verticillium* it seems advisable to divide these into groups or sections according to their characteristics. Van der Mere[1] divided *Verticillium* strains into two groups, (1), *Dahliae*, (2), *albo-atrum*, but further groupings can be made. The following classification and names of groups are proposed.

Dahliae group,—producing microsclerotia in culture.

Section *Niger*,—microsclerotia black and produced very abundantly, forming a black crust over surface of culture. Aerial mycelium scanty or absent.

Section *Bicolor*,—microsclerotia black, produced more or less abundantly. Aerial mycelium well-developed, white, cottony, covering the surface of the culture and obscuring the black microsclerotia from above.

Albo-atrum group,—producing black mycelium in culture but no microsclerotia.

Album group,—producing no black in culture.

Most of the strains have remained remarkably constant during the four years or less that they have been under culture. Strain A., *(Verticillium ovatum)* for example was isolated in September, 1923, and has been carried in culture continuously through hundreds of transfers without change in cultural characteristics or pathogenicity. *Verticillium* strain E was transferred weekly throughout 1927 on four different media, and at the end of the year no resulting change in cultural characteristics could be observed. It was noted, when transfers were made by smearing the inoculum over the surface of the agar slant, that production of black occurred from two to four days sooner than when transfers were made by means of a single stab in the centre of the slant. After three weeks, however, there was no distinguishable difference between the two cultures.

PATHOGENIC STUDIES

Cross inoculations of all the strains under study are being made on the following hosts:—tomato, cucumber, potato, raspberry, snapdragon, chrysanthemum, China aster, peach, barberry, and maple. This work is fairly well completed on most of these hosts, but final results will not be available for a few months and will be given in a publication.

[1] Van der Mere, J. H. H., *Verticillium* Wilt of Herbaceous and Woody Plants.

The plants were inoculated in two ways.

(*a*) The soil was sterilized, then inoculated with a spore suspension. Seedlings were planted in this soil with as little injury to the roots as possible.

(*b*) The soil was sterilized and the seedlings were planted in it. When these plants were about six inches high, they were inoculated by means of a slit in the stem, made either above or below the ground. The latter method gave somewhat quicker results.

The work has indicated a wide variation in pathogenicity among the different strains. The strains of the *albo-atrum* group, named *Verticillial* strains O, P, and 59, are the most virulent of those under study and are severe on tomato, cucumber, potato, and snapdragon. Most of the strains of the *Dahliae* group, such as *Verticillial* strains A, D, C, K, R, T, V, 61, 62, 63, 64, are strong parasites on tomato, potato, raspberry, and snapdragon, but weak on cucumber.

Raspberry Spur Blight

Spur blight on raspberries has been increasing to quite an appreciable extent during the past few years. Numerous cases have been noted recently where "spur blight" was having a decidedly detrimental effect on growth. This has been particularly noticeable on the Herbert variety.

Very little of a definite nature is known concerning the various spore forms of this disease. The susceptibility of varieties, general life history, and control are by no means perfectly known, therefore, during the past year, a start has been made towards a complete study of this disease from the standpoints both of the host and of the causal organism.

Isolations made from spur blight canes gave invariably *Phoma* spp., although early in the season several *Coniothyrium* cultures were isolated. In no case, however, did *Coniothyrium* appear after June 1.

At various times during the past season inoculations were effected by slightly abrading the bark with a flamed scalpel and inserting in the abrasion mycelium from a pure culture. In all one hundred and thirty-five inoculations were made on several varieties, with both *Phoma* and *Coniothyrium* spp. Spur blight was readily produced artificially in the following varieties:—Herbert, Cuthbert, Seneca, Marlboro, Adams 87, Adams 107, Count, Viking, King, Cayuga, St. Regis, Idaho, Columbia, and Erskine Park. Also spur blight was produced when either *Phoma* sp. or *Coniothyrium* sp. was used as inoculum. There was, however, a slight difference between the symptoms. The discoloration caused by *Phoma* sp. had quite a purplish tinge, while the *Coniothyrium* infection had more of a brown or blackish appearance. This is more apparent on certain varieties.

Attempts were made to infect healthy plants with "spur blight" by means of spraying uninjured healthy canes with a suspension of *Phoma* and *Coniothyrium* spores, but negative results were obtained in all cases. The fact that the "spore suspension" method of inoculation was not tried until fall may, in part, account for the negative results.

Erskine Park appears to be the most susceptible variety, with St. Regis, Seneca, Count, Herbert next in order. Newman 23 and Columbia were very resistant. It must be pointed out, however, that these results are from this past year's work only, and that the inoculations were not made on the different varieties at the same time. The inoculations on some varieties were made in the early summer, whereas, on some of the other varieties, inoculations were not made until fall. This may account for some of the apparent differences in susceptibility.

Over one hundred and fifty artificially inoculated and naturally infected canes of various varieties were labelled this past fall for examination during the winter and early spring.

This problem will be continued during 1928.

Observations on the Development of the Perfect Stage of *Venturia inaequalis*, (Cke.) Wint.

The apple scab disease caused by this fungus is undoubtedly the most serious disease that apple orchardists have to contend with in this district. For several seasons past, the efforts of this laboratory have been directed to attempts to improve the spraying schedule for this disease. Through an organized spray service, advice has been given as to the time of application of the sprays, based on the ascospore discharge and the development of the host. As the time of primary ascospore discharge has been found to vary considerably each year, an attempt is being made to ascertain the factor or factors responsible for this variation. The effects of temperature and time of leaf fall on perithecial formation are now being studied.

Scabbed leaves were gathered from McIntosh trees on October 15, 1926, and again on November 15, 1926,—the latter date being approximately the time of normal leaf fall. These leaves were, through the kindness of Dr. W. H. Burkholder, placed in incubators located at Cornell University. The incubators were controlled at the following temperatures 3°, 6°, 9°, and 12° C. An additional lot of leaves was placed on frosted pipes, at 0° C. Check leaves were kept under natural conditions out of doors.

Commencing January 1, 1927, and continuing on the first of each month until May, leaves from each temperature were brought into the laboratory, examined, and portions prepared for paraffin sectioning to determine the progress of perithecial formation.

The examination of the material on hand has not as yet progressed far enough to permit of the drawing of definite conclusions. However, the following general observations can be made.

(1) Perithecial formation takes place at various temperatures ranging from approximately 0° to 12° C. Leaves held at these temperatures were at no time exposed to winter frosts.

(2) Perithecial formation was evidenced by January 1, 1927. At this time there was no differentiation within the perithecia.

(3) Perithecial development is more advanced in material held at controlled temperatures than in the check material held under natural conditions. A number of perithecia showing mature ascospores were found in material from the 3° incubators on February 1. At other temperatures (6°, 9°, 12° C.) perithecia showed distinct lining of contents and some formation of asci. The perithecia in the check material at the same time showed very little differentiation.

(4) Perithecial formation is greater in leaves taken from the tree on November 15 (time of normal leaf fall), than in leaves taken from the trees on October 15. This points out the possibility that time of leaf fall may have some influence on the rate of perithecial formation.

(5) It was found that perithecial formation is checked in leaves that lie covered by other leaves. It was repeatedly observed that few, if any, perithecia were found in leaves that were covered by other leaves, and any perithecia, that were found, were considerably delayed in development in comparison with perithecia from uncovered leaves.

Immature perithecia were produced in culture on oatmeal agar after six weeks incubation at both 0° C. and 5° C. The fungus grows very slowly, and at 0° C. the perithecia were produced in a frozen agar medium. It was inter-

esting to watch the growth and production of perithecia in a frozen medium with the perithecia encased in flakes of ice. The observation has also been made that apparently healthy leaves and those very lightly infected with scab may show quite abundant perithecial production.

Seed Treatment Tests

Many diseases of vegetables, grains, etc. are carried on the seed. Notable examples are grain smuts, blackleg and black rot of cabbage, various wilts, and bacterial rots. The organisms causing these diseases may be present on the outside of the seed ready to infect the young seedling when germination takes place. Seed treatment kills such organisms and, consequently, gives the young seedling a better chance. Seed treatment, however, may not entirely prevent these diseases, since the organisms causing them may be in the soil as well as on the seed; yet seed disinfection pays, since it tends to reduce the extent of infection or to entirely prevent disease if the seeds are planted in clean soil.

Seeds are often imported from foreign countries or are obtained from other localities, and such seeds often harbour dangerous diseases. Seed treatment prevents the introduction of such diseases into the soil and is worth while on this account alone.

Experiments were conducted with a view to finding out what treatments may safely be used on different seeds. Corrosive sublimate 1:1000 is the most commonly used seed disinfectant, and this material was used on a variety of seeds for different lengths of time and at high and low temperatures. Results are given in the following table. It will be noted that the treatment usually causes a slight loss in the percentage of germination. This loss is negligible where the treatment is given for ten minutes, but sometimes severe where the treatment is for twenty or thirty minutes. The seeds most affected by the mercuric chloride were those of celery and egg plant. Treatments at temperatures of 15° to 30° C. (60° to 85° F.) decrease the percentage of germination but little, whereas, when the temperature of the treatment is 45° to 60° C. (112° to 149° F.), the loss in germination is serious. The conclusion to be drawn is, that seed treatments with 1:1000 mercuric chloride should be at room temperature (60° to 70° F.) and for ten minutes. On account of the severe loss in germination it is not advisable, as a general practice, to treat celery seed with mercuric chloride.

Table 47.—Seed Treatment Tests at Room Temperature (17° to 22°C.) with 1:1000 Mercuric Chloride Results are the Average of Two Tests, and the Figures show the Percentage Germination in each Case Twenty Days after Planting

Seed	Check No treatment	Treatment		
		10 min.	20 min.	30 min.
Cabbage	58	57	52	40
Cauliflower	80	80	67	74
Celery	67	31	3	1
Cucumber	85	88	85	74
Egg Plant	78	56	48	39
Pepper	76	63	68	43
Radish	86	80	62	76
Lettuce	85	87	78	78
Tobacco	73	52	38	37
Tomato	82	68	70	68
Tomato (Uspulun 25%)	79	62	58	56

The following figures give the percentage germination of tomato seed after being treated with 1:1000 mercuric chloride for ten minutes but at different temperatures.

	15°C.	30°C.	45°C.	60°C.
Tomato seed	83	77	68	15

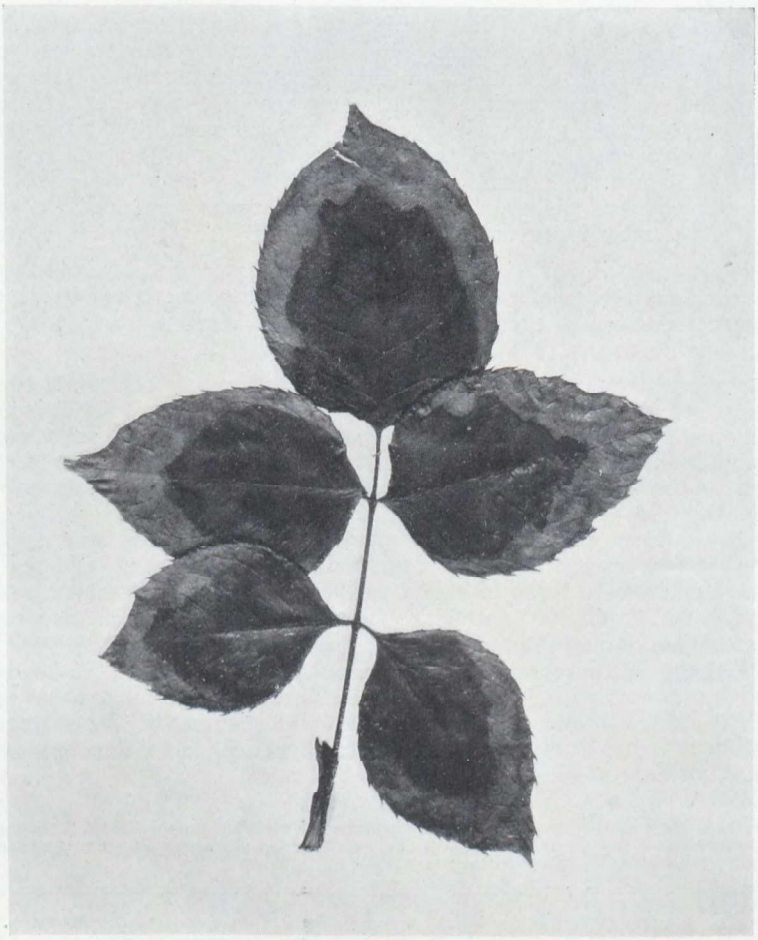

FIG. 23.—Rose leaf disease due to saline water.

EFFECT OF SALINE WATER ON ROSES

In January, 1927, our attention was called to a trouble in a rose house at Vineland. The bushes of the Tea type were in a sickly condition with defoliation very pronounced in many cases. The leaves were bronze in colour, particularly around the margin, although yellowish areas were often present. Later the bronzed margin became lighter in colour and necrotic. Generally, deep purplish areas were apparent between the necrotic margin and the healthy tissue (fig. 23). No signs of fungous or insect trouble could be found. The roots of

affected plants had by no means made the growth they should have; the lack of fine white rootlets was particularly noticeable. The trouble, therefore, appeared to be one of a physiological nature.

Analysis of the soil, fertilizers, and water used on the roses showed that, although the soil and fertilizer were satisfactory, the water used in the greenhouse was found to be very saline. This water came from a deep well recently dug, and was strongly mineral in nature as shown by the following report of analysis made by the Dominion Chemist, Dr. F. T. Shutt.

FIG. 24.—Left, normal apple leaves. Right, frozen buds.

"The analysis of this water furnished the following data:—

Total solids at 100°C	5840	p.p.m.
Solids after ignition	5310	"
Chlorine	2199	"
Sulphuric acid (SO_3)	775	"
Lime (CaO)	708	"
Magnesia (MgO)	344	"

From the foregoing results we calculate that this water contains the following saline content:—

	p.p.m.	grs. per gal.
Common salt (NaCl)	3196	223·7
Sulphate of lime $CaSO_4$	1317	92·2
Carbonate of lime ($CaCO_3$)		
Calcium chloride ($CaCl_2$)	527	36·9
Magnesium carbonate	719	50·3

This water must be considered as strongly saline. The total mineral matter in solution is almost an ounce per gallon of which more than half is common salt.

FIG. 25.—Slime mould on celery.

It would seem that this analysis explains the trouble; undoubtedly, the water is too saline for greenhouse use."

It is interesting to note that, in other greenhouses of this same range where this saline water was used, slight injury was apparent on the leaves of several other plants besides the roses.

This trouble was severe during the winter months when the water supply was taken entirely from the well; however, towards spring, when surface water filled the well to overflowing, and other sources of water were used as well, the trouble began to disappear. This, therefore, seems to be a case where saline water produced a serious leaf necrosis and defoliation on roses.

Frost Injury on Apple Leaf Buds

Severe spring frosts caused considerable damage to unfolding leaf buds, particularly along the Niagara escarpment. In several orchards around Fenwick frost injury was particularly severe on the Greening variety.

The injury was apparent as a crinkling, puckering, or curling of the leaf tissue, producing an effect not unlike "peach leaf curl" on peach leaves (fig. 24). The lower epidermis of badly affected leaves was blistered and raised, that is, separated from the underlying mesophyll. This raised epidermis very readily cracks, exposing the interior leaf tissue.

Such badly frozen leaves remained reduced in size, and eventually dried up and fell. On the whole, however, the frost injury was not serious, since other leaves were formed to take the place of the fallen leaves, and the trees later on functioned normally and produced a fair crop.

Slime Mould on Celery

A very interesting case of a slime mould over-running celery was observed this past season. About two dozen celery plants out of several hundred, growing under unusually moist conditions in a cold frame, were over-run by a slime mould which was later identified as *Physarum cinereum* (fig. 25). In two or three cases the celery plants were almost completely suffocated by the slime mould, and the plants eventually died. On the whole, however, little damage was done.

During 1927 the research work of this laboratory was allotted as follows:—

(1) (a) *Verticillium* wilts.
(b) Seed sterilization.—Mr. A. B. Jackson.
(2) Apple scab.—Mr. G. C. Chamberlain.
(3) Strawberry root rots.—Mr. A. R. Walker.
(4) Ginseng root rots.—Mr. C. Perrault.
(5) Raspberry spur blight.—Mr. L. W. Koch.
(6) Blossom blight of peaches.—Mr. J. H. Johnson.
(7) (a) Tomato streak.—Dr. G. H. Berkeley and Mr. Perrault.
(b) Strawberry mosaic.—Dr. G. H. Berkeley.

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, KENTVILLE, N.S.

(J. Fred Hockey, Plant Pathologist, Officer in Charge)

For the third successive year apple scab has been the cause of a serious loss to Nova Scotia orchardists. Following an early infection period for scab were two late spring frosts, which also did considerable damage to leaves (fig. 26) and blossoms (fig. 27) in some sections of the Annapolis Valley. A further injury resulting from the combined effects of copper fungicides and the secretion of the European apple sucker was very severe in some orchards, and resulted in a total loss of orchard revenue to many fruit growers. The season was, therefore, a very difficult one for the apple orchardist.

This laboratory co-operated with the Nova Scotia Fruit Growers' Association in issuing press bulletins which would aid the orchardists in timing their

spray applications. Warnings were given through the press of probable periods of ascospore discharge and of general infection periods. Many growers were assisted in their disease control problems by these bulletins.

A spray and dust calendar was published jointly with Mr. A. Kelsall, Entomological Laboratory, Annapolis Royal, N.S., and given very general distribution in the province. A pamphlet, "Apple Scab," was also published during the past year for popular use.

A series of community meetings was held during the early part of the year, at which the District Inspector, and Officer-in-Charge discussed certified seed potato growing and orchard spraying for disease control respectively. The meetings were well attended.

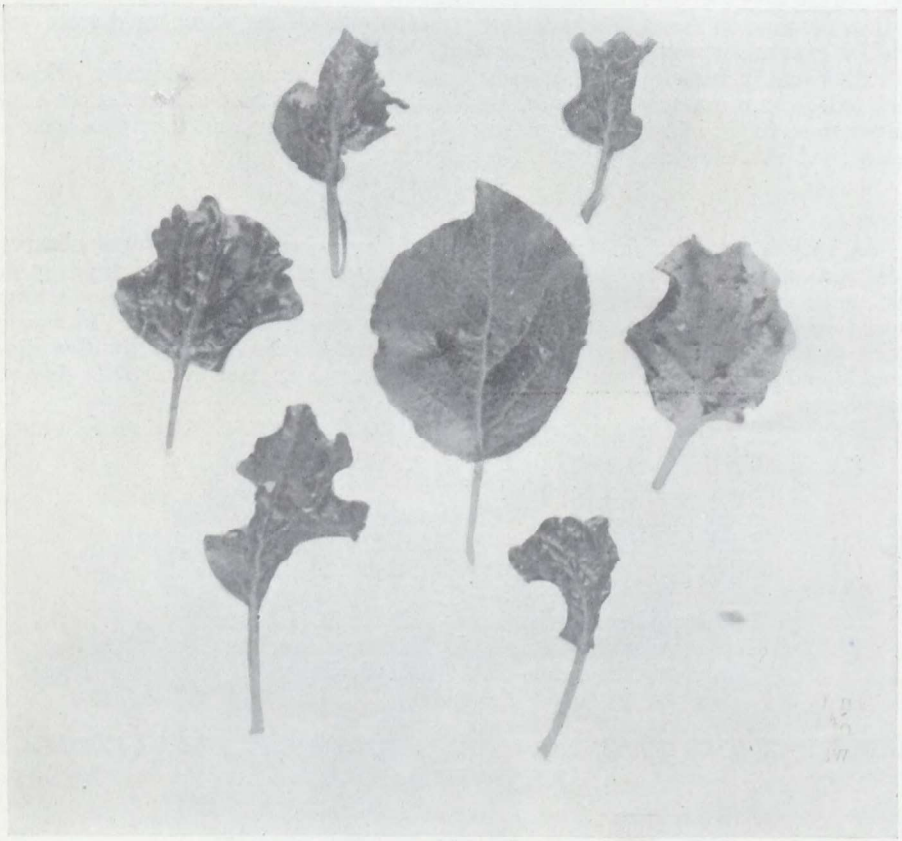

FIG. 26.—Frost injury to apple leaves.

This past season witnessed a very heavy demand on this laboratory for extension work with orchardists. Requests for personal visits were more than could be met, and much time was lost to our investigational work from the necessity of doing such extension work. Efforts are being made to increase the extension service of the provincial department to meet this situation, and so allow the staff of investigational laboratories to devote more of their time to investigational work.

This laboratory co-operated with the Entomological Laboratory, Annapolis Royal, N.S., in orchard spraying and dusting experiments. Duplication of effort is thus avoided. A member of the staff of this laboratory was at Middleton, N.S., from May to July taking records on the seasonal development of *Venturia inaequalis,* (Cke.) Wint., and assisting in spraying and dusting operations there. Records of leaf infection were taken on over one hundred plots in these experiments to compare with the final counts on fruit infection. This information is being accumulated over a period of years for summary information. Co-operative projects on toxicity of various chemicals to spores of *V. inaequalis* are under way with the Entomological Laboratory. These are mostly of a preliminary nature and as a guide to field work, in order to ascertain the strength of solutions necessary to produce toxicity.

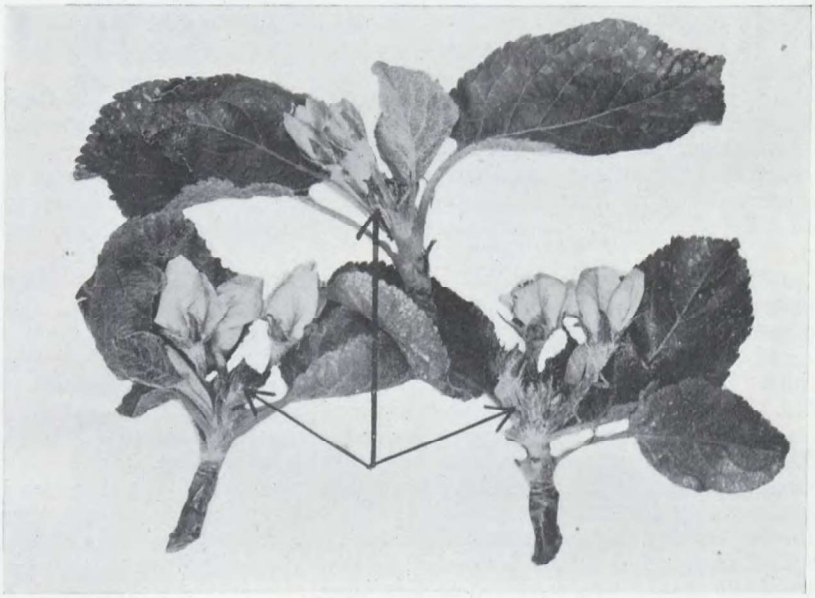

FIG. 27.—Frost injury to blossoms. Note the dead, centre blossoms in each cluster.

In October, 1926, this laboratory was made responsible for the determinations of moisture content of dehydrated and evaporated apples and waste. This work was formerly done by the Division of Chemistry at Ottawa. Up to April 1, 1927, some seventy-four samples were received and tested. From October, 1927, to January, 1928, two hundred and forty samples were received and the moisture content determined. Of the two hundred and forty samples ten per cent have been in excess of the 25 per cent standard. The average moisture content of all samples received was 21·5 per cent. This work is more or less continuous from October 1 to March 31.

Investigations have begun on a serious disease of willow, which appears to lead to the death of trees in three or four years. The disease first appears as a leaf and twig blight on the earliest foliage. Successive growth is periodically affected throughout the season, causing leaf blight and drop. Several organisms are under observation and trial to establish their pathogenicity, but no further information can be given as yet. It is regretted that some good illustrations of this disease are not available for inclusion in this report.

Apple Scab (*Venturia inaequalis*, (Cke.) Wint.)

SEASONAL DEVELOPMENT

Periodical examinations of fallen leaves were begun on October 1, 1926, and continued until July, 1927. Perithecial formation became visible in November, 1926, and by the end of January, 1927, after a period of mild weather, during which the maximum temperature was 48°, and minimum temperature 32°, with a mean of approximately 40°, the number and size of perithecia had increased considerably. Ostiole cells were showing prominently at this time, but no definite ascus formation was apparent.

The month of April was warmer than the corresponding month of the two preceding years, with a mean temperature of 39·01° compared to 38·99° as the twelve year average, as against means of approximately 30° and 35° in the two preceding years. Total precipitation was also above the twelve year average. The spring season was considered an average one judging from the development of the plants. The 1925 and 1926 seasons were two or three weeks later than normal.

On April 19, 1927, leaves showed very prominent perithecia. Asci were forming and filled with vacuolate protoplasm. There were faint signs of ascospore formation. It was observed at this time that the thinnest leaves on the surface of the ground contained the largest perithecia. Six days later mature spores were found in some of the perithecia. It was noticeable, however, that matted leaves exhibited slower fungous development than the loose, scattered leaves.

On April 28 one and one-half inches of rain fell, and the first spore discharge was recorded at that time. This was earlier than the initial discharge in the two preceding years, and was confined to the thin, scattered leaves on the surface of the ground, as thicker, matted leaves did not show mature spores at this time. From this date to May 12, nearly three-quarters of an inch of rain fell, but there was no consequential discharge until May 13, when 0·81 inches of rain fell. At this time a heavy discharge was experienced. This ejection constituted the first general one from the majority of perithecia. Mature spores were readily found in all collections from widely scattered communities in the Annapolis valley immediately preceding this rain. Light rains, not exceeding 0·13 inches on any day, were experienced on five days up to May 26-27, when a total of one and one-half inches of rain was recorded. The heaviest discharge of the season was recorded at this time.

At the time of the previous discharge on May 13, apple buds were in the "mouse-ear" stage, the earliest not exceeding three-quarters of an inch in diameter. By May 26 the trees were in the "blossom pink" stage, and some of the earliest varieties were opening into bloom. At the time of full bloom, about June 5, another moderate spore discharge was recorded. Subsequent discharges were not of great importance.

The month of June was comparatively dry, only 1·27 inches of rainfall being recorded at Kentville. Perithecial development was disturbed, and a light discharge of ascospores was experienced June 21-23. Following this no discharge of importance was recorded. The final discharge, a very light one, was recorded at Kentville on July 4.

The heaviest ascospore ejections were recorded on days when the mean temperature was below 46° F. The lightest recorded discharges were observed on days when the mean temperature was above 60° F. Perithecial development and spore formation were greatest during periods when the mean temperature averaged about 50° F.

The annual report of this laboratory for 1926 gives summary information on the seasonal development of the scab fungus for that year and 1925. Table 48, p. 143, gives an idea of the variations in temperature and rainfall from the twelve year mean for those months in which ascospore discharges have

been recorded during the past three years. Variations above or below normal are signified by "+" and "—" respectively. Relative spore discharge is denoted by actual comparative figures taken from the spore trap readings for the respective seasons.

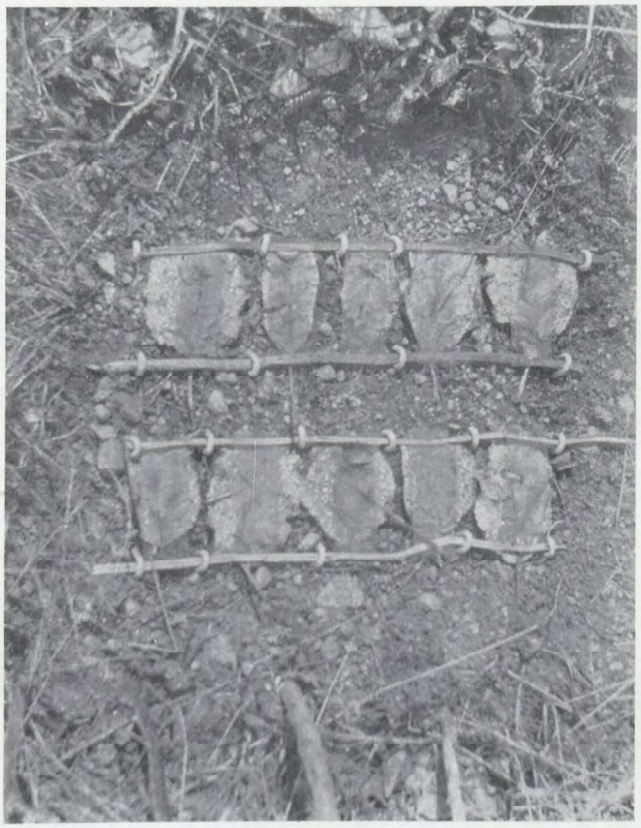

FIG. 28.—Orchard spore traps.

TABLE 48.—CORRELATION OF METEOROLOGICAL RECORDS AND ASCOSPORE DISCHARGES

—	Temperature variation from 12 year mean	Precipitation variation from 12 year mean	Relative ascospore discharge
April mean	38·99	2·80	.....
April, 1925	−8·86	−0·91	0
April, 1926	−4·03	+0·68	0
April, 1927	+0·02	+0·47	3
May mean	49·52	1·90	.....
May, 1925	−0·09	+0·47	5
May, 1926	−2·19	+1·85	7
May, 1927	−0·42	+1·83	41
June mean	59·00	3·19	.....
June, 1925	+1·82	+1·78	38
June, 1926	+0·01	+0·14	25
June, 1927	−2·56	−1·92	11
July mean	65·49	2·84	.....
July, 1925	+0·09	+0·50	2·0
July, 1926	−1·28	+0·14	0·2
July, 1927	+2·97	+2·74	0·1

From this table it can be observed that spore discharge has only occurred in the month of April when the temperature was approximately that of the 12-year average. Slight variations in rainfall above and below normal with sub-normal temperatures have not promoted ascospore discharge.

In the month of May, in all three seasons, the temperature was below the average and the rainfall above. Since ascospore discharges had not been experienced in April, 1925, or 1926, there was evidently little perithecial development compared to that which took place in April, 1927. This was verified by observations during the respective seasons. In 1925 the first ascospore discharge was on May 15, and in 1926 this event took place on May 18, compared to April 28 in 1927. These facts indicate that the temperature of the month of April has a marked influence on perithecial development.

A comparison of the means of temperature and precipitation for the preceding six months of each of the three years with the 12-year average and with each other revealed no factors, which had a consistent influence on perithecial development, as pronounced as the temperature and precipitation of the month of April.

The first observed leaf infection from ascospores was found May 26, thirteen days after the first heavy discharge. Close examinations of buds at this time also revealed infection on calyces. Petiole infection was general on trees unsprayed before May 13 this year.

Some orchards were found almost defoliated by June 7 from scab. The fungous growth was so extensive on the leaves in such orchards that the appearance gave rise to the descriptive expression, "mossy. with black spot." The fruit which later developed under such conditions was useless. In spite of the possibility of such severe infection, many orchardists were able to keep their fruit and foliage remarkably free from spot.

At least three pre-blossom fungicidal applications were necessary to control scab, and some orchards received four. In some orchards examined, the control of scab on the fruit was in direct proportion to the prevention of early infections. Late infection was experienced in some of the well-sprayed orchards on sides exposed to adjacent unsprayed or poorly sprayed trees on a neighbour's farm.

INFECTION FROM EARLY SPORE DISCHARGES

On May 13, 1927, a very heavy discharge of ascospores was observed at Kentville. The leaves were expanding and in the mouse-ear stage of development. Some few leaves were one-half to three-quarters of an inch broad at that time. In order to ascertain the probable extent of natural infection from ascospores at that stage, several twigs were covered with paper bags three days after the discharge and prior to the subsequent ejection of spores. The object of bagging at that time was to allow a period of about 72 hours for natural infection to take place and then protect the twigs from further infection by subsequent discharges. The bags were removed after 14 days and counts taken of the number of leaves with scab spots and number of spots per leaf.

Of 507 leaves counted 109, or 21·5 per cent of the leaves had 248 spots, or an average of 2·27 spots per leaf. This represented the probable extent of leaf infection from a comparatively heavy discharge of spores at a time when the foliage was very susceptible and unprotected by a fungicide. On June 22, when the twigs had been uncovered for over three weeks and had received two applications of spray, the leaves were again counted for scab infection. Scab spots were found on 37·2 per cent of the leaves on the previously bagged twigs.

Those not sprayed until after two heavy spore discharges had from 42 to 57 per cent scab showing on the foliage by the time of full bloom, June 7.

At harvest, counts were taken on the amount of old scab spots and new scab spots present on fruit sprayed before and after May 13. The same variety was compared throughout. Trees sprayed before May 13 averaged 2·5 per cent old scab spots, whereas those sprayed after May 13 and before the next heavy spore discharge varied from 12 to 25 per cent. These observations would lead to the conclusion that the application of a fungicide prior to the first heavy discharge of ascospores is essential to the cleanness of the fruit.

That some fungicides may be partially effective when applied within two or three days following spore discharge is indicated by counts of foliage infection, taken on six spray and dust plots and a check, about the time of full bloom. All plots had received two applications of fungicide prior to taking the counts —the first application on May 16, three days after the first heavy spore discharge; the second, May 31, five days after the heaviest discharge of the season. The counts given in table 49 were made on June 6 and 7, 1927.

TABLE 49.—FOLIAGE INFECTION OF EARLY SCAB, BISHOP PIPPIN

Materials	Per cent foliage scabbed
	%
Lime-sulphur, 1–40	15·4
Bordeaux mixture, 4–8–40	24·5
Bordeaux dust, 12–8–80	32·6
Sulphur dust, 90–10	37·3
Bordeaux mixture, 3–10–40	43·1
No treatment	57·1

Calyx infection, some of which occurred when the buds were still in the mouse-ear stage, appeared in abundance on fruit harvested from the above and similar plots. As much as fifty per cent of the fruit, which otherwise would have graded No. 1, was rejected for slight scab at the calyx end of the fruit. This could have been avoided by early spraying as generally advised.

LEAF FALL AND PERITHECIAL FORMATION

Several investigators have put forth the suggestion that the leaves which fall earliest develop the first mature ascospores. For two successive years collections have been made of apple leaves on approximately October 1, 15, November 1 and 15. These leaves were collected from the same trees in each case. The trees were shaken and only yellowing leaves which fell naturally were collected. All collections were placed under identical conditions on the ground in the orchard. Natural defoliation was completed about November 25, 1926.

Frequent examinations of the 1926 collections were made until ascospore formation was general. Leaves collected on November 1 showed the largest number of perithecia in January, but, on April 22, leaves from all four collections had some perithecia at the early stage of asci formation. Mature spores were found in leaves from each collection at approximately the same time. Mid-season examinations revealed no difference between the four lots in the average number of perithecia formed nor in the relative amount of non-ejected ascospores.

It is believed that the location of the fallen leaves has more influence than the time of leaf fall on perithecial formation. Leaves in loose piles, or partially wedged in grass or weeds near the surface of the ground where they will not dry out quickly, have been found more favourable for early perithecial formation than leaves matted together from the pressure of ice and snow. In years with open weather, as 1927, early fungous development in some leaves can be accounted for in part by the mild weather during the winter, when thaws

took the snow off the higher spots and left the heavier mats of leaves in the furrows in water and ice. Fallen leaves in higher locations exhibited a distinct perithecial formation during the mild spells of weather in January. Thin leaves appeared to predominate in such collections.

The comparative activity of the fungus in its saprophytic stage between the thick and the thinner leaves is difficult to interpret. The thinner leaves on the tree are usually produced on the older wood. Current season's twig growth produces the thickest leaves. The thin leaves are ordinarily the first developed on the tree, but they do not fall necessarily early in the season. During dry seasons, or on account of spray injuries, etc., the oldest leaves may fall first. The observation that these leaves produce the first mature spores does not necessitate the view that these are the first to fall in the autumn. The 1926 collections referred to above included, in each lot, thin leaves from the old wood, and, on subsequent examination, these leaves undoubtedly showed slightly greater perithecial development than the thicker leaves of the same collection, irrespective of the time of collection.

However, this condition did not exist in the two preceding years. In both 1925 and 1926 the thicker leaves contained the best developed perithecia and first mature ascospores. In both these seasons, however, snow remained on the ground throughout the winter.

In 1927 there were several periods during the winter months when the ground in the orchards was practically free from snow.

From a study of the meteorological records of the past three years, there is undoubtedly a distinct relationship between the earliness of ascospore development and rainfall combined with mean temperature. There is a negative correlation between snowfall and early spore development. That is, when snow has remained on the ground late in the spring, ascospore development has been delayed, irrespective of total precipitation during the three or four months preceding spore maturity.

The age of the leaf or the time of leaf fall are apparently not of as great importance as the prevailing weather conditions of temperature and rainfall for the particular season.

Effect of Chemicals on the Development of Perithecia of *Venturia inaequalis*, (Cke.) Wint.

LABORATORY TESTS

Tests in three series with eight chemicals and one combination were carried out during the spring of 1927 to ascertain their effect on perithecial development and ascospore discharge.

Leaves were brought in from the orchard, placed in moist chambers, and kept therein untreated and slightly moist, at room temperature, for one week before treatment. At the end of the week perithecia were found to contain asci with differentiated ascospores. A number of the leaves were then selected and placed on blotters or damp sand in moist chambers. Oiled slides, used as spore traps, were supported about an eighth of an inch above the surface of the leaves and counts taken on the spore discharge every morning. Treatments were made by using an atomizer and spraying 2cc. of each chemical on the leaves in each moist chamber. In the first series, 1 per cent NaOH and 25 per cent $NaNO_3$ stopped discharge completely, and the following gave nearly complete control: Cyanamid dust, 10 per cent NaCl, 5 per cent Urea, 25 per cent $Ca(NO_3)_2$. The 2 per cent $CuSO_4$ and a combination of 2 per cent $CuSO_4$ plus 10 per cent $NaNO_3$ both gave stimulation for a very heavy discharge immediately after the treatment, but only a trace of discharge afterward.

The second series gave very indefinite results. The discharges throughout were poor from checks as well as from the treated material, so much so that they were considered unfit for anything but negative results. None of the chemicals used completely stopped discharges. The two that ranked first in Series I, 1 per cent NaOH and 25 per cent $NaNO_3$, seemed to have some effect, but it was so slight that there was no indication of an economic control.

Series III was especially arranged in an attempt to overcome the variation in discharges of spores from different leaves. Leaves were divided into two or four parts according to the abundance of the perithecia, and the parts used for different treatment, the same leaf being under two or four treatments. The discharges were excellent from the first day, and they were treated after first spore discharge record. Treatments with chemicals had little effect in inhibiting spore discharge. One leaf in a treatment would show a check in discharge while the other would show the opposite. For two days after treatment $CuSO_4$, alone and with $NaNO_3$, showed a stimulation. Discharge, however, was not stopped at the end of this stimulation. This final test showed that none of the chemicals, under the conditions which existed, would completely check the discharge of spores from mature and discharging perithecia.

Examinations of perithecia from each series were made several days after treatment. NaOH invariably caused partial disintegration of leaf and fungus. None of the others was consistent throughout the three series.

TREATMENT OF FALLEN LEAVES IN ORCHARD

An area of orchard was divided into three plots, each containing about 225 trees. One plot was treated with a 1 per cent solution of caustic potash, another with a 10 per cent solution of nitrate of soda, while the third plot was left untreated as a check. The treatments were made by applying the solutions with a spray gun to the fallen leaves. Efforts were made to cover the leaves evenly and with sufficient material to wet them. The first treatment was made on May 3 and 4; the second treatment on June 1 and 2.

Counts on relative amounts of leaf infection of apple scab were made on June 22 in the three plots. Slight differences were noted, probably influenced in a large measure by the more or less thorough spray applications which had been made on the trees. The actual counts for the nitrate of soda and caustic potash treatments were 4·9 and 5·0 per cent respectively. The untreated plot had 6·6 per cent primary infection of scab.

On account of the slight differences between the plots, no reliable conclusions could be drawn. Later in the season another examination was made of the orchard. At this time there was an indication that the two treatments had assisted in the control of early scab infections, but the differences were such that no definite results were established. No counts were made on fruit infection at harvest on account of the several periods of summer infections, and the added factor of spraying which, in itself, may cause a considerable variation in control in different parts of an orchard.

LATE AUTUMN SPRAYING

A preliminary test on the probable value of spraying apple trees with a copper sulphate solution immediately after harvest, to ascertain the effect on the perithecial development of *Venturia inaequalis,* (Cke.) Wint., was made in November, 1926. Several twigs were heavily sprayed with a 1 per cent solution of copper sulphate. The leaves were collected, at intervals of a week for three weeks, and placed on the ground in the orchard. Some of the leaves were considerably browned and burned by the spray and all showed a limited amount of characteristic copper burn.

In April, 1927, the leaves were examined for perithecial development. The sprayed leaves as well as the check leaves showed normal perithecial development, and subsequently discharged mature ascospores. It is evident that, either the concentration of the spray was not sufficient, or the copper leached from the leaves too quickly to have a permanent toxic effect on the fungus.

Copper Injury in Apple Orchards

A considerable amount of burn in the form of small red scars dotted on the surface of the fruit appeared during July in some orchards this year. The injury was accompanied by a slight burning on the foliage which had the appearance of a fungous leaf spot.

Samples of spray and dust material used in post-blossom applications on affected orchards were collected from several growers and dealers. Hydrated lime and dust samples were put through sieves to determine the degree of fineness. Particles rejected by 80-, 100-, and 150-mesh sieves were examined microscopically. In some cases large particles of lime were rejected by the 80-mesh sieve, and in the mixed dusts these were usually associated with copper sulphate particles. Crystals of copper sulphate were also detected.

It was quite apparent that there were particles of such size as would cause injury, if sufficient blast were used in dusting. To prove that the particles could cause injury, small plants of *Apocynum androsaemifolium,* L. were used as an index, on account of the exudate produced by the plant on being injured. Samples of the dust rejected by each sieve were applied to the foliage of these plants by using a miniature duster as employed in the laboratory. Injury was evidenced by the size and number of droplets of milky exudate appearing on the leaves immediately after treatment. Dust particles rejected by the 80- and 100-mesh sieves caused pronounced injury to the leaves of the dogbane. Dust particles rejected by, or that passed through, the 150-mesh sieve caused practically no injury, but in heavy blasts produced a slight flecking.

The spots produced on the apple fruit formed surface scabs which were readily removed by the finger nail. The fruit by late August had formed a callous layer below the injury and, on removing the surface scab, a russeted spot was left which eventually left little or no scar on the fruit of serious nature.

This type of injury is quite alarming when first recognized, but it is believed that no permanent injury is done to the fruit. At time of harvest many of the scabs had disappeared, leaving only slightly russeted spots less than one-eighth inch in diameter.

Another type of injury appeared early in August on plots which had received four applications of 4-8-40 or 3-8-40 Bordeaux mixture. The injury was confined to a reddish-purple flecking on the foliage. On close examination the flecked areas were observed to be depressed. The injury was due to copper freed on the leaf surface during periods of extended wet weather in July, resulting in the washing and leaching out of the lime. This foliage injury was not apparent on dusted plots. Analyses of leaves from sprayed and dusted plots were made for the presence of copper. Dusted plots gave a negative reaction in every sample. Sprayed plots indicated an average of 20 mg. of copper on each sample of 20 leaves used. Determinations were made by immersing the leaves in a solution of 1 per cent HNO_3 and shaking. The solution was then filtered and tested for copper by using 10 per cent potassium ferrocyanide, and comparing with standard solutions containing known quantities of copper.

Avoidance of Injury

Dusting materials should be of such a degree of fineness that at least 99 per cent should pass through a 200-mesh sieve. Copper dusts should be kept in a dry place and, preferably, in containers which will not absorb moisture.

Spraying material used in Bordeaux mixture should be dissolved and put through a strainer when filling the tank, unless very good agitation is used to dissolve the pulverized copper sulphate in the tank. Small particles of the copper sulphate remaining undissolved in the mixture and forced under pressure through a spray nozzle may cause mechanical injury.

Orchard Farm Survey

During the summer of 1927 an orchard disease and farm survey was conducted in one of the oldest apple growing sections of the Annapolis valley. The area covered was approximately twenty-seven square miles. The main purposes of the survey were to ascertain the approximate orchard acreage, methods of culture, system of treatment for insect and disease control, together with equipment for such purposes, main orchard pests and diseases, approximate cost of insecticide and fungicide treatments, and other points bearing directly or indirectly on factors influencing the development of clean fruit.

In conjunction with this survey an attempt was made to collect information on general farm crops, in order that such information might be available for other divisions of the department, and so to eliminate the necessity of duplication in field work.

In making the survey each farm was plotted, so that it has been possible to make a map of the area showing the location of each orchard. This was considered advisable in order that a map study could be readily made at any time to facilitate investigations on the spread of any orchard pests.

In the area covered there were 193 farms plotted; of these, it was possible to get fairly complete information on all questions from 139 farm operators. In the following summaries, therefore, the information and figures are based on the 139 farms. These include the more successful growers. The majority of farms on which incomplete information was obtained were small holdings.

The 139 farms contained a total of 10,477 acres, of which 2,246·25 acres were in apple orchard over 10 years of age and 418·5 acres in apple orchard under 10 years of age. This makes a total apple orchard area of 2,664·75 acres, or approximately 26 per cent of the total farm acreage. The growers on these farms considered that 4,737 acres, or approximately 45 per cent of this area, were suitable for profitable orchard planting; and the prospective planting for the next few years was placed at 1·2 per cent of the farm acreage.

Spraying and Dusting

Information concerning the fungicidal and insecticidal treatment given orchards in this area was of prime importance and at the same time most difficult to obtain. Very few growers were able to give close estimates on the quantity of fungicides applied or the dates of application. Twenty-nine per cent of the growers reporting used dust entirely; forty-three per cent used spray alone; and 28 per cent used both spray and dust for various applications.

The materials used in dusting were Bordeaux dust and sulphur dust with varying proportions of arsenicals as insecticides. Nicotine contact dust was also used by a number of growers for apple sucker, green apple bug, or bud moth control. Spraying materials were chiefly lime-sulphur in concentrations varying from 1 gallon with 40 gallons of water to 1 gallon with 100 of water. Bordeaux mixture varying from 1-10-40 to 4-12-40 strength was used for copper liquid fungicides. Modified proportions of hydrated lime were used in this fungicide, but the most popular ratio was approximately three pounds of hydrated lime to every pound of copper sulphate. A few growers used the stone lime, and prepared a stock lime solution in preference to the hydrated lime method of making Bordeaux.

Wettable sulphur has been used by many growers for the calyx spray, and a number of orchards received applications of spray made up of lime-sulphur 1-100 with the addition of 15 pounds of wettable sulphur to 100 gallons of the solution. This material has given fairly good results in apple scab control but will not adhere to the foliage as long as a straight lime-sulphur solution. It is, however, possible to use this solution more drenchingly in post-blossom sprays than lime-sulphur alone, on account of the elimination of possible injury to foliage or fruit.

In summarizing the number of spray or dust applications made on the orchards covered by the survey, it was found that there was an average for all farms of 4·3 per acre made at an average cost of 27·9 cents per barrel of apples yielded. Taking into consideration the farms with less than ten acres of orchard, it was found that these received an average of 3·3 applications per acre, which, based on the estimated yield for 1927 on those farms, cost 29·3 cents per barrel. The orchards from ten to twenty-five acres in area not only received an average of 4·6 applications per acre, but the extra treatment was given at a lower cost of 27·1 cents per barrel on the estimated yield. Twenty-one farms with over 25 acres each, received 5·1 spray or dust applications at a cost of 27·3 cents per barrel on the estimated yield.

From these figures it can be seen that the growers with the larger acreages, i.e., 10 or more acres, pay much more attention to spraying and dusting, and are able to put on more fungicidal applications at a lower cost per barrel of yield, than their neighbours with smaller orchards.

SPRAYING AND DUSTING EQUIPMENT

In order to control orchard insects and diseases it was found that the growers interviewed in this survey owned sufficient sprayers or dusters to allow one machine for every 21 acres. Only power dusters and sprayers with a capacity of 100 gallons or over were taken into consideration. A few growers have small, 40-gallon, hand-pump sprayers, but seldom use them in their regular orchard-spraying operations. Of the total number of machines found on these farms, 46 per cent were power dusters and 54 per cent were power sprayers. Some growers have both a duster and sprayer, and as many as three syrayers and one duster were found on one farm with nearly 150 acres of orchard.

Twenty-six per cent of the growers hired their neighbours to do their spraying or dusting. Most of such orchards were five acres or less in area, but a few were over ten acres and of sufficient value to warrant a privately owned sprayer or duster.

As stated above, few growers were able to give any idea of the quantity of spray or dust used in their orchards. From 50 gallons to 200 gallons of liquid were used per acre in spray applications. The average sprayed orchard would not receive much over 100 gallons per acre, which would mean from 2·5 to 3 gallons per tree per application. This is sufficient for young trees, but, for mature trees thirty years or over in age, much heavier applications are necessary to supply adequate protection from insects and diseases, unless applications are made weekly. Even then it is doubtful if good control of pests can be obtained with such light applications.

The dusted orchards received applications varying from 30 to 100 pounds per acre. The average application would be approximately 60 pounds per acre.

Copper fungicides, applied in liquid at the rate of 100 gallons per acre of 3-10-40 Bordeaux mixture, would supply approximately 2 pounds of metallic copper per acre. If used in dust form as 12-8-80 copper dust, at 60 pounds per acre, there would be 2·6 pounds of metallic copper applied per acre. Continued throughout the season with five sprays or seven dusts as the average

maximum number of applications, it is seen that the sprayed orchard would receive 10 pounds of metallic copper per acre and the dusted orchard 16·2 pounds of metallic copper. Since it has been found that, other factors being equal and up to certain limits of host reaction, the control of apple scab is in proportion to the amount of fungicide applied, it is, therefore, feasible to conclude that many of the local claims for superior control of disease by the use of copper dusts can be attributed to the greater amount of copper applied per acre.

ORCHARD DISEASES

The main disease of the apple orchards was scab. It was found in every orchard visited and in all proportions, the incidence of the attack varying from two to one hundred per cent of the fruit. This survey revealed most decidedly the influence of adjacent poorly sprayed orchards on the control of pests. Growers in such predicaments persistently complain that not only insects, such as bud moth, cankerworm, aphis, apple sucker, and green apple bug, spread from uncared for or poorly cared for orchards, but evidence was secured of the positive spread of late summer infections of apple scab from such orchards, and from isolated trees distant up to 200 feet from well sprayed fruit. This condition has brought a demand for a compulsory spraying program; and it is probable that some communities may take the matter in their own hands and attempt some such scheme, in order to safeguard themselves from the further spread of orchard diseases and insects.

Cankers, especially the black rot canker *(Physalospora Cydoniae,* Arn.) and European canker *(Nectria galligena,* Bres.), are on the decrease in the orchards examined. Some growers own to difficulty in successfully growing young trees of the Wagener variety on account of the European canker, but other varieties are not as severely affected. Excision and pruning of cankered branches and limbs is practised during regular pruning operations. This has brought successful control to many orchardists.

VARIETIES OF APPLES

The number of varieties of apples in an orchard has a pronounced influence on the factor of disease and pest control. Most of the older orchards and some of those 10 to 20 years of age were planted in a very irregular manner as far as varieties are concerned. A few trees of early blooming varieties will be found interplanted with late blooming trees. Little attempt was made to plant blocks of one, two, or three rows of the same variety. Hence it is now found that, when the time of the year comes for spraying or dusting operations, growers find it difficult to apply the factor of " timeliness " to their early applications.

The general advice of starting to spray when the earliest commercial variety has reached the desired stage of development is the best recommendation that can be made to operators of such orchards. Many growers are grafting out some of these interplanted varieties in order to obtain solid rows of the same variety. During the survey the growers were asked to name the five best varieties from their point of view. Many listed ten varieties. In summarizing these lists it was found that the 157 growers who named their best apples had listed altogether fifty-three varieties of apples. When the first five varieties only are considered, it was found that there were still twenty-six varieties listed among the five best by these growers.

This condition is not surprising after a trip through many of the orchard farms, as some individual growers in Nova Scotia can still boast of having over fifty varieties in their own orchard.

The five most favoured varieties of the entire fifty-three listed are: King, Baldwin, Gravenstein, Ribston, and Golden Russet. These and a few newer sorts are being grafted in to replace some of the less desirable varieties now found. There is a consistent effort being made by many orchardists to re-arrange the varieties in their orchards so that blocks or rows of the same variety will be more or less unbroken. This has been found necessary, not only to assist in spraying operations, but also in harvesting.

Apple Storage, 1926-27

In the fall of 1926 two storage rooms were constructed in the cellar of the station warehouse; one room (A), with a concrete floor, and the other (B), with a false floor on a dirt bottom. Ventilation was secured by windows and inside vents. A thermograph and a hygrometer were placed in one room and a thermo-hygrograph in the other.

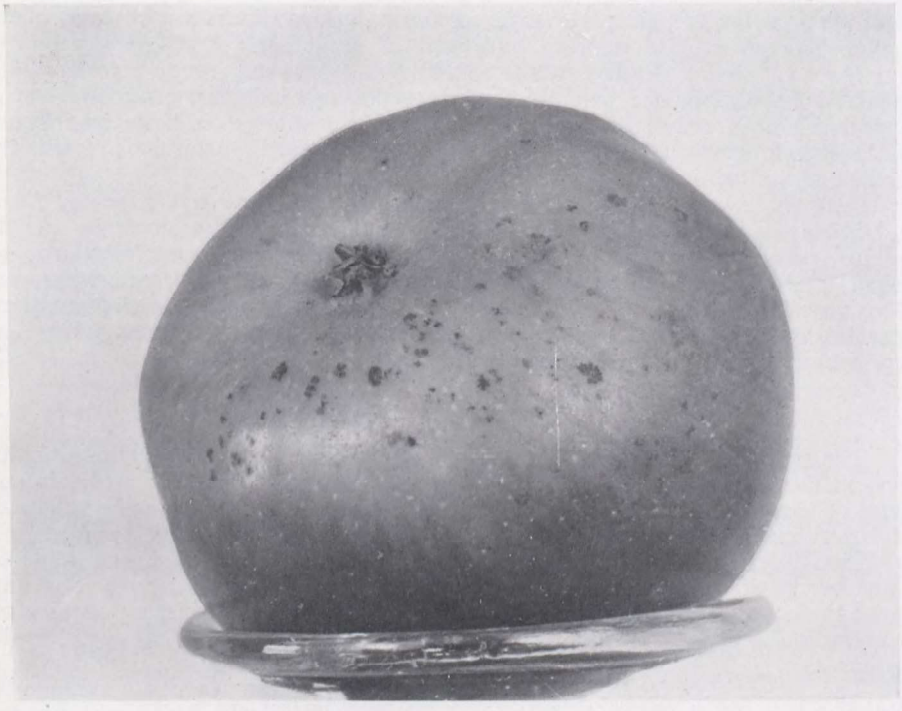

Fig. 29.—"Pin head spot"—the late infection symptom of apple scab as commonly found on the Wagener.

Various lots of apples were placed in each storage room, in order to compare keeping qualities and to ascertain the effect of humidity on some of the commercially stored varieties. Pressure tests were made on ten fruits of each lot at the beginning of the storage period and at regular intervals thereafter, by means of the improved pressure tester, described by Magness (U. S. D. A. Cir. 350).

There was little difference in the average temperature of the two rooms throughout the season. The humidity in storage A ranged between 70 and 75 per cent during this period, and that of storage B ranged from 90 per cent to absolute.

During these tests it was observed that the fruit softened during the first few weeks of storage up to December 1. The temperature from October 15 to December 1, averaged nearly 43°. From December 1, 1926, to April 1, 1927, the average temperature in the storage was 35°. During this latter period there was little change in the hardness of the fruit, but a gradual change in quality.

In storage B the humidity during March ranged between 95 per cent and absolute. Considerable rotting (fig. 31) took place at this time on some varieties, and moulds were very prevalent.

The varieties stored in the two rooms included Golden Russet, Nonpareil, Stark, Greening, Baldwin, and Wagener. The Russets were immature when picked, and the samples were discarded in January on account of severe wilting. The Nonpareils in storage B, where humidity was highest, were superior throughout the period of storage to those in storage A. The other varieties showed no consistent difference, indicating that, at the temperatures employed, a relative humidity of 75 per cent or over is satisfactory for these varieties.

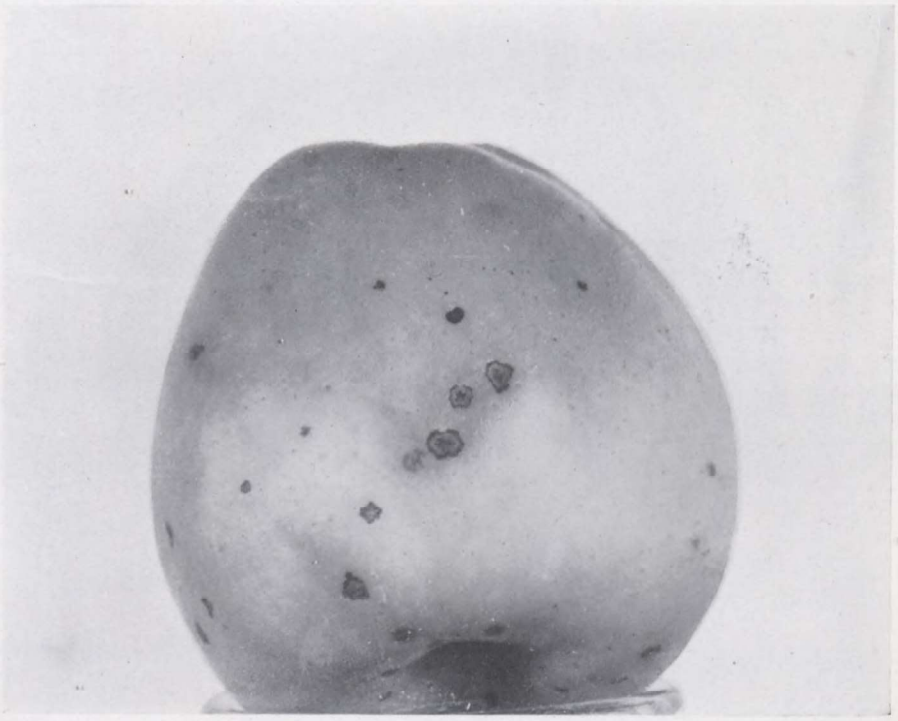

FIG. 30.—Apple scab "extension"—a condition commonly found in storage. The outer rings of the spots also produce conidia.

The following table, No. 50, gives the pressure test, at their optimum condition for use, of varieties held in storage during the season.

TABLE 50.—PRESSURE TEST OF APPLES AT OPTIMUM CONDITION FOR USE

Gravensteins	10–11
McIntosh	8–10
Wagener	10–11
Russets	16–17
Nonpareils	17–18
Starks	15–16
Greenings	13–14
Baldwins	16–17

A further report on some preliminary apple storage investigations was made in an address delivered to the Nova Scotia Fruit Growers' Association and published in their report for 1926.

Supervision was also given to a survey investigation conducted by the National Research Council to ascertain existing conditions in the average apple warehouse in Nova Scotia. A brief report on this was presented to the National Research Council in the spring of 1927. Since September, 1927, the Research Council have employed Dr. S. G. Lipsett to conduct special investigations in warehouse ventilation at Kentville and nearby warehouses. The staff of this laboratory have co-operated with Dr. Lipsett in phases of the work where our facilities were of value.

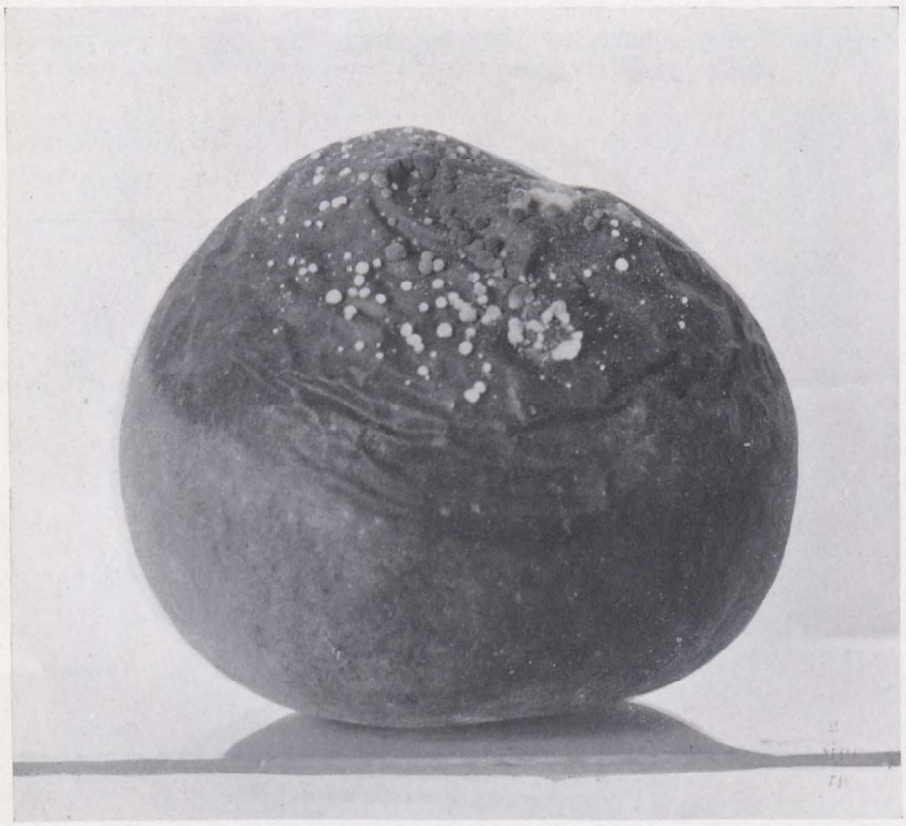

FIG. 31.—The commonest apple rot of the storage house, caused by *Penicillium expansum*, Link.

CURRANT RUST

Spraying and dusting black currants for the control of rust (*Cronartium ribicola*, F. de Wald.) were continued this past season in pursuance of the results obtained in 1926. The area treated was divided into three large plots with an additional small check plot.

One series of plots received two applications of lime-sulphur of 1·008 sp. gr. The other two plots each received sulphur dust—two brands of dust being used. The first application was made on May 10-11 on account of the matur-

ing condition of aecia on nearby white pines. On May 18 a second application was made. At this time the leaves were from one to two inches broad and the flower buds becoming exposed. The third dust applications were made June 9, immediately after bloom; and a late, fourth dust, was applied on July 15.

The first uredinia were found on untreated black currants on June 16. There was no apparent spread of the fungus until late in July and August on treated plots. By September 10 the check plots were completely defoliated, and the lime-sulphur plots which had received but two sprays were losing their leaves, and were practically defoliated by September 15. At this time the other plots were still green.

Counts of percentage leaf infection and type of infection—(relative area of leaf surface affected)—were made early in August, immediately after picking the fruit. A short summary is given in table 51.

TABLE 51.—RUST CONTROL OF BLACK CURRANTS

Treatment	Leaves infected	Type of infection
	%	
Lime-sulphur, 2 applications	83·2	9·0
Sulphur dust, 4 applications (av. of both brands)	34·3	1·5
Check, no treatment	100·0	52·5

There was practically no difference in yields of fruit between the various plots. This may be partially accounted for by the fact that the check plot of 1926 was included in the treated plots for 1927, with the exception of one bush. The yield from this bush was twenty-five per cent less than from adjacent bushes of equal vigour. No conclusion can be drawn from this single observation.

It appears from these results that thorough treatment with lime-sulphur spray or sulphur dust, starting with an application just previous to the maturity and liberation of aeciospores, will give excellent commercial control of the rust. Whether or not it can be completely controlled in order to satisfy the foresters' demands remains to be found by further trial on a more extensive scale.

CLUB-ROOT OF TURNIPS

It is not possible to make more than a progress report on this project at the present time, as breeding and selection from resistant and high-yielding strains are the main objects, and have been carried on for but three seasons. The majority of selections have been made from various strains of Bangholm after having been grown on soil heavily infested with club-root. A few stecklings of commercial varieties of swedes have also been selected, either because of their apparent slight resistance to club-root or their superior yield, to be developed into pure lines and used in crosses with Bangholms to obtain a strain with greater yield and resistance.

Stecklings have been planted in isolated locations for open insect pollination, or in nursery rows and bagged for selfing. The isolated method has been more successful for quantity production of plump, viable seed. A limited number of pure line strains have been made available in this manner, and the best of these were used as parents in cross pollinating with some of the commercial swedes. Yields from the first generation pure line selections have, in most instances, been higher than yields from parent stock. These lines are being continued for further multiplication and trial.

Tests and Varieties

For the past four years efforts have been made to give rigid tests for club-root resistance to many strains of turnips and swedes. Approximately ninety commercial varieties have been planted during that time, and of these some thirty-two were Bangholms or other strains recommended as resistant.

These tests have been conducted on soil varying from pH 6·0 to 7·2. A gradual elimination of varieties has taken place until this past season, when some twenty varieties and selections were planted on soil varying from pH 6·0-6·6. The soil was heavily inoculated with club-root material.

In the 1927 trial plots the Kentville strain of Bangholm was used as a basis of comparison with other strains, as this is now a standard strain and exhibits a fair resistance to clubbing. Of the twenty strains tested, ten have now been eliminated as inferior to the Kentville Bangholm. Of the remaining ten strains, two were original selections from the same source as the Kentville strain, two were imported Bangholms, and six were pure line selections from various Bangholm strains. This process of selection by elimination is leaving a few pure lines which will be used in future hybridizing work.

Thirty lots of seed from pure line selections and five crosses, from 1926 stecklings, together with the material carried over from previous years' selections, will form the basis of future work. It is felt that pure line seed is necessary for satisfactory breeding work, and, as it had not been possible to secure pure line stecklings until the 1927 planting, the past season's crosses are the first to be attempted.

Soil Acidity

The acidity of the soil has a depressing influence on yield when the soil is infested with the organism *Plasmodiophora Brassicae,* Wor. It has not yet been possible to determine the effect of acidity alone in comparative plots. Continuous records, however, have shown that soil varying from pH 6·8 to 7·0, free from club-root, gives very satisfactory yield; but whether higher yields can be obtained at greater acidities or at a higher alkalinity has not been determined from local investigation. The combined effects of acidity and the club-root organism can be seen from the following information.

H-ion determinations by the colorimetric method were made on soil samples from each of the 1927 plots. These were found to vary throughout the series from pH 6·0 to 6·6. The Kentville Bangholm variety was used throughout the plots.

Table 52.—Soil Acidity and Yield of Turnips on Club-Root Infested Soil

No. plants harvested	pH range	Average weight per root
47	6·0–6·19	58·96 gms.
169	6·2–6·39	103·71 gms.
330	6·4–6·59	156·46 gms.

The average weight per root of the same variety on infested soil with a pH value of 7·0-7·2 was approximately 500 gms. Just how much of the influence on weight per root can be attributed to soil acidity and how much to the parasite remain to be found out. It is apparent from an examination of the roots developed in soil above pH 6·8 that the organism affects only the secondary roots of the plant, and does not cause the severe malformations usually present on roots grown on soil of pH up to 6·2.

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

(H. R. McLarty, Officer in Charge)

An Experiment to determine whether Fire Blight is Spread by Pruning Tools, if these are not Disinfected when used in Cutting during the Winter Season

The season of 1927 completed the five-year period, during which this experiment has been carried on. This past season, the method of procedure was similar to that followed in previous years. Pruning shears or saw were cut into live cankers of the disease, and then used immediately in cutting off a twig or branch of the tree being tested. On March 2, 215 inoculations were made and there resulted no infection during the season. A summary of the results obtained for the five-year period may be of interest, and is presented in the following table. (Table 53.)

Table 53

Date of inoculation	Number of inoculations	Number of infections
1923 Mar. 6, 7	70	0
1924 Feb. 26	10	0
Feb. 29	140	0
Mar. 1	115	0
Mar. 3	20	0
Mar. 6	15	0
1925 Mar. 25	343	
Mar. 26	185	2
1926 Mar. 19	695	9
1927 Mar. 2	215	0
Total	1,808	11

The results show that the possibility of causing fire blight infection by means of naturally infected pruning tools is very slight. In 1926, when the greatest number of infections occurred, the probability of causing infections through pruning methods was only 1 in 77.

The Longevity of *Bacillus amylovorus* on Boxes of Fruit

This experiment was commenced in 1924, in conjunction with our investigation of the longevity of *B. amylovorus* in mature fruit, but, hitherto, the results have not been reported. The purpose of the experiment was to determine whether or not it was possible for fire blight bacteria to be carried from an infected district to an uninfected one on the fruit boxes. In 1925, the method followed was to sterilize, in dry test tubes, small pieces of box wood one-half inch square. These pieces were then carefully smeared with fresh cultures of *B. amylovorus*, and were then stored in test tubes under ordinary laboratory room conditions of temperature and humidity. At successive later dates, a certain number of these pieces was removed from the test tubes and planted on sterile potato agar. The results obtained in 1925 are as follows:—

Table 54

Date	Number of pieces smeared	Number of pieces removed and placed on agar	Number showing *Bacillus amylovorus*
May 10	12		
May 12		3	None
May 14		3	"
May 15		3	"
May 16		3	"

In 1927 the same experiment was repeated with a slight modification. The pieces of box wood, in the test tubes, were divided into two lots—in one (lot A) a few drops of sterile distilled water were placed; while in the other (lot B) the pieces of wood were left dry as before.

The smearing of the pieces of wood with a tested culture of *B. amylovorus* was made on February 28. The results obtained are presented in table 55.

TABLE 55

Date of transfer of smeared wood to sterile potato sugar	Lot No.	Number of pieces cultured	Number of pieces showing bacterial growth
Mar. 7	A	3	2
	B	3	0
Mar. 14	A	3	1
	B	3	0
Mar. 25	A	4	1
	B	4	0
April 6	A	5	2
	B	5	0
April 11	A	5	0
	B	5	0
April 19	A	5	0
	B	5	0
April 27	A	5	0
	B	5	0

These results seem to indicate that the bacteria will not live on dry box wood, but that it is possible for them to live on slightly moistened wood for a period of one month.

THE RESISTANCE OF CERTAIN PEAR TREES TO FIRE BLIGHT

Since the establishment of the laboratory at Summerland, there has been collected together a small number of pear species and varieties, which, it was hoped, would show evidence of being resistant to fire blight. The names of these varieties and species, together with certain results on their resistance to *B. amylovorus,* are presented.

As a beginning, 50 trees of *Pyrus ussuriensis* were obtained from the A. L. Wisker Nurseries, Grass valley, California. These were used as a foundational stock on which to graft other varieties.

1923.—Dr. M. B. Waite of the Bureau of Plant Industry, Washington, D.C., kindly supplied the laboratory with grafts of new seedling pears, originated by his department. From this source, the following have been successfully grafted on *Pyrus ussuriensis*:—

S.P.I.—49489
S.P.I.—49490
S.P.I.—49492
S.P.I.—49494
S.P.I.—49495
S.P.I.—52461
S.P.I.—52462
S.P.I.—52464

In the same year, grafts of the Patten Pear were received from the Iowa State University and were successfully grafted on *Pyrus ussuriensis.*

1924.—Twenty-five Rimes Pineapple pears were received from the Altamaha Nurseries, Ludowici, Georgia.

At the same time, living scions of the following Chinese varieties were received from Mr. Hy. Parsons, Yunnan, West China, and were successfully grafted on *Pyrus ussuriensis*:—

Muh Kua Lih
Siao Huang Lih (The Litle Yellow Pear)
Ruh Shiang Lih (The Scented Pear)
Suan Lih (The Sour Pear)
Ta Huang Lih (Big Yellow Pear)

From the Coldstream Ranch, Vernon, B.C., grafts from a Flemish Beauty tree, which was never known to blight, were received and grafted.

1925—Scions of a seedling pear from Sicamous, B.C., were received. These pears are of fair quality, hardy, and apparently resistant to blight. This seedling was budded on a *Pyrus ussuriensis*.

In 1924 and again in 1927, some inoculation tests were carried out with fresh cultures of *B. amylovorus*. The results are shown in the following table:—

TABLE 56

Species or variety	Number of inoculations made	Number inoculations taking	Remarks	Number inoculations made	Number inoculations taking	Remarks
Patten	16	15	3 took freely	6	6	Took freely
Flemish Beauty	12	5	2 took slightly 4 took moderately 1 took very slightly	28	28	27 took moderately 1 took slightly
Rimes Pineapple	25	21	21 took slightly	27	12	Took slightly
S.P.I. 49489	4	1	Took slightly	19	4	Took slightly.
S.P.I. 49490				4	0	None took
S.P.I. 49492	3	0	None took	39	25	Took moderately.
S.P.I. 49494	4	4	Took freely	6	6	Took moderately
S.P.I. 49495	2	0	None took	3	0	None took
S.P.I. 52461				14	1	1 took slightly
S.P.I. 52462				4	2	Took slightly
S.P.I. 52464				15	2	Took slightly
Muh Kua Lih				3	3	Took fairly freely.
Ruh Shiang Lih				4	3	Took slightly
Ta Huang Lih				3	0	None took

FROST INJURY ON APPLES

In September, 1926, an unusually hard frost was recorded throughout the Okanagan Valley; the official record at the Summerland Station showed a temperature of 25° F., while on some of the higher benches, the temperature was considerably lower. In one such district, the local thermometers showed a temperature of 20° F.

As a large percentage of apples was still on the trees at the time of the frost, it was decided to collect some of this fruit and test its storage qualities. Accordingly, one box each of Jonathan, Grimes Golden, Northern Spy, Wagener, and Yellow Newtown, was collected. The fruit for each box was collected from a number of trees and ranged in size from large to small. The picking was done after the apples had completely thawed out, and all fruits already showing external evidence of injury were rejected. Apples from the field, similar to those being collected, were cut open and records were made on their condition, as being representative of the condition of the apples being stored. Definitions of terms used in this examination are as follows:—

1. *Water-core*
   (*a*) Slight—the flesh appears very slightly translucent.
   (*b*) Medium—the flesh appears distinctly translucent, but has no brown tinge.
   (*c*) Severe—the flesh appears distinctly translucent over a large area and is accompanied by a distinct browning.

2. *Radial water-core*
   (*a*) Slight—small translucent spots can be detected.
   (*b*) Medium—the spots are 1 mm. or more in diameter, but are distinct and not joined together.
   (*c*) Severe—the spots are large and joined together, forming a ring around the core.

3. *Flesh Injury*
   (*a*) Slight—slight mealiness or has slight rubbery texture; no noticeable change in the taste.
   (*b*) Medium—the flesh is mealy, slightly browned, showing a brown network when the apple is peeled; taste is slightly off normal.
   (*c*) Severe—the mealiness and browning in the flesh are distinct and the flesh has a fermented taste.

The boxes of apples were stored in an ordinary cool storage cellar, and examinations were made from time to time on this stored material. The results of the examinations made in the field are presented in table 57. The results of the examinations made periodically throughout the storage season are presented in table 58.

These results show that apples are capable of enduring quite severe frosts, while they are still on the trees, without losing very much in their storage quality. The frost was quite severe enough to cause distinct shrivelling of the fruit, but this disappeared after the fruit thawed. A complete disappearing of water-core in storage occurs when the injury has not been too severe.

TABLE 57—EXAMINATION OF APPLES IN THE FIELD

Variety	Number of apples examined	Number showing water-core				Number showing radial water-core				Number showing flesh injury				Foliage injury
		none	slight	medium	severe	none	slight	medium	severe	none	slight	medium	severe	
														per cent
Jonathan	60	13	10	21	16	18	15	22	5	0	53	6	1	25
Wagener	61	37	19	5	0	30	25	4	2	1	37	22	1	50
Yellow Newtown	61	43	13	3	2	8	15	23	15	0	21	26	14	20–40
Northern Spy	60	57	0	0	3	18	31	8	3	2	30	19	9	20–40
Grimes Golden	50	30	12	2	6	1	11	11	27	0	10	16	24	50–60

TABLE 58.—EXAMINATION OF APPLES IN STORAGE

Date	Number of apples examined		Variety	Number with surface injury		Number with water-core		Number with radial water-core		Number with flesh injury		Number with texture			Number with taste		No. with *Penicillium* rot or internal breakdown
	for surface injury	for internal injury		absent	present	absent	present	absent	present	absent	present	normal	rubbery	mealy	normal	abnormal	
Oct. 27/26	132	13	G. Golden	129	3	11	1	9	3	9	3	5	4	3	7	5	1
Dec. 17/26	119	10	G. Golden	115	4	8	1	6	3	4	5	4	5	0	4	5	1
Jan. 28/27	107	107	G. Golden	100	7	104	0	103	1	91	13	91	1	12	91	13	3
Oct. 27/26	96	10	Wagener	93	3	8	2	8	2	7	3	4	2	4	8	2	0
Dec. 17/26	85	10	Wagener	83	2	10	0	10	0	6	4	6	1	3	6	4	0
Jan. 28/27	71	10	Wagener	69	2	10	0	8	2	6	4	5	0	5	6	4	0
Feb. 10/27	59	59	Wagener	58	1	57	2	58	1	57	2	57	0	2	57	2	0
Oct. 27/26	138	10	Jonathan	138	0	10	0	10	0	10	0	9	0	1	10	0	0
Dec. 17/26	123	10	Jonathan	119	4	8	0	7	1	4	4	4	0	4	4	4	2
Jan. 28/27	113	10	Jonathan	113	0	10	0	10	0	10	0	10	0	0	10	0	0
Feb. 10/27	100	100	Jonathan	98	2	100	0	100	0	98	2	98	0	2	98	2	0
Oct. 27/26	110	10	N. Spy	109	1	10	0	10	0	8	2	4	1	5	7	3	0
Dec. 17/26	95	10	N. Spy	95	0	10	0	10	0	10	0	10	0	0	10	0	0
Jan. 28/27	86	10	N. Spy	86	0	10	0	10	0	10	0	10	0	0	10	0	0
April 5/27	70	70	N. Spy	70	0	70	0	70	0	68	2	68	2	0	68	2	0
Oct. 27/26	132	10	Y. Newtown	125	7	6	3	3	6	0	9	0	9	0	0	9	1
Dec. 17/26	122	11	Y. Newtown	119	3	10	0	7	3	7	3	7	3	0	7	3	1
Jan. 28/27	111	10	Y. Newtown	109	2	10	0	10	0	5	5	5	3	2	5	5	0
April 5/27	80	80	Y. Newtown	79	1	79	0	79	0	74	5	74	5	0	74	5	1

Collar Rot

A beginning on this problem was made this year. A five-acre block of McIntosh trees, where the disease has been exceptionally bad, has been taken over, and several different treatments are being carried out. Information is being sought on the following points:—

1. The value of exposing the crowns of diseased trees to the sun, throughout the summer without further treatment.
2. The value of cutting out diseased tissue around the crown, and of treating it with one of the following wound dressings:—
    1. Solution of potassium bichromate and copper sulphate (French solution), and coal tar.
    2. Coal tar.
    3. Bordeaux paste.
    4. White lead in linseed oil.
3. The value of leaving trees without any treatment whatever, that is, locating the extent of the injury and then filling in the earth again.
4. The value of bridge grafting over the diseased areas.
5. The value of inarching, that is, the planting of young seedlings around diseased trees and of grafting them into the trunks above the diseased area.

The number of trees in this block, which has been thoroughly examined, is 188. Of these, we found 100 showing collar rot in different stages of development.

The following is a summary of the work carried on up to date:—

1. The number of trees cleaned, and left exposed for the summer to the sun	(fig. 32)	63
2. The number of trees cleaned, sterilized, and painted		33
1. French solution and coal tar		8
2. Coal tar		10
3. Bordeaux paste	(fig. 33)	7
4. White lead in linseed oil	(fig. 34)	8
		33
3. The number of trees not cleaned, and around which the soil was at once replaced		2
4. The number of trees bridge grafted	(figs. 35 and 36)	27
5. The number of trees inarched	(fig. 37)	13

The bridge grafting and the inarching were done by the officials of the Provincial Department of Agriculture. The seedlings used were Duchess and Yellow Transparent, and were supplied by the Horticultural Division of the Summerland Experimental Station.

FIG. 32.—Collar Rot—A typical tree cleaned and left exposed for the summer to the sun.

FIG. 33.—Collar Rot—showing tree cleaned and painted with Bordeaux paste.

FIG. 34.—Collar Rot—showing tree cleaned and painted with white lead and linseed oil.

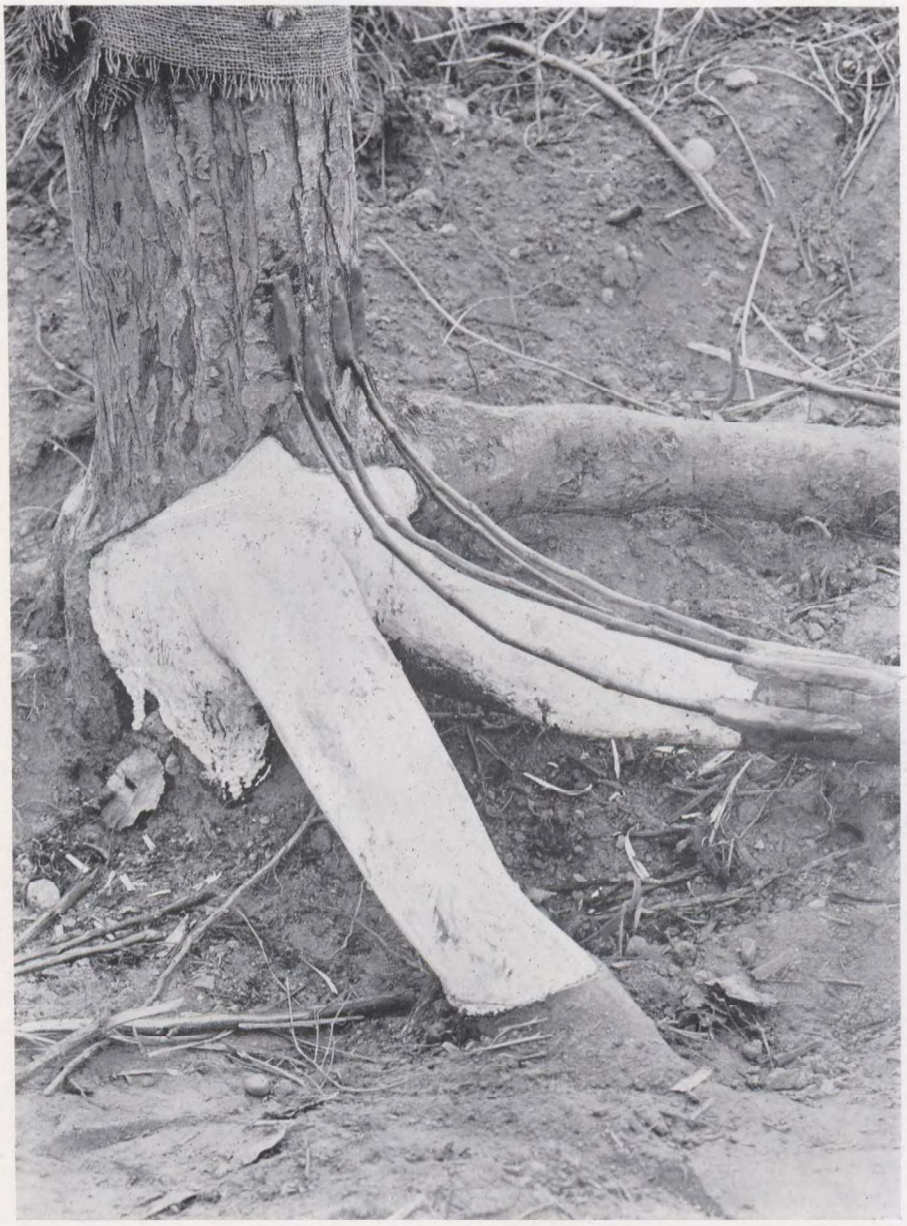

FIG. 35.—Collar Rot—showing the same tree as in Fig. 34 with bridge-graft in place over one root.

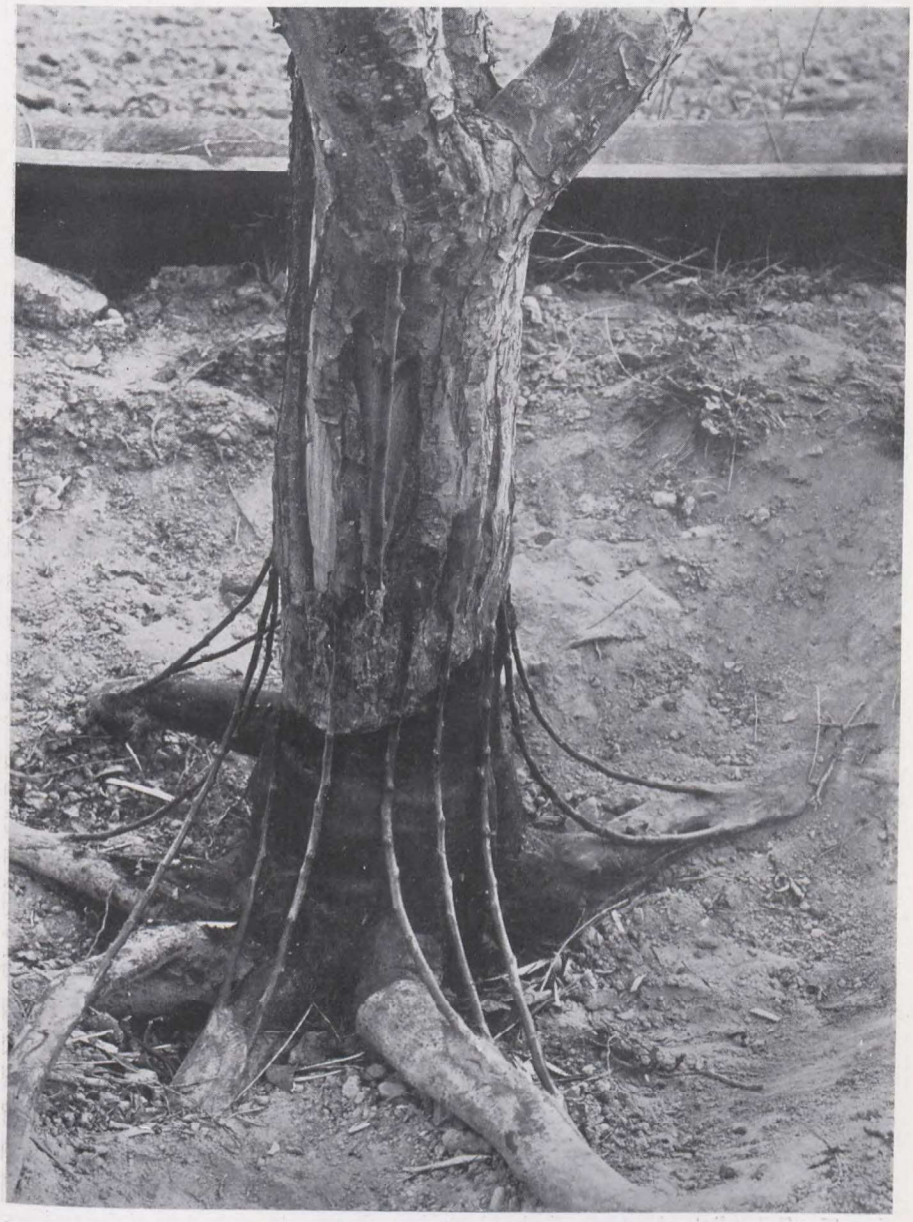

FIG. 36.—Collar Rot—another view of the bridge-grafted tree totally girdled.

FIG. 37.—Collar Rot—showing method of inarching. On some trees the tops of the seedlings were removed and others were left as shown in the photograph.

Perennial Canker

The definite relationship between the spread of this canker-forming fungus and the presence of woolly aphis in the orchard, as first reported in the annual report for 1926, has been substantiated by many further observations. During the year further information has been gained on the following points:—

1. Spore germination for the season 1927.
2. The value of wound dressings in keeping out the woolly aphis from the cankers, thus controlling the spread of the disease.
3. The value of oil sprays in controlling the insect.
4. The spread of woolly aphis through the orchards.
5. The pathogenicity of the fungus in artificial inoculations.

Table 59.—Germination Tests—Season, 1927

Date material collected	Date of test	Germination
		%
June 6	June 15	100
" 14	" 18	100
" 23	July 4	100
July 8	" 12	100
" 28	" 30	25
Aug. 3	Aug. 8	.....
" 12	" 17	70
" 18	" 22	100
Sept. 2	Sept. 8	5
" 8	" 16	100
Nov. 11	Nov. 15	100

These results are in agreement with those recorded for the season, 1926.

Efficiency of Certain Materials as Woolly Aphis Repellents

It is hoped in this work that we shall find an efficient wound dressing that will repel the insect and prevent its feeding on the healing callus. If this can be done, we believe that it will serve as an efficient control of the disease on the trunk and main branches of the trees, as these are the parts of the tree which suffer most from this disease. In making the applications, we had in mind the economic aspect of the treatment and only such care was taken as we thought would be feasible for any grower to observe.

All the materials were applied with a brush. Loose bark that could be removed with the fingers was first broken off, but the healing callus was not in all cases exposed. The different repellents used have been suggested as follows: Collodion and glycerine, linseed and coconut oil, rape seed oil, and castor oil by the Dominion Chemist, Central Experimental Farm, Ottawa; coal tar by Mr. Leroy Childs, Hood River, Oregon; pine tar by Mr. Keane, a local grower.

Observations were kept on the efficiency of the material as repellents and the amount of injury produced to the callus.

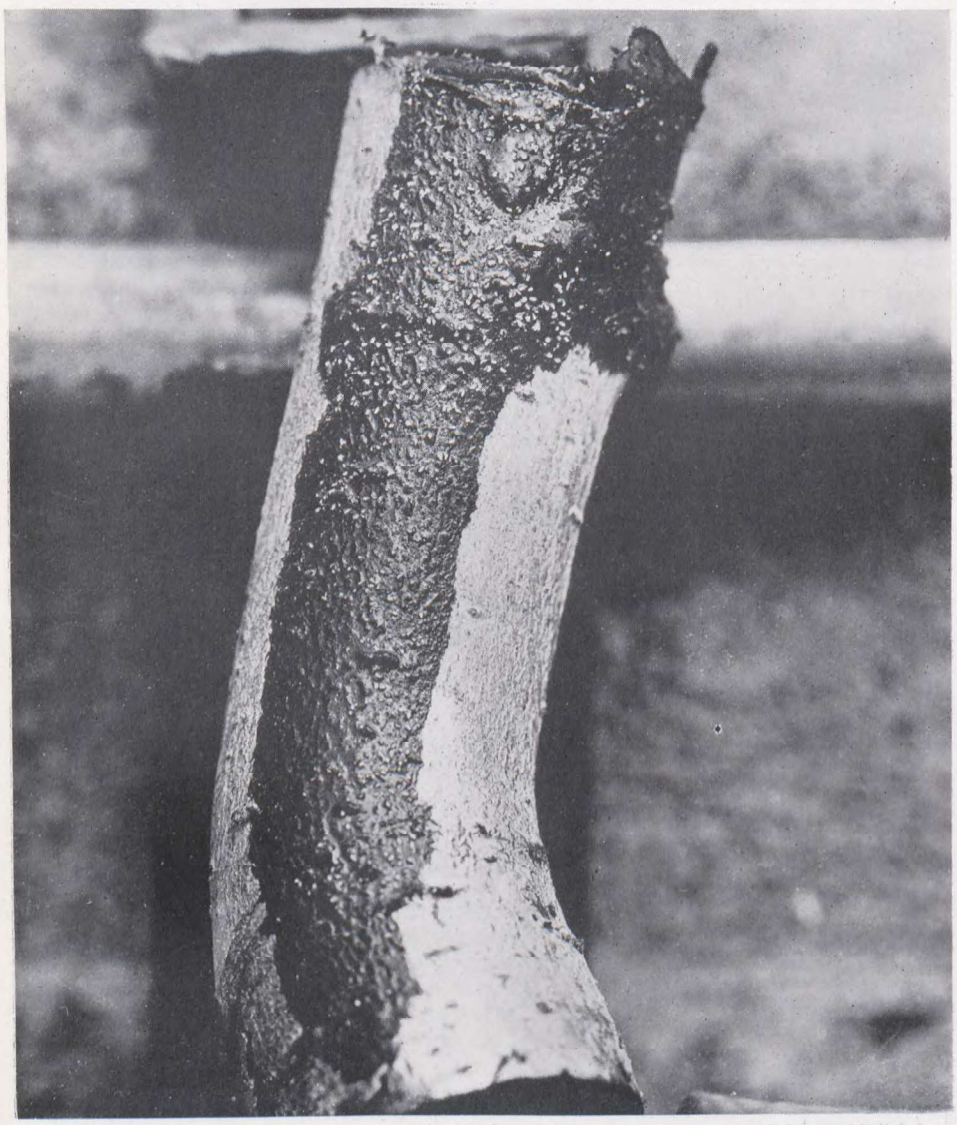

FIG. 38.—Woolly aphis—showing the young aphids which have been caught on the surface of the pine tar.

TABLE 60.—APHIS REPELLENTS IN CANKERS

Date of application	Material	Number of cankers treated	Efficiency as repellent	Date of examination for efficiency	Injury	Date of examination for injury
			%		%	
Aug. 26, 1926	Coal tar	150	*		90–100	June 22, 1927
" 17, 1926	"	138	*		90–100	" 23, 1927
Oct. 1, 1926	"	145	*		90–100	" 23, 1927
May 19, 1927	Collodion glycerine	50	30	July 7, 1927	none	Oct. 9, 1927
July 7, 1927	Coal tar	90	51	Oct. 9, 1927	none	" 9, 1927
" 7, 1927	Pine tar	45	85	" 9, 1927	none	" 9, 1927
" 8, 1927	Linseed and coconut oil	140	71	" 2, 1927	none	" 2, 1927
" 8, 1927	Coal tar	283	50	" 2, 1927	none	" 2, 1927
" 8, 1927	Pine tar	150	96	" 2, 1927	none	" 2, 1927
" 22	Rape seed oil	112	100	" 2, 1927	none	" 2, 1927
" 22, 1927	Castor oil	118	93	" 2, 1927	none	" 2, 1927
" 22, 1927	Oronite crystal oil	112	100	" 2, 1927	5	" 2, 1927

*Counts not made in the fall of 1926.

Although coal tar showed a high percentage of callus injury, it was noted that here and there parts of cankers were found uninjured and yet were generously coated with the tar. This suggested the possibility that the coal tar in itself was not responsible for the injury, but that it was necessary to combine with it the action of the aphis. Additional weight attached to this suggestion from the fact that, in 1926, the tar had been applied only to cankers in which woolly aphis were already present and had been feeding. In order to get more light on this point, it was decided to give the coal tar another trial again this year, and, accordingly, it was applied earlier in the season, at a time when most of the cankers had not yet become infected with woolly aphis.

Of the other wound protectors, the collodion and glycerine mixture treatment was not satisfactory. Woolly aphids were again present in treated cankers soon after the application. Linseed and coconut oil appeared to be only fairly efficient. Oronite crystal oil was highly efficient, for the two and one-half months under observation; evidence of injury, however, was appearing at the end of this period. Pine tar, rape seed oil, and castor oil were all highly efficient and show very fair promise; cankers treated with these three latter materials have remained free or practically free from the aphis since the time of the application in July.

VALUE OF OIL SPRAYS IN CONTROLLING THE INSECT

An attempt was made to control woolly aphis with the use of oil sprays. The following oils were tried:—

Volck Oil—2 per cent solution.
Petrotine—2 per cent solution.
Oronite Crystal Oil—2 per cent and 4 per cent solutions.

The results were somewhat contradictory and nothing very definite could be concluded. This work, however, is worthy, we feel, of further trial.

SPREAD OF WOOLLY APHIS THROUGH THE ORCHARD

In connection with the application of the pine tar, interesting observations were made on the spread of the aphis through the orchard. Pine tar remains sticky for a considerable period of time after it is applied. This sticky surface served as a trap for young aphids that were drifting through the air. It is evident that they drift, as the aphids were distributed fairly evenly over the whole surface; young aphids could not possibly crawl across the sticky surface

to such a distance as the centre of the area painted. The first pine tar treatment was made in July, and when it was noticed that this material served as a trap to catch the aphids, later applications were made on September 16 and on October 5 (fig. 38). After both these applications, many aphids were caught, showing that the drift of the aphids through the orchard extends well into the fall period. On the October 5 application, there were fewer caught, however, over a similar period of time, than on the July and September applications.

PATHOGENICITY OF THE FUNGUS BY ARTIFICIAL INOCULATION

During the period April, 1926–May, 1927, a series of inoculations was made, at approximately weekly intervals, on Rome Beauty trees in the laboratory grounds. In all, 920 inoculations and 460 checks were made. The method of inoculation was to cut several times through to the cambium with a scalpel well smeared with a culture of the fungus. The checks were made with a flamed scalpel, the cutting being done in a similar manner to that by which the inoculations were made. In 1924–1925, this system of inoculating was successful in producing many young cankers in the spring of 1925. In this series of inoculations, however, there was no outward evidence of the inoculation, i.e., the phloem did not become infected. In many cases, however, where an examination has since been carried out, it was found that the inoculations took in the wood tissue and spread rapidly up and down the limb, causing dark brown streaks. All the inoculations have not yet been examined, as it was thought best to leave several to see whether or not any evidence of the disease will yet appear in the tree. Isolations made from the diseased wood, taken one year and more after the inoculations were made, show that the fungus is still alive.

Physiological Diseases

DIE-BACK, DROUGHT SPOT, AND CORKY CORE OF APPLE

In the spring of 1922, there was undertaken by this laboratory, as a major project, an investigation of certain physiological diseases in apple trees. In the annual reports since, only brief mention has been made of this work and the results presented of only some phases of the work. It is now felt that some fuller account of this investigation should be presented. The investigation is not considered to be by any means complete. We have, however, discovered many definite facts with regard to the occurrence of these diseases, which throw some light on the probable cause of the trouble.

Of several diseases which we believe are physiological in nature, and which are common in British Columbia, there are three distinct diseases of the apple in which we have been particularly interested in this investigation. These are, calling them by their local names,—die-back, drought spot, and corky core.

By the term die-back there is not meant that type of injury which results from a direct killing by heavy winter frosts, and which is characterized by a browning of the cambium immediately after the frost occurs. Rather, the die-back in which we are interested, and the type which is far more common here than the one referred to above, is characterized by the apparent inability of the tree to put out normally its buds on last year's terminal growth, or by its tendency to put out a sickly cluster of leaves that soon shrivel and die, the bark and the cambium being at the same time in an apparently healthy condition, with death occurring in these tissues only later in the year (figs. 39 and 40).

By drought spot we mean that condition of the fruit which results from a dying of the epidermal layers of the fruit at a time when the apple has just passed the blossoming period. The amount of tissue killed varies greatly in different apples and in different seasons, and, as a result, there are produced apples showing various degrees of injury. When the killing is extremely slight,

apples are produced having only a slightly russeted condition around the calyx. When the injury is more severe, we find apples showing many depressions and, at the base of each depression, is found dead corky tissue. This type of apple, in the early stage, often exudes drops of ooze. When the killing on the surface is severe, that is, when several of the outer layers of cells are killed, the resulting apples are small, severely cracked, and absolutely worthless from a market standpoint (figs. 41 and 42).

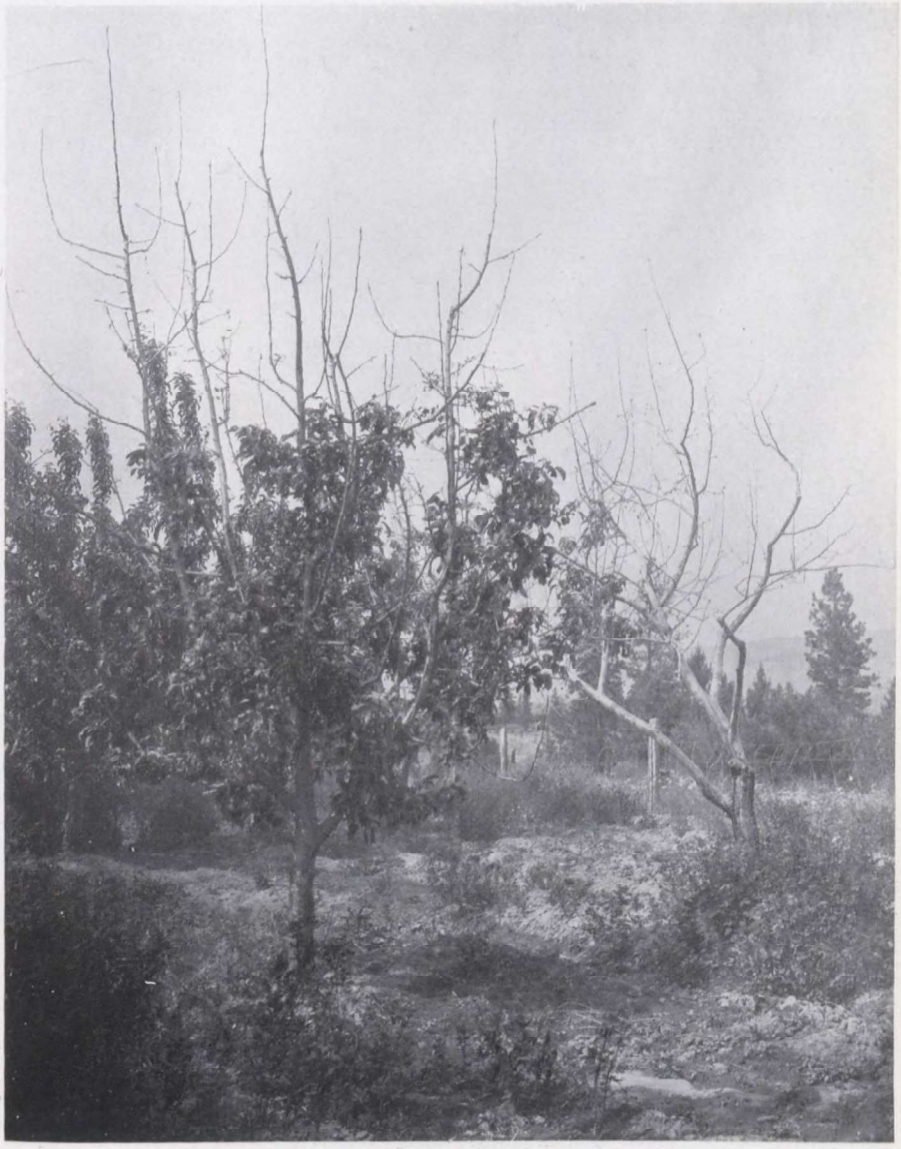

FIG. 39.—Showing a tree in the foreground having the die-back condition, but which is making fair recovery. One tree is seen in the background which will not recover.

By corky core we refer to that condition of the fruit in which light brown spots of dead corky tissue occur in the core area, and, sometimes, even throughout the whole flesh of the fruit. These spots appear throughout a considerable period during the development of the fruit, but are usually not found until the apple is about half grown. The spots can continue to appear from that time

FIG. 40.—Showing a very typical die-back condition. Note the small leaves and the bare twigs. In the foreground a few branches can be seen of another tree showing normal foliage.

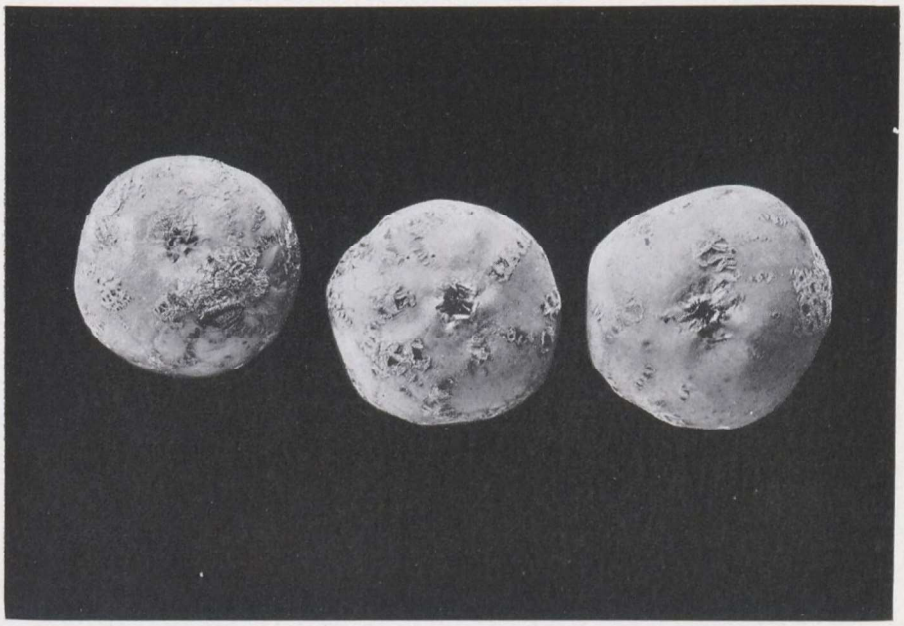

FIG. 41.—Drought spot of apples showing the severe conditions where apples have become absolutely worthless.

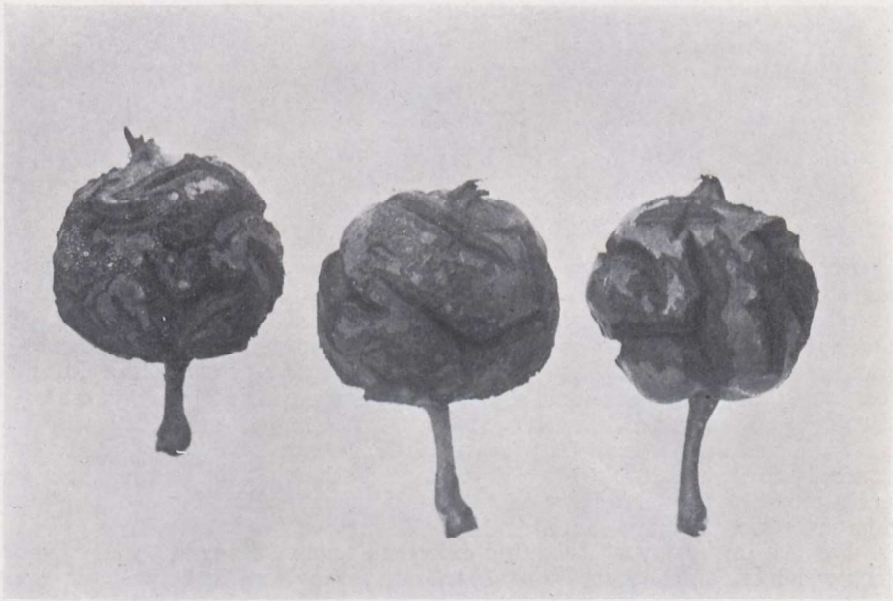

FIG. 42.—Drought spot of apples showing an extreme case where the apples are severely cracked and are absolutely worthless.

until the fruit is picked, but they do not develop further in storage. No evidence of the trouble is apparent from the exterior, and it is only by cutting into the fruit that the diseased condition can be found (figs. 43 and 44).

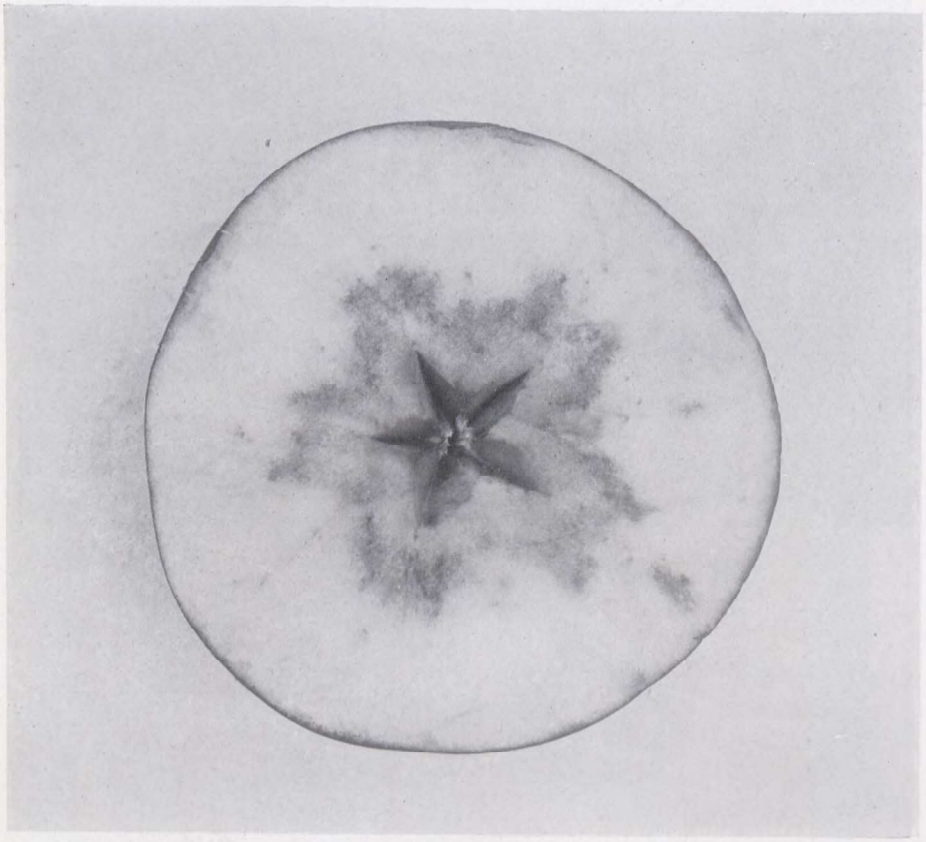

FIG. 43.—Corky cored McIntosh showing typical diseased area in the flesh.

Prevalence of the Diseases.—This group of diseases causes more economic loss to the apple industry of the Okanagan than does possibly any other disease. Their severity varies greatly from year to year, and it is difficult to get exact data on the financial loss incurred. By way of illustration, however, a few examples might be cited. In the spring of 1927, a five-acre block of McIntosh trees was practically wiped out by the die-back condition. In this case, the injury was so severe that the limbs, as well as the twigs, were affected, and the trees produced only a few sickly growths which sprouted out around the lower branches near the trunk. It is interesting to note that, last year, these trees bore a crop of corky cored apples, but, when examined in the winter, appeared to be in a fairly healthy condition (fig. 45).

For the drought spot condition reference might be made to one ten-acre block which has not produced a commercially paying crop in the last four years. The trees have blossomed well, have set fruit in abundance, but the fruit has been so affected with drought spot that it has been worthless for market. Examples such as this can be duplicated many times.

Losses incurred through the corky core condition might be illustrated by the Salmon Arm situation in the fall of 1922. Out of an estimated crop of 120,000 boxes, 60,000 to 80,000 boxes were left untouched on the trees, it being considered at that time that a corky cored apple was totally unfit for market.*

Investigational Work.—In starting an investigation of these diseases, it was at once noticed that the three seemed to be in some way associated; trees susceptible to one showed a susceptibility to the others. For example, a tree might have drought spot one year, corky core the next, and die-back the next. It is true that sometimes a tree appears to be subject to only one of these diseases, in which case the disease is usually corky core. The tendency is, however, for a tree to vary from one to the other throughout a period of years, or even, at times, to have two or all of the diseases concurrently. Seeing, however, that corky core has been the one that has caused the greatest amount of loss, special attention has been given to it in this investigation. In this problem, however, the three diseases are being considered as a group, the causes of which appear to be in some way associated.

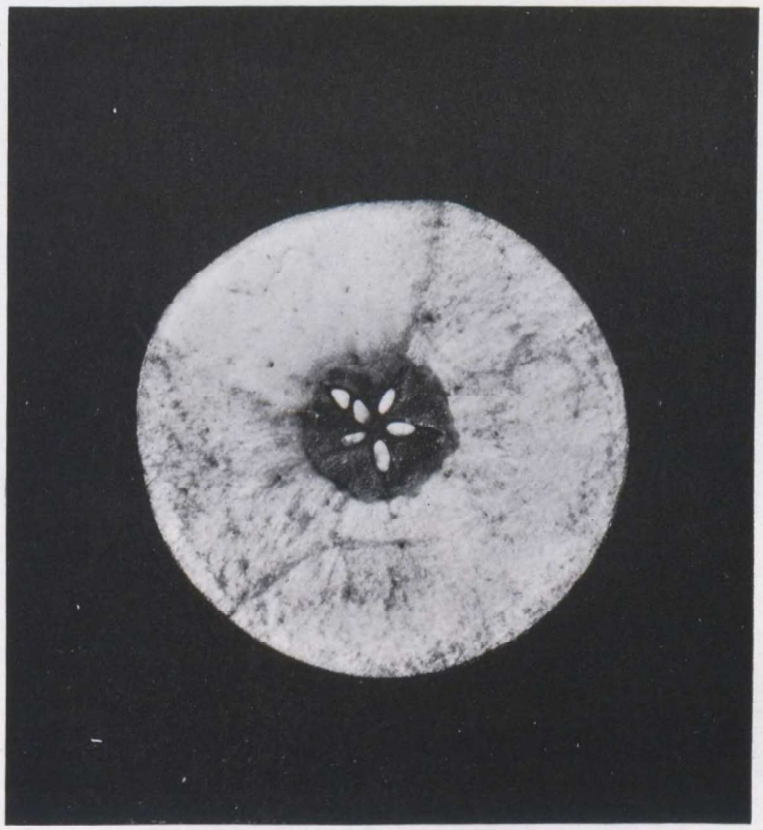

FIG. 44.—Corky cored Jonathan showing the tendency in this variety for the injury to remain within the core area.

* More recently corky cored apples, when not badly affected, are shipped as low grade fruit.

While there were many observational evidences that these diseases were physiological in nature, nevertheless, as an initial and precautionary step, a careful search was made for any pathogenic organism in the diseased tissues. Following the most approved methods, isolations have been faithfully made, but all efforts to isolate pathogenic organisms have proved futile. These diseases were, therefore, considered to be physiological in nature and, basing our work on this assumption, we laid out our plan of attack.

Since we knew nothing concerning the cause of the diseases, our plan of attack had to be general. We laid out, therefore, a broad field of operations, and we hoped, by a process of elimination by comparison, to discover the cause. While, perhaps, our reach has exceeded our grasp, we have, however, maintained, through five years, the same general plan and we hope, later, to fill in many of the details, which, for the time being, have been allowed to remain untouched.

FIG. 45.—Showing a part of the trees which have been completely killed out owing to the die-back condition. Note the normal foliage of the orchard in the background.

In general, we proposed two main fields of activity. We desired first,—to learn whether or not the use of certain cultural methods would prevent the re-occurrence of these diseases; and second,—to ascertain, if possible, whether there was any outstanding difference in the factors influencing growth, between orchards affected with and those free from the disease.

Influence of Cultural Conditions.—To test out the influence of cultural methods, a plot of ground, of approximately 2 acres extent, of uniform slope and soil, and planted to Wealthy apple trees, was taken over. The plot was divided into sub-plots of 16 trees each, and on each a different cultural method was applied. These cultural methods were: plot No. 1, a cover crop of vetch with the addition of water; plot No. 2, clean cultivation with manure and water; plot No. 3, clean cultivation and water; plot No. 4, clean cultivation and manure. Only sufficient water was added to ensure, as we thought, no injury to the trees through drought. The amount of water applied was measured by

meter, and the resultant influence was judged by soil moisture determinations. Soil samples were collected from each plot at weekly intervals at a 15-inch level.

This experiment was begun in the spring of 1923 on a plot of ground situated in the Salmon Arm district. In this district irrigation is not practised. For our plots, however, sufficient water was procured from the town water supply. The plots receiving manure received an application each spring at the rate of 16 tons per acre.

In the season previous to the taking over of this plot, the district of Salmon Arm generally was very badly affected with corky core, and the area taken over for investigation was uniformly and severely affected with the trouble. We were unfortunate in not being able to obtain a check plot exactly comparable to the treated plots. The one chosen was a plot in the same orchard, but in which the soil was of slightly different type from that of the experimental plots. In checking the effect of the experiments, therefore, we have made observations on the check plots and on the district in general.

The following is a summary of the results obtained:—

TABLE 61

	—	Amount of corky core	Amount of irrigation in acre inches
1923	Plot No. 1	None	4·54
	Plot No. 2	None	1·56
	Plot No. 3	None	1·56
	Plot No. 4	1 tree	
	Check	Affected slightly	
		District, slightly affected	
1924	Plot No. 1	None	12·79
	Plot No. 2	None	3·89
	Plot No. 3	None	5·64
	Plot No. 4	1 tree affected	
	Check	Fairly severe	
		District, not severe	
1925	Plot No. 1	1 side of 1 tree	17·7
	Plot No. 2	15 trees affected	6·3
	Plot No. 3	5 trees affected	7·32
	Plot No. 4	13 trees affected	
	Check	Badly affected	
		District, severe	
1926	Plot No. 1	5 trees slight evidence	3·6
	Plot No. 2	13 trees	3·6
	Plot No. 3	2 trees	3·6
	Plot No. 4	12 trees	
	Check	14 trees	
		District, quite severe	
1927	Plot No. 1	2 trees	3·6
	Plot No. 2	5 trees	3·6
	Plot No. 3	1 tree	3·6
	Plot No. 4	5 trees	
	Check	13 trees	
		Not severe in district	

It is difficult to record in a table the results obtained on a disease expressing such wide variation in severity as does corky core. The table shows, for example, especially in the year 1926, a fairly severe occurrence of the disease in plot No. 1. As a matter of fact, the disease, though present in five trees, was so slight that the whole crop from the plot was marketed in the usual manner. The results of these experiments over a five-year period show, first, that cultural conditions do have a marked effect on the occurrence of the disease, and, second, that the disease can be controlled from a commercial viewpoint, in the Salmon Arm district at least, by the use of a vetch cover crop, with the addition of water.

Investigation of Factors Influencing Growth in Healthy and Diseased Orchards

The second part of our attack on the problem was to ascertain, if possible, whether or not there was any outstanding difference in the factors influencing growth, between orchards affected with and those free from the disease. It so happens that these diseases often occur on trees growing under apparently identical conditions of environment as are healthy trees in their immediate vicinity. In fact, it sometimes happens that these diseases persist on even one branch of a tree which otherwise produces healthy fruit. The occurrence or non-occurence of these diseases on trees growing under apparently similar conditions suggested to us that there might be only some small difference in environment which was responsible for the trouble: a difference which we might be able to discover in an intensive study.

It was, therefore, proposed that observations be made in eight plots, situated in four different districts. In each district, a good plot, free from the disease, and a susceptible one were to be chosen. The plots were to be chosen in separated districts, first, in order that greater publicity might be given to the work, especially if worth-while results were obtained, and second, in order to obtain a higher possibility of having the disease occur in at least one of the plots each year, as it was felt that variation in climate and water supply would greatly heighten the probability of its occurrence.

The plots have been located as follows: Kelowna 2, Glenmore 2, Westbank 2, and Summerland 2. Since 1926, however, for the Westbank and Summerland plots there have been substituted plots in the Winfield district. The size of plot chosen in each district was the area in which were growing four trees of similar variety, age, and vigour. This small size of plot was necessitated by the difficulty of obtaining larger areas where soil conditions were uniform. The two plots chosen in each district were as similar in all details, as regards type of soil, age, variety, and vigour of trees, as it was possible to obtain. The growers interested have co-operated in allowing free use of their orchards for the obtaining of all experimental data.

The problem was then divided into three main divisions: first, the investigation of soil conditions in a healthy and in a diseased orchard; second, the investigation of air conditions in a healthy and in a diseased orchard; third, the study of conditions in the trees themselves.

Investigation of Soil Conditions in Healthy and Diseased Orchards

Observations were made in each orchard on the following:—

(*a*) Depth of soil.
(*b*) Kind of soil, determined by laboratory tests.
(*c*) Physical condition of the soil throughout the season, observations being made each week.
(*d*) Cultural conditions employed in the orchard.
(*e*) Effect of fertilizers.
(*f*) Soil moisture, samples being collected each week.

Air Conditions in Healthy and Diseased Orchards

It was recognized that, to obtain all meteorological data from each orchard, which might have an influence on the problem, was beyond our ability; nevertheless, it was considered necessary to have information on certain conditions that bear directly and markedly on the metabolism of the tree. It was, therefore, proposed: to obtain daily maximum and minimum temperatures, this record

to be kept by the grower, the thermometers to be supplied by the laboratory; to obtain records of high winds from observations of the grower and from the meteorological branch of the Summerland Station; and to obtain the amount of weekly evaporation in each orchard as recorded by the Livingstone atmometers.

A STUDY OF CONDITIONS IN THE TREES THEMSELVES

It was hoped that, by making as many observations as possible on healthy and diseased trees, we might find a varying condition responsible for the trouble. Observations were made and records kept on:—

(*a*) Vigour of the trees as expressed by leaf size, colour, the amount of terminal growth, and the colour of the bark.
(*b*) Age of tree.
(*c*) Crop—
    1. Thinning practices.
    2. Amount of crop.
(*d*) Colour and texture of the fruit.
(*e*) Pruning methods.
(*f*) Winter injury.
(*g*) Varieties affected.
(*h*) Apple growth.
(*i*) Root development.

RESULTS

1. SOIL CONDITIONS

(*a*) *Depth of Soil.*—These diseases are present on shallow soils, medium deep soils, and on very deep soils. We have also found healthy trees growing on soils of similar depths. There is to be found, however, a higher percentage of susceptible trees in shallow soils and in deep poorly drained soils. While susceptibility to the disease does vary thus, in different depths of soil, the occurrence of healthy trees under these conditions would make it appear that depth of soil of itself is not a contributing factor. Apparently, then, there is no varying factor here responsible.

(*b*) *Kind of Soil.*—We have found the disease on gravelly soils, sandy soils, loams, silts, and in clay. We have also found healthy trees growing under these same conditions. We have found, however, that trees growing in sand and gravelly soils, and in silt and clay soils where drainage was poor, have a greater tendency to become diseased, than those growing in a good, deep loam. In fact, it has been rare for us to find diseased trees in good, deep, loamy soils. They have been found there, but not often. There is, therefore, some indication that the kind of soil is in some way associated with the disease, but here again the occurrence of healthy trees under the same conditions shows us that these conditions in themselves are not responsible factors.

(*c*) *Physical Condition.*—Where physical condition is poor, and the soil cakes easily and becomes very hard, or where the physical condition is such that a hard pan occurs a short distance below the surface, we find a higher susceptibility in the trees growing in such soils.

(*d*) *Cultural Conditions.*—So far as we have been able to observe, the cultural method employed in an orchard is not in itself a responsible factor in producing these diseases. We have found both healthy and diseased orchards under all of our commonly used cultural practices. We have observed, however, that a changing over from one cultural practice to another does seem to influence susceptibility to these diseases. For example, we know of one orchard where

the changing over from a cover crop to clean cultivation reduced the amount of disease. We know of another orchard where the planting of a cover crop of vetch in place of former clean cultivation lessened the amount of disease. We know of still another orchard where the putting in of a cover crop of alfalfa on former clean cultivation greatly increased the amount of disease. We have also found these diseases in orchards which have been totally neglected for as much as eight years or more.

(*e*) *Effect of Fertilizers.*—In general, good humus content in a soil, providing the latter is of reasonable depth, is apparently a protection against the disease, for we rarely find it occurring under such conditions. When trees, however, are growing under conditions where either the depth of soil or the openness of the soil combine with inadequate water supply to the degree of being a limiting factor for good root growth, then any sudden increase in the food supply of the tree, which will induce rapid growth during the early part of the season, has a tendency to produce or increase the disease. That is, in a district such as Salmon Arm, where we have a fair depth and texture of soil, but a great lack of sufficient moisture in dry summers and falls, we can greatly increase the amount of disease by heavy applications of manure or nitrate of soda. Trees so treated increase greatly in terminal growth and improve greatly in colour of foliage. Corky core and drought spot, however, have been increased greatly in these same trees and, in one case, even die-back has been promoted.

(*f*) *Soil Moisture.*—The amount of soil moisture present in the orchards used in this investigation was determined by laboratory tests of soil samples collected each week. The samples were taken usually from a 15 inch level, as we found at this depth that we received the best average of the soil moisture around the majority of the feeding roots of the tree. They were taken at a constant distance from the irrigation furrow.

We expected to find an excessively dry condition of the soil associated in some way with the simultaneous appearance of the disease. This, however, was not the case, as at the actual time of the appearance of the disease, soil moisture conditions around diseased trees are often of the most favourable character. While we have found the disease occurring on trees where the soil moisture drops low during this period, we have so commonly found the other condition that we have rejected the idea that low moisture content is a responsible factor during this period. Moreover, we have observed that low moisture content may prevail at this period even to the extent of a wilting of the fruit, and yet no disease be produced.

On the other hand, we do find a very definite relationship between soil moisture and the occurrence of the disease, but we find the unfavourable soil moisture, whether it be super-dry or super-wet, occurring around trees in the late summer and fall previous to the season that the disease actually appears in the tree. That is, we find greater susceptibility in orchards where they either become very much dried out in the late summer or fall, or where the soil becomes water-logged during that same period.

2. Air Conditions in Healthy and Diseased Orchards.

When the investigation was started, it was hoped that daily maximum and minimum temperatures could be procured in each orchard under test; also, that humidity and wind velocity would be recorded. It was impossible, owing to the distance of the orchards from the laboratory, to obtain these ourselves, and we found that it was very difficult to get the growers to take them satisfactorily. We have had, therefore, to rely on the nearest official recording station for our climatic conditions, and on our own observations made at the time of the weekly visit.

From these, we have found no one individual factor which might seem to produce the disease. The air conditions, so far as we could see, were identical around both healthy and diseased trees.

3. A Study of the Conditions in the Trees Themselves.

(a) *Vigour, as expressed by the size and colour of leaf, the amount of terminal growth, and the colour of the bark.*—We found that trees could have excellent vigour, yet be badly affected with drought spot and corky core. Trees showing die-back were affected in their vigour, though many of such trees made wonderful recoveries, during the growing season. Some of the finest foliage is to be found on trees having drought spot and corky core very badly.

(b) *Age of Tree.*—We have found the disease on trees just coming into bearing and on trees of any age after that time.

(c) *Crop.*—1. Thinning. We have found the disease on trees which have been thinned heavily, thinned lightly, and not thinned at all.

2. Amount of crop.—We have found drought spot and corky core on trees where there were only a few apples on the whole tree. Again, we have found drought spot and corky core when the trees have been loaded to the ground and on all intermediate stages.

(d) *Colour and Texture of the Fruit.*—It is believed by many that corky core apples may be detected on a tree by their higher colour and by a certain feeling of the fruit when gripped in the hand. We have not been able to verify either of these suppositions. Sometimes corky core fruit does appear to be of higher colour than fruit on nearby healthy trees. On the other hand we often find corky core apples quite off shade and distinctly under coloured. Tests carried out on gripping the apple have given about 50 per cent error.

(e) *Pruning Methods.*—While no definite pruning experiment has been carried out, we have observed the effects of different amounts of pruning. For example, certain trees, in our experimental plots, were heavily pruned because of the die-back condition; nevertheless, those trees continued to be affected with one or other of these three diseases. On the other hand, where no pruning whatever was practised, as in neglected orchards, the disease was also found. Pruning, as ordinarily carried out, has no apparent effect on the occurrence of the trouble.

(f) *Winter Injury.*—It was believed for a time that these diseases were associated with some type of winter injury. So far as corky core is concerned, we had an excellent opportunity, during the winter of 1924-1925 and the following summer, to study the effect of winter root killing on the production of this disease.

Casual examinations of trees early in the spring of 1925 disclosed the fact that there had occurred, very generally, an exceedingly severe killing of the small-root systems. Since there was thought to be a definite relationship between this type of winter killing and the occurrence of one or more of these diseases, it was thought advisable to carry out a fairly extensive examination. Accordingly, the root injury on 114 trees located in different districts was estimated by digging 4 holes 2 feet deep around each tree and recording the amount of killing on the roots so exposed. This examination showed that a very severe killing did take place, chiefly on the small roots and rootlets of the trees. In some cases no good roots less than one-half inch in diameter could be found within 2 feet of the surface of the ground. Such a killing removed, in many cases, 90 to 95 per cent of the absorbing root surface of the tree. A later examination of the fruit on these trees, made by cutting apples on limbs directly

above the positions where holes had been dug, showed there was no evidence of a relationship between the amount of this type of root killing and the occurrence of the disease.

(g) *Varieties Affected.*—While we have found no variety altogether immune from these diseases, we have found that some varieties are more susceptible than others. The important commercial varieties worst affected, in their order of susceptibility, are as follows:—McIntosh, Wealthy, Jonathan, and Rome Beauty.

FIG. 46.—An apple-measuring machine in position on the limb. The apple being measured can be noticed just underneath the raised end of the measuring box.

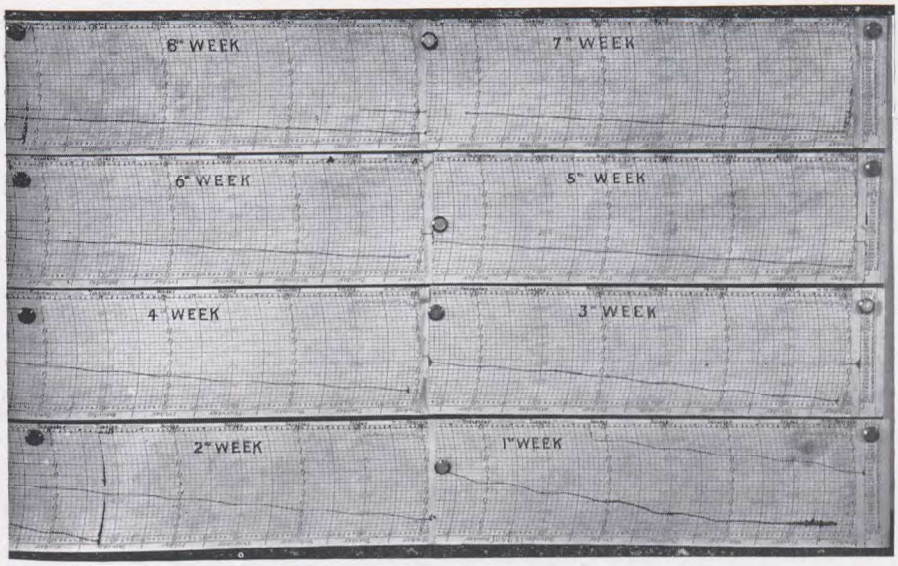

FIG. 47.—The charts showing the growth graph of an apple which developed corky core. Note the great daily fluctuation when the apple is small.

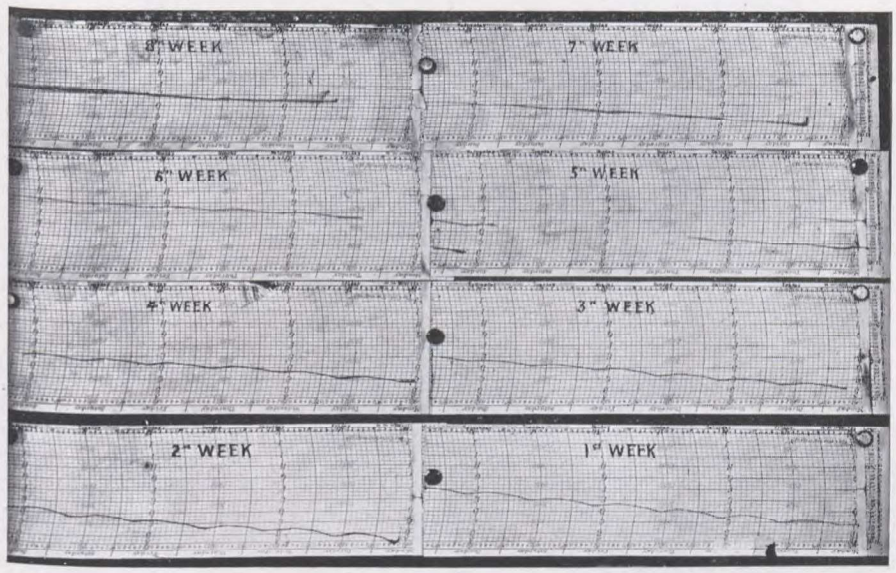

FIG. 48.—The charts showing the growth graph of a healthy apple taken in the same orchard as shown in Fig. 47. Though heavy shrinkage occurred in the early stages of growth, no corky core developed. These clock works did not vary more than 15 minutes in a week's time. Note that the greatest amount of shrinkage occurred at approximately 4 o'clock in the afternoon and that growth stopped between 6 and 8 o'clock in the morning.

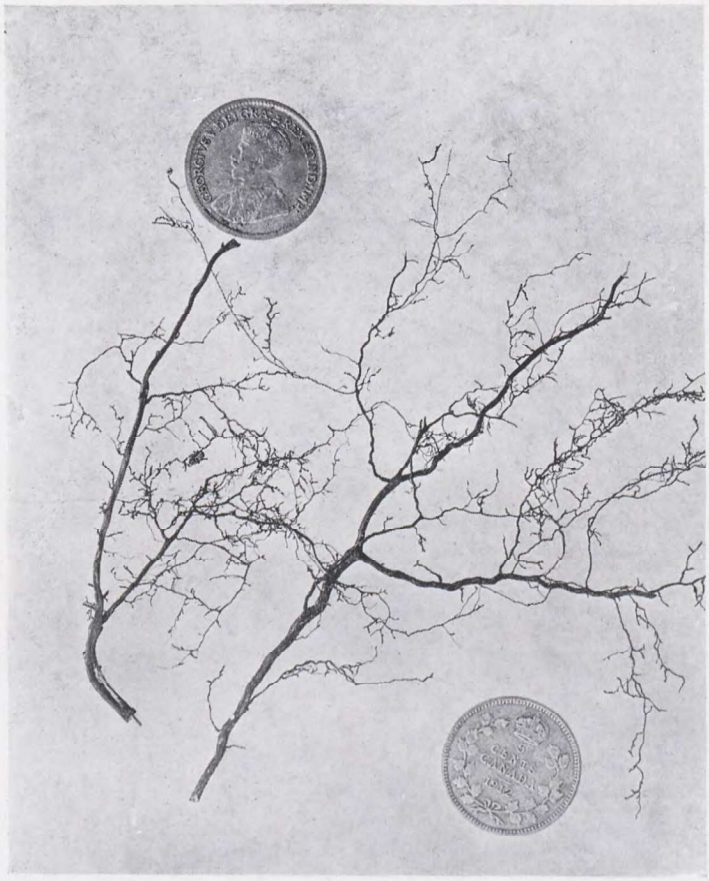

FIG. 49.—Showing dead rootlets taken from the soil which had been allowed to become too dry.

(h) *Apple Growth.*—In this study it was hoped we would find some difference in the way a diseased and a healthy apple grew. We were of the opinion that the dying of the cells in the case of corky core was brought about by lack of moisture in the fruit. There ought to be, we thought, some evidence of this desiccation in the growing apple. To test out this point, we developed an apple measuring machine which records on a chart the daily increase or decrease in size (fig. 46). The photographs show the nature of the chart it produces. Diseased and healthy apples have been measured by these machines, but we find no marked difference in the way they grow. The charts show us that both susceptible and healthy apples show a distinct fluctuation in growth between day and night. This fluctuation is especially marked when the apple is small, and decreases gradually with the increase in the apple's size. The charts show that rapid growth takes place at night while there is practically no increase in size during the day. Sometimes there is shown to be even a shrinkage during the day, this shrinkage occurring in both diseased and healthy fruit (figs. 47 and 48).

(i) *Root Development.*—When this investigation was begun, we had the idea that the injury in the fruit was associated with very dry soil conditions prevailing at the time injury appeared. We thought that, by making a root study, we might be able to demonstrate the occurrence of a plasmolysis of the root hairs and young rootlets at the time or just previous to the time the injury occurred in the fruit.

We did not find anything of this nature occurring. Root development was commonly as vigorous and rapid in diseased trees as on a normal tree at the very time that one or other of the diseases was making its appearance. The continued study of root development on both diseased and healthy trees, throughout the whole growing season, however, has shown that there is a period at which a distinct difference is apparent in the rootlet development in the two classes of trees. This period occurs during the late summer and fall, at which time soil moistures are often allowed to run low in the orchards. We have found that a killing of the root hairs and succulent rootlets occurs at this time whenever the soil moisture approaches the wilting coefficient (figs. 49 and 50). Some rootlet killing of this nature occurs on many trees, some of which, in the

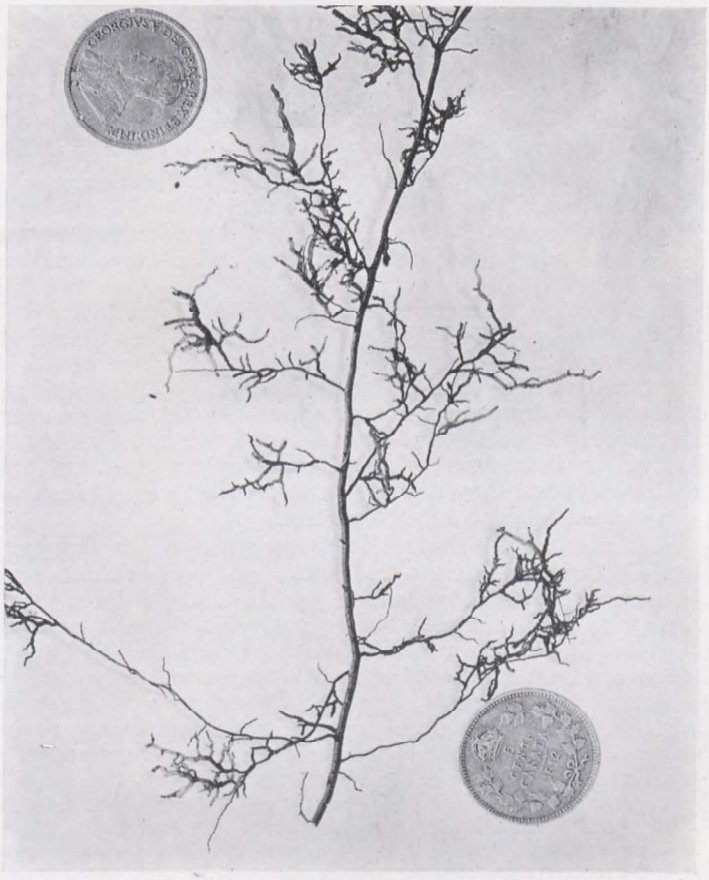

FIG. 50.—Showing normal rootlets taken from the soil where soil moisture conditions have been correct.

following season, prove healthy and others diseased, but the percentage of rootlet killing is much greater on the trees which show the disease during the following season, than it is on the trees that are healthy. For example, in a comparison between two neighbouring trees, one healthy and one diseased, on the diseased tree (which had die-back the next season) we could not discover any live rootlets in October, whereas on the healthy tree, though many dead rootlets were found, here and there we also observed many live root tips which were apparently functioning in a normal manner. In such examinations, of course, only sample rootlets were examined from each tree; it is not to be inferred that the trees were removed for examination. This relationship between the percentage of live and dead rootlets on healthy and on diseased trees has been verified many times in many orchards.

The possibility that excessive rootlet killing at this period was responsible for the disease, where excessive drought occurs, suggested the idea that it was also rootlet killing which produced the disease under excessive moisture conditions. A study of rootlets which suddenly become exposed to conditions of super-moisture convinces us that an excessive rootlet killing here also does take place.

It would seem, therefore, in our study up to the present, that the responsible factor is the sudden killing off of too high a percentage of absorbing rootlets during the late summer and fall previous to the season when the disease appears in the fruit.

DISCUSSION

The discovery of this excessive root killing at this period in the seasonal growth of the apple tree, and its relationship to the occurrence of the disease has led to the development of a theory as to the cause of the disease. It is briefly presented here, not with the idea that it is yet thoroughly established, but that it seems to offer a reasonable explanation for the occurrence of these diseases.

We believe that, as a result of this sudden killing off of an excessively high percentage of the absorbing system of the whole tree, or even of only one main root, there occurs a lack of balance in the manufacture of the food in the tissues of the tree, or in the limb above the affected root.* If this unbalancing in the food exceeds the degree of tolerance allowed by nature for normal development, it produces in the protoplasm of the developing buds, which, during that time are just in the formative period, a pathological condition from which, during later development, they are unable to recover, even though food supply during this later development may be perfect.

In other words, this unbalanced food supply so affects the protoplasm in the young buds in their formative period that there occurs a fundamental change in the protoplasm itself, a change so inherent that it reproduces that condition, whatever it may be, in all the cells subsequently laid down from these primary ones so affected. The evidence of the resulting weakness in the protoplasm, however, is not apparent at the time, and is expressed only when the fruit passes through any unfavourable physiological condition in its later development. That fruit, in its development, does pass through such periods of strain, has been shown by the automatic apple measuring machines which have been used in this investigation. These have demonstrated that the apple has a distinct, daily fluctuation in growth, especially in the earlier stages of develop-

* E. C. Auchter has shown that the mineral nutrients absorbed by the roots on one side of a tree are in a large measure translocated to and used by the trunk, limbs, and leaves directly above them. There is apparently very little cross transfer of such nutrients in the plant. (E. C. Auchter, "Is there normally a cross transfer of foods, water, and mineral nutrients in woody plants?" Maryland A. E. S. Bul. 257, Sept., 1923.)

ment. We find that an apple, under our climatic conditions, grows almost wholly during the night, while, during the day, there is little or no enlargement and often, even, a shrinkage.

This arresting of the growth or the production of a shrinkage is thought to be brought about by the rapid transpiration of moisture by the leaves. The loss of moisture is so rapid, under certain conditions of temperature, humidity, and wind, that even in normal trees, the supply cannot be kept up by the roots; as a result, moisture is entirely withheld from the developing fruit, or it may be withdrawn from the fruit and cause a shrinkage. When such conditions arise as to completely arrest development, we believe these cells are put under more or less of a physiological strain. To this strain, cells of both healthy and diseased apples are subjected. Those which are healthy withstand it, but those which carry this inherent weakness are unable to do so and succumb. In other words, it would seem that the apple is capable of receiving, during its initial stages of growth, certain inherent weaknesses that later express themselves as diseases. The final mode of expression of this weakened condition, whether it takes the form of corky core, drought spot, or die-back, is, we believe, dependent upon either a variation in the severity of the unbalanced condition or because of the time at which it occurs and the duration of that period.

Just what degree of inherent susceptibility, if any, to other of our physiological diseases is carried over in apples and other fruits will have to be established by further experimental work. It appears, however, in the light of this theory, that the susceptibility to such common diseases as breakdown and bitter pit in apples, russeting on apricots, gum-spot on prunes, excessive stone formation in the outer layers of the pear, and a sunken spot condition on peach and plum might become inherent in the fall previous to the season in which the disease actually occurs on the trees.

FUSARIUM BULB-ROT OF ONIONS AT SUMMERLAND, B.C.

(G. E. Woolliams, Assistant Plant Pathologist)

In the Okanagan valley, there has developed a serious bulb-rot of onions. The trouble was apparent to a slight extent about three years ago in fields which were situated in rich, low-lying soil, where this crop has been grown for a number of years. The trouble has spread until it is now quite extensive; a brief survey shows that, in nearly all fields situated in this type of soil, the disease is evident. Field losses this year range from 1 to 60 per cent, with an average of about 10 per cent of the crop. Since it has proved to be a serious menace to the industry, the presence of the disease has caused considerable uneasiness to the growers.

The rot does not appear until about the first week in July, when the plants have developed a good-sized bulb. At first there are only a few diseased plants in the fields, but, as the season advances, the number of affected bulbs steadily increases, until a maximum infection is reached at harvest time. The disease does not limit itself to one area but appears promiscuously throughout the field. Affected bulbs usually occur singly, but occasionally two or three diseased plants are found in a group.

The first indication of the presence of the disease in the field is seen in a wilting and bending of the outer leaves, followed by yellowing, a condition

which spreads and subsequently involves the whole plant. A characteristic of the disease is that all the leaves of each individual plant fall to only one side of the bulb (figs. 51 and 52).

The wilting, however, does not occur until quite an extensive rot has already developed in the bulb. When such a plant is pulled, there is found a brown rotted area that centres on the bottom and usually radiates uniformly to the outer scales of the bulb. Occasionally, the rot begins at one side of the base and enlarges along this side of the plant, and, by stopping growth in the affected portion, produces a crescent-shaped bulb.

During early infection the roots appear to be normal and healthy; later, they are sloughed off until sometimes all the roots have disappeared. If the decay develops on one side of the bulb only, the roots on the unaffected side often appear to be healthy and able to function normally (fig. 53).

FIG. 51.—Showing a field of onions badly affected with *Fusarium* bulb-rot.

The diseased flesh is usually a light brown colour, but occasionally bulbs are found in which a portion of the affected tissue becomes pink. In other cases the roots take on this colour rather than the bulb. When the rot becomes well developed, there occasionally occurs a fluffy white fungous growth on the surface of the rotted area.

Isolations were made from diseased bulbs and, in all cases, by the methods of technique ordinarily followed, numerous cultures of species of *Fusaria* were obtained. From these a typical culture was used in making inoculation tests in the field. As the fungus was not isolated until the growing season was well advanced, inoculations could be made only in plants that had reached an advanced stage of maturity. The point of inoculation was the side of the bulb just above the base, but below the surface of the ground. The method of inoculation was as follows: the soil was carefully removed from one side of the bulb and a wound was made with a flamed scalpel. The fungus mycelium was then inserted by means of a flamed needle, after which the soil was carefully replaced.

Approximately every eighth plant was treated as a check. The results of the inoculations are as follows:—

TABLE 62

Treatment	Number treated	Result
Inoculation	54	52 infected; 1 eaten away by onion maggots
Check	7	no infection

The development of the disease was slow. Inoculations were made on August 4, and on August 29, when the examination of the growing inoculated plants was made, no symptoms of infection having taken place were yet evi-

FIG. 52.—Typical specimen of diseased onion (marked X) as it appears in the field. Note that the leaves first droop from the top, falling over at the neck later.

dent in the leaves. When these plants were pulled, a brown rot was found on each bulb. The lesions were small in diameter and extended only a short distance into the plant.

Cured bulbs were also inoculated with the organism in the same manner as those in the field. This rot, also, was found to develop slowly, but more extensively than it did in the growing bulbs during a similar period.

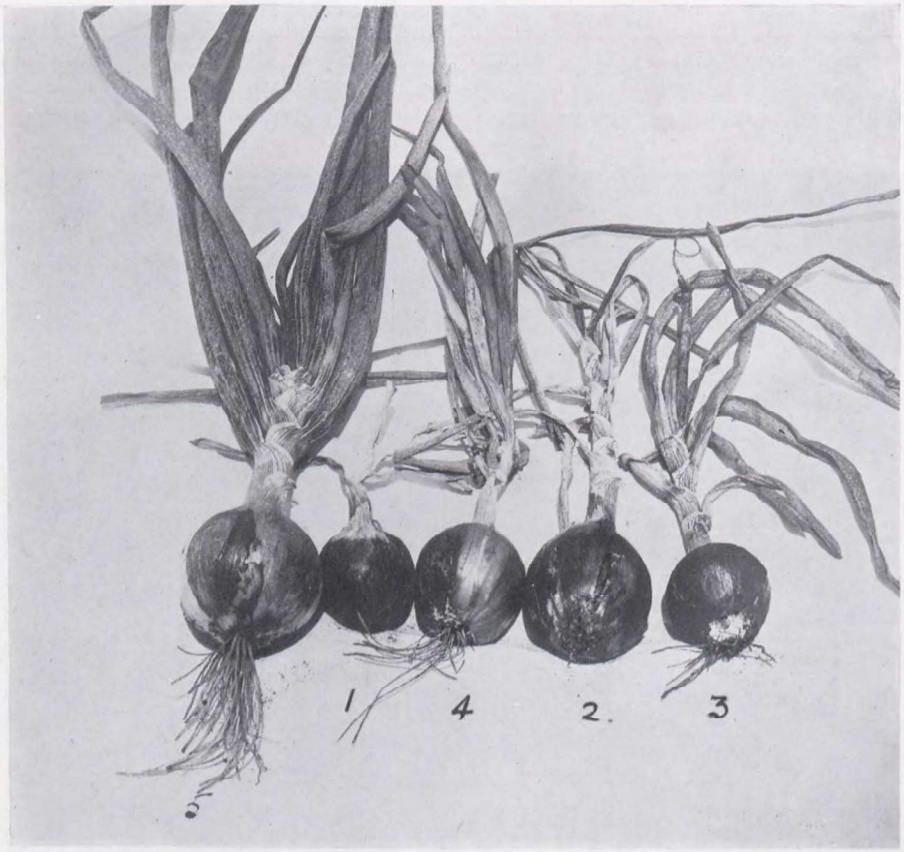

FIG. 53.—A number of onions showing different stages in the development of the disease. (1 and 2) Show complete loss of the roots. (3 and 4) Show a partial loss. Note in No. 3 the white fungous growth at the base. (5) Check.

PLANT DISEASE SURVEY IN THE OKANAGAN VALLEY

(H. R. McLarty)

The plant disease survey of the chief economic diseases in the Okanagan Valley for the season 1927 is as follows:—

A. FRUIT DISEASES

FIRE BLIGHT *Bacillus amylovorus*, Burr.—The provincial inspection service, inaugurated in 1922, which demands a clean-up of all over-wintering cankers before a blight-free certificate is issued to every grower, has had its effect in

steadily decreasing the losses from this disease. The season of 1927 was, perhaps, the best on record. It is felt that a continuance of this service will completely solve the problem of control of this disease.

SCAB *Venturia inaequalis*, (Cke.) Wint.—The exceptionally moist season of 1927 has caused a marked spread of this disease to sections of the fruit-growing areas which are usually entirely free from it, and its presence has been noted considerably farther south, that is, to the drier sections of the valley, than is usual. Many late infections on the fruit, appearing as pin-point infections at the time of picking, have caused a very considerable loss in storage. Should weather conditions in the spring of 1928 favour its spread, an extensive spray programme in all the fruit-growing sections from Kelowna north will be necessary.

POWDERY MILDEW *Podosphaera leucotricha*, (E. & E.) Salm.—While, in a general way, this disease has not caused serious losses, a few restricted areas have suffered severely. In the severely affected areas, however, plans are being made to carry out a thorough spray program which, it is felt, will greatly lessen the possibility of future loss from the disease.

COLLAR ROT.—Additional survey work during the past season impresses upon us the seriousness of this disease throughout the whole fruit-growing district. Of the orchards examined, many were found to be suffering heavily from the trouble. In some, the disease in some stage of development was found to occur on as many as 80 per cent of the trees in the orchard.

PHYSIOLOGICAL DISEASES—Drought Spot, Die-back, and Corky Core.—Losses suffered from this type of disease were greatly reduced from those of the previous season. The general improvement in the water supply throughout the Okanagan has, no doubt, had considerable influence. The losses, nevertheless, are still severe, and with many orchardists their occurrence constitutes the greatest problem which they have to face in orchard work.

Russeting in apricots and a sunken spot condition of peach plum were two newly met with diseases, which did a considerable amount of damage in the orchards where they occurred. Their causes are not known, but we judge from observational evidences that they are of physiological origin.

B. VEGETABLE DISEASES

TOMATO.—Western Yellow Blight occurred in the vegetable growing sections as far north as Kelowna, but did not cause serious loss.

Owing to the exceptionally moist weather during the harvesting season, tomatoes did not ripen properly, and great losses occurred because of the premature rotting of the fruit in the field.

ONION—*Fusarium* bulb-rot.—A survey has shown that this disease occurred in approximately one-half of the onion acreages in the Kelowna district. Throughout the affected area, losses varied greatly, running from 1 to 60 per cent. An estimate over the whole area indicated that possibly 5 per cent of all the bulbs in this area were affected.

NECK-ROT *Botrytis Allii*, Munn.—The early and excessive fall rains contributed greatly in causing the large amount of neck-rot which occurred this year. Practically the whole crop grown on the upper bench lands in the Kelowna district was a total loss. It is estimated that approximately 2,000 tons of onions were not even removed from the fields.

SEASONAL DEVELOPMENT OF APPLE SCAB

(D. J. MacLeod, Fredericton, N.B.)

This work has been carried on for three seasons during which the life cycle of the scab organism, as influenced by climatic factors in certain fruit growing areas in the St. John river valley, has been given special attention.

A detailed study of the correlation between the development and activity of the scab fungus and moisture and temperature factors of the natural environment obtaining in the localities studied has enabled prediction of scab-infection periods in the spring, making possible correct timing of pre-blossom application of fungicides necessary for the control of initial scab attack. Where this timing was successful little difficulty was experienced in controlling subsequent infections and, moreover, as a result, labour and materials were economized upon in later applications.

The development of the fungus was followed closely in the laboratory, and periods of initial as well as subsequent ascospore discharges were determined with a fair degree of accuracy. During 1925 and 1926 this work was confined to a study of apple scab as occurring in the Experimental Station orchard. In 1927, however, records were kept of the development of the disease in two additional orchards, one at Springhill, and the other at Oromocto. The estimation of ascospore discharge in the three different orchards was carried on by one man to insure uniform interpretation of results. The observations made revealed that there was some variation in the dates of initial ascospore discharge, the dates coinciding largely with periods of optimum moisture and temperature occurring in the respective localities under consideration. Initial discharge occurred in the Oromocto orchard, which was farthest south, on May 9, and in that at Springhill, the farthest north, on May 13, while no discharge was observed in the one at Fredericton, which occupies a position intermediate between the other two, until May 16. Subsequent discharges in each case were concurrent with intermittent periods of rainfall and optimum temperature occurring until the end of June, when observations were discontinued. Maximum discharges occurred at Oromocto, Springhill, and Fredericton on June 8, 13, and 16, respectively. Marked variation was observed in the number of discharge periods, as well as in the actual number of spores discharged in each orchard. The heaviest and greatest number of discharges occurred in the Oromocto orchard, while the lightest and least number were observed in that at Fredericton.

Observations on the development of the disease revealed that primary infection regularly followed periods of initial heavy ascospore discharges in each case, as evidenced by the presence of primary lesions on both sepals and leaves; indicating that, during these critical periods, timely application of fungicides is imperative in order to preclude infection of the host parts, which are most susceptible at this stage of development.

Observations also disclosed that more infected fruit occurred in cases where severest sepal infection appeared; indicating that infection of these parts affords readier exposure of the fruit, in its most susceptible stage, to secondary infection by conidia.

These observations are in general agreement with those of many other investigators, further confirming that local climatic factors influence to an important extent the severity of occurrence of the disease. Consequently, an accurate study of these varying factors as occurring in different localities from season to season, is absolutely essential in order to formulate control programs and orient the same to periods of impending infection. With this aim in view the work will be continued from year to year with the hope that the information secured will prove useful in defining critical periods in the epidemiology and control of the disease.

RASPBERRY INSPECTION AND CERTIFICATION IN QUEBEC

(H. N. Racicot, Ste. Anne de la Pocatière)

The service of inspection and certification of raspberry plantations was inaugurated in 1926. During the first year, thirty-one inspections were made and only seven plantations were certified. In 1927, sixty-eight plantations were inspected and twenty-seven plantations were certified. Many of the plantations inspected in 1926 were young plantations, and the owners rogued out all the diseased plants, with the result that these plantations qualified for certification in 1927. Therefore it is believed that this service has already justified its existence, and that it will become more and more important each year. The regulations governing the inspection and certification of raspberry plantations were not very severe in 1926, but they were made more strict in 1927. The standards will be raised as the service becomes better established.

A summary of the standards adopted for the inspection and certification of raspberry plantations for 1927 is given below.

TABLE 63

—	Amount of disease allowed	
	1st inspection	2nd inspection
	%	%
Mosaic and leaf curl	5	2
Anthracnose	5	5
Spur-blight	.....	Moderate amount
Foreign varieties	.....	None

The whole plantation must be inspected. It must be at least 100 feet from all other uncertified raspberries. Two inspections will be made, the first in June and the second in August or September. Any diseased plants and any plants of foreign varieties found in the plantations accepted for certification must be rogued out, in the presence of the inspector, at each inspection.

SECTION V.

INVESTIGATIONS OF THE DISEASES OF POTATOES AND FIELD CROPS; POTATO CERTIFICATION SERVICE

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

(R. R. Hurst, Officer in Charge)

Investigational work during the past year has been featured by expansion in field and laboratory activities. The closest possible relationship between these phases has been the aim in operating the various projects. The problems of the farmer have absorbed our attention, and bear a direct relation to the investigational work. A course of lectures on plant diseases was given at the farmers' winter school in Charlottetown. A lecture on potato diseases was also given at each illustration station on their respective field days.

The earliest recorded appearance of late blight of potatoes (July 26), in this province, and its subsequent alarming development justified much concern among potato growers. However, while the premature death of the plants materially reduced the yield, actual loss through blight rot was surprisingly slight as revealed by final reports. Carefully sprayed fields produced a minimum of rotted tubers, and most of these came from the ends of rows where the required pressure was not maintained in turning the sprayer.

Other diseases of importance were raspberry mosaic, apple scab, cucumber mosaic, and seedling blight of barley, caused by *Helminthosporium* sp. An active disease of willows threatens to destroy most of these trees in the province. This disease has destroyed most of the willows on the eastern half of the Island.

Certification of raspberry nursery stock was effected in 1927. Several nurserymen have shown an active interest in this service, but, on account of the widespread nature of mosaic in the popular variety (Herbert), only two plantations have been certified.

In addition to the foregoing, the following projects were studied in 1927:—

Number	Name	Co-operating Laboratory
B. C. 4A	Date of digging in relation to control of *Rhizoctonia*	Fredericton· Ste. Anne.
B. C. 8	Dust vs. spray for control of late blight of potatoes	Fredericton.
B. C. 8A	"Pota" dust as a control for late blight of potatoes	
B.C. 10	Size of potato sets	
B. C. 12	Spacing of potato sets	Fredericton.
B. C. 16	An investigation of the modified hot water treatment as applied to Huron wheat	
B. C. 20	Deterioration of mercuric bi-chloride solutions in treating potatoes	
B. C. 25	Hollyhock rust control	Kentville.
B. C. 26	Investigation of misses in potato fields in 1927	

RHIZOCTONIA CONTROL

Date of Digging in Relation to Control of *Rhizoctonia*

The influence of digging dates upon the development of *Rhizoctonia* sclerotia on potatoes has been well established.* The development of the winter or resting stage of this fungus depends more or less on the conditions existing at digging time. Potatoes dug early in September generally show but a small percentage of sclerotia. The nature of this tendency suggested a possible control of *Rhizoctonia*. Accordingly, experiments were devised to investigate the matter.

* See Division of Botany Reports, 1924-25.

Irish Cobblers and Green Mountains were used in this experiment. The land chosen was known to be heavily infested with *Rhizoctonia*. Each digging date was represented by three replications arranged in a manner giving uniform spacing throughout the plot.

The results embodied in the following table reveal in a measure that the practice of early digging possesses considerable virtue as a control for *Rhizoctonia*. Similar observations were made at Fredericton and Ste. Anne. Bearing in mind the advantage gained by the practice of digging early, it would appear, on the other hand, that immature tubers are exposed to the probability of injury during harvest and subsequent handling, thus rendering them less valuable for seed purposes. This applies particularly to Irish Cobblers and other thin-skinned varieties.

TABLE 64.—RESULTS OF DATE-OF-DIGGING EXPERIMENT IN RELATION TO *Rhizoctonia* CONTROL

Date of digging	Percentage *Rhizoctonia* infected tubers[1]	
	Cobblers	Mountains
September 1	2	0
8	12	3
15[2]	27	21
28	63	39
29	80	76
October 6	100	60
13	98	84

[1] Results are based on the percentage number of tubers.

[2] Usual digging date.

SIZE OF POTATO SEED-PIECE

AN EXPERIMENT TO DETERMINE WHETHER SMALL SETS CAN BE USED ECONOMICALLY FOR SEED PURPOSES

This project is in its fourth year of investigation. The object of the experiment was to determine whether or not there is any economic value in using small sets for seed purposes, obtained year after year from the same source. Culls graded from certified seed of the Irish Cobbler variety were used in the original experiment, and successive seedings have been the progeny culls from this source. The sizes were—whole tubers weighing 3, 2, 1½, 1, and ½ ounces, and cut sets weighing 1½, 1, and ½ ounces. Culls from the harvest of these respectively were used in successive years' experiments. The sets were spaced 10 inches in the rows, which were 36 inches apart. The plan of experiment comprised 4 replications including buffer rows and ends.

Fertilizer applications were made at the rate of 1,560 pounds per acre, the chemicals supplied being as follows: nitrate of soda, 260 pounds, sulphate of ammonia, 400 pounds, superphosphate, 600 pounds, muriate of potash, 300 pounds.

Plate 9 illustrates the conformity of plant growth with the size of seed-piece. Four years' observations reveal the constancy of this tendency. Not only have whole tubers produced heavier and more vigorous plants than cut sets, but the size of the plant increased in direct proportion to the weight of seed-piece used.

PLATE 9.—Size of potato seed-piece experiment. Note conformity of plant growth with size of seed-piece.

TABLE 65.—RESULTS OF SIZE OF SET EXPERIMENT—1926

Kind of set	Yield per Acre in Bushels				Percentage of Culls	Order of Merit
	Marketable	Culls	Total	Seed deducted		
oz. *Whole Tubers:*	bushels	bushels	bushels	bushels	%	
3	268½	94½	363	306¾	26	2
2	230	80½	310½	273	25·9	4
1½	228	71¼	299¼	271¼	23·8	5
1	206	63¼	269¼	250½	23·5	6
½	196	55¼	251¼	241¾	22·0	7
oz. *Cut Sets:*						
1½	275½	75¼	350¾	325¾	21·4	1
1	232¼	62	294¼	274¾	21·07	3
½	201½	44	245½	236¼	17·9	8

TABLE 66.—RESULTS OF SIZE OF SET EXPERIMENT—1927

Kind of set	Yield per Acre in Bushels				Percentage of Culls	Order of Merit
	Marketable	Culls	Total	Seed deducted		
oz. *Whole Tubers:*	bushels	bushels	bushels	bushels	%	
3	161¼	140	301¼	245	46·5	4
2	187½	97½	285	247½	34·2	3
1½	199¼	104½	303¾	275½	34·5	1
1	177	91¼	268¼	248½	34	2
½	143¼	64¼	207½	198	31	8
oz. *Cut Sets:*						
1½	178¾	70½	249¼	231	28·3	5
1	164½	60	224½	204½	26·7	6
½	161¼	48	209¼	199¾	23	7

TABLE 67.—AVERAGE YIELDS IN BUSHELS PER ACRE FROM POTATO SETS OF DIFFERENT WEIGHTS OVER A PERIOD OF 4 YEARS

Seed-piece	Seed per acre	Yield per acre		Percentage of culls	Seed deducted	Order of yield of culls	Order of merit
		Total	Marketable				
oz. *Whole Tubers:*	bushels	bushels	bushels	%	bushels		
3	56¼	394¾	276¼	31	338½	1	1
2	37½	350½	255¼	29	313	2	4
1½	28	347¾	256½	27	319¾	3	3
1	19¾	317	239¾	25·5	297¼	4	6
½	9¼	272	219¼	21·5	262¾	7	7
oz. *Cut Sets:*							
1½	28	358¼	279¼	22	330¼	6	2
1	19¾	321¼	254	22	301½	5	5
½	9¼	266½	217½	20	257¼	8	8

One important observation is the perceptible yearly decrease in yield. Inasmuch as the plants in this experiment have been practically free from virus diseases, this reduction might be better explained by the fact that the same plot has been given over to potato experiments continuously. Where a rotation is

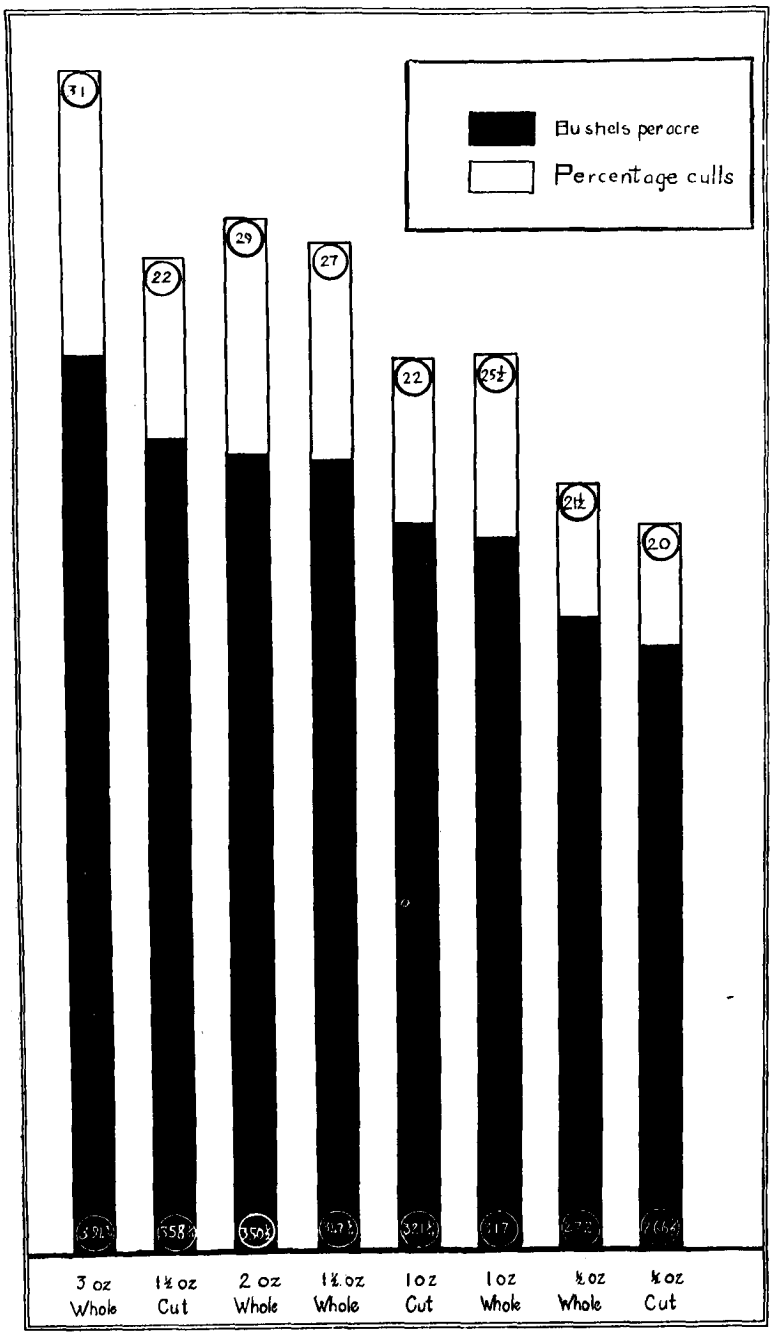

FIG. 54.—Average yields in bushels per acre from potato sets of different weights over a period of 4 years.

followed, it is doubtful if this noticeable reduction in yield would occur. It is evident that small tubers planted whole will return fairly good crops; but the practice should be indulged in only when seed is scarce or expensive, and the farmer is sure the seed represents a good-yielding, disease-free strain, bearing in mind that good seed stock is found only in healthy tubers which conform to type and variety.

The results from these experiments (tables 65 and 66) must be analysed from the view point of the growers of Certified Seed Potatoes. As might be expected, yields have not been in absolute agreement from year to year. In the main, however, tendencies have been comparable. Larger seed-pieces have returned greater yields, along with a proportionate increase in culls, as will be seen in the averaged results of four years' work (table 67 and fig. 54). In addition to producing the most culls, 3-ounce tubers require the greatest amount of seed per acre. On the other hand the 1½-ounce cut set (3-ounce tuber halved), requiring one-half as much for seed, yields slightly less certified seed. Similarly it will be seen that the 1½-ounce whole tuber is more profitable than the 2-ounce whole.

LATE BLIGHT CONTROL

Experiment with "Pota" Dust

The plot in this experiment was slightly over one acre in area, and spaced as follows: ⅖ sprayed, ⅖ dusted, and centre section, ⅕ check. The "Pota" dust was supplied by the Stewart-Hudson-Stewart Company of Vancouver, B.C., and each application was made with a "Niagara" duster at the rate of 25 pounds per acre. Liquid Bordeaux mixture (4-4-40) constituted the spray, and was applied at the rate of 80 gallons per acre. A "Hardie" sprayer was used in this case, the pressure being maintained at 200 pounds per square inch. Five applications of each fungicide were made at intervals of 10 days from the time the plants were 10 inches high. The spray and dust were applied on the same days. The Irish Cobblers were dug on September 27, and the Green Mountains October 4. The following tabulation compares the results obtained in this experiment.*

Table 68.—Value of "Pota" Dust as a Control for Late Blight of Potatoes

Irish Cobblers				Treatment	Green Mountains			
Marketable	Small	Rot	Increase over check		Marketable	Small	Rot	Increase over check
332	23	½	13	Sprayed 4-4-40..	328½	16½	2	92½
350	26	8	31	Dusted "Pota".	334½	18½	23½	98½
319	20	24	.....	Check sprayed for insect control.	236	20½	114	

* All figures represent yield in bushels per acre.

The figures indicate that Bordeaux liquid afforded a more effective control than did "Pota" dust. However, a comparison of results from the check and dust plots shows a marked measure of control in favour of the dust.

The Effect of Mercuric Bi-Chloride upon the Viability of *Rhizoctonia* Sclerotia on Potatoes

The foregoing observations point to the necessity of determining the quantity of potatoes that can be treated before the solution should be discarded. A

point of attack was found in laboratory tests, whereby tubers infected with *Rhizoctonia* were treated in solutions of mercuric bi-chloride at strengths representing the deteriorations observed in seed treatment. Solutions of mercuric bi-chloride were made up in double distilled water at strengths from 1-1000 (4 ounces to 25 gallons) to 1-20,000. For the purpose of determining the strength at which fungicidal effect ceased, culture platings were made with sclerotia from tubers infected with *Rhizoctonia,* treated in these solutions as follows:

1. Mercuric chloride (cold) 1½ hours in situ.
2. 1 repeated but presoaked 24 hours.

Realizing the probability that the effect of treatment is governed partially by the size of sclerotia, both large and small sclerotia were selected for culture plating. Small and large sclerotia were approximately ½ to 3 millimeters in diameter respectively.

Tubers treated in this manner were also placed in moist chambers. Large sclerotia in untreated checks showed 100 per cent germination both in moist chambers and on potato dextrose agar. In the dilution tests difficulty was experienced in culturing the organism on agar. In moist chambers, however, there was general germination of sclerotia on the tubers treated in all solutions lower than and including 1-1250. One per cent germination occurred in treatment 1-1000, and increased as the solutions became weaker. All small sclerotia were killed in the stronger solutions, viability occurring only in dilutions weaker than 1-1100. Pre-moistening for 24 hours rendered sclerotia more susceptible to treatment in that a lower percentage showed viability after treatment. Washing treated tubers in sterile water had no apparent effect.

From the foregoing it is evident that solutions should be discarded when reduced to 1-1250. Just how this can be applied on the farm is a difficult problem. For it is seen that mercuric bi-chloride solutions deteriorate rapidly, even where great care is exercised to eliminate the factors causing this condition. On this basis, however, it would seem advisable to prepare a new solution when three lots have been treated. This would mean approximately 15 bushels.

AN INVESTIGATION INTO THE CAUSE OF MISSES IN POTATO FIELDS IN PRINCE EDWARD ISLAND DURING THE SEASON OF 1927

The early growing season of 1927 found a large number of potato fields showing a high percentage of misses. This condition caused serious concern to potato growers and prompted an investigation into the matter.

In this work a large number of farms were visited, and a point was made of studying the conditions associated with good, as well as poor stands. In this manner a comparison of the methods used in handling seed potatoes aided in the search for an explanation of the trouble under consideration. Observations were made on the basis of (*a*) storage history and conditions, (*b*) methods of seed treatment and subsequent care of sets, (*c*) methods of cutting and seeding, (*d*) methods of applying fertilizer, (*e*) source of seed.

In summing up the evidence gained by observations, it was found that at least one of the following conditions was associated with misses in potato fields.

1. Seconds served as seed.
2. Seed-pieces were constantly found with no eyes.
3. Fertilizer injury to seed-piece.
4. Inefficient working of planters causing accidental "skips."
5. Undried treated seed placed in barns and basements in unventilated piles for an extended period before seeding.
6. Backward weather conditions after seeding.

In several instances it was apparent that a partial combination of these factors accounted for the failure of plant development. In certain cases it was evident that a single factor was responsible and, in this connection, conditions 1, 4, and 5 were the chief offenders.

It was found that a minimum of misses occurred in cases where large quantities of seed were cut some weeks before seeding, properly dried after treatment, and turned repeatedly to facilitate ventilation. This practice is followed by growers of large acreages. Liming was practised by some growers, but it was difficult to obtain an index of its usefulness.

It is of first importance for us to realize that this carefully executed investigation revealed no evidence to suggest a condition of disease in Prince Edward Island seed potatoes as an explanation for misses. However, from the results obtained, it is apparent that immeasurable loss is sustained through the operation of harmful factors which can be controlled by exercising reasonable care.

CO-OPERATIVE PROJECTS

Three acres were devoted to a project dealing with the comparative values of dust and spray as a control for late blight of potatoes. This was operated cojointly with the Pathologist in Charge of the Fredericton Laboratory, to whom a full report has been submitted.

The experiment on spacing of sets was also carried on at Charlottetown, using Irish Cobblers and Green Mountains, a full report of which has gone to the Fredericton Laboratory.

The laboratory staff express appreciation of the valuable aid rendered by Mr. Clark and his assistants, who gave freely of their time in the discussion of investigational work. In addition, machinery, equipment, horses, and land were generously provided as required.

THE CONTROL OF SPREAD OF MOSAIC OF POTATOES BY THE USE OF NICOTINE DUST

(J. Fred Hockey, Kentville, N.S.)

In the spring of 1924 a project was started at Kentville to obtain evidence on the value of nicotine dust (2 per cent actual nicotine) in the control of aphids on potatoes, and the resultant effect on the percentage of virus diseases present. Duplicate series of plots containing 2, 5, and 25 per cent mosaic, and 2, 5, and 25 per cent leaf roll were planted. All plots received regular applications of copper dust, and one half of the plots received applications of nicotine dust during the season, as the presence of aphids demanded.

In 1925 the entire series of plots was replanted with stock harvested from identical hills of the 1924 plots. A duplicate of the series was also planted by the Laboratory of Plant Pathology at Fredericton, N.B., from identical stock used at Kentville.

Readings on the amount of virus diseases present were made at the two stations at approximately the same date. The figures obtained were then summarized as to percentage of disease. The results were unsatisfactory. Plots that received the nicotine dust showed consistently a greater amount of virus diseases than the checks. This varied between 26 and 69 per cent, and averaged on all plots 52·7 per cent increased disease.

In the spring of 1925, however, the seed from all plots which had received the nicotine dust in 1924 started growth sooner and bloomed five days earlier than those which received no nicotine. On account of a severe outbreak of late blight and rot no comparable yields were obtained at Kentville. The yields at Fredericton gave no consistent results.

It appeared from a critical study of the results obtained up to and including those of 1925 that no satisfactory control of the spread of disease was being effected by the use of nicotine in spite of the apparent control of aphids. The project plan was altered in 1926, and a series of plots was used each containing approximately 10 per cent mosaic. Each hill was numbered as in previous plots, and the progeny replanted in 1927.

Twelve plots were used in this series, each containing 80 plants. Six treatments were employed in duplicate, involving complete copper dust calendar (12-8-80), nicotine dust, or a curtain dragged over the vines after each dusting, or some combination of these three treatments, and two check plots.

Readings were taken, at approximately the same stage of plant growth in both seasons, on the amount of virus disease present. The results are presented as the increased percentage of diseased plants in 1927 over 1926.

TABLE 69.—EFFECT OF DUSTING ON CONTROL OF SPREAD OF MOSAIC IN POTATOES

Treatment	Percentage increase in disease
Dust calendar alone	28·75
Dust calendar and nicotine dust	22·98
No treatment	21·25
Dust calendar and curtain	19·37
Curtain alone	18·75
Dust calendar, nicotine dust, and curtain	15·15

From the above it will be seen that the use of a curtain with nicotine dust and the regular copper dustings gave the least increase in diseased plants.

These results are not conclusive and indicate that further trial will have to be made under different conditions, before definite recommendations can be made on the use of a drag curtain in dusting potatoes.

It was not possible in 1926 or 1927 to get accurate counts on the number of aphids present before and after treatment. This phase is essential for a successful conclusion to such a project. While the use of a drag curtain following each application of Bordeaux dust and nicotine has apparently effected a control varying from 7·8 to 9·4 per cent decrease in disease in comparable plots, the seasonal variation in aphis population has not been included. Hence the reason for stating that the results are inconclusive.

This project is being discontinued at Kentville this year. It has been conducted as a minor project, but, with the increased area necessary for potato work of greater local importance, it is felt that this project should be summarized to date and discontinued as far as the Kentville laboratory is concerned.

SEED POTATO IMPROVEMENT

(W. K. McCulloch, District Inspector, Kentville, N.S.)

THE REJUVENATION OF GARNET CHILI SEED POTATOES ORIGINATING IN NOVA SCOTIA FOR THE BERMUDA TRADE

The Garnet Chili variety is somewhat susceptible to leaf roll, and this so-called "running out" disease was becoming a menace to the trade. The rejuvenation test consisted in trying whether the progeny of seed grown for a period in Northern Ontario would be superior in vigour and health to seed produced wholly in Nova Scotia. In the spring of 1922 seed from one of the best strains in Clifton, N.S., was planted at three points in Northern Ontario, namely, Dorion, Huntsville, and Murillo. At the same time similar seed was planted at Kentville, N.S. Careful inspection was made at all the above places. In the spring of 1924 separate lots were sent from these Northern Ontario points and

planted at Kentville, N.S., beside the Kentville-grown stock. Seed was saved separately from each plot and planted again at Kentville in 1925. The results averaged for the two years and for the various plots are given in table 70 as follows:—

TABLE 70.—REJUVENATION OF GARNET CHILI POTATOES

Seed	Leaf roll	Average yield per acre
	%	bush.
Northern Ontario-grown seed	0·6	262·8
Kentville-grown seed	0·8	261·9

In the interval the seed stock at Clifton had been subjected to careful roguing and selection, and the parent stock, from which the above lots were taken in 1922, showed freedom from disease in 1924 and 1925, and yielded an average of 284·5 bushels per acre for the two years. It would, therefore, appear that, while little or no rejuvenation was accomplished, careful roguing and selection gave results of equal value.

IMPROVEMENT OF SEED STOCKS OF IMPORTANT COMMERCIAL VARIETIES

The reason for this experiment was the presence of diseased and low-yielding strains in the Garnet Chili potatoes,—the basis of a valuable seed trade with Bermuda,—and also in Green Mountain and Irish Cobbler foundation stocks. Previous to the beginning of this work large percentages of leaf roll disease were complained of by Bermuda customers, and there was a lack of reliable stocks of Green Mountain and Irish Cobbler that could be recommended to the increasing number of inquirers. Selection and planting by the tuber unit method were carried out on five different farms for two years. At the end of that time there were large multiplying plots of stock from which the virus diseases had been eliminated, and, as the growers had become interested, it was decided to let them carry on under supervision. The result is that excellent foundation stock is now available. Satisfaction is expressed by the Bermuda customers who are getting all the seed they can handle. With regard to Green Mountain and Irish Cobbler varieties there are at least 5,000 bushels of the former and 2,000 of the latter, from which the virus diseases have been practically eliminated, and which are available for foundation stock.

THE EFFECT OF PERSISTENT SELECTION ON THE SHAPE OF THE TUBERS OF POTATOES

When the above experiment was begun, it was the custom of many of the growers to ship the best of their stock, and the residue which was used for seed contained a large percentage of rough and badly shaped tubers.

It seemed desirable, therefore, to find out what effect the selection, for a period of years, of tubers of ideal shape for the variety would have on a grower's crop. The work has been carried on on three farms, and table 71 shows the result to date.

TABLE 71.—EFFECT OF SELECTION ON THE SHAPE OF GARNET CHILI TUBERS

Grower	Per cent of tubers of ideal shape for the variety				
	1923	1924	1925	1926	1927
1. E. Jennings	21·6	56·0	26·0	54·3	34·0
2. R. K. Loughead	40·0	40·2	55·0	59·5	47·5
3. A. Kent	38·6	50·9	35·0	55·0	47·5

The soils of Nos. 2 and 3 are practically the same—a sandy loam,—but that of No. 2 is kept better supplied with humus, and more deeply cultivated. The soil of No. 1 is heavier. It has a clay subsoil and, during the growing season of 1927 which was very wet, water stood in the rows for a considerable time.

The Isolation of Pure Lines, Disease-Free and High-Yielding, of the Following Varieties of Potatoes: Irish Cobbler, Green Mountain, Bliss Triumph, Garnet Chili, and Others

By pure line is here meant tuber line. A tuber, cut into several pieces which are planted consecutively, forms a tuber unit; the progeny, on being multiplied again and again, yield a tuber line. Two phases were kept in mind in respect to this experiment. It was hoped to be able to furnish, from time to time, small lots of healthy stock to be used as foundation stock in seed centres. Also it was hoped that, by recording the history of a number of tubers, especially their reaction to the virus diseases, some light might be thrown on the so-called "running out" of potatoes.

In 1924, out of a large number of Bliss Triumph, Garnet Chili, Green Mountain, and Irish Cobbler tubers indexed in the greenhouse and planted in tuber units in the field, ten units of each of the above varieties were selected for multiplication and study in 1925. Garnet Chili developed off-type symptoms and was discarded in order to avoid injury to the other lines. Nine Bliss Triumph, seven Green Mountain, and nine Irish Cobbler lines were retained. Of these 25 lines, four have remained healthy during the four seasons. Table 72 gives a summary of the reaction of the various lines to the virus diseases, together with the average yield per hill for four years.

Table 72.—Record of Tuber Unit Lines of Potatoes

Line No.	Virus diseases, present (x), absent (0)				Average yield per hill less weight of seed (4 years)
	1924	1925	1926	1927	
					lb.
8. B. T.	0	x	x	0	2·11
9. "	0	0	0	0	2·08
45. "	0	x	x	0	2·41
46. "	0	0	0	0	2·09
47. "	0	0	x	x	.....
48. "	0	0	x	x	2·19
59. "	0	0	x	x	2·07
61. "	0	0	x	x	2·33
62. "	0	x	x	x	2·32
121. G.M.	0	x	0	x	2·14
122. "	0	0	0	x	1·98
126. "	0	0	x	0	1·98
129. "	0	0	0	0	2 03
146. "	0	0	x	0	1·94
147. "	0	0	x	x	2·13
153. "	0	0	0	0	2·08
168. I.C.	0	0	x	0	1·72
170. "	0	0	0	x	1·88
176. "	0	0	0	x	1·68
190. "	0	0	0	x	1·71
193. "	0	0	0	x	1·83
195. "	0	0	0	x	1·86
199. "	0	0	0	x	1·85
209. "	0	0	x	x	1·79
211. "	0	0	0	x	1·65

Two factors of the greatest importance to the success of this work are careful roguing and isolation from other potatoes likely to carry infectious

diseases. Up to the present isolation has been poor, but better conditions were obtained in 1927, and it is expected that the 1928 crop will show some improvement.

In 1926 twenty-five tuber units of Early Rose were planted, and six were retained and planted in 1927. These six lines have remained healthy to date. The highest average yield for the two seasons was 2·06 pounds, and the lowest 1·39 pounds. At the same time a preliminary trial was made of over 500 tubers of different varieties, and the following were selected and planted in tuber units this year:—twenty-two Green Mountain, thirty-five Irish Cobbler, seven Bliss Triumph, and eight Early Noroton.

As an extension of the foregoing experiment an endeavour is being made to become better acquainted with the varieties of potatoes grown in the province, more especially with a view to studying the reaction of any variety of good table quality to late blight. As a preliminary to more detailed study of a variety it is necessary to eliminate, as far as possible, such diseases as leaf roll and mosaic. This year thirty-eight different varieties were obtained and given a preliminary trial. Three plots showed 100 per cent mosaic disease and were destroyed. The remainder were rogued and retained for further trial. Table 72 shows the most promising varieties judged by the amount of late blight rot found on the tubers. The plots were sprayed twice with Bordeaux mixture and arsenate of lead. Incidentally an excellent opportunity was also afforded to test susceptibility to scab.

TABLE 73.—TEST OF LATE BLIGHT RESISTANT VARIETIES OF POTATOES

Variety		Per cent diseases				Average yield per hill	Notes (Tuber)
No.	Local name	Leaf roll	Mosaic	Rot	Scab		
						lb.	
16	Never-Rot	.....	28·0	.....	46·0	2·0	Tuber white, resembles Green Mountain.
15	Never-Rot	4·0	4·0	0·6	74·0	2·13	" " "
31	Erin Victor	.....	.....	.....	100·0 (slight)	1·62	Tuber blue, roundish oblong, flattened.
35	Irish Daisy	.....	30·0	2·5	20·0	2·17	White, short oblong.
18	White Garnet	.....	.....	3·0	80·0	2·60	Creamy white with pink eyes.
23	Unnamed	.....	.....	5·0	80·0	4·36	Very long, flesh coloured.
9	Russet	.....	.....	6·4	15·0	2·05	Russet skin, short oblong.
1	Unnamed	.....	5·0	9·25	55·6	2·44	Cobbler-like.

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

(D. J. MacLeod, Plant Pathologist, Officer in Charge)

Work was continued on the principal projects under way, embracing chiefly problems relating to the potato. This work has progressed steadily during the year, but a constantly increasing pressure exists towards amplifying the field and undertaking new investigations on a number of plant pathological problems of the province, still unsolved. Some of these problems can be solved by empirical methods, while others require the most painstaking fundamental research. Research of the latter type requires concentrated thought and continuous effort over a long period of time, which is not always possible in a field laboratory, where routine work, involving attention to emergent problems of a practical nature, includes a large part of the work carried on. However, the hope is that, as time goes on and the expansion of the work warrants increasing the staff, it will be possible to develop a properly balanced program, embracing the two general types of research, empirical and fundamental. This is abso-

lutely essential, because on the one hand practical problems must be solved for the public, while on the other due consideration should be given to certain phases of fundamental research in order to solve some of the more complex pathological problems confronting agricultural progress.

Owing to the fact that the supervision of inspection and certification of seed potatoes formed part of the duties of the pathological staff of this laboratory during the past three years, the responsibilities and routine work incident to the same interfered in some measure with the proper prosecution of research work contemplated. However, with the appointment of a new district inspector to carry on this important phase of work, the pathological staff will be relieved of the duties thus devolving upon them in the future, affording more time for actual research.

During the year addresses on plant diseases were given before the Provincial Normal School, conference of officers of the Provincial Department of Agriculture, and field days were held at the Experimental Station. A course of twelve lectures on general plant pathology was delivered before the New Brunswick Agricultural School in November.

At a conference of the officers of the Provincial Department of Agriculture, the officer in charge was appointed plant pathological adviser to the newly formed Provincial Seed Board, which augurs well for the establishment of greater co-operation between this laboratory and the Provincial Department in the matter of important pathological problems demanding most attention.

Grateful acknowledgment is made to the department for providing the up-to-date pathological greenhouse erected during the summer (which will enable the prosecution of additional research work, particularly during the winter months), as well as the newly constructed darkroom in the attic of the office building, replacing the temporary one in the basement previously used.

Investigation of Uncommon Potato Varieties

There are a number of varieties of potatoes grown in this province knowledge of which is quite limited in many cases, and entirely lacking in others. Inasmuch as the attention of this laboratory has been directed from time to time to such unusual varieties, it was deemed advisable to assemble as many as possible of these, and conduct a careful study of them, in order to secure useful information for dissemination to interested parties.

During the course of this investigation recognized methods for the identification of potato varieties, particularly those developed by Stuart and Salaman, have been followed. The specific merits of each variety, in so far as disease-resistance and yielding qualities are concerned, have been given consideration with the hope of finding varieties among these eminently suitable for table or seed purposes in New Brunswick.

The investigation as conducted in a preliminary form included a study of twenty-eight differently-named varieties collected in various localities throughout the province. Observations made during the course of two seasons revealed that certain of the group studied were merely standard varieties which had been given new names, either by the grower himself or the seedsman from whom they were originally procured; while others proved to be properly named, well-known varieties of uncommon occurrence in this province. A number still remain unidentified upon which further study is proposed.

The matter of mixtures among the varieties studied, complicated this problem to a considerable extent. In certain instances what was assumed to be one variety proved to be apparently two or more varieties, differing quite frequently only in minor detail.

Another perplexing difficulty encountered was the presence of virus diseases, which cause malformation of different structures, rendering it difficult and impossible at times to determine, with any degree of accuracy, the natural habit of a variety so affected; this knowledge is absolutely essential for comparative purposes. In addition virus diseases have a marked effect upon the yield, rendering correct determination of the same a difficult matter in the case of infected plants. Consequently, a problem of this sort involves a careful pathological study as well as a horticultural investigation of the varieties under consideration, before their identity is correctly determined. Therefore, a study of virus diseases as they occur in such varieties is being carried on, and efforts are being put forth to secure specimens of these potatoes free from such diseases, in order to afford a study of the same in the normal state.

Another confusing factor met with was the failure of a few varieties to produce flowers, rendering impossible an examination of the floral structure, which is quite necessary for the identification of certain varieties.

Among the several varieties studied eighteen were identified. These are included in the following list, which embodies the name attributed to the variety when secured, as well as that found to be the proper name according to the classifications used.

TABLE 74

Name of variety as secured	Name of variety as identified
Mortgage Lifter	Green Mountain.
Netted Gem	Netted Gem.
Garnet Chili	Garnet Chili.
Dakota Red	Bliss Triumph.
Early Ohio	Early Ohio.
Beauty of Hebron	Beauty of Hebron.
Early Rose	Early Rose.
Spaulding Rose	Spaulding Rose.
Dooley	Rural New Yorker.
Russet	Late Petoskey.
Quick Lunch	Bliss Triumph.
Eureka	Irish Cobbler.
Gold Coin	Green Mountain.
Delaware	Green Mountain.
Burbank	Burbank.
Puritan	Early Michigan.
Blush	Early Rose.
Money Maker	Burbank.

Publication of the other phases of this problem studied is not warranted, until further confirmation of the results is obtained. These will be included in considerable detail in a complete report of the investigation as carried on at a number of other laboratories throughout the Dominion.

BEST SPACING OF POTATO PLANTS FOR THE PRODUCTION OF CERTIFIED SEED

This investigation, as conducted at the Fredericton and Charlottetown laboratories over a period of two seasons, demonstrated that close planting modified the resulting crop to a marked extent by improving the quality and increasing the total yield. The information thus secured gave evidence of useful possibilities towards producing a greater amount of tubers ranging from 3 to 12 ounces, and so rendering the largest possible amount of tubers from the average crop, intended for seed purposes, eligible for certification.

The results from two seasons' work were sufficiently fruitful to make evident the merits of close as opposed to wide planting, but, in order to secure more conclusive results warranting recommendation of this practice to growers, the project was continued for another season at both laboratories.

The following tables include the results obtained during 1927:—

TABLE 75.—FREDERICTON—BEST SPACING FOR THE PRODUCTION OF CERTIFIED SEED[1]

Irish Cobbler

Spacing interval	Yield per row in pounds				Yield per acre in bushels			
	Under 3 oz.	3–12 oz.	Over 12 oz.	Total	Under 3 oz.	3–12 oz.	Over 12 oz.	Total
6 inches	22·5	60·53	0	83·03	68·06	183·10	0	251·16
8 "	26·125	59·5	0	85·625	79·03	179·98	0	259·01
9 "	25·5	69·5	0	95·0	77·13	210·21	0	287·34
10 "	22·75	65·25	0	88·0	68·82	197·38	0	266·20
12 "	20·375	61·125	0	81·5	61·63	184·90	0	246·53
14 "	18·25	50·75	0	69·0	55·20	153·52	0	208·72
Green Mountain								
6 inches	38·0	60·0	0	98·0	114·95	181·50	0	296·45
8 "	36·0	46·5	0	82·5	108·90	140·66	0	249·56
9 "	39·25	47·25	0	86·5	118·73	142·93	0	261·66
10 "	29·25	57·0	0	86·25	88·48	172·43	0	260·91
12 "	29·0	57·75	0	86·75	87·73	174·69	0	262·42
14 "	25·25	63·75	0	89·0	76·38	192·86	0	269·24

[1] The tabulated data represent the average results from duplicate plots.

TABLE 76.—CHARLOTTETOWN—BEST SPACING FOR THE PRODUCTION OF CERTIFIED SEED

Irish Cobbler

Spacing interval	Yield per Row in pounds				Yield per acre in bushels			
	Under 3 oz.	3–12 oz.	Over 12 oz.	Total	Under 3 oz.	3–12 oz.	Over 12 oz.	Total
6 inches	18·8	18·6	0	37·4	113·3	112·0	0	225·3
8 "	17·8	22·1	0	39·9	107·0	147·6	0	254·6
9 "	17·0	27·3	0	44·3	102·0	164·0	0	266·0
10 "	14·0	26·1	0	40·1	84·0	157·0	0	241·0
12 "	11·5	33·1	0	44·6	69·0	199·0	0	268·0
14 "	11·0	29·1	0	40·1	66·0	175·0	0	241·0
Green Mountain								
6 inches	14·8	32·8	0	47·6	88·0	187·0	0	275·0
8 "	31·5	31·0	0	62·5	63·0	186·0	0	249·0
9 "	11·6	31·0	0	42·6	70·0	186·0	0	256·0
10 "	12·6	31·1	0	43·7	87·0	187·0	0	274·0
12 "	8·0	28·1	0	36·1	48·0	170·0	0	218·0
14 "	9·0	29·8	0	38·8	54·0	179·0	0	233·0

While certain discrepancies are evident in the foregoing tables, due to the impossibility of controlling certain influencing factors entering into a problem of this sort, the results confirm in considerable measure those afforded by previous experiment; that close spacing yields a better quality and greater quantity of tubers commensurate with the Dominion standards for certification. Spacing intervals, ranging from 10 to 12 inches, are recommended because successful roguing cannot be performed when plants are any closer.

Black Heart

This undesirable condition occurring in potatoes is characterized by the appearance of discoloured dead tissue in the central or medullary region of the tuber. This discoloured area usually has quite an irregular outline, frequently extending in branched form to the surface region of the tuber. In early stages the colour of involved tissue is gray, gradually changing to a brown and finally to a black as the condition becomes severe. The discoloration is not always confined to the central region of the tuber, for it may occur in diffuse form throughout the flesh, or it may appear as isolated spots scattered irregularly through the whole interior of the tuber. Cases have been observed where the vascular tissues were involved as indicated by discoloration in these parts. In advanced stages a cavity forms in the centre of the tuber due to shrinkage of the tissues involved, which, extending to the surface region, may permit the entry of decay-producing organisms, ultimately resulting in destruction of the entire tuber.

Black heart results from the subjection of tubers, either at high or low temperatures, to conditions where the necessary amount of oxygen required for respiration is deficient. Such conditions might easily arise in storage cellars or heater cars equipped with improperly controlled source of heat and insufficient means of ventilation.

The object of this investigation was not to determine the cause of the trouble, for that has been admirably explained by the findings of other investigators elsewhere; but to ascertain the extent to which different degrees of black heart impair the vitality of tubers so affected, particularly in so far as their seed value is concerned.

Accordingly, different degrees of black heart, designated in this report as slight, moderate, and severe, were produced experimentally in tubers of the Green Mountain variety by subjecting the same to varying oxygen deficiencies at 40° Centigrade.

The tubers so treated, after being numbered and the degree of black heart recorded in each case, were planted in soil of average fertility. Sound tubers of the same strain were planted for check purposes. Throughout the growing season observations were made upon the germination, vigour, and general condition of plants produced in each case. At harvesting time the quality and yield of tubers from each plant were determined and recorded.

The following are the tabulated results:—

Table 77

—	Number of Seed pieces planted	Number of plants produced	Yield of tubers		
			Under 3 oz.	Over 3 oz.	Total
			lb.	lb.	lb.
Check (sound tubers)	80	80	24·2	15·1	39·3
Slight black heart	80	56	16·3	6·5	22·8
Moderate black heart	80	48	4·3	1·8	6·1
Severe black heart	80	21	3·8	2·8	6·6

Perusal of the foregoing results reveals that a number of the tubers affected with black heart in each case failed to germinate, particularly those moderately and severely involved. Observations made after the potatoes were planted and during the growing season showed that the affected seed-pieces which grew, germinated slower and gave rise to plants of a less vigorous nature than those emanating from the sound tubers included in the check. This was particularly evident in the case of tubers moderately and severely affected. The yield of

tubers in each case correlated with variations in germination and vigour of plants produced; showing a progressive decrease corresponding to the different degrees of black heart—slight, moderate, and severe—respectively.

These results demonstrate that even tubers manifesting only slight evidence of black heart as well as those moderately and severely affected, impair the seed value of potatoes so involved, warranting recommendation of the elimination of such tubers from potatoes intended for seed purposes.

Control of Late Blight Tuber Rot of the Potato

It is a well known fact that *Phytophthora infestans*, (Mont.) de Bary, in addition to attacking the leaves and stems of the potato plant, produces a destructive rot in the tubers which, from time to time, results in serious losses.

During certain seasons when excessive rainfall causes the removal of fungicides applied for the control of late blight, before they adhere sufficiently to the leaf and stem surfaces to be effective, these parts consequently succumb to the ravages of the disease. When the tops have been thus destroyed, applications of fungicide are discontinued ordinarily, thereby permitting further development of the fungus, which releases large numbers of spores capable of infecting the tubers, when carried through the soil by the action of rains into contact with the same.

The season of 1928, by virtue of a severe epidemic of late blight, afforded an excellent opportunity for the study of control measures for the disease as occurring on the tubers. Therefore, while making observations upon a field of potatoes, the foliage of which was practically decimated by the disease, the suggestion presented itself that the application of standard fungicides in concentrated form to the dead infected tops and surrounding soil, might possibly prevent, in slight measure at least, infection of the tubers exposed to the fungus in the soil. Accordingly four adjacent rows of Bliss Triumph so affected were chosen for the purpose of studying the effect of the treatment already mentioned. One of these rows was left untreated while the remaining three were given heavy applications of formalin, Bordeaux spray, and copper-lime dust, respectively.

The following table includes a list of the fungicides used, number and rate of applications in each case, as well as the results recorded at harvesting time, October 14:—

Table 78

Fungicide	Number of applications	Rate of application	Percentage late blight rot
			%
Check untreated			12·62
Bordeaux spray 8–8–40	2	211 gallons per acre	2·39
Formalin	2	240 gallons per acre	1·01
Copper-lime dust 20-80	2	120 pounds per acre	0·00

The above results indicate that treatment of the dead tops and soil with the fungicides used possesses some virtue in minimizing the amount of late blight ordinarily developing. However, these results embracing one season's work are not sufficiently conclusive to warrant general recommendation of the method studied, but suggest possibilities along this line worthy of further consideration, for which reason the experiment will be continued during future seasons when serious outbreaks of late blight provide material essential for such a study.

Dusting versus Spraying

This project has been carried on for two consecutive seasons with a view to comparing the fungicidal values of certain standard and other spray and dust mixtures for the control of early and late blight diseases of the potato.

The results obtained, which are outlined in the reports of this laboratory for the years 1925 and 1926, revealed interesting information concerning the relative merits of the several fungicides under consideration, as influenced by different seasonal conditions.

These results, however, were not considered sufficiently conclusive to warrant useful deductions, for which reason it was deemed advisable to continue the project for another season, in order to secure further information and confirm, if possible, that evinced by previous experiment.

The project was conducted in 1927 in exact accordance with the plan originally outlined in 1925, with the exception that Burgundy spray mixture, and a dust sold under the proprietary name of "Pota" were included among the fungicides compared.

Burgundy mixture is prepared in the same manner as Bordeaux mixture, differing, however, in that carbonate of soda (sal soda) replaces the lime used as an ingredient of the latter. This fungicide has been used with considerable success in Ireland for the control of late blight particularly, but has received only slight recognition in this country owing to the fact that the inferior sal soda used for its preparation caused undesirable burning of the foliage. This was, however, due to certain impurities in the brands of sal soda used, which can now be eliminated by a new chemical process evolved for the preparation of this substance. A sample of this specially prepared sal soda was obtained from a well known chemical distributing firm in Saint John, N.B., and it was considered interesting to test the efficacy of Burgundy mixture prepared with this in comparison with other fungicides commonly used.

Owing to the fact that Pota is prepared according to a secret process no information can be communicated relative to its ingredients.

Seven plots were used in connection with the experiments, six of which, comprising one-half acre each, received different fungicidal treatments, including Bordeaux spray, copper-lime dust, copper carbonate spray and dust, Burgundy mixture, and Pota, respectively. The seventh comprising one-eighth acre served as a check and received only insecticidal treatment, for obvious reasons. The Green Mountain variety of potatoes was used.

The weather throughout the growing season was cool and cloudy with the amount of rainfall considerably above the average. These humid conditions enhanced the development of early and late blight, both of which reached epidemic proportions in potato areas where insufficient or no fungicides were applied.

The following includes a record of the disease as occurring on the vines.

Early and late blight appeared during the latter part of July in the copper-lime dust and Bordeaux spray plots, while no infection was observed in the remaining plots until August 10. Subsequent to that date, the disease gradually increased until August 26, when moderate infection was apparent in the copper-lime dust, Bordeaux spray, copper carbonate dust, Pota, and check plots. The remaining plots showed only slight infection on that date.

Late blight was first observed on August 5 in the Pota and check plots, and on August 12 in the copper-lime dust and copper carbonate dust plots. No infection appeared in the Bordeaux spray, copper carbonate spray, and Burgundy mixture plots until August 18. On August 26 when the final readings were taken, the copper-lime dust, copper carbonate dust, Pota, and check plots manifested severe infection, while the remaining three, namely, Bordeaux

spray, copper carbonate spray, and Burgundy mixture, showed the disease only to a moderate extent. The check plot showed most infection, that treated with Burgundy the least. The latter remained vigorous until the vines eventually died as a result of frost, while the remaining ones succumbed to the ravages of the disease long before that date.

The results recorded at harvesting time, including the percentage of late blight rot both by weight and number of tubers, correlated to a great extent with the amount of disease occurring on the foliage in each case.

The following table includes a list of the fungicides compared, as well as the number of applications, total metallic copper, and yield per acre in each case.

TABLE 79.—DUST VS. SPRAY—APPLICATIONS AND YIELD

Fungicide	Number of applications	Total metallic copper per acre	Yield per acre
		lb.	bush.
Copper-lime dust	6	14·53	244·6
Bordeaux spray	6	15·86	239·5
Copper carbonate dust	6	9·76	240·5
Copper carbonate spray	6	11·50	294·1
Pota dust	5	.....	199·4
Burgundy spray	6	15·32	306·2
Check (poison only)	2	.....	215·2

The following includes in tabulated form the percentages of diseases on the vines and tubers in the case of each fungicide tested.

TABLE 80.—DUST VS. SPRAY—COMPARISONS

Fungicide	Percentage early blight on vines						Percentage late blight on vines						Percentage late blight rot in tubers	
	August 18			August 26			August 18			August 26			By weight	By number
	Slt.	Mod.	Sev.	Slt.	Mod.	Sev.	Slt.	Mod.	Sev.	Slt.	Mod.	Sev.		
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Copper-lime dust	27·2	0·0	0·0	20·1	7·9	0·4	8·5	2·5	0·0	18·5	18·3	14·2	12·58	8·65
Bordeaux spray	30·4	0·0	0·0	31·0	0·8	0·0	0·4	0·0	0·0	18·9	4·6	0·0	2·03	4·74
Copper carbonate dust	4·8	0·0	0·0	1·2	4·4	0·3	8·8	1·0	0·0	19·9	41·8	21·0	7·64	7·85
Copper carbonate spray	2·3	0·0	0·0	1·5	0·9	0·3	0·1	0·0	0·0	30·9	5·4	0·2	4·79	3·48
Pota dust	4·6	0·1	0·0	68·9	12·0	0·0	33·5	2·9	0·0	0·6	72·5	14·5	23·72	18·16
Burgundy spray	0·4	0·0	0·0	3·1	1·5	0·1	0·5	0·0	0·0	20·5	3·4	0·4	1·84	1·61
Check (poison only)	3·0	0·0	0·0	0·0	4·0	0·0	17·3	5·0	3·0	0·0	2·0	98·0	24·28	20·00

Comparing the relative merits of spray and dust mixtures, under the conditions obtaining during 1927, the former were superior to the latter for the control of late blight, but both were equally effective in so far as controlling early blight was concerned.

Considering the respective values of the several fungicides compared for the control of early and late blight, their effectiveness, in order of merit, is as follows:—

Early blight	Late blight
Copper carbonate spray.	Burgundy spray.
Burgundy spray.	Bordeaux spray.
Copper carbonate dust.	Copper carbonate spray.
Copper-lime dust.	Copper carbonate dust.
Bordeaux spray.	Copper-lime dust.
Pota dust.	Pota dust.

Summarizing the results, spray mixtures in general appear to be superior to dust mixtures during seasons when frequent rains tend to remove the fungicide before it had sufficiently adhered to the foliage surfaces to be effective; this indicates the greater adhering qualities of the former.

Burgundy mixture proved to be more effective for the control of late blight than any of the other fungicides compared, which warrants greater recognition of this fungicide in the future. A noteworthy feature of this spray mixture is that it does not stain the foliage to the same extent as Bordeaux, thereby affording readier detection of mild forms of mosaic frequently obscured by the heavy precipitate formed in the case of the latter on the foliage. In addition, the ingredients of Burgundy mixture entirely dissolve, leaving no precipitate in the sprayer tank, as is the case with Bordeaux, to clog the feed pipes and nozzles, materially impairing the proper action of these parts. Further study of this fungicide is contemplated in order to secure fuller information.

The carbonate mixtures in both spray and dust form proved more effective than the copper sulphate mixtures for the control of early blight, being slightly superior to Burgundy in this respect.

Pota dust was vastly inferior to all the other fungicides tested for the control of each of the diseases under consideration.

The project was carried on in a restricted form at the Charlottetown laboratory, including only a comparison of Bordeaux spray and copper-lime dust, as applied to both Green Mountains and Irish Cobblers.

The results obtained correlated in considerable measure with those of the experiment at Fredericton, further confirming the superiority of spray over dust mixtures for the control of late blight during seasons of exceptionally heavy rainfall.

These results, in condensed form, are as follows:—

TABLE 81.—DUST VS. SPRAY—CHARLOTTETOWN

Irish Cobbler

Fungicide	Number of applications	Yield per acre in bushels				Percentage late blight rot by weight
		3-12 oz.	Under 3 oz.	Late blight rot	Total	
		bush.	bush.	bush.	bush.	%
Bordeaux spray	6	246·84	15·00	21·78	283·62	7·68
Check (poison only)	2	182·95	17·42	46·50	246·87	18·83
Copper-lime dust	6	214·89	23·23	36·22	274·34	13·20
Green Mountain						
Bordeaux spray	6	254·58	36·78	31·00	322·36	9·61
Check (poison only)	2	194·58	21·78	66·30	282·66	26·99
Copper-lime dust	6	254·58	14·03	58·56	327·17	17·89

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, STE. ANNE DE LA POCATIERE, P.Q.

(H. N. Racicot, Officer in Charge)

The laboratory is continuously becoming better known among the growers and farmers throughout the whole province. The number of requests, for information about plant diseases and their control, and to visit diseased crops, has greatly increased over previous years. Owing to the limited time of the pathologist, many of those visits were made by the potato inspectors while performing their duties.

It is also gratifying to report the construction of a potting house and greenhouse of convenient size. These provide facilities that were greatly needed, that are really indispensable, for carrying out the research work of this laboratory. With some trained assistance, the research, experimental, and extension work of the laboratory could be greatly increased.

The projects on the control by seed disinfection of common scab and *Rhizoctonia* of potatoes, and of the seedling-infecting smuts and bunts of cereals had to be temporarily discontinued. The soil in the experimental plots became infected by the organisms producing these potato diseases, and masked any beneficial effect these treatments may have had. In the case of cereals, even with seeds harvested from diseased fields, the check plots showed so little disease that the results were not of any value. The Superintendent of the Experimental Farm has had new land broken in, which will be suitable for potato growing. This will permit changing the location of the experiments, and it is hoped to be able to resume these projects on potato diseases.

In general, the weather conditions were favourable for plant growth and for the development of plant diseases. However, with but two exceptions,—apple scab and late blight of potatoes,—no serious outbreak occurred. Considerable apple scab occurred early in the spring in sprayed orchards near Montreal, in a way unaccounted for. The very wet weather of the fall induced further development of apple scab, thus causing considerable loss to the fruit growers in that district. Much late blight also developed, causing considerable loss throughout the province, except in the eastern part along the St. Lawrence. It may appropriately be pointed out at this time that many of the demands for pathological assistance come from the fruit and truck crop growers in the vicinity of Montreal, and that they annually lose considerable sums of money through plant diseases. The great distance between here and Montreal, 255 miles, prevents the laboratory from giving as effective aid to that district as it deserves.

BEAN MOSAIC

In 1926, the following plan was adopted to study the seed and field transmission of bean mosaic:—

(1)	Row 1. Healthy.	Row 4.	Mosaic.
	2. Healthy.	5.	Healthy.
	3. Healthy.	6.	Mosaic.

These rows were planted isolated from all other beans. The aim of this arrangement was to see if mosaic was more readily transmitted to adjacent rows than to the second or third row away from diseased plants; also to determine if mosaic was more readily transmitted to a row of healthy plants with a row of diseased plants on each side of it, than to a row of healthy plants with diseased plants on only one side.

(2) Row 7. Seed harvested in 1925 from apparently healthy plants in row corresponding to Row 1.
Row 8. Seed harvested in 1925 from apparently healthy plants in row corresponding to Row 2.
Row 9. Seed harvested in 1925 from apparently healthy plants in row corresponding to Row 3.
Row 10. Seed harvested in 1925 from apparently healthy plants in row corresponding to Row 5.

The arrangement of this section allowed of ascertaining the amount of mosaic transmitted to the healthy rows during the growing season of the previous year.

The experiment was planted in duplicate, the rows being fifty feet long, with 100 plants in each row. The White Pea Bean variety was used throughout the experiment.

In 1926, the plants from diseased seeds, supposedly due to much cloudy weather, showed no symptoms of mosaic, except about half a dozen plants from a total of three hundred. However, these plants were treated as if diseased, and the seed harvested from these supposedly diseased plants was planted in 1927 as the diseased seed in rows No. 4 and 6. These rows gave as good a yield as the healthy rows.

TABLE 82.—THE RESULTS OBTAINED IN 1927

Row	Mosaic	Yield, per acre
	%	bush.
(1) 1	1·0	16·3
2	2·2	13·8
3	0·0	14·9
4	5·7	16·0
5	1·1	15·3
6	5·7	13·8
(2) 7	5·6	.....
8	3·3	.....
9	3·0	.....
10	5·2	.....

STUDIES ON DISEASES CAUSED BY SCLEROTIA-PRODUCING FUNGI IN QUEBEC

(B. Baribeau and H. N. Racicot)

The main objects of this work are (1) to collect and culture as many as possible of the forms occurring in the province, (2) to make morphological and physiological studies of these forms, (3) to make cross-inoculations, and determine as far as possible the susceptible hosts, (4) to determine the longevity of the sclerotia, (5) to obtain reliable means, whether morphological or physiological, for differentiating genera, species, or strains, (6) to determine at what period in their life history the sunflower and other plants are susceptible to infection, and (7) to ascertain if infection takes place through spores or mycelium, or through both.

Table 83 gives the counties and the crops on which sclerotia of *Sclerotinia* spp. have been collected up to date.

TABLE 83.—COUNTIES AND HOSTS ON WHICH *Sclerotinia* SPP. WERE COLLECTED

Hosts	Counties					
	Kamouraska	Temiscouata	Rimouski	Champlain	Portneuf	Laval
Bean	x	x	x	x	x	
Cabbage	x	x				x
Carrot	x	x				
Lettuce	x	x		x		x
Sunflower (L)	x	x				
Sunflower (S)	x					
Potato	x		x			
Tomato	x	x				x

Sunflower (L) = *Sclerotinia* spp. producing large sclerotia.
Sunflower (S) = *Sclerotinia* spp. producing small sclerotia.

Cultures were made on various media and compared to determine any difference there might be between the different species or strains collected, and also to ascertain if there would be any difference in the cultures if these were inoculated with mycelium or with sclerotia. In this last case, the only difference noted was that the cultures inoculated with mycelium developed and produced sclerotia much quicker than the cultures inoculated with sclerotia. Table 84 gives the results obtained on various sterilized media. The x sign indicates that the fungus developed, and the — sign, that it failed to develop. These cultures were grown at room temperature, which varied from 18°-22° C.

TABLE 84.—RESULTS OF INOCULATION ON VARIOUS MEDIA

Source of culture	Media														
	Beet slants	Beet leaves	Parsnip slants	Turnip slants	Potato stems	Potato slants	Carrot slants	Orange	Celery stalks	Lettuce	Tomato	Apple slants	Cabbage	Potato dextrose agar	Gelatine dextrose broth
Sunflower stalk (large sclerotia)	x	x	x	x	—	x	x	x	x	x	x	—	x	x	—
Bean pods	x	—	x	x	x	x	x	—	x	—	—	x	—	x	—
Tomato stem	x	x	x	—	—	x	x	x	x	x	x	x	x	x	—
Potato stem	x	—	x	—	x	x	x	x	—	—	x	—	x	x	x

On the following media the sclerotia produced were smaller than the normal sclerotia, namely, on potato dextrose agar (which is taken as standard for comparison), orange, tomato, apple, gelatine dextrose broth, and celery stalks. However, when these smaller sclerotia were transferred to potato dextrose agar, the sclerotia produced were normal in size. Therefore, on media favourable for the development of the fungus, the sclerotia formed are larger than those formed on less favourable media.

Cultures of species or strains of *Sclerotinia* isolated from potato stem, sunflower (large sclerotia), sunflower (small sclerotia), cabbage, tomato stem, and beans, were grown at temperatures of 0°-2° C., 4°-10° C., and 18°-22° C. (room temperature). The cultures grew well at the low temperatures, except that the growth was much slower than at room temperature.

The cultures of the strain isolated from potato stems produced at the low temperatures sclerotia about one half the size of those produced by the cultures at 18°-22° C. Many of these sclerotia remained white, or merely took on a smoky tinge. When cultures were made with these small sclerotia and kept at

18°-22° C., the sclerotia produced were normal in size. The other species or strains of sclerotia produced the same sized sclerotia at the low temperature as at room temperature.

Cultures of the potato strain of *Sclerotinia* described in the preceding paragraph, together with cultures of the sunflower strain producing small sclerotia, were sent to Prof. H. H. Whetzel of Cornell University. Prof. Whetzel cultured these strains, together with six other strains that he had, including a known strain of *Sclerotinia minor*, at 6° C. All the cultures, except the potato strain and the *Sclerotinia minor*, gave the same sized sclerotia at the two temperatures. The potato strain and *Sclerotinia minor* were identical in producing small sclerotia at the low temperature.

Sclerotia kept in sand outdoors all winter did not germinate more quickly or more uniformly than freshly collected sclerotia, or sclerotia kept in the dry air of the laboratory for shorter or longer periods of time. Therefore chilling or freezing of the sclerotia do not appear to affect the germination of the sclerotia in any way. According to Ramsay,* freezing or a rest period are not necessary for the sclerotia to produce apothecia, but such factors as light, temperature, and moisture determine the formation of apothecia.

Sclerotia, collected in 1921 and kept at room temperature in the dry air of the laboratory, have germinated as well in 1928 as in each preceding year since the time of collection. Therefore sclerotia will remain alive in a dry state for at least seven years, and probably much longer.

Different varieties of sunflowers, grown in the laboratory, were inoculated with the large sclerotia-producing sunflower strain of *Sclerotinia*. One set of plants was inoculated when they were 10 to 14 inches tall, and the other set when the plants were about to bloom and were about 2½ feet tall. Table 85 gives a summary of these inoculations. The results of the two sets of inoculations are not in complete agreement, but they indicate that there may be varieties less susceptible than others, and perhaps highly resistant. These inoculations are being repeated in the greenhouse, but the results are not yet available.

TABLE 85.—RESULTS OF INOCULATION OF VARIETIES OF SUNFLOWER

Variety	Plants 10 to 14 inches high			Plants 2½ feet high, and about to bloom	
	Number of plants inoculated	Number of plants infected	Number of plants that died	Number of plants inoculated	Number of plants infected
Manchurian, C.P.R.	8	1	.....	4	1
Mammoth Russian, C.P.R.	3	1	1	3	.....
Black, C.P.R.	6	.....	.....	4	.....
Mennonite Rosthern	7	1	1	4	.....
Manchurian McKenzie	12	2	.....	4	.....
Manteca, C.P.R.	11	2	.....	4	1
Mixed Mammoth	3	1	1	3	1

EXTENSION WORK

The laboratory continued the practice adopted the previous year of sending out circular letters describing prevailing diseases and their control. About 1,500 such circulars were sent out during the year. Addresses were given at meetings of various farmers' organizations. Visits were made, where it was thought advisable, to view diseased crops and ascertain the cause of the disease or

* Ramsay, G. B. Sclerotinia Species causing Decay of Vegetables under Transit and Market Conditions. Journ. Agric. Res., 31, pp. 597-632, 1925.

diseases, and to advise concerning methods of control. Many lengthy replies were sent to individuals concerning diseases and their control. Plant disease exhibits were shown at the county fall fairs at Ile-Verte, Rimouski, and St. Jean Port-Joli.

Potato Growing on the Magdalen Islands

On account of the fact that the Provincial Department of Agriculture is encouraging the inhabitants of the Magdalen Islands to grow seed potatoes, observations were made there to ascertain the potato diseases present, and if conditions in general were favourable for the growing of that crop. It was found that the soil was ideal for potatoes, being a red sandy soil similar to that of Prince Edward Island. From observations made in 1926, the first year that inspection was made there, it was thought that potato aphids did not occur on these islands. Also, no late blight had been seen. This year, however, aphids occurred in large numbers, and, as early as the 10th of September, all the vines had been killed by late blight. There are no Colorado beetles on the islands. These observations show that care must be exercised in urging these people to grow seed potatoes, and that they must be warned of the losses liable to occur due to mosaic and late blight, and of the advisability of securing proper spraying apparatus to combat the latter, if they undertake the growing of potatoes.

Late Blight of Potatoes (*Phytophthora infestans* (Mont.) de B.)

This experiment is conducted with Bordeaux mixture, 4-4-40, to determine the time and number of applications for the control of late blight of potatoes in this district, and the effect of the Bordeaux mixture upon the yield in blight-free years. In 1925 and 1926, which were blight-free years, a period of drought occurred during the middle of the growing season. The treated plots survived the drought better and gave higher yields than the untreated plots. In 1927, there was no period of drought, and only a trace of late blight occurred on the vines and tubers of the untreated plots. The treated plots gave a slight increase in yield, an average of 12 bushels per acre, over the untreated plots.

Table 86.—Spraying Potatoes With Bordeaux Mixture and Dusting With "Pota"

Plot	Number and time of applications	Late blight		Yield, bushels per acre	
		Vines	Tubers	Total	Marketable
	Bordeaux mixture				
1	Control, unsprayed	Trace	Trace	344	278
2	4, beginning June 30	.....	.....	351	289
3	6, beginning June 30	.....	.....	351	287
4	4, beginning July 20	.....	.....	370	303
5	6, beginning July 20	.....	.....	347	285
6	4, beginning Aug. 10	.....	.....	375	306
7	6, beginning Aug. 10	.....	.....	343	274
	"Pota" dust				
8	8, beginning July 10	.....	.....	370	306

Observations on the Virus Diseases of Potatoes

It must here be pointed out that the results of experiments on the virus diseases of potatoes can only be ascertained the following year, and, therefore, that reports on such work must of necessity be a year late.

In 1926, experiments were conducted under insect-proof cages to determine if the rubbing of mosaic plants against healthy plants, similar to that which takes place in the field on a very windy day, would transmit the disease. Cages, 3 feet square, 2½ feet high, covered with heavy cotton sheeting, were used for

this experiment. Tubers were selected from a practically disease-free field. One set from each tuber, near the stem end, was removed and grown in a pot in the laboratory to determine the absence of disease. The rest of each tuber was cut in two, one part planted in one of the experimental cages, the other part in another cage as check. Three healthy sets and one diseased set, affected with the type of mosaic known as "mild mosaic," were planted in each cage. On two occasions the diseased vines were shaken vigorously against the healthy vines. The check plants remained healthy throughout the season. In 1927, tubers from all of the healthy hills from the experimental cages were planted under cages, and they produced healthy vines, which remained healthy throughout the season. No conclusion can be drawn from only one year's experiments.

An experiment to determine if potato mosaic undergoes an incubation period in the potato aphid (*Macrosiphum solanifolii*, Ashmead) before it can be transmitted to potatoes, was carried out in 1926. The materials used were the same as described above. One insect-proof cage was planted with tubers affected with "mild mosaic." Other cages were planted with healthy potatoes, tested as described above, and with part of each tuber in one of the experimental cages, and the other part in the check cages. Aphids kept in the laboratory on beans and healthy potatoes were transferred, partly to the cage containing the "mild mosaic" potatoes, and partly to one of the check cages. The potatoes in this check cage remained healthy throughout the season, showing that the aphids did not carry the disease. The aphids were left on the diseased potatoes for 24 hours. Some were then transferred to healthy potatoes in two cages (four plants under each cage), others to beets and beans under cages. At the end of 24 hours some of the aphids from the beets and beans were transferred to two cages containing healthy potatoes. After 48 hours, more aphids were transferred from the beets and beans to two cages containing healthy potatoes. In the first transfer about fifty aphids were placed in each cage. In the second transfer, only about twenty-five aphids were placed in each cage. In the third transfer, only about twenty-five aphids were recovered, twelve being placed in each cage, making four aphids for each hill. Aphids succumb easily to injuries sustained in handling. In 1927, tubers produced by these plants were planted under insect-proof cages. They produced healthy vines which remained healthy throughout the season. These experiments were repeated in 1927. No attempt to draw conclusions will be made.

It is desired here to gratefully acknowledge the receipt from Dr. Schultz, of Washington, D.C., of Green Mountain tubers affected with the following types of virus diseases: mild mosaic, rugose mosaic, crinkle mosaic, leaf-roll mosaic, leaf-roll, and spindle tuber. Also to thank Mr. Ross, Entomologist, Vineland, Ont., for identifying the aphids that were used in these experiments.

AN EXPERIMENT TO DEVELOP DISEASE-FREE STRAINS OF POTATOES AT SUMMERLAND, B.C.

(G. E. Woolliams, Assistant Plant Pathologist)

In the Dry Belt of the province virus diseases of potatoes are quite general. Of these diseases, mosaic has been, up to the present, the most prevalent, and growers have had difficulty in trying to keep their various strains of potatoes free of infection. In an attempt to overcome this difficulty, many growers began importing certified seed from another section of the province. These attempts appeared to be disappointing, for, although for the first year results were sometimes fairly satisfactory, during the second year infection was fairly severe, and in the third year's growth the crop was nearly wholly affected.

The existing conditions may well be illustrated by observations made by this laboratory on plots at the Summerland Experimental Station. It so happened that at the Farm there were growing three different plots: one from northern grown seed that had been planted locally for the two previous seasons; one from similar seed that had been grown locally for one season; and one plot from the current season's northern grown seed. A comparison of the three plots showed that in the plot of new seed the infection was less than 2 per cent; in that of seed grown locally for one year infection ran about 85 per cent; and in the plot of seed grown locally for two years 100 per cent of the crop was affected.

As a result of this condition the growers have recently adopted the practice of importing new seed each year, and naturally the question has arisen as to why there is this rapid deterioration in their imported seed. There seem to be two possibilities as to the reason for this trouble. One is that the imported seed may already be inherently infected with mosaic when it is brought in. As is generally believed, mosaic symptoms are sometimes masked due to certain environmental conditions of climate, and it is possible that the seed comes from localities where masking occurs. The second reason is that there may exist certain local environmental conditions whereby vines, although originally free of the virus trouble, readily become affected.

Investigational Work

To decide this point it was, therefore, deemed advisable to undertake definite tests at the laboratory on the growing, for several consecutive years, of certified seed potatoes imported from different districts of British Columbia outside of the Okanagan Valley. It is hoped that, possibly by selecting only disease-free seed and growing it under isolated conditions, this degeneracy may be overcome.

Accordingly, in the spring of 1927, seed potatoes of the following varieties were imported from different sections of the province: Early St. George, Early Ohio, Bliss Triumph, Early Rose, Early Surprise, Irish Cobbler, Beauty of Hebron, Wee McGregor, Gold Coin, Up-to-Date, Rural Russet, Green Mountain, Burbank, Netted Gem, and Sir Walter Raleigh.

Control of the Disease in the Field

To obtain as high a percentage of purity in the seed as possible, an indexing test was run on the tubers, and all which showed any symptoms of disease were discarded. A field, isolated from all other potato plantings, was chosen for the setting out of those tubers which had shown themselves to be free of disease, and periodic inspections were made on these throughout the growing season. Affected plants were found only on Gold Coin and Green Mountain varieties, and plants showing infection were removed as soon as the disease appeared.

Control of the Disease in Cages

At the laboratory, plants of each variety were also grown, under insect-proof cages, in order to eliminate, as far as possible, all possibility of infection by means of aphids. With the exception of the plants in two cages, which, in spite of all precautions, became infested with aphids and died, the remaining plants remained healthy.

The seed obtained in the field and in the cages is being carefully stored, and it is proposed to carry on the experiment along the same lines during next season, when the occurrence of disease and the yield of crop will be noted.

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TOBACCO DISEASES AT SUMMERLAND, B.C.

(G. E. Woolliams, Assistant Plant Pathologist)

Tobacco Leaf-Drop

The growing of tobacco was reintroduced into the Okanagan Valley in 1925. It has developed rapidly since that time and has given promise of becoming an important industry. In 1925 an initial planting of 12 acres was started for experimental purposes; in 1927 the land planted to this crop was increased to 275 acres, and it is expected that there will be a further increase in acreage during the coming season.

A brief disease survey showed that the diseases commonly affecting this plant, such as frenching, physiological leaf-spot, and mosaic, were going to give trouble here as they have done elsewhere. In addition, there is a fourth disease of apparently local occurrence only, the cause of which is unknown and which has been present each year to quite a serious extent. The nature of the trouble is an unusual loss of foliage. The leaves break off from the main stem and drop to the ground, whence the name of " tobacco leaf-drop " is suggested (fig. 55).

Fig. 55.—Showing tobacco plants affected with leaf-drop.

Tobacco leaf-drop was first observed in 1925 and has been present during the two succeeding years. As a rule, the trouble does not become apparent until the first part of August when the plants have been headed back, or even until later when the leaf is nearly ready to harvest. At first the disease makes its appearance in the field only on an occasional plant; soon other adjacent plants likewise lose their leaves, until the majority of those in a block may reach this condition. The loss of foliage begins at the base and advances up the stem. According to the severity of the disease, some plants lose only one or two of the lowest leaves; in other cases, they may become semi-defoliated; and, in still others, all the foliage may be lost. According to a statement of a local grower, early morning appears to be the time at which the plants are most subject to loss of foliage, and soon after daybreak the leaves can be heard to drop off the plant with a distinct snapping sound. The petiole appears brittle and suggests that the weight of the leaf is sufficient to cause the snapping off. The point at which the leaves drop off the plant appears to remain fairly constant. The petioles of the leaves break about one inch from the point of attachment of the leaf, and often plants with a number of petiole stubs of similar length are found on the stem. In the majority of cases when loss of foliage occurs on the upper part of the stalk, the petioles are broken off completely; but usually this does not happen when the leaves nearer the ground break off. When these leaves fall the leaf blades rest on the ground and, as the petioles are thus relieved of much of the weight of the foliage, the leaves usually remain attached to the stalk by means of a very small portion of the lower side of the petiole. Since there remains practically no conductive tissue to supply moisture, these leaves soon wilt and die. But occasionally the petioles of the lowest leaves break only half way through. As there is still enough conductive tissue left to supply these broken leaves with sufficient moisture, they remain turgid and continue growth to maturity. In the majority of cases, no blemishes are found on the plants affected with leaf-drop. But on the main stalk of an occasional plant, at a point just below the spot where the leaf is attached, there are observed short, longitudinal, sunken areas of an irregular, oval outline.

Casual observations on White Burley and Connecticut Havana 38 varieties, in the same or adjacent fields, seemed to indicate that White Burley is more susceptible than is Connecticut Havana 38. While in many cases both crops showed some disease, there were fields noted in which the drop in White Burley was quite heavy, while the Connecticut Havana 38 seemed to be quite normal.

The farming country around Kelowna, where the disease has been troublesome, consists, roughly, of two different districts. In one section farming is conducted on high bench lands where irrigation is always essential, and in the other section the lands are low-lying. Due to an existing high water table in these latter fields, there is sometimes sufficient sub-irrigation for the water requirements of certain crops, so that the application of irrigation water is sometimes unnecessary. It was noticed that leaf-drop occurred in tobacco fields situated on these low-lying soils. For this reason the idea was suggested that the loss of foliage may be the result of some detrimental influence exerted by this high water table on the development of the plant.

Investigational Work

Affected plants were collected, and attempts were made to isolate an organism that might possibly be responsible for the trouble. Results in this respect were negative, all cultures set up remaining sterile. No test has yet been made to determine whether the trouble is caused by a virus.

An experiment, in co-operation with the Tobacco Division at Ottawa, was arranged and, to obtain evidence as to the influence of the water table on the occurrence of the disease, a test was made to determine whether, by

lowering the water table, the disease might be controlled. A location in which the disease had been severe during the previous season was chosen for the experiment. About the first of May, a wooden frame 20 feet square and 10 inches high was built on this situation. The frame was then filled with soil taken from the adjacent part of the field, and, in order to change the characteristics of the top-soil as little as possible, only the top foot of soil was used. On June 1, 77 young plants of the Connecticut Havana 38 variety were transplanted to the frame where they were placed in rows 3 feet apart and 2 feet apart in the row. About the same time plants of the same variety were also set out in the adjacent field. During the summer the plants in the frame and those in the field received similar cultivation. Although in the earlier part of the summer, the plants in the frame did not grow as rapidly as those in the field, growth was rapid later in the season, so that, when the crop was harvested, there was little difference between the size of the plants in the frame and those in the field.

A careful examination of the plants was made on August 29. Around the frame were many plants that were affected with leaf-drop. Of the 77 plants in the frame, 31 or 40 per cent were diseased. Though the growing of plants in a frame represented a water table ten inches lower than that existing in the field, there was no appreciable difference in the degree of severity of the disease in the plants growing at the two levels.

POTATO INSPECTION AND CERTIFICATION SERVICE

(John Tucker, Chief Inspector, Central Experimental Farm, Ottawa)

Approximately $1,500,000 were received by the certified seed potato growers for potatoes from the 1927 crop, exported under the official "Extra No. 1 Seed" tag. In addition, over 2,500,000 bushels of certified seed were made available to the potato growers of the Dominion for the improvement of their table stocks.

This specialized seed trade is growing rapidly, and is well worth the best efforts and the keenest interest of all concerned. Very considerable responsibility rests with the inspection service to see that the quality of the produce is maintained, especially as many hundred new growers join the ranks of certified seed producers each year. There must be no slackening, otherwise this extensive business which has been so carefully built up would soon crumble away.

All inspections were made free of charge to the growers; official tags were supplied free for seed which passed all inspections.

Cost of the Inspection Service

The total cost chargeable to this service in 1927 amounted to approximately $78,000. Of this amount $62,000 were spent on actual field and tuber inspection work, for salaries and travelling expenses, and supervision; this amount, however, included other necessary work performed by the temporary inspectors, such as planting potato experimental plots, etc., before actual field inspection work commenced, and digging plots and recording experiments in the interval between field and tuber inspections.

The balance of $16,000 was expended for salaries of all the permanent inspectors between seasons. This may reasonably be charged to extension work, Short Course lectures, addressing meetings, issuing foreign certificates on potato shipments, etc., and for printing, supplies, etc.

The staff of inspectors employed for this work throughout the Dominion consisted of two senior inspectors, and seven district inspectors on full time pay, and fifty temporary inspectors engaged for varying periods. The inspection work necessitated total travelling on the part of the inspectors of over 200,000 miles by rail and car.

The inspections made included one field inspection on 31,601 acres, and a second field inspection on approximately 28,500 acres—a total of 60,100 acres inspected. On the crop, after digging, over 6,000 tuber inspections were made at the farms, and approximately 2,000 shipping inspections.

The total cost of inspections works out at $32,923 for field inspections, and $29,821 for tuber and shipping inspections; $62,000 for 31,601 acres, approximately $2 per acre for all the inspections performed.

The cost varies considerably according to locality—in Prince Edward Island the cost per acre is lowest, being approximately $1.20 for all inspections. Cost is highest in British Columbia, running at $8.72 per acre. The low cost per acre in Prince Edward Island is made possible by the large acreage inspected, and the short distances travelled.

Acreage Entered for Inspection

A total of 31,601 acres of potatoes was entered for field inspection with a view to certification, in 1927. This is an increase of approximately 18,000 acres, or 130 per cent over the acreage inspected in 1926.

In view of this increase, it is particularly gratifying to find the percentage of fields and acreage "passed" maintained at the 1926 level.

The summary of the field inspection figures for the past seven years, tabulated below, will best demonstrate the progress and success of this popular service during that period.

Table 87

Year	Number of fields inspected	Number of acres inspected	Number of fields passed	Number of acres passed	Percentage of fields passed	Percentage of acres passed
		acres		acres	%	%
1921	2,646	7,900·0	1,634	4,290·0	61·7	54·3
1922	3,283	11,250·0	2,139	6,991·0	65·3	62·1
1923	2,914	9,681·0	2,061	7,099·7	70·7	73·3
1924	5,586	19,238·87	3,868	13,916·64	69·25	72·3
1925	4,542	14,451·51	3,307	10,856·88	72·8	75·1
1926	4,212	13,714·57	3,094	10,392·61	73·5	75·8
1927	8,388	31,601	6,125	23,875	73·0	75·6

Of the 7,900 acres inspected in 1921, only 54·3 per cent passed as meeting the required standard of freedom from disease, whereas in 1927, in spite of the much higher standard required, 75·6 per cent of the 31,601 acres inspected reached the new standard. The acreage entered for inspection in 1927, therefore, represents a 300 per cent increase over that entered in 1921.

It may be of interest to examine this increase in terms of the percentages of the total acreage planted to potatoes in Canada during these years.

TABLE 88

—	1921	1922	1923	1924	1925	1926	1927
	%	%	%	%	%	%	%
Acreage entered for inspection as percentage of the total potato crop	1·12	1·65	1·72	3·43	2·79	2·62	5·52

That this increase has been shared by all provinces is shown by the following table:—

TABLE 89.—COMPARISON OF ACREAGE INSPECTED WITH TOTAL CROP GROWN IN 1926 AND 1927

Province	1926		1927	
	Acres inspected	Percentage of total acreage planted	Acres inspected	Percentage of total acreage planted
	acres	%	acres	%
Prince Edward Island	9,275	26·58	24,845	50·91
Nova Scotia	219	0·71	620	1·90
New Brunswick	2,031	4·75	2,777	5·91
Quebec	340	0·21	590	0·36
Ontario	826	0·54	1,205	0·76
Manitoba	146	0·50	145	0·52
Saskatchewan	213	0·48	407	0·93
Alberta	152	0·47	250	0·80
British Columbia	512	2·57	762	3·81

POTATO EXPORTS, 1927

The total exports of potatoes from Canada during 1927 amounted to 7,686,992 bushels, valued at $7,855,565. Shipments to the United States were 5,007,966 bushels, valued at $4,693,389; to Cuba 2,353,333 bushels, valued at $2,886,346; to Bermuda 21,590 bushels, valued at $23,270. Newfoundland, British Guiana, and Jamaica accounted for the remainder.

Included in the above figures are Certified Seed Potato shipments exceeding one million bushels to the United States. The Bermuda shipments were practically all Certified Seed. Total shipments of Certified Seed exceeded one and one-half million bushels.

Special certificates are required by the Cuban Government covering all importations of potatoes into Cuba. The certificates are issued by the potato inspection staff of the Division of Botany, many thousands being required for the purpose each year. These are issued, officially stamped and signed, by the District Inspectors at Kentville, N.S., Fredericton, N.B., and Charlottetown, P.E.I. Duplicate reports on all shipments are filed at Ottawa.

Several shipments of certified seed potatoes were sent to Cuba during the past season for test in trial plots. It is expected these will result in an increased demand for Canadian grown certified seed next season.

The large shipments made to the southern United States' potato growing districts during the past season have proven very satisfactory, and an increased demand for seed from these districts may reasonably be expected.

A Summary of the Field Inspection Work

Included in the two following tables are summaries of the distribution and results of the work in the nine provinces of Canada during 1927, and the average percentage of the principal diseases found in the fields inspected, passed, and rejected.

Table 90.—Summary of the Field Inspection Work by Provinces

Province	Number of applications	Number of fields inspected	Number of acres inspected	Number of fields passed	Number of acres passed	Percentage of fields passed	Percentage of acres passed
			acres		acres	%	%
Prince Edward Island	4,385	5,642	24,845	4,471	19,915	79·2	80·1
Nova Scotia	248	336	620	185	377	55·0	60·8
New Brunswick	338	654	2,777	418	1,732	63·9	62·4
Quebec	319	398	590	261	385	65·6	65·3
Ontario	354	467	1,205	359	950	76·9	78·8
Manitoba	24	53	145	32	57	60·4	39·3
Saskatchewan	50	113	407	50	131	44·2	32·2
Alberta	72	115	250	63	50	54·8	20·0
British Columbia	320	610	762	286	278	46·9	36·6
Total (Canada)	6,110	8,388	31,601	6,125	23,875	73·0	75·6

TABLE 91.—PERCENTAGE OF DISEASE FOUND—BY PROVINCES

—	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
	%	%	%	%	%	%	%	%	%
Average percentage of disease in total fields inspected—									
Blackleg	0·26	0·26	0·6	0·37	0·51	1·5	1·54	1·72	0·18
Leaf roll	0·01	0·3	0·2	0·13	0·35	0·04	0·07	0·52	0·09
Mosaic	0·43	1·5	2·5	1·23	0·43	0·46	0·42	0·93	1·94
Wilts	0·01	0·1	0	0·12	0	0	0	0	0·16
Average percentage of disease in fields passed—									
Blackleg	0·12	0·15	0·4	0·11	0·27	0·77	0·11	0·21	0·08
Leaf roll	Tr.	0·2	0·1	0·07	0·16	0·04	0·06	0·06	0·07
Mosaic	0·05	0·2	0·4	0·35	0·16	0·32	0·13	0·1	0·43
Wilts	Tr.	0·12	0	0·09	0	0	0	0	0·1
Average percentage of disease in fields rejected—									
Blackleg	0·74	0·48	1·8	0·88	1·3	3·22	3·53	3·55	0·27
Leaf roll	0·05	0·4	0·4	0·23	0·96	0·07	0·08	0·55	0·11
Mosaic	1·83	3·8	5·8	2·9	1·3	0·62	2·15	1·8	3·27
Wilts	0·11	0·11	0	0·26	0	0	0	0	0·22

Comments on Field Inspection Work

One outstanding feature is the lead the Prince Edward Island growers have taken in the production of certified seed over all other provinces, not only in increased acreage, but also in the total quantity of seed shipped out under the official tag. Of the 1,500,000 bushels so shipped from the 1927 crop, 1,243,196 bushels were Prince Edward Island stock.

The following increases are noted for Prince Edward Island in 1927 over 1926: fields inspected rose from 2,300 to 5,642, acres inspected from 9,275 to 24,845, fields passed from 1,801 to 4,471, acres passed from 7,597 to 19,915, percentage of fields passed from 78·3 to 79·2.

The Island is particularly well adapted for the production of good seed potatoes for the export trade, not only in so far as soil and climatic conditions are concerned, but also because of its facilities for shipping by rail or water. The growers are wideawake to the possibilities of extending their markets, and the shipping facilities are being extended to keep pace with production.

While it is not possible to show such extraordinary increases in seed potato production in other provinces, nevertheless it is gratifying to see general improvement in the seed potato stocks available to the public throughout the Dominion. The increased production was quite large in all provinces with the exception of Manitoba, Alberta, and British Columbia. In these latter provinces the acreage entered for inspection increased, but the rejections also increased. One result of this should be higher quality seed for next season's plantings, as the inspections were rigidly carried out, and all doubtful fields excluded.

Nova Scotia in 1927, while its acreage entered for inspection was still small, nevertheless had nearly three times the acreage inspection of that in 1926. In New Brunswick a steady improvement in quantity and quality is apparent. Quebec had over double the acreage passed, with a great improvement in the quality, and the crop improvement work of the previous season, therefore, is showing good results. In Ontario a steady, consistent improvement is apparent each year.

Fig. 56.—A 30-acre field of Certified Irish Cobblers. Perfect stand—Perfect score.

TABLE 92.—FIELDS REJECTED FOR CERTIFICATION, 1927—REASONS

Province	Blackleg	Leaf roll	Mosaic	Wilts	Foreign varieties	Lack of vigour	Adjacent to disease	Lack of cultivation and insect injury	Late blight	Misses	Not eligible	Rejected fields	Rejected area
													acres
Prince Edward Island	224	6	401	51	154	66	78	.....	10	.....	111	1,171	4,930
Nova Scotia	11	9	26	5	42	.....	24	4	.....	1	29	151	243
New Brunswick	49	7	155	.....	8	.....	17	.....	.....	.....	.....	236	1,045
Quebec	17	3	50	6	7	.....	40	8	6	.....	.....	137	205
Ontario	23	16	25	.....	8	.....	27	6	.....	3	.....	108	255
Manitoba	9	1	2	.....	3	5	1	.....	.....	.....	.....	21	88
Saskatchewan	30	2	11	.....	8	.....	9	.....	.....	2	1	63	276
Alberta	22	6	11	.....	6	2	4	1	.....	.....	.....	52	200
British Columbia	6	.....	132	10	22	22	89	.....	.....	.....	43	324	484
Totals	461	50	813	72	258	95	289	19	16	6	184	2,263	7,726

Comments on Rejections

The fact that 27 per cent of the total fields inspected were rejected for various causes at once makes apparent the need for continuing the seed potato certification work. These fields were, for the most part, planted with seed which passed field inspections the previous year,—the best obtainable anywhere,—yet certain conditions developed that caused the rejection of 2,263 fields out of a total of 8,388 fields inspected. It is no exaggeration to state that, if field inspections were discontinued, within five years less than 5 per cent of an equal number of fields would pass the standard for certification.

Mosaic and black leg caused most rejections in 1927, the former being responsible for 36 per cent of the total rejections, and the latter for 20 per cent. In New Brunswick mosaic was the cause of 60 per cent and in British Columbia of 40 per cent of the rejections. Blackleg caused 48 per cent of the rejections in Saskatchewan, 42 per cent in Alberta, and 45 per cent in Manitoba.

Fig. 57.—A 10-acre field of Certified Seed Potatoes.

Reference to table 92 shows that 289 fields were rejected on account of being adjacent to fields planted for table purposes, which contained considerably more disease than is allowed in fields accepted for certification. It has been shown that the presence of mosaic in some certified seed stocks was directly traceable to the fact that the seed stock had been grown alongside of table stock potatoes, which contained quite a high percentage of mosaic. The fact that diseases will very easily spread in the field, and even to adjacent fields, has been well advertised, and it is hoped that growers will be much more particular in this respect in future. A distance of at least 200 feet should separate the plots; 500 feet would be more desirable.

Benefits of Inspection Shared by Many Growers

A feature well worthy of notice is the fact that the seed potato industry is so widely distributed, benefiting the many rather than the few. A study of the acreage of Certified Seed potatoes, and of the number of growers specializing in the business, reveals the following conditions: 70 per cent of the growers entered less than 5 acres; 20 per cent over 5 acres and under 10 acres; 9 per cent over 10 acres and less than 20 acres; and 1 per cent over 20 acres. The average acreage per person who applied for inspection was as follows: P.E.I., 5·7 acres; N.S., 2·5 acres; N.B., 8·1 acres; Que., 1·9 acres; Ont., 3·4 acres; Man., 6·0 acres; Sask., 8·1 acres; Alta., 3·5 acres; B.C., 2·4 acres; and the total for Canada was 5·2 acres.

Opinions have been expressed in certain quarters that the good results of certification might lead farmers to over-specialize in seed potato production, to the detriment of the crops essential to sound husbandry.

These returns show, without possibility of doubt, that, while the seed growers are appreciating each year to a greater extent the value of improved seed, they are not allowing the increased value of their potatoes to disturb the usual crop rotation.

Attitude Towards the Inspection Service

There has been an encouraging improvement in recent years in the attitude of the potato growers toward the inspection service. When the service was started, many individuals expressed their belief that the standards set for certification were altogether too high to be workable and were too rigidly enforced, whereas now the majority are just as anxious to see the strict enforcement of the standards. They realize that a few shipments below grade might easily mean the loss of valuable markets which have been built up on the very grades that were previously taken exception to.

There are also great changes in consumption, and as all are customers, these are of general interest. Consumers have become keen students of goods of all kinds, they are becoming more accustomed to standardization, and have definite ideas of what they wish in variety, quality, and price. A premium is paid for quality goods, and the poorer grades are hard to dispose of even at lower prices.

The demand for better table stock means that better seed must be planted, and the demand for better seed is stimulating the growers to still further effort in reducing the disease content of their crop, and in the selection of potatoes true to the type demanded under the variety name under which they are sold.

Evidence of the desire for improvement on the part of the seed potato growers is shown in the attendance at the many potato meetings and field days arranged during 1927, at which the District Inspectors were the principal speakers. We are indebted to many of the Agricultural Representatives for their efforts in organizing these meetings.

It is desired to cordially acknowledge the hearty co-operation extended by many other Divisions and Branch Experimental Farms, and by the Provincial Departments of Agriculture, toward the successful conduct of the work. Space has been allotted to us for our exhibits at many fairs, our press articles have been given wide distribution, invitations to address farmers' meetings have been very numerous, office space has been provided where desired, and car lots of certified seed have been distributed free to school children by the Provincial Departments. The Ontario Department of Agriculture, in addition, supplies the services of two field inspectors to assist in the field work in that province. In return our inspectors have endeavoured to co-operate wherever possible by judging field crops in their respective districts, judging vegetables at fall fairs, giving addresses at short course lectures, providing exhibits, etc.

We consider the year's operations have been the most successful since the work commenced, and we look forward to 1928 with the confidence that Canadian Certified Seed potatoes will maintain, and possibly surpass, the enviable records set up in the past for seed potatoes, " second to none."

INSPECTION STANDARD, 1927, FOR CERTIFIED SEED POTATOES

The following was the inspection standard for 1927 for Certified Seed potatoes:—

Field

	1st inspection per cent	2nd inspection per cent
Blackleg	3	1
Leaf roll, curly dwarf	2	1
Mosaic	2	1
Wilts	3	2
Foreign	1	½
Misses (if due to roguing)	2	—

Providing that in no case shall a total of more than 6 per cent disease be allowed on first inspection and more than 3 per cent on second inspection.

Tuber

Tags to be issued by inspector only on the express understanding that tubers must conform to the following standard when shipped:—

	Per cent
Wet rot (bacterial)	½
Late blight or dry rot	1
Scabs or *Rhizoctonia*—	
Slight	10
Severe	5
Necrosis, wilts, and internal discolorations, other than due to variety	5

Providing that in no case shall a total of more than 7 per cent be allowed except in the case of slight scab or *Rhizoctonia*.

Not more than 1 per cent of powdery scab allowed under scabs.

Not more than 2 per cent of the tubers to be malformed or spindly or badly damaged by sunburn, cuts, cracks, bruises, insects, etc.

No frost injury or foreign tubers shall be allowed.

Not more than 5 per cent by weight of the tubers shall be below three ounces or above twelve ounces.

At fall bin inspection, if more than 3 per cent late blight be found in bin, grower will not be allowed to grade for fall shipment but may hold for spring shipment, subject to reinspection.

Potatoes must not be sold as Certified Extra No. 1 seed potatoes unless they have the official Certification Tags attached to the containers.

This standard was found to be satisfactory in 1927. The question of " Misses " was the cause of some comment in the western districts, the claim being made that no fields would pass with that standard for " Misses." As a matter of fact only six fields were rejected on that account, one in Nova Scotia, three in Ontario, and two in Saskatchewan.

In actual practice it was found that many fields, which had a small percentage of disease showing, were left unrogued until after the inspector had made his first inspection. In view of the fact that for seed purposes we advocate continuous roguing of all diseased plants from fields, in order to prevent spread of disease in the fields, from the time the plants are quite small, it has been decided to delete " Misses " from the standard altogether on that account. We recommend the roguing, early and often, of all fields intended for seed purposes. If

more than a small percentage of disease appears in a field it is far better to withdraw it from certification altogether, and to sell the produce for table stock, than to attempt to keep it rogued clean of disease all through the season.

Official Certified Seed Potato Tags

Purchasers of certified seed should carefully note the tags on seed potatoes when they purchase them, to ensure their obtaining only fully certified seed. There are many imitation tags brought to our notice each year. Some resemble our tags fairy closely, even to the colour and stamp. Needless to say, these other potatoes are inferior to the fully certified potatoes for seed purposes.

The official Certified Seed potato tags are coloured yellow for the Irish Cobbler variety, green for the Green Mountain variety, and buff, manila tags are used for all other varieties.

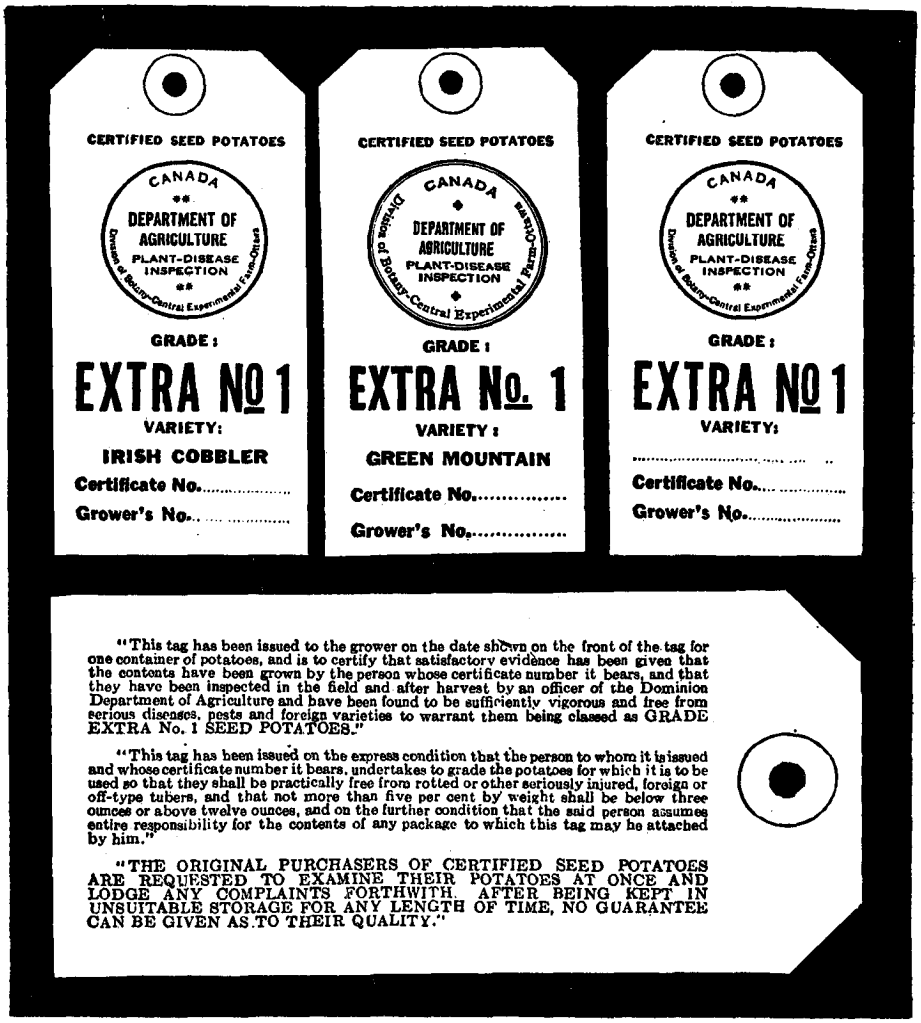

FIG. 58.—Each tag bears on its reverse side the lettering shown above.

INSPECTION WORK IN EACH PROVINCE

PRINCE EDWARD ISLAND.—Mr. S. G. Peppin, Senior Inspector, Laboratory of Plant Pathology, Charlottetown, P.E.I.

The production of certified seed potatoes in Prince Edward Island has become an established industry. Since the discovery in 1916, that certain varieties being grown here were practically disease-free, the fame of Island-grown seed potatoes has spread to many districts and countries which, up to that time, were unaware that such a place existed. The steady increase in the area under inspection since 1920 reached enormous proportions in the present season, as illustrated in the following table:—

TABLE 93

Year	Acres inspected	Acres passed
1920	886	523
1921	963	541
1922	2,367	2,155
1923	3,213	3,049
1924	9,004	8,339
1925	7,331	6,516
1926	9,275	7,597
1927	24,845	19,915

Several factors are responsible for the increased acreage inspected in 1927. (1) The more favourable prices prevailing for Certified Seed over Table or Commercial potatoes. (2) The lower prices obtaining in the larger Table Stock markets for the red and blue skinned varieties in comparison with white stock. (3) The steady and increasing demand for our Irish Cobbler and Green Mountain seed. (4) The changing demand from red to white stock of that large market in Cuba. (5) The greater yielding qualities of Certified Seed. (6) The better keeping qualities of white stock, which, generally speaking, was thoroughly sprayed to prevent blight rot. (7) The fact that the ultimate consumer insists on quality, and, while tastes may vary, the general demand to-day is for a white, dry, mealy tuber,

The farmer here, then, had to decide whether he would continue to grow potatoes for which there was a decreasing demand and lower prices, or to grow those which could be used for a dual purpose, either for seed or table use. While the former may have been easier to grow, in as much as disease control and inspection did not enter into the transaction, nevertheless we believe the average grower will be amply repaid for the extra effort put forth to keep diseases down to a minimum by the increased yields obtained from growing his potatoes under inspection, and endeavouring to have them come within the limits of the Government standards of certification.

Black leg was less prevalent than in 1926. The presence of mosaic in quite a number of Green Mountain fields was responsible for their rejection. Leaf roll, as usual, was rarely found, and then only in small amounts. Spindle tuber has not been reported in this province, a fact which draws many buyers from other seed producing centres to purchase their foundation stock here. The presence of foreign plants in the fields entered for inspection is gradually being reduced to an absolute minimum. Some wilt was found, particularly on low, wet soils, and those lacking humus.

To date, fourteen large steamers, with cargoes totalling 640,000 bushels, have been loaded at Charlottetown and Summerside by the Potato Growers' Association. Another 100,000 bushels are now being assembled at the winter port of Georgetown. In addition to this, sixty-five car-loads have gone for-

ward by rail. The principal markets for these shipments are in the states of Maine, New York (Long Island), New Jersey, Virginia, North Carolina, South Carolina, Georgia, and Florida.

While the Association handles the bulk of the seed shipped out of the province, there are individual dealers who forward large quantities either by schooner or rail.

The Inspection Service has had the busiest season since its inception, necessitating the continuous employment of from twenty to twenty-five trained inspectors for the field and tuber inspection periods. The fact that sales have increased with each succeeding year is sufficient evidence that the stock under inspection measures up as well as or better than that being produced elsewhere. The Inspection Service was greatly appreciated by all growers and dealers connected with the trade.

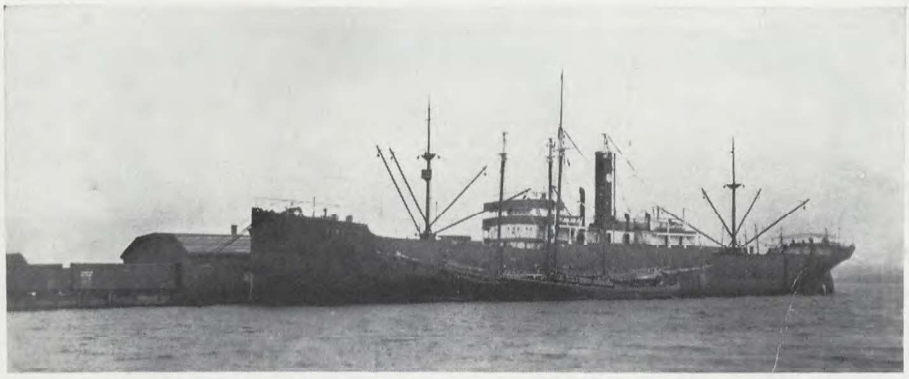

FIG. 59.—SS. *Bur* loading cargo of certified seed potatoes at Charlottetown, P.E.I., 29,591 sacks.

OTHER ACTIVITIES

Lectures on potato growing and potato disease control methods were given at the Agricultural Short Course, held in Charlottetown during the winter season. Special meetings called by the farmers in various districts were also addressed on the same subject.

The standing Field Crop Competition for potatoes is judged by the Inspection Staff. Notes are taken at the time of field and fall inspections and points allotted according to a special score card. Assistance was also given in judging at the School Fairs.

Demonstration plots are planted annually at the Experiment Station. These include potato diseases of all kinds, seed treatments, spraying, dusting, varietal tests, size of set, distance of planting, etc. The plots afford a splendid opportunity for the farmer to receive first-hand information on the diseases represented, and particularly in making correct diagnoses.

A special field day and picnic is a yearly event attended by hundreds of farmers on the occasion of the Potato Growers Association Annual Meeting. The morning is devoted to an inspection of the disease and variety test plots, and demonstrations are given in spraying and dusting. The afternoon is given over to a discussion of potato diseases and inspection methods in conjunction with the business meeting.

Field days also are held at the various Illustration Stations throughout the province, when a short talk is usually given on potato disease control measures.

Undoubtedly an era of prosperity has been introduced into this province which is directly traceable to the Certified Seed Potato Industry.

NOVA SCOTIA.—Mr. W. K. McCulloch, District Inspector, Laboratory of Plant Pathology, Kentville, N.S.

The summary of field inspection of potatoes reveals a decided increase of interest in Certified Seed Potatoes in Nova Scotia. The number of applications was 150 per cent greater in 1927 than in 1926, and there was 180 per cent greater acreage. Twenty per cent less of the fields passed inspection than in the previous year. This was due mainly to the use of non-certified seed. In many of the districts where the work was undertaken for the first time the farmers decided to have their own seed inspected. The result was that practically all such crops failed to pass, chiefly on account of a mixture of varieties.

FIG. 60.—Loading cargo of certified seed potatoes at Charlottetown, P.E.I. Note arrangement of staging and slings to prevent unnecessary bruising of tubers.

Of the 134 tuber inspection cards sent out, 129 were returned.

As in previous years the bulk of the shipments of Certified Seed potatoes was made to Bermuda, and comprised 27,000 bushels of Garnet Chili, 1,600 bushels of Irish Cobbler, and 340 bushels of Bliss Triumph. A sample shipment of 115 bushels of Bliss Triumph was sent to Cuba.

Other activities of the Inspection Service included addresses at potato growers' meetings, demonstrational work in tuber unit planting of seed plots, roguing of seed plots, and investigational work.

During the months of March and April a total of 24 meetings was attended, and addresses were given on Certified Seed potatoes. These meetings were distributed among the counties as follows: Annapolis 4, Antigonish 3, Colchester 1, Hants 1, Kings 10, Pictou 5.

At the Kings County Illustration Station on North Mountain seed potato development is being made a strong feature, and the inspection service has made itself responsible for the disease control of the crop. To this end half an acre of Green Mountain and half an acre of Irish Cobbler were planted in tuber units in 1927. Growers' seed plots in the counties of Colchester, Kings, and Pictou were inspected and rogued.

NEW BRUNSWICK.—Mr. C. H. Godwin, District Inspector, Laboratory of Plant Pathology, Fredericton, N.B.

The number of applicants for field inspection was greater than in 1926, which resulted in a larger acreage for inspection, showing an increase of 36·6 per cent.

The past season has shown that many of the growers are beginning to realize the value of the information communicated, and assistance rendered by the inspection service.

This is evidenced by the fact that growers, and dealers, are procuring more certified seed. Sprayers of the latest models can be noticed on many farms, and a number of dusters have been purchased during the season. Another noteworthy feature is that many growers have erected potato houses, affording better storage facilities, and accommodation for grading purposes. Roguing and thorough cultivation have become established practices in many districts, particularly where seed is grown for foundation stock.

The past season was unfavourable for the potato crop, owing to the unusually wet weather prevailing during the summer—a condition predisposing to late blight. This disease reached epidemic proportions in the latter part of August.

Weather conditions were ideal for mosaic symptom manifestation and blackleg development; the detection of the former during first inspection was, therefore, made easy. Leafroll was conspicuous at this time of the season. Later on, late blight appeared and increased rapidly throughout the southern and western part of the province. This resulted in a considerable loss in yield.

Tuber unit seed plots of the Bliss Triumph variety were established. One plot of seven acres was planted by hand, and another plot of the same size was planted by machinery. A number of smaller plots, consisting of a few hundred hills up to one-quarter acre in size, were also started from tuber-unit, indexed stock obtained from Maine. All of these plots, together with the larger fields of Green Mountains which are maintained as seed plots, were given attention by the inspection staff. In this connection assistance was given in roguing a number of times, and selecting seed for future seed plots.

There is a slight increase in the amount of each disease recorded for 1927 over 1926, for both total fields inspected and total fields passed. The greatest amount of disease occurred in fields planted with stock which failed to pass the second inspection the previous season. These growers neglected to make the explanation on the application forms that they were using such stock for seed. This information was, however, secured later by the inspectors when performing first field inspection.

An opportunity was afforded to complete the tuber inspection during the fall months. From the reports of the inspectors, the percentage of diseases remains practically the same as the preceding year, with the exception of late blight rot, which showed an average of 4·2 per cent. Other rots were in evidence, but of insignificant percentages. Scab and *Rhizoctonia* averaged 1·1 and 3·1 per cent, respectively.

Yield was reduced by unfavourable weather conditions and the effects of late blight, which resulted in a loss estimated at 100,000 bushels. Total production for the year was approximately 370,000 bushels, including all varieties. The Bliss Triumph variety yield was well over the average, particularly in the seed plots.

The production of each variety, and the average yield per acre are as follows:—

TABLE 94

Variety	Total production in bushels	Yield per acre in bushels
Green Mountain	211,939	200
Irish Cobbler	141,309	230
Spaulding Rose	2,255	330
Bliss Triumph	11,892	340
Netted Gem	1,650	330

The movement of seed potatoes from the province showed an increase over last year. Unfortunately, no record is kept of the destination of seed shipped untagged, which makes it impossible to get information about them. During 1927, the amount of untagged seed moved to various markets in the Atlantic and New England States was approximately 125,000 bushels, including all varieties; 70,000 bushels of this amount moved into Maine during the fall months. There is, also, an increase of 15,000 bushels in the amount of tagged seed exported.

CUBAN SHIPMENTS

An increase in the Cuban tariff, which became effective on December 1, caused a large amount of potatoes to be exported during October and November. After the 1st of December, a very small amount, compared with the two previous months, was shipped to Cuba.

Total number of packages and amount in bushels for 1927, are as follows:—

Packages	399,323
Bushels	1,052,122

Approximately 4,000 health certificates were used in connection with the shipments.

OTHER ACTIVITIES

During the month of August a field day was held, which was attended by potato buyers from Maine, Cuba, and this province. A series of lectures was given to the students of the New Brunswick Provincial Agricultural School on the merits of Certified Seed potatoes, and methods to be followed for the best production of potatoes intended for seed purposes. A lecture was given before the members of the New Brunswick Seed Growers' Association on standards for certification and grading methods. Assistance was given by the whole inspectional staff to the Provincial Department of Agriculture in the matter of judging fields entered in the Provincial Field Crop Competition.

During the growing season, buyers from a number of states, and Cuba, were conducted through the various parts of the province where Certified Seed is grown.

Seed plots maintained by several growers throughout the province were kept under close observation, and every assistance possible was rendered these growers in the matter of properly conducting these seed plots and securing seed for future seed plots. Many inquiries were received from potato buyers in the United States, Cuba, and Bermuda, for Certified Seed, and in each and every case all the information possible was communicated to these growers as to the place where the best seed could be obtained.

QUEBEC—Mr. B. Baribeau, District Inspector, Laboratory of Plant Pathology, Ste. Anne de la Pocatière, Que.

A brief outline of the potato crop improvement work in Quebec during the past few years is given, to show that much greater progress is now being made each year than formerly.

Up to 1924 a large acreage of potatoes was entered each year for inspection, with a view to certification. Due to mixed varieties, disease, etc., only a very small percentage (approximately 25 per cent) ever succeeded in passing.

This condition has been impressed upon the seed growers, and we have encouraged many of them to dispose of their old mixed stocks entirely, and to plant only improved certified seed. Other growers, who had more promising material, were advised to select choice seed from their crop, to plant it out in seed plots isolated from their main fields, and so improve their seed stocks for the following season's planting. Table 95 shows the comparative results obtained from following these recommendations.

TABLE 95

Year	Number of fields inspected	Number of acres inspected	Number of fields passed	Number of acres passed	Percentage of fields passed	Percentage of acres passed
		acres		acres	%	%
1924	530	1,350	*172*	351	32·45	*26*
1927	308	590	*261*	384	65·6	*65*

The increase in the number of fields passed is entirely attributed to the more general use of certified seed in the fields entered for inspection.

Green Mountain and Irish Cobblers are in demand in the larger consuming centers, therefore a special effort was made to improve these varieties by special tuber unit plot work, and to increase the acreage planted to these varieties. In 1927, over 500 acres of the 590 acres entered for inspection were Green Mountains and Irish Cobblers.

There were for disposal in Quebec province from the 1927 crop approximately 20,000 bushels of Green Mountains, and 3,400 bushels of Irish Cobblers. Approximately 5,000 bushels were sold in the fall, at an average price of $1.95 per 90-pound bag, and disposed of in the province of Quebec. Table stock potatoes at the same shipping dates sold at an average of 90 cents per bag. The improved type of Certified Green Mountains grown in the province is apparent in the fact that most of the prizes awarded, at the Toronto Royal Winter Fair in 1927, for Green Mountains, were awarded to Quebec grown stock.

In Bonaventure county during the past season, there were 22 seed plots of certified seed entered for inspection, which gave an average yield of 270·1 bushels per acre; this makes available approximately 4,000 bushels of seed for the improvement of the 1928 crop in that district.

In the parish of St-André, Kamouraska county, 19 growers were organized, and each planted 3 bushels of certified Green Mountains. These plots gave an average return of 316 bushels per acre. In some cases the yield obtained was 66 per cent above that obtained from grower's own seed.

In addition to the inspection work, variety test plot work was started in 1927 at our Laboratory of Plant Pathology at Ste. Anne de la Pocatière, to

improve certain varieties which were submitted by growers as being most suited to their condition. Many varieties were found to be wrongly named, others very poor yielders. This work will be continued in 1928.

The inspection staff of this Division working on seed potato inspections in Quebec Province consists of one District Inspector, full time, and three temporary inspectors employed for varying periods of three to six months.

Mr. B. Baribeau, in addition to supervising the inspection work, has co-operated with the Provincial Department of Agricultural in every possible way, by giving lectures at the various agricultural Short Courses, and Truck Crop growers' meetings, judging potatoes at the Provincial Seed and county fairs, giving seed treatment demonstrations on farms, inspecting fields and plots of the Illustration Station for Provincial Field Husbandry and Horticultural Departments, attending potato field days, lecturing at various agricultural meetings put on by the Agricultural Representatives, local co-operative societies, and United Farmers, and judging collections of plant disease exhibits at the Agricultural College. In addition to this, five press articles were published on "Certified Seed Potato Production," which reached practically every farmer of the province; and exhibits showing plant diseases were set up at many local fairs.

We cordially acknowledge here the very valuable co-operation of many Provincial Officials of the Department of Agriculture, more especially of Messrs. M. J. H. Lavoie, N. Antonio Mathieu, and the Agricultural Representatives.

ONTARIO.—Mr. O. W. Lachaine, District Inspector, c/o Ontario Agricultural College, Guelph.

There was a considerable increase in the acreage entered in 1927 over 1926, and it is worthy of note that 8·7 per cent more fields passed inspection, due to the use of better seed.

Interest in the certification work is quite keen, and the fact that the bulk of the 1927 crop of Ontario-grown Certified Seed was sold before November 1, at good prices, shows that it is in demand, and gives every satisfaction.

Due to a severe frost in August, Northern Ontario growers could not supply the demand from Colorado, Minneapolis, and Chicago, for Certified Seed. Most of the seed was sold within the province. Several car lots of Rurals went to Pennsylvania, U.S.A., from Alliston.

The Provincial Department of Agriculture purchased four carlots of Certified Seed for distribution to the school children, through the Agricultural Representatives Branch, for seed plots and School Fair work.

The greatest loss in grading for certification was due to *Rhizoctonia* on the tubers.

Potato "Field Days" were arranged in several districts; also lectures on potato certification work at growers' meetings, in the more important potato districts. A series of lectures was given in January and February at the Provincial Short Courses throughout the province.

Exhibits of potatoes showing specimens, diseases, types, etc., were set up at the Toronto, London, and Lindsay Fall Fairs. Inspectors have, in addition to potato inspection work, acted as judges in the field crop competitions, and as potato judges at county and winter fairs.

We are glad to acknowledge the hearty co-operation of the many provincial officials of the Department of Agriculture, more especially of Professors A. H. MacLennan, R. S. Duncan, F. C. Hart, and the Agricultural Representatives, who have consistently supported this work in Ontario.

MANITOBA, SASKATCHEWAN, ALBERTA

District headquarters at the Dominion Laboratory, Experimental Farm, Indian Head, Sask.

Messrs. J. W. Scannell, J. W. Marritt, District Inspectors.

The potato inspection work in the three Prairie Provinces is divided between two district inspectors, formerly with headquarters at the Dominion Laboratory of Plant Pathology, Saskatoon, Sask. Early in 1927 it was found necessary to transfer the potato inspection work from this laboratory, as all available floor space was required for research work in grain diseases. District headquarters are now established at Indian Head, Sask.

The former district inspector for Alberta, Mr. H. S. MacLeod, was transferred in July to British Columbia, leaving Mr. J. W. Scannell in charge of the work in the three Prairie Provinces until November, when he was relieved by Mr. J. W. Marritt, the newly appointed district inspector for Alberta.

Over 800 acres were entered for inspection with a view to certification, of which only 238 acres passed the two field inspections. All available Certified Seed in Manitoba and Saskatchewan was readily disposed of, and, in addition, several car lots were purchased by the trade from other provinces. This points to increased plantings of better quality seed for 1928. Alberta growers had a small surplus of Russet Burbanks.

Some small shipments of the Sharples Strain of Bliss Triumphs were imported by growers in Alberta, with a view to testing this variety for western conditions, the main object being to develop an export trade to the Southern States. Some lots did exceedingly well, one lot in particular, grown at the Dominion Experimental Farm at Indian Head, yielded at the rate of 400 bushels to the acre on a plot seven-tenths of an acre in size, despite the fact that the tops were hailed down badly in July. Samples of seed from these seed plots have been sent south to Louisiana to be grown in test plots with potatoes from other districts. Should this seed be found to be superior to the others, it will likely open up a market there for western grown Certified Seed.

A "strain test" plot of the Certified Seed produced in the three Prairie Provinces, was laid down at Indian Head under the direction of the district inspector. Samples sent in for test were grown side by side. A mimeographed report on the results was sent to all who submitted samples for test. A number of varieties were also collected for varietal studies, and a potato disease nursery was maintained for educational purposes.

An experiment on seed treatment for *Rhizoctonia* and common scab was carried out under the direction of Dr. Sanford. The results of this experiment were negative, but it is hoped that it may be carried on another year.

At the Provincial Seed Fairs the inspectors were in demand as judges for the potato exhibits, and a series of addresses was given on the value of Certified Seed.

BRITISH COLUMBIA.—Mr. H. S. MacLeod, District Inspector, Parliament Buildings, Victoria, B.C.

The seed potato certification work has been carried on co-operatively between the Dominion and Provincial Departments of Agriculture since 1924, with Mr. Cecil Tice, the Provincial Agronomist, as District Inspector in charge. Owing to the extension of his work in other lines, Mr. Tice relinquished the potato work in the spring of 1927 to Mr. H. S. MacLeod, the Dominion District Inspector, who was transferred from Alberta to take over the supervision of the seed potato certification in British Columbia. To maintain the close co-operation which has existed between both departments, the headquarters for the inspection service in British Columbia continues at the office of the Provincial Agronomist at Victoria, B.C., with Mr. H. S. MacLeod in charge of inspections.

In addition to the permanent District Inspector, there were four temporary inspectors employed by the Dominion for periods varying from three to six months. Two inspectors were provided by the Provincial Department, one full time, and one part time, and, in addition, the necessary clerical and stenographic assistance was made available to us.

The acreage which passed field inspections was below that passed last year. The chief cause for rejections was mosaic. In many cases the high percentage of mosaic found in the crop was directly traceable to planting adjacent to fields which contained a high percentage of mosaic the previous year. In spite of the decrease in acreage passed, it is believed the quantity of Certified Seed sold will much exceed that of the previous year.

Several inquiries have been received for Bliss Triumphs, and Irish Cobblers, from the western United States' growers, and the possibilities of developing an export market appear good, providing high quality seed is produced. Small quantities of the best seed obtainable of these two varieties have been procured, to be used as foundation stock. Bliss Triumphs of the Sharples strain, and Prince Edward Island Irish Cobblers, will be planted this coming spring by progressive growers interested in securing this export trade.

We received several invitations to address potato growers on crop improvement work, at meetings put on during the winter months. It is encouraging to see the interest displayed, and we hope for a banner season in 1928.

We take pleasure in acknowledging the hearty co-operation of the many Provincial Officials, and the many growers who have consistently supported the work during the trying season of 1927.

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