DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF BOTANY

REPORT OF THE DOMINION BOTANIST

H. T. GÜSSOW

FOR THE YEAR 1928

A potato field day affords a good opportunity for farmers to become familiar with the causes and control of many diseases of the potato crop. (Photo by W. M. Croskery)

Printed by Authority of the Hon. W. R. Motherwell, Minister of Agriculture,
Ottawa, 1929

TABLE OF CONTENTS

SECTION I

General and Economic Botany; Diseases of Ornamentals, Systematic Mycology, Surveys, and Miscellanea

SECTION II

Forest Pathology and Related Subjects

SECTION III

Investigations of the Diseases of Cereals and Grasses

SECTION III—*Concluded*

SECTION IV

Investigations of the Diseases of Fruits and Vegetables

SECTION V

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

SECTION V—*Concluded*

SECTION I

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

GENERAL AND ECONOMIC BOTANY

CENTRAL EXPERIMENTAL FARM, OTTAWA

(J. Adams, Botanist)

During the year there were the usual inquiries relating to a number of medicinal plants such as ginseng, peppermint, seneca snake root, golden seal, liquorice root, rhubarb root, chamomile, etc. Other correspondence dealt with such plants as anise, lavender, mustard, chicory, tarragon, and castor oil bean. Considerable interest was manifested in the propagation of foods suitable for muskrats, such as cat-tail, wild rice, etc.

A number of requests were received for suitable literature dealing with the wild flowers of Canada as a whole, or of some particular province, from persons interested in the study of the native flora.

The Annual Exchange List of Seeds, collected in the year 1927, containing the names of 1,336 species and varieties, was sent to 120 Botanical Gardens and Botanical Institutions.

During the year 1,985 packets of seeds were received from foreign botanical gardens. Among these were 155 packets of various species of *Colchicum, Crocus, Lilium,* and *Tulipa*, for the use of the Horticultural Division. Three cuttings of species of willow were received from British Columbia, and 43 rooted specimens of various shrubs from the Morton Arboretum, Lisle, Ill., U.S.A. In exchange 5,548 packets of seeds were sent out and 148 rooted plants and cuttings.

There were several requests for seeds of sugar maple; in response to one of these a package of small trees of this species was despatched to the island of Grenada, British West Indies.

In response to a request from the Experimental Station for Rice Culture, Vercelli, Italy, a sample of wild rice was sent to that address for the purpose of determining whether it was possible to hybridize it with the cultivated rice of commerce.

A clearer idea of the extent to which the exchange of seeds with foreign countries is carried on will be gained from the following figures. Included in the above total were 665 packets despatched to various parts of Canada, 810 to the United States, 11 to Mexico, 14 to Bermuda, and 42 to Uruguay.

Among European countries 7 packets were sent to the Irish Free State, 7 to Wales, 133 to England, 103 to Norway, 127 to Sweden, 9 to Denmark, 32 to Finland, 18 to Esthonia, 22 to Latvia, 117 to Lithuania, 156 to Holland, 13 to Belgium, 686 to France, 59 to Spain, 48 to Portugal, 111 to Germany, 227 to Switzerland, 285 to Poland, 41 to Hungary, 78 to Austria, 121 to Czechoslovakia, 45 to Jugoslavia, 66 to Bulgaria, and 128 to Roumania. To the various states in Europe and Asia of which Russia (U.S.S.R.) is composed 940 packets were sent, while 56 were sent to Japan.

Among African countries 116 packets were sent to Tunisia and 189 to Egypt.

To the state of Victoria, Australia, 28 packets were sent.

With reference to the sample of hill rice received from Madagascar some of the seeds were sown indoors in a large flower pot on January 19. They made a good growth but were attacked by red spider which stopped the growth for a time. They were planted out in the open after the danger from frost was over, and eventually recovered from the effects of the spider attack and made a good growth subsequently, but did not come into flower.

On June 8, 1928, a larger sample of the seed was sown out of doors on three plots, A, B, C. Plot A was moderately dry, plot B was of the consistency of mud, while there was a little water on the surface of C. On September 5, 1928, the plants on plot A were about a foot high, while those on B were about 18 inches in height. The smallest plants were those on plot C. All the plants were healthy looking but none of them produced flowers. Apparently the growing season at Ottawa is not sufficiently long for this species.

Considerable progress was made in classifying and arranging in bottles the collection of seeds received from foreign botanical gardens.

A "Bibliography of Canadian Plant Geography," covering the period to the end of the year 1900 and containing nearly a thousand entries, was published by the University of Toronto Press as No. 36, Part 2 of Transactions of the Royal Canadian Institute, Toronto, Vol. XVI, 1928. The remaining part, covering the next twenty years and containing 1,400 entries, is at present in the hands of the same publishers and will probably appear during the year 1929. With the exception of the work of Professor Penhallow, which was along somewhat different lines, there has been no comprehensive survey of the literature on this subject available for Canadian botanists. It was commenced during a visit to the libraries at Washington and Philadelphia in the year 1914, and has been added to since that date from time to time.

That this publication has been much appreciated by fellow workers is evident from some of the letters received in acknowledgment. One botanist in the United States who inquired where a copy could be purchased wrote as follows:

"I have just received the above, and I wish to thank you very much for it. Such a work apparently is a thank you job, but it is appreciated by every botanical worker for all time to come. It appears to me to be very complete and that is what makes it the more valuable. Too many writers do not keep in touch with the literature already extant. I note it is to be continued and I hope I may be favoured with the remainder."

AGRICULTURAL BOTANY AND WEED STUDIES

CENTRAL EXPERIMENTAL FARM, OTTAWA

(H. Groh, Botanist)

The weed investigations, commenced on present lines in 1922, and planned to cover survey, life history, and control studies, were developed in several directions during the year. As heretofore, they have been confined to the time that can be spared by one officer from other duties of a more general botanical character. Consequently it has not yet been possible to carry forward such a systematic program of attack on weed problems as is to be desired, convenience or the exigencies of the occasion prompting much of what is being done. It is hoped that provision may soon be made so that not only the full time of one officer, but that of several, may be employed on some of the more urgent phases of weed study.

Weed Survey

Early in the year appointment to a committee to make a special study of certain orchard problems in Nova Scotia determined largely the field work that could be undertaken, and delayed any further extension westward of the weed survey previously carried as far as Sault Ste. Marie, Ont. Instead, the investigations in connection with the orchard problems in Nova Scotia (to be reported later elsewhere) were made to contribute to aspects of the weed survey project, which could not ordinarily receive so much attention.

As one of the fruits of the month's stay in Nova Scotia, the Cornwallis Valley and contiguous territory in Kings county received a closer inspection as regards weeds than has been given to any similar area previously. No less than

250 species of weedy and poisonous plants were recorded from orchards or from neighbouring fields, from woods, countryside, and town. These are roughly one quarter of what are to be found altogether in the eastern half of Canada, and were still being added to at the end of the period. Just what should be regarded as weeds from among native plants and fugitives from abroad and from cultivation, when only of minor or local concern, is often a debatable question, determinable only on the basis of whether or not the plants maintain themselves strongly under man-made conditions. Certainly not all weeds in this sense need to be regarded as noxious; but, if intruding at all, or if harmful to man or his animals, they may well be included as weeds.

Quite satisfactory determinations of prevalence were obtained from notes taken at some twenty stations throughout the orchard belt. Fifty of the principal orchard weeds of the district are here listed in this order of prevalence, which proves to be in marked contrast to that from some other localities with other than orchard conditions. In separate columns are given ratings for prevalence obtained in similar manner in two other areas. It will be noticed that several of these Kings County weeds do not appear at all in the other lists; others (marked by a query) were not recorded as weeds; and the remainder differ widely in prevalence, being sometimes far down in their respective lists. No stronger argument than this is needed, surely, to emphasize the importance of dealing with the weed problems of different regions on their own merits, and in the light of careful local surveys.

TABLE I.—ORDER OF PREVALENCE OF WEEDS

Kings County, N.S., orchards compared with Prince Edward Island and Lake St. John district, Que.

—	Kings County, N.S. 1928	Prince Edward Island 1926	Lake St. John district, Que., 1927
Couch grass—*Agropyron repens*	1	20	17
Wild radish—*Raphanus Raphanistrum*	2	64	....
Creeping buttercup—*Ranunculus repens*	3	55	109
Sheep sorrel—*Rumex Acetosella*	4	22	51
Kentucky blue grass—*Poa pratenzis*	5	84	52
Golden rod—*Solidago* spp.	6	16	12
Hemp nettle—*Galeopsis Tetrahit*	7	44	26
Bitter dock—*Rumex obtusifolius*	8	76	134
Common chickweed—*Stellaria media*	9	59	22
Grass-leaved stitchwort—*Stellaria graminea*	10	35	94
Common dandelion—*Taraxacum officinale*	11	21	1
Hedge bindweed—*Convolvulus sepium*	12	65	107
Canada thistle—*Cirsium arvense*	13	5	2
Dogbane—*Apocynum androsaemifolium*	14	83	44
Common burdock—*Arctium minus*	15	36	27
Corn spurrey—*Spergula arvensis*	16	43	67
Curled dock—*Rumex crispus*	17	17	28
King devil—*Hieracium floribundum*	18	52	....
Ox-eye daisy—*Chrysanthemum Leucanthemum*	19	6	29
Wood rush—*Luzula campestris*	20	66	135
Sweet vernal grass—*Anthoxanthum odoratum*	21	131	....
Common cinquefoil—*Potentilla canadensis*	22	158	....
Ground ivy—*Nepeta hederacea*	23	112	82
Perennial sow thistle—*Sonchus arvensis*	24	30	36
Common horsetail—*Equisetum arvense*	25	46	13
Common yarrow—*Achillea Millefolium*	26	1	3
Low spear grass—*Poa annua*	27	60	53
Evening primrose—*Oenothera* sp.	28	31	18
White clover—*Trifolium repens*	29	7	19
White sweet clover—*Melilotus alba*	30	105	45
Wild strawberry—*Fragaria* sp.	31	?	?
Pearly everlasting—*Anaphalis margaritacea*	32	2	4
Caraway—*Carum Carvi*	33	68	75
Wild carrot—*Daucus Carota*	34	....	....
Common mugwort—*Artemisia vulgaris*	35	132	5
Floating foxtail grass—*Alopecurus geniculatus*	36	....	....

TABLE I.—ORDER OF PREVALENCE OF WEEDS—*Concluded*

—	Kings County, N.S. 1928	Prince Edward Island 1926	Lake St. John district Que., 1927
Tufted vetch—*Vicia Cracca*	37	12	6
Daisy fleabane—*Erigeron ramosus*	38	13	68
Canadian blue grass—*Poa compressa*	39	45	37
Rugel's plantain—*Plantago Rugelii*	40	?	108
Timothy—*Phleum pratense*	41	15	7
Wormseed mustard—*Erysimum cheiranthoides*	42	100	46
Common mouse-ear chickweed—*Cerastium vulgatum*	43	29	54
Thyme-leaved speedwell—*Veronica serpyllifolia*	44	....	136
St. John's wort—*Hypericum perforatum*	45	69	137
Red osier dogwood—*Cornus stolonifera*	46	?	?
Scentless chamomile—*Matricaria inodora*	47	40	....
Smartweed—*Polygonum Hydropiper*	48	63	30
Lady's thumb—*Polygonum Persicaria*	49	53	38
Slender rush—*Juncus tenuis*	50	110	?

Field surveys, such as these, may easily collect data more rapidly than they can be utilized afterwards, and this is the situation now existing. The Maritime Province check list of some 600 weedy species at last report has been enlarged somewhat; and the files of place records, amounting to as many as 400 for some weeds, have been kept up to date. The same work for Quebec and Ontario data collected is still far in arrears. This is unfortunate, as important extensions of range, and even new records, remain unpublished because uncertain of being such until some progress has been made with compilation. Occasional notes, based on survey data, have been made public, however, during the year. Other finds of interest may be given brief reference here.

Small-flowered evening primrose (*Oenothera cruciata*) was collected at Brackley Beach, P.E.I., from field and lawn, in July, by Mr. Blythe Hurst, Sr. The nearest previously known occurrences of this species are in Maine and on Sable Island. It is a plant of sandy soils, in most respects resembling the common evening primrose.

A plant, identified as *Radicula amphibium*, a cruciferous species allied to horseradish, was collected in early bloom, in an orchard at Starr's Point, N.S., on June 21. It is an old world plant perhaps not really established here, and not included, at any rate, in American manuals.

A small colony of western perennial ragweed (*Ambrosia psilostachya*), found at South Berwick, N.S., extends the eastern range of this weed considerably.

Madia glomerata, one of the western tarweeds, was sent for identification from Trois Pistoles, Que., in September, by Mr. Mathias D'Amours. It was found growing in a hayfield, evidently established as a weed, and probably for the first time noticed in an eastern province.

Tickseed sunflower (*Bidens trichosperma*), a plant of adjacent States, and already reported in Ontario from Point Pelee, was sent to us from Thedford, just south of Lake Huron, by Mr. W. A. Dent.

Through the kindness of Prof. W. P. Fraser, University of Saskatchewan, and of Dr. S. E. Clarke, Agrostologist for range investigations in southern Alberta, plants of Russian knapweed (*Centaurea picris*) were received for the first time this year. Dr. Clarke's specimens were collected near Medicine Hat, Alta.; those sent by Prof. Fraser coming from Landis and Gull Lake, Sask. Although named in the regulations issued under the Seeds Act, this weed appears to have been previously found growing only in some of the western States, where it has attracted notice since 1920. The seed had been coming to America for some years—we first received it at this office in 1901, from Petrolea, Ont.—

and almost invariably it had been carried in Turkestan alfalfa seed, so much so indeed, that its presence was regarded as sufficient evidence of the south Russian origin of the alfalfa. According to Dr. F. T. Wahlen, Seed Branch, Ottawa, it is extremely unlikely that the weed would have reached this country through such channels since about 1922. That being so, it is to be expected that systematic search for it, beginning at the centres named above, will find it to be well entrenched already. It is a deep-rooting perennial that is considered in other places to require two years of careful fallow plowing to eradicate.

Through Prof. Fraser also, specimens were received, in September, from the Grenfell district in Saskatchewan, of a weed of grain fields, *Rapistrum perenne,* of European origin, which has not previously, to our knowledge, been reported in America. It has two-jointed pods resembling those of the American sea rocket (*Cakile*). The plant has biennial or perennial roots, and should be regarded as potentially another pest, until the contrary has been shown.

During 1928 the known distribution in the western provinces of a spurge, *Euphorbia virgata* (which has passed in the east as *E. Esula*), has been extended by a number of specimens received. This is another coarse, extensively creeping perennial.

Many other occurrences of interest came to light, either in the field, or in the course of identification of nearly 1,000 plant specimens submitted by correspondents. Records of these are made for the survey files, where they are available, whenever there is occasion to use them.

Specimens collected in field work, or prepared from some of the better material sent in for identification, added several hundred sheets to the herbarium, which is maintained for reference purposes, and as a depository for the evidence on which many important records are based. This herbarium is now at a strength of nearly 9,000 sheets of flowering plants and ferns and their allies. With the extensive National Herbarium also at Ottawa, the aim is to strengthen this Division's collections more particularly in plants affecting human welfare; but, in view of the numerous general collections every year coming here for naming, it continues to be necessary to be equipped for broader work. Even so there is frequent necessity to use the excellent facilities of the larger herbarium, which have been always freely at our disposal through the kindness of Dr. M. O. Malte, Chief Botanist, Canadian National Herbarium.

LIFE-HISTORY

Concurrently with the Nova Scotia surveys, phenological observations were made for the period May 26 to June 25 inclusive, and data secured on the flowering of over 125 species of plants growing about orchards. At least 30 of these were already in bloom at the earlier date. Many other plants were not yet blooming when the observations had to cease. In general it would appear that the native wild flowers are earlier in blooming than introduced plants (weeds); and from observations continued throughout the season, mostly at Ottawa, it is evident that it is chiefly these weeds, with their less perfect adjustment to our seasons, that go on blooming until stopped by frost. Comparatively few plants had yet matured seed by June 25, the dandelions, already seeding on May 26, being perhaps the first.

It was a matter of some interest to find the red-seeded dandelion sharing with the common dandelion in occupation of suitable ground in Nova Scotia, to an extent never noticed anywhere before. They were, moreover, seldom in competition; the less robust-looking, red-seeded species choosing the drier, thinner, and shorter-grassed turf as a rule, where the other did not thrive. A most striking instance of this unlikeness of habit appeared on the grounds of the Experimental Station at Kentville, where the main driveway, with an elevated knoll of thin, closely clipped grass on one side, and luxuriant, unmown grass opposite, marked almost complete segregation of the two species.

A somewhat different and curious illustration of mutual replacement of species, this time on a regional scale, is afforded by the predominance of wild radish over wild mustard in the greater part of the Maritime province area, and the complete reversal of the situation as one passes westward. The two weeds are so similar in general appearance and habit, as well as in economic importance in their respective strongholds, that they are seldom clearly distinguished. The belt of overlapping, somewhere in New Brunswick, must be studied further before an explanation can be hazarded.

The whole question of the ecological relationships of weeds, as regards habitat, association with other weeds, and with crops and pasture plants, is a most inviting field for research. Only incidentally could attention be given to such points, but occasionally, when an interesting association was encountered, the plant population of a small area was determined. Usually a couple of dozen species at the most, with one or a few forming the bulk of the herbage, formed the stand in such a plot. Even aggressive weeds were only dominant under certain conditions, and gave place to other aggressors under another set of conditions. This can be well illustrated by reference to one weed, unhappily familiar to everyone.

Couch grass (quack, twitch, etc.) is a pest of general distribution in Canada, which is especially prevalent in the Cornwallis Valley. Although so generally troublesome, at least two inhibiting factors were observed. In an orchard where fertilizer had been applied beneath the trees only, on evidently impoverished soil, remarkably distinct vegetation contrasts were shown up. Everywhere beyond the periphery of a tree couch grass was a very minor constituent of the grass and weed cover, while in the fertilized zone its vigour made it dominant over everything else. It is a greedy feeder that may survive but not thrive, where other weeds, (in this case creeping buttercup to a large extent), are well nourished.

The growth of couch grass, again, is inhibited by permanent sod, as contrasted with arable conditions. In a field where part of a ten-year-old sod had been broken up and reseeded to timothy, alsike, and red clover a year or two previously, couch grass had been completely superseded by sweet vernal grass and associated plants, but appeared in the hay stand about equally with any of the crop plants named. Its rejuvenation by the ploughing, and by the amount or kind of cultivation received, was clearly evident right up to the line, where, in the old sod, no proof of its survival could be seen. It is well known that couch grass tends to become "sod-bound" after its first luxuriant growth, the tangle of root-stocks becoming constantly more shallow and matted, and the herbage more "run to seed" each year. Advantage is often taken of this peculiarity, to plough no deeper than is necessary to upset the rooted layer, and then, with favouring dry weather, to work it out into the sun, instead of mixing it through a deep furrow, in which cultivation can do little but transplant it for more vigorous growth. That couch grass should derive a new lease of life from such essentials in crop production as tillage and fertility is perhaps unfortunate; but handled judiciously, intensive farming methods are still a better alternative from the standpoint of net returns than under-farming, with its merely partial relief from an inveterate foe.

Grassland Investigations

At the beginning of August, upon the request of the Superintendent of the Experimental Station at Fredericton, N.B., a few days were spent in botanical analysis of a series of pastures and grass plots at that station. With this initial survey as a basis for comparison, it is the intention to observe what changes can be brought about over a period of years in the composition of stands of herbage, under various lines of pasture management. At the present time brown top is the principal grass and constituent of all the stands, white clover is also abundant, moss covers much of the ground, and fall dandelion is, (at that time of summer at least), the predominant weed among more than 70 weeds and pasture plants noted. Moss appears to have increased under pasturage, and distinctly so under close cropping of the plots, as compared with untouched sod lying alongside. Conversely, the total number of species of plants in the stands has undergone a decrease. Instead of an average of 25 species, as in the wild sod, the close cropped plots of like area contained but 16 species. This difference may be due in part to other treatments received by the plots, but is believed to be due largely to the above factor. Among the plants practically eliminated from the plots are hemp nettle, smartweed, lady's thumb, common chickweed, alsike clover, and tufted vetch. Most of these are plants of upright growth, while the plants persisting strongly are generally more inclined to a low or rosette habit, which can better survive the repeated clippings which they receive.

Principally during the time spent in Nova Scotia, other examinations of stands in hay and pasture land were frequently made. Usually, in areas of a square rod taken for analysis, from 15 to 25 species of plants were found associated; and not only were the most of these weeds, but the dominant herbage was commonly something inferior like marsh foxtail (*Alopecurus*), sweet vernal grass (*Anthoxanthum*), wild oat-grass (*Danthonia*), wood rush (*Luzula*), sedge (*Carex*), once or twice Yorkshire fog (*Holcus*), and couch grass, which last may be good enough pasture but hardly to be recommended. There is undoubtedly urgent need for the taking of steps to reclaim such relatively unproductive land to the real carrying capacity of which it is capable, in this, as in other parts of the great, eastern, grass belt of America. More frequent breaking, re-seeding, manuring or top-dressing with fertilizer, and drainage are among the needs indicated in various situations, but, until some systematic study is made of the whole problem, it will be impossible to say what is the greatest present weakness in the handling of these oftentimes non-arable lands.

Western grazing lands, for some years already, have been receiving just such study as is required in the east. This year, as in past years, this Division has co-operated to the extent of making botanical analyses of samples of herbage submitted, and identifying collections of range plants.

EXAMINATION OF PLANT IMPORTATIONS

CENTRAL EXPERIMENTAL FARM, OTTAWA

(F. L. Drayton, Plant Pathologist)

During the past calendar year 827 shipments of nursery stock were intercepted at the ports of importation. Of these, 687 showed injuries from various causes other than insects, and were dealt with by the Division of Botany. As in previous years, bulbs and corms of ornamental plants constituted the largest proportion of the intercepted material. This year 2,819 samples were examined, an increase of 527 over those submitted in 1927.

Prior to September 1, 1928, all shipments of nursery stock from abroad, excepting the United States, were subject to inspection before being admitted. From that date, shipments from the United States also became subject to inspection.

The following table gives the various kinds of material examined and the number of samples of each:—

TABLE 2.—NURSERY STOCK EXAMINED AT PORTS OF IMPORTATION

Name of plant	Number of samples	Name of plant	Number of samples
Aspidistra elatior Blume	4	*Iris* spp. (bulbous)	29
Azalea spp	4	*Ixia* sp	2
Begonia spp. (tuberous)	10	*Lilium* spp	9
Bulbocodium vernum L	1	*Muscari botryoides* Mill. (grape hyacinth)	3
Chionodoxa Luciliae Boiss. (Glory of-the-snow)	3	*Narcissus* spp	61
Colchicum autumnale L	1	*Paeonia* spp. (peony)	5
Crocus spp	231	*Ranunculus* sp	1
Dahlia spp	3	*Rhododendron* spp	3
Freesia refracta Klatt	21	*Rosa* sp	1
Fritillaria imperialis L	1	*Scilla* spp	3
Galanthus nivalis L. (snowdrop)	8	*Sinningia speciosa* Benth. et Hook. (Gloxinia)	6
Galtonia candicans Decne. (Summer-hyacinth)	1	*Tigridia Pavonia* Ker	2
Gladiolus spp. (Summer flowering)	2,076	*Tritonia crocosmaeflora* Lem. (Montbretia)	21
Gladiolus nanus types (for forcing)	34	*Tulipa* spp. (tulip)	238
Hyacinthus orientalis L	18	Miscellaneous shrubs and trees	12
Iris spp. (rhizomatous)	4	Miscellaneous vegetables	3

As in previous years, the gladioli figured prominently in the amount of diseased material found. In small shipments we granted permission for the removal of all diseased corms and allowed the healthy ones to proceed to destination. In large shipments, however, some 148 variety lots consisting of 245,000 corms had to be refused admission and were either burned, or returned at the exporter's expense.

Visit to Holland

As indicated in the foregoing section, and in sections on the same subject in the Reports of the Dominion Botanist for 1926 and 1927, it has been necessary to refuse admission to a large number of shipments of gladiolus corms. This action had become necessary because, on investigation, it was found that the diseases which were present in high percentages in the imported stock were potentially limiting factors in the successful growing of this plant in Canada, either in commercial culture or in home gardens.

Holland, among other countries, sending the largest proportion of gladiolus corms to Canada, became concerned about the losses sustained through the refusal of admission to these shipments, and took up the matter with the Destructive Insect and Pest Act Advisory Board through their Consul General in Montreal. As an outcome of suggestions made to this representative by the Dominion Botanist an invitation was subsequently received from the Netherlands Government to send a representative of the Board to Holland, at their expense, to spend the summer there to study conditions of bulb culture and to render every possible assistance. The author was instructed to undertake this visit, and left Ottawa on May 15, returning on October 1.

Every possible courtesy was extended to me during this visit. We desire especially to acknowledge our indebtedness to Professor Dr. E. van Slogteren and his staff at the Bulb Research Laboratory at Lisse, who generously provided laboratory accommodation and extended every possible facility for a thorough and instructive survey of conditions. Our thanks are also due to Ir. N. van Poeteren, Director of the Official Phytopathological Service of Holland, and his staff, and to the many growers and exporters, with whom contact was established, for their sympathetic co-operation and personal interest. Most instructive and valuable information has been secured during this visit, a detailed account of which has been published for the benefit of Canadian growers in "Scientific Agriculture", Vol. 9, No. 8, 1929.

The Yellow Disease of Hyacinths

Commercial bulb growers of British Columbia, florists, and amateurs have made repeated requests to the Division for information on this destructive disease, and pamphlet No. 104, New Series, has been prepared during the year in order to meet this demand, describing in detail the symptoms and methods of dissemination of the disease, the degrees of resistance and susceptibility exhibited by certain varieties, and measures recommended for its control. Certain points of more technical interest in connection with this disease follow herewith.

The causal organism was first described by J. H. Wakker in 1883 and named *Bacterium Hyacinthi*. In 1901 the name was changed to *Pseudomonas Hyacinthi* by E. F. Smith. It is a bright yellow, rod-shaped organism with rounded ends, measuring ·8 to 1·2 by ·4 to ·6μ, actively motile by means of one polar flagellum, and not spore producing. E. F. Smith states that the minimum temperature for its growth is 4° C., an optimum of 28° to 30° C., a maximum of 34° to 35° C., and a thermal death point of 47·5° C. Dr. J. J. Beijer, of the Bulb Research Laboratory of Lisse, Holland, gave me the interesting information that this organism is fully motile when present in leaf tissue, non-motile after it enters the bulb, only slightly motile in agar cultures, and actively so in young bouillon cultures.

Since Wakker's work, many investigators have confirmed his work as to the pathogenicity of this organism. The period of incubation varies from 3 to 30 days depending upon the susceptibility of the variety inoculated, and environmental conditions. The comparatively slow development of the parasite in the host plant, which has been observed, is attributed to the feeble action of the organism on cellulose and starch, its sensitiveness to light, and its strict aerobism.

A serious outbreak of this disease occurred in Holland during the years 1923 to 1927, which resulted in great loss. On my visit there in 1928, I made enquiries as to the possible conditions, which had led up to the development of this outbreak. These proved to be interesting and instructive, and are herewith recorded.

Dr. J. H. Wakker, working in Holland, published five papers on this disease between 1883 and 1888; at this time serious losses were being incurred through this disease in that country. From this time up to the time of the 1923-1927 outbreak, no serious, widespread infections had occurred, although the records show that in the intervening years many varieties were discarded by the growers, apparently because of their extreme susceptibility to this disease. I was informed that during this period there was a partial neglect by the growers in the vigilance necessary for detecting diseased plants, and the carrying out of measures for localizing attacks. At the same time, the increase in the value of hyacinth bulbs during the latter part of this period, induced the growers to make more frequent use of the scoring method of propagation, as opposed to scooping, and to utilize larger quantities of nitrogenous fertilizers, so as to shorten the time necessary for obtaining marketable bulbs from propagation material. These two factors resulted in the spread of the disease and greater susceptibility of the plants, respectively.

This cumulative increase in the amount of disease present in the hyacinth stocks during these years, was precipitated into an outbreak of epidemic proportions by a prolonged period of cold, rain, and fog in May, 1923; and the unusual absence of warmth and sunshine in the months of May and June of the next two years maintained this state of affairs. Conditions of high relative humidity when the plants are making rapid leaf growth provide ideal conditions for the spread of the causal organism and for the infection and progress of the disease in the plants.

An energetic research program was undertaken by Dr. E. van Slogteren and his staff at the Bulb Research Laboratory at Lisse, and, as a result of their recommendations and the faithful execution of them by the growers, accompanied by favourable weather conditions, the amount of disease has been very greatly reduced. In fact, very little was seen during my numerous visits to fields and bulb houses.

Miscellaneous Notes on Bulb Diseases

"IRIS "BULB SCAB" OR "INK DISEASE"

This disease has been responsible for the almost entire discontinuance of the commercial culture of the bulbs of *Iris reticulata* Bieb. in England and Holland. Of all the growers' establishments visited in Holland, only one of them was found to be growing these bulbs to any extent. In this lot, as I saw them in the bulb house, about 50 per cent had been rendered worthless, or almost so, from this disease, even though the bulbs had been soaked in a dilute formalin solution before being planted.

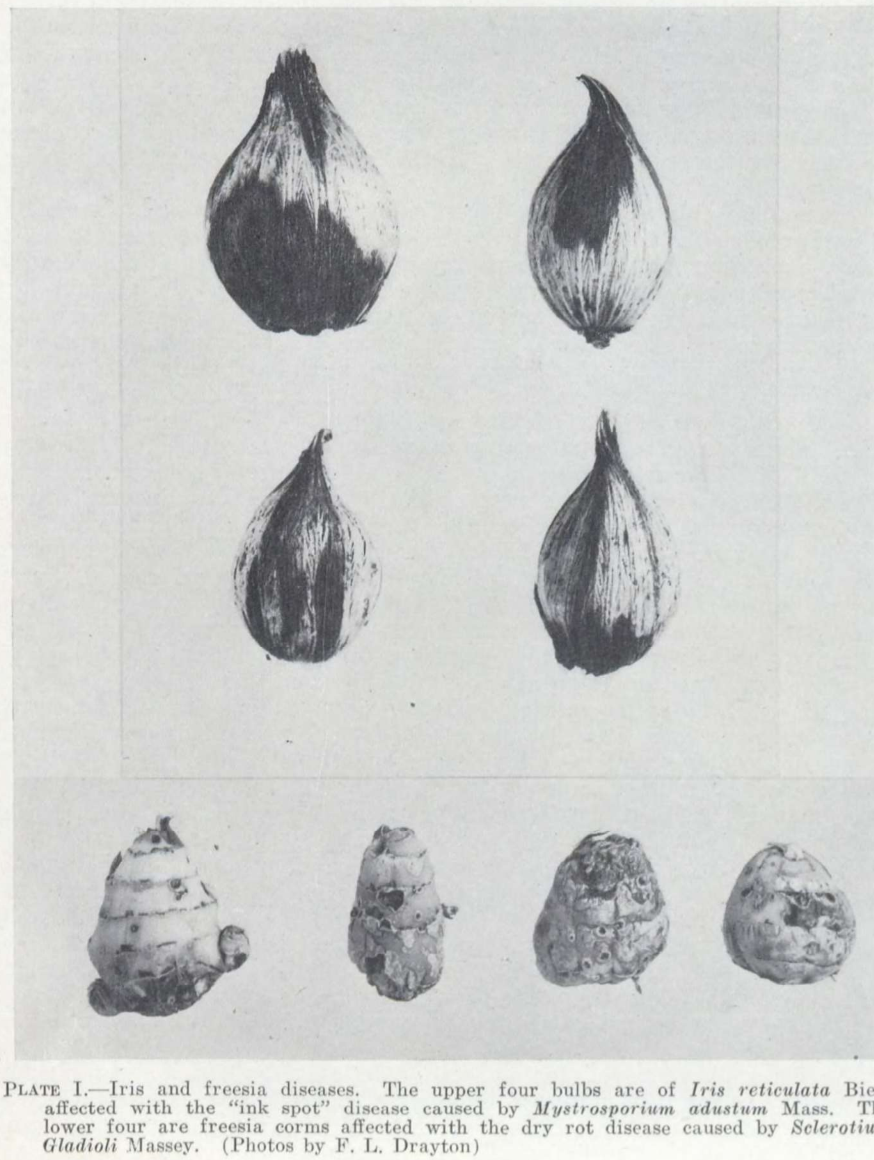


PLATE I.—Iris and freesia diseases. The upper four bulbs are of *Iris reticulata* Bieb. affected with the "ink spot" disease caused by *Mystrosporium adustum* Mass. The lower four are freesia corms affected with the dry rot disease caused by *Sclerotium Gladioli* Massey. (Photos by F. L. Drayton)

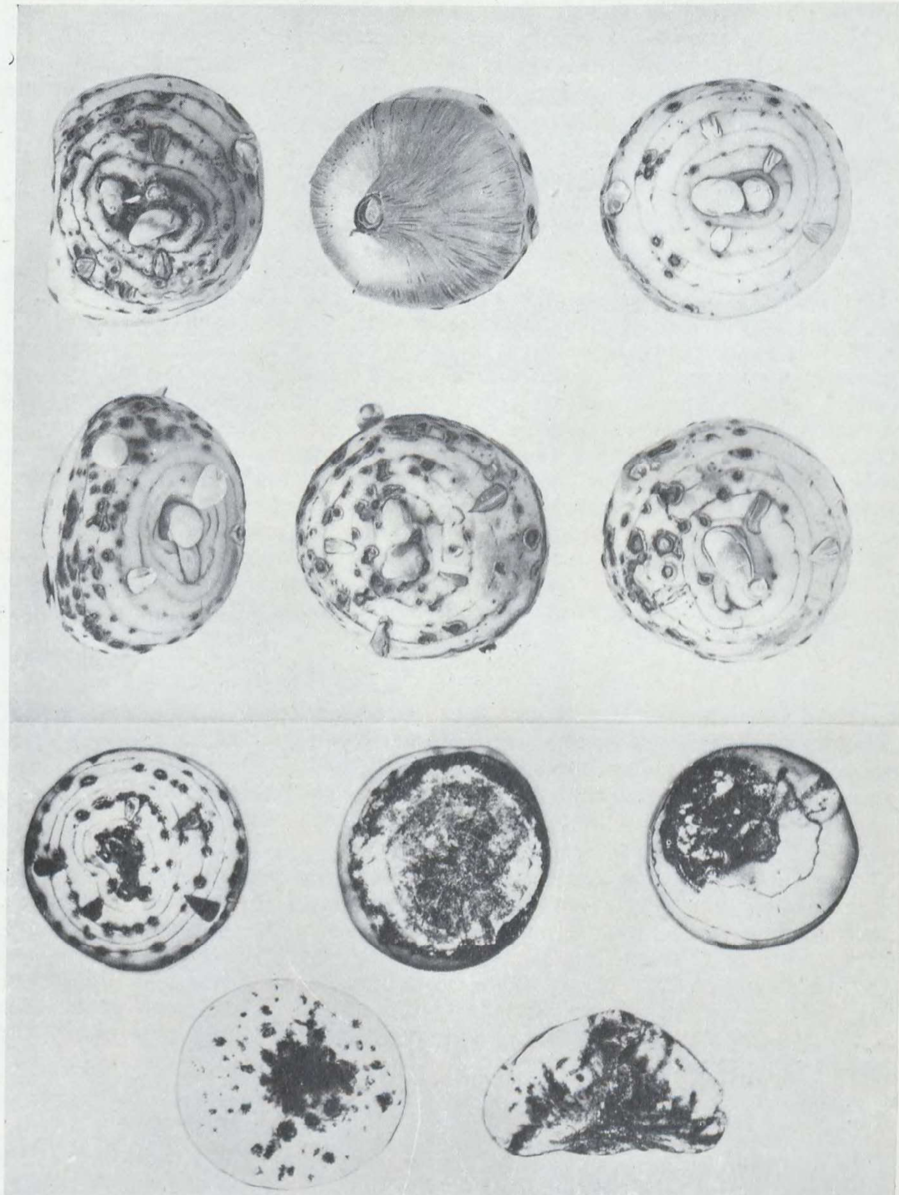


PLATE II.—Crocus diseases. The upper six corms are affected with the dry rot disease caused by *Sclerotium Gladioli* Massey. Note the small black sclerotia on the corm scales of the upper middle corm. The lower five corms are affected with a decay caused by a *Fusarium* sp. From the left on the top row showing, the vascular bundle ending lesions on the top of the corm, the basal decay of the same corm, and a slight basal infection. The two lower ones are transverse and longitudinal sections showing the vascular necrosis. (Photo by F. L. Drayton)

The original description of the fungus causing this disease was made by Geo. Massee, who named it *Mystrosporium adustum*.*

The fungus forms black crusty patches on the outer scale (see plate I). The mycelium penetrates to the centre of the bulb and destroys it. The conidia are described as elliptic-oblong or ovate, ends obtuse, 5-7 septate, becoming muriform, sometimes with transverse septa only, 45 to 60 by 20 to 22 μ, smooth dark brown, solitary on the tips of short branches. The disease is now being studied. At present we can only recommend careful inspection of bulbs to be planted, and the rejection of any showing symptoms of the disease.

CROCUS DISEASES

In the Report of the Dominion Botanist for 1926, page 16, fig. 3, a corm decay, caused by a *Fusarium* sp. was illustrated, and in the Report for 1927, page 29, this corm decay is referred to again together with the occurrence of *Septoria Gladioli* Pass. and *Sclerotium Gladioli* Massey. During my visit to Holland I was too late to see these diseases in the field, but I had the opportunity of going over several lots as they arrived in the bulb house from the field. In some of these lots I found that the *Fusarium* sp. and *Sclerotium Gladioli* were responsible for considerable loss, and particularly the former. In one lot, one half-hectolitre (1½ bushel) basket out of every eight had to be discarded and these of course included only those which were obviously affected. Of 185 corms examined from one of the baskets of discarded corms, 19 per cent were affected with *Sclerotium Gladioli* and 81 per cent with the *Fusarium* decay. On inquiry I was informed that the occurrence of the latter in the field was accompanied by an early yellowing and dying of the foliage. In the corms affected with this decay, which were examined, all the various stages from early infection to complete destruction were found. Apparently the disease is primarily a basal decay; the fungus then spreads upwards through the vascular bundles, and rings of lesions are formed at the top of the corms corresponding with the vascular bundle endings (see plate II). Subsequently the fungus destroys the tissue between the bundles, and complete decay results. A characteristic external symptom of badly diseased corms is the dark bluish green colour of the corm scales.

When the infection of the corms takes place too late to accomplish their complete destruction, only a part of the corm tissue is invaded by the fungus. A great many corms of this description are found in the shipments of crocus corms arriving in Canada, and in October, 1927, 2,000 of these were planted and in the spring of 1928 it was found that only 53 of these grew, the others having decayed in the soil. This disease, therefore, is of great importance from the standpoint of the grower, and must be taken into account in the inspection of imported crocus stock.

INCREASED HOST RANGE OF CERTAIN BULB DISEASES

Sclerotium Gladioli Massey.

From observations in Holland and examination of imported material, the following plants have been found to be naturally infected by this fungus:—

Gladiolus (Primulinus and Gandavensis types).

Gladiolus (Nanus types), *Crocus*, Montbretia (*Tritonia crocosmaeflora* Lem.)

Freesia, and *Lapeyrousia* (*Anomatheca*).

---

* Massee, Geo. Iris bulbs diseased. Gard. Chron. 25:652: page 412, 1899, and Massee, Geo. Diseases of cultivated plants and trees, page 505, 1910.

Penicillium Gladioli Mach.

In addition to being found on *Gladiolus* and *Tigridia* spp. this fungus has also been isolated from *Freesia.*

Sclerotium Delphinii Welch.

Reported on *Iris Xiphium hybridum* in the Report of the Dominion Botanist for 1927, this fungus was also observed in Holland on *Scilla sibirica* Andr.

GLADIOLUS FIELD EXPERIMENTS

Field experiments on the control of the gladiolus diseases, dry rot (*Sclerotium Gladioli* Mass.), hard rot (*Septoria Gladioli* Pass.), and scab (*Bacterium marginatum* McC.), have been conducted for the past five years at this laboratory. Many different substances have been used, in different ways, in an attempt to find some practical method of destroying the causal organisms present in diseased corms, and of protecting from infection plants which are grown from sound corms planted in contaminated soil. The following treatments have been tried with these two objects in view:—

A. For the sterilization of diseased corms:—

1. Uspulun,
    - (*a*) At 20° C.:—·25 per cent for 1 hour; ·5 per cent for 5 hours; 2 per cent for 7 hours; 5 per cent for 2 hours; 10 per cent for 1 hour.
    - (*b*) At 50° C.:—5 per cent for 15 mins.; 10 per cent for 15 mins.
2. Semesan,
    - (*a*) At 20° C.:—·25 per cent for 1 hour; 2 per cent for 7 hours; 5 per cent for 2 hours; 10 per cent for 1 hour.
    - (*b*) At 50° C.:—5 per cent for 15 mins.; 10 per cent for 15 mins.
3. Formalin,
    - (*a*) At 20° C.:—5 per cent for 30 mins.; 5 per cent for 5 hours; 10 per cent for 2 hours; 15 per cent for 1 hour.
    - (*b*) At 50° C.:—2·5 per cent for 15 mins.; 5 per cent for 15 mins.
4. Mercuric Chloride,
    - (*a*) At 20° C.:—1:1000 for 1 hour; 1:1000 for 5 hours; 1:500 for 2 hours; and 1:500 with 1 per cent hydrochloric acid for 2 hours.
    - (*b*) At 50° C.:—1:1000 for 15 mins.
5. Germisan, ·25 per cent for 1 hour.
6. Bayer Compound, ·25 per cent for 1 hour.
7. Copper Sulphate, 2·5 per cent for 2 hours.
8. Dipdust, 1 pound in 2½ gals. water, corms dipped for 1 min. and dried.
9. Sulphur, dusted thickly on corms after they were moistened with water.
10. Rectisoil, broadcast in the trench at the rate of 1 ounce per foot before the corms were planted.
11. Hot water, at 125° to 130° F. for 30 mins.

B. For the protection from infection of plants grown from sound corms planted in soil contaminated with dry rot:—

1. By watering the soil over the bulbs, 24 hours after they were planted, with the following solutions at the rate of 8 litres per 10 feet of trench:—
    - (*a*) Mercuric chloride, 1:1000.
    - (*b*) Uspulun, ·25 per cent.
    - (*c*) Bayer compound, ·25 per cent.
    - (*d*) Formalin, 1 per cent.

2. By broadcasting various substances in the bottom of the trench, and on the soil dug out, so that, when the corms were planted and covered, there would be some of these substances in the soil both below and above the corms:—

(*a*) Infusorial earth saturated with 5 per cent formalin, and used at the rate of 2 ounces per foot of trench.

(*b*) Same as (*a*) but with 10 per cent formalin.
(*c*) Same as (*a*) but with 20 per cent formalin.
(*d*) Same as (*a*) but with 40 per cent formalin.
(*e*) Sulphur dust at the rate of 1 ounce per foot of trench.
(*f*) Semesan Junior at the rate of 12 ounces per 20 feet of trench.
(*g*) Bayer dust at the rate of 12 ounces per 20 feet of trench.
(*h*) Copper carbonate at the rate of 10 ounces per 40 feet of trench.
(*i*) Copper carbonate at the rate of 20 ounces per 40 feet of trench.
(*j*) Powdered copper sulphate at the rate of 4 ounces per 40 feet of trench.
(*k*) Chloride of lime at the rate of 20 ounces per 40 feet of trench.
(*l*) Rectisoil at the rate of 2 pounds per 40 feet of trench.
(*m*) Hydrated lime at the rate of 20 ounces per 40 feet of trench.
(*n*) Acid phosphate at the rate of 10 ounces per 40 feet of trench.
(*o*) Ammonium sulphate at the rate of 5 ounces per 40 feet of trench.

3. By moistening the corms with water and covering them with a heavy coating of the following substances, before they were planted: Bayer dust, Semesan Junior, and sulphur.

General Conclusions

1. All of the treatments listed under B, used in an attempt to grow healthy plants from sound corms planted in soil which had grown one or more crops of plants affected with dry rot, were entirely unsuccessful. It is questionable whether there will ever be a practical means of accomplishing this. In Holland, where the soil is sandy and the cost of labour reasonably low, it is possible to reduce materially the amount of inoculum in the top 14 or 18 inches of soil by the process known as "rigolen", in which the top and second 15 to 18-inch depths are exchanged by means of deep trenching with a spade. This practice would be impracticable in most of our gladiolus plantations, because of the heavier nature of the soil and the prohibitive cost of such an operation. The only procedure for our commercial gladiolus growers to follow will be the deep ploughing of slightly contaminated soil, combined with a strict roguing of infected plants; and, in the case of badly contaminated soil, discontinuance of its use for gladioli during a period of at least five years or more.

2. As to a means of disinfecting diseased corms, so that they may be planted in clean land without fear of introducing contamination, the most successful treatments among those tried, and listed under A of this section are:

For dry rot—Semesan, 10 per cent for 15 minutes at 50° C. and Uspulun, 10 per cent for 1 hour at 20° C. and 10 per cent for 15 minutes at 50° C.

For hard rot—Semesan, 5 per cent for 15 minutes at 50° C. and Uspulun, 5 per cent and 10 per cent for 15 minutes at 50° C.

In the case of scab the results were inconclusive, for very little of this disease appeared in the untreated checks. Apparently, in the Ottawa district, or at any rate in the experimental plots at the Central Farm used for these experiments, little or no scab ever develops, even although it is the most serious gladiolus disease in other parts of Canada and the United States.

The use of Semesan or Uspulun solutions in strengths of 5 per cent and 10 per cent, and particularly in the case of hard rot control where these solutions were only effective when used at 50° C., is impracticable because of the cost and difficulty involved, except where small quantities of expensive varieties are to be treated. These substances were originally recommended by the manufacturers for use as soaks for diseased gladiolus corms at a suggested strength of a ·25 per cent solution for one hour. This strength as well as strengths of ·5 per cent and 2 per cent for 7 hours have all proved to be ineffective.

For the time being, therefore, the gladiolus growers will have to confine their attention to the elimination of disease from their stocks by the methods described in the Report of the Dominion Botanist for 1926, page 13, combined with strict rotations, and to the special treatment of valuable varieties with the solutions mentioned above.

RESISTANCE OF TIMOTHY SELECTIONS TO RUST

(*Puccinia Phleipratensis* Erikss. et Henn.)

(R. R. Hurst, Assistant Plant Pathologist, Charlottetown, P.E.I.)

This investigation was undertaken with a view of procuring a rust resistant strain of timothy possessing, as well, the necessary desirable qualities of a forage plant. For this purpose twenty-two strains were procured from the Dominion Agrostologist. These were grown for two years and records were made of rust tolerance. A heavy outbreak of rust in 1928 afforded an excellent opportunity to study the reaction of timothy strains to rust. However, the field observations recorded herein can be considered only as preliminary to investigations performed under greenhouse conditions, where strains of timothy showing resistance to rust in the field in all probability will react more favourably to it.

It will be seen that certain strains exhibited well defined resistance to rust, namely, Ottawa Nos. 2, 11, 13. (See table 2a). Furthermore, this feature was consistent in all of the plants in each respective selection, and accordingly suggests that the factor for resistance is dominant. Observations made on the same strains at Kentville, Nova Scotia, show a striking agreement with rust tolerance at Charlottetown. This has a direct bearing upon the question of biologic specialization, and indicates that distinct forms are of rare occurrence, or if they do exist are not greatly different in character.

Several strains of timothy were rust tolerant to a marked degree. Head infection impaired the development of seed in Huron and Ohio 28, thereby rendering them less valuable as varieties for seed production in Prince Edward Island.

Studies on the viability of over-wintered spores revealed no satisfactory evidence bearing on the winter survival of timothy rust. Repeated attempts to germinate uredospores, both in nutrient solutions and tap water, gave negative results. Examinations were made fortnightly of spores gathered from the field as well as material held in moisture proof cages. Furthermore, infection has not been observed on timothy plants until late in the growing season, thus rendering remote the possibility of primary infection from over-wintered uredospores. This late season infection might be better explained through the agency of wind, air currents, birds, and insects.

TABLE 2A—RESISTANCE OF TIMOTHY SELECTIONS TO RUST

(*Puccinia Phleipratensis* Erikss. et Henn.)

Strain	Degree Infection		Susceptibility	
Number	Kentville	Charlottetown	Kentville	Charlottetown
1 Ottawa	Trace	Moderate	Resistance	Resistance tr.
2 Ottawa	Trace	Moderate	Resistance	Resistance tr.
3 Ottawa	Severe	Susceptible+		
3A Ottawa	0		Immune	
4 Ottawa	Severe	Severe	Susceptible	Susceptible+
5 Ottawa	0	Trace	Immune	Susceptible
6 Ottawa	0	Trace	Immune	Susceptible
7 Ottawa	Moderate	Severe	Susceptible	Susceptible+
8 Ottawa	0	Trace	Immune	Susceptible
9 Ottawa	0	Trace	Immune	Resistance+
10 Ottawa	0	Trace	Immune	Resistance
11 Ottawa	0	Trace	Immune	Resistance
12 Ottawa	Moderate	Severe	Susceptible	Susceptible+
13 Ottawa	0	Trace	Immune	Resistance
17 Ottawa	Trace	Moderate	Resistance sl.	Resistance sl.
18 Ottawa	Trace	Moderate	Resistance sl.	Resistance sl.
21 Ottawa	Trace	Severe	Resistance sl.	Susceptible.
17 Ohio	Trace	Severe	Resistance sl.	Susceptible.
18 Gloria	0	Trace	Resistance	Resistance sl
19 Huron	Trace	Severe	Resistance sl.	Susceptible+
20 Ohio	Trace	Severe	Resistance sl.	Susceptible
28 Ohio	Trace	Severe	Resistance sl.	Susceptible+

NOTE.—sl. indicates slight.

LEAF SPOT OF HOLLYHOCK

(*Ascochyta althaeina* Sacc. et Bizz.)

(R. R. Hurst, Assistant Plant Pathologist, Charlottetown, P.E.I.)

This disease was first observed in late July, 1928, continuing to be active until the plants were destroyed by frost. Upon first appearance it was thought to be the result of heavy rust infection, as it was observed that each leaf spot developed around a rust pustule. In fact some doubt existed as to the pathogenicity of the organism associated with the condition until its infecting capabilities were demonstrated and the fungus reclaimed. The disease was confined to a clump of hollyhocks at the Experimental Station. Careful search did not reveal its occurrence in nearby clumps of hollyhocks.

DESCRIPTION

Affected leaves show numerous circular spots which range in size from one-sixteenth to one-quarter inch in diameter. In the early stages infection is indicated by small black areas not larger than a pin head. In colour the diseased areas are greyish-brown with light green to yellow margins. When infection is severe the leaf tissue becomes brittle and tears readily. Figure 1 illustrates this feature occurring in the centre of the leaf as well as at the margin.

THE FUNGUS

With the aid of a hand lens numerous small pycnidia were seen on the upper surface of the spots. These pycnidia were dark brown and osteolate. The spores were discharged in a thin, winding, colourless mass; they were 1-septate, constricted at the septation and blunt at both ends. The fungus was procured readily on a medium of potato dextrose agar by pouring dilution plates and

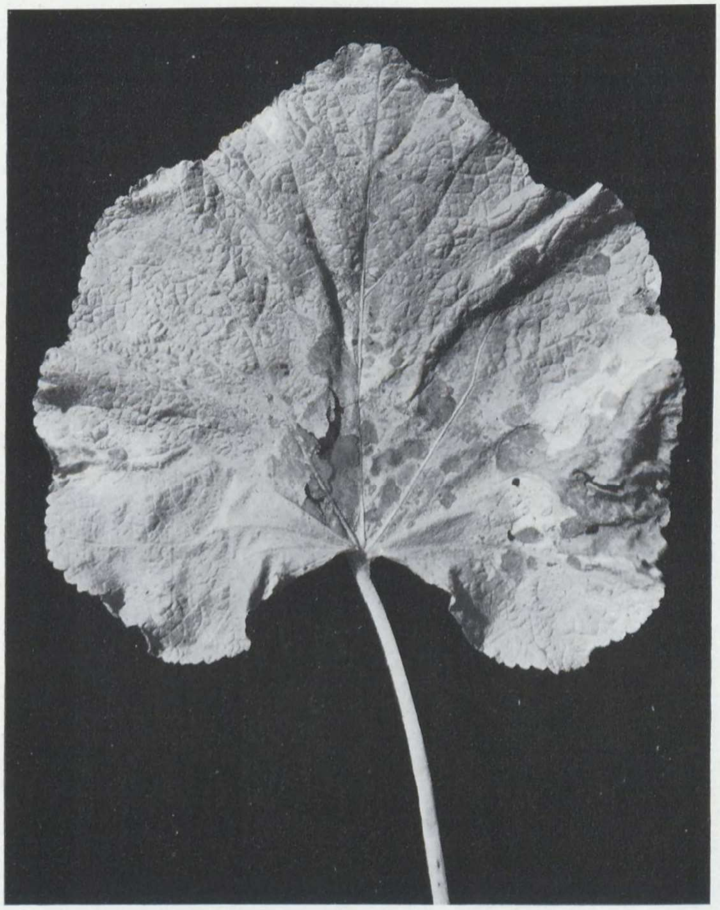


Fig. 1.—Leaf spot of hollyhock caused by *Ascochyta althaeina* Sacc. et Bizz. (Note the tendency for diseased tissue to tear where the spots become confluent.)

transferring individual colonies. Pycnidia were produced abundantly in test tube cultures. Inoculation tests made with this organism gave proof of its pathogenicity. Out of twenty inoculations, infection occurred in twelve instances as indicated by the production of typical leaf spots with abundant pycnidia from which the organism was recultured and by means of which additional typical lesions were produced.

CONTROL

Because of the lateness of the season it was difficult to give thorough consideration to the control of this disease. Bordeaux mixture (4-4-40) was applied every ten days over a period of six weeks without producing any apparent effect as a control measure. It was observed that the disease first made its appearance in a section of hollyhocks from which the dead tops had not been removed the previous year. These were left for a check against the destruction of old tops as a measure to control the rust of hollyhock.

On the other hand it was observed that September 8 was the first date on which infection occurred in the area from which all dead leaves and tops had been removed. This evidence will serve as a basis for future studies on the control of this disease.

PHYSIOLOGY OF FUNGI

(William Newton, Plant Pathologist, Vancouver, B.C.)

Over forty pure cultures of pathogenic fungi and bacteria have been isolated. Many of these are pathogens of great economic importance. These isolations are maintained as a living herbarium, but, as time permits, systematic studies of their physiology are undertaken. These studies are attempts to discover the optimum growth requirements of the organisms, and also to discover factors that inhibit their growth without pronounced injury to their hosts. Progress has been made in the study of *Rhizoctonia Solani* Kuhn. This fungus was grown on standard potato dextrose agar at temperatures ranging from 13° C. to 30° C. The optimum temperature requirements of the strains so far isolated appear to be approximately 24° C. At 30° C. growth is almost completely inhibited, but this temperature does not appear to injure the fungus, for normal growth is resumed when the temperature is lowered. An investigation is in progress upon the influence of the hydrogen ion concentration and other factors.

The morphological and physiological characters have been studied of ten species of *Fusaria* on standard potato dextrose agar, and when grown in nitrate and glycerine broth. None of the ten species reduced nitrates and none oxidized glycerine to dioxyacetone in significant amounts.

Pathogenic species of *Sclerotinia* have been isolated from alfalfa, clover, sunflower, and Jerusalem artichoke. A comparative study of their morphology and physiology is under way.

SECTION II

FOREST PATHOLOGY AND RELATED SUBJECTS

NEEDLE BLIGHT OF WHITE PINE

(H. T. Güssow, Dominion Botanist, Ottawa, Ont.)

Even some of our hardy native trees may suffer seriously through, or be fatally injured by, excessively unfavourable weather conditions. Records exist in our arboretum of several sturdy red oaks of 14-16 inches diameter having been killed by the severe winter of 1920. The summer of 1928 in certain sections of Ontario has been excessively wet. The official meteorological records indicate that in June there was a general excess of precipitation, and in July frequent and heavy rains occurred. In August the precipitation was considerably greater than normal, and in September there was a rainfall of from 6 to 9 inches. Whether the phenomenon to be described later occurred as a mere coincidence or as an actual consequence of the excessive moisture is an open question. It is remarkable, though, that residents for many years in the region where this trouble occurred were emphatic that it had never been observed before, at any rate, to the extent noticeable last season—and that, again, rather supports our theory that the unusual moist weather might have been the cause. From about June onwards were received many specimens and inquiries as to the nature of a peculiar condition of white pine (*Pinus Strobus* L.), and these came from regions far apart. White pines, of all ages from 3 years to several hundreds of years old, showed a similar peculiarity. More or less all the young growth on a tree had turned a bright, rusty red. The new leaves had grown to a length of about 2 to 3 inches when, suddenly, the whole tuft would assume this conspicuous colour from the tips downwards for about one half of their length. From a distance affected trees looked conspicuously tinted and rusty all over, but this tint only involved the growth of the current year. In most cases people believed that white pine blister rust had at last commenced to do the damage to white pines, which this service has predicted for some years. An examination enabled us to assure correspondents at once that the condition was not due to blister rust. Still specimens kept on coming in and complaints increased—especially reports became frequent from the Muskoka region, where we were assured every white pine showed this effect for a radius of 40 miles and more around a certain centre. Then the provincial forest service of Ontario appealed for assistance, since they also received numerous complaints. After having visited a number of places in the vicinity of Ottawa whence complaints had come, a visit was paid to the Muskoka district, where a condition existed among the white pines that truly gave rise to alarm. A sound white pine was an exception rather than a rule, old trees, young trees, solitary, or in dense woods, along the lake's edge, up to and along the hill tops, everywhere the same condition existed. The trouble was immediately recognized as needle blight of White Pine, briefly referred to in our report for the year 1921-22, p. 9, calling attention to this phenomenon widely prevalent then as in former years in the Temagami district, where Dr. J. H. Faull—formerly Professor of Botany at the University of Toronto, co-operating with the Ontario Forest Service with headquarters on Bear Island, Temagami— had paid considerable attention to its cause, effect on the annual accretion of wood, and its general economic importance in and around the region. Dr. Faull[1] concluded " that this malady is due to a killing of the absorbing roots, ascribable to a drying out that takes place in periods of drought in shallow or leachy soils. The result is that at the time the new needles are expanding, there is a sudden demand for water that cannot be supplied and in consequence the young needles turn pale and then redden from

[1] Report of Dr. J. H. Faull for 1921 on Forest Pathology in Report of the Minister of Lands and Forests of the Province of Ontario, 1921, p. 259 "Needle Blight of White Pine."

the tips downward." Dr. Faull also reports that a similar situation has prevailed in the pine forests on sandy soils in the southern part of Maine. The conclusions at that time—Dr. Faull promises the publication of a full account later—" from the results obtained were 1, that young stands are not likely to be seriously depleted by needle blight and 2, that injury to heavily blighted mature stands may be so great as to be a deciding factor in determining the time of harvesting."

In this connection it is interesting to record that, during the season of 1928, this malady appeared in regions usually naturally moist but excessively so that year, and apparently was less prevalent in the localities where the excess of rain this season presumedly supplied the lack of water necessary to balance the conditions of drought referred to by Dr. Faull. It is further most interesting that we, too, ascribe the condition of the trees as being brought about by the killing of the fine roothairs, but due this time to excess of moisture. If both theories be true, it is important to note that either extreme may cause the death of these essential root organs, and that the effect on the tree is exactly similar in both cases. When a tree has completed its annual period of active growth, it has accumulated that balance of reserve food materials in its limbs, that enables it to start growth from the dormant buds in spring. That this takes place, with or without feeble root action, seems to be indicated by the fact that large pines blown over in winter or spring will frequently produce a fair growth from the buds; but, when stored food supply is exhausted, the result is that the new growth turns reddish brown from the tip downward. The normal sequence is—the buds make rapid growth,—the leaves unfold, grow in length, and soon depend upon assistance through root action; if, however, this be not forthcoming for the reasons indicated—either drought or excess of moisture—the leaves, which are very tender and delicate in spring, quickly succumb, dying from the tips downward, progressively, until revived root action,—or rather new formation or replacement of the injured organs,—comes to the rescue. This regeneration is apparently fairly rapid; hence one rarely observes the entire killing of the leaves unless the supply be permanently cut off, as in the broken down trees, where the leaves—certainly much reduced in size—turn wholly reddish and die.

Obviously, such drastic interference with leaf action must interfere with the annual accretion of wood as recorded by Dr. Faull. It is to be expected and hoped that the untoward conditions of the summer of 1928 may not repeat themselves immediately, and, if so, a recovery of the pines from this temporary set back may be promised. Naturally a wide spread phenomenon of this conspicuous nature has aroused general interest and speculation in many quarters.

Mention may be made here of a theory advanced in the daily press by an investigator of this trouble who attributes it to the action of minute mites. In a basal ⅛ inch of one of these five leaved tufts, with the aid of a microscope, he counted no fewer than 84 of these mites, which he suggests might be suitably described as white pine needle mites. Technically they are a species of *Eriophyes.* The only *Eriophyes* known on pines is *E. pini* of Nalepa, which produces (in Europe) spongy galls, pea to beanlike in size, primarily with smooth, later furrowed and torn, bark, frequently in enormous numbers on twigs of pines, which elongate abnormally and shed their leaves, and, after a time, appear to die through drying up. They are of little economic significance, though, when numerous, they cause formations like witch's broom. This trouble is entirely different from needle blight, and bears no relation even in general appearance to it,—at least from what we observed in Europe. The author himself states that the needles are dwarfed and yellowed or browned at the base, and are easily pulled out of the sheath with mites attached to them. Even this description,—while obviously quite the reverse from what takes place in needle blight, where the leaves die from the tips downward and remain firm within the sheath,—does not fit the general habits of mites of the genus referred to. There is no doubt that the needle blight in question is not due to this mite, and doubtfully to any other cause than the consequence of the physical conditions just described.

In conclusion we may state that, in a way, one must feel gratified that this phenomenon occurred, since it afforded a welcome opportunity to drive home lessons in regard to the destructive and permanent nature of blister rust with which it had been confused. Many copies of the pamphlet on blister rust were distributed at the time, and, as a result, the residents, alarmed at the possibility of losing their pines from this destructive disease, uprooted large numbers of wild currants and gooseberries—which laudable practice should become much more general throughout this district. Verily "it is an ill wind, etc."

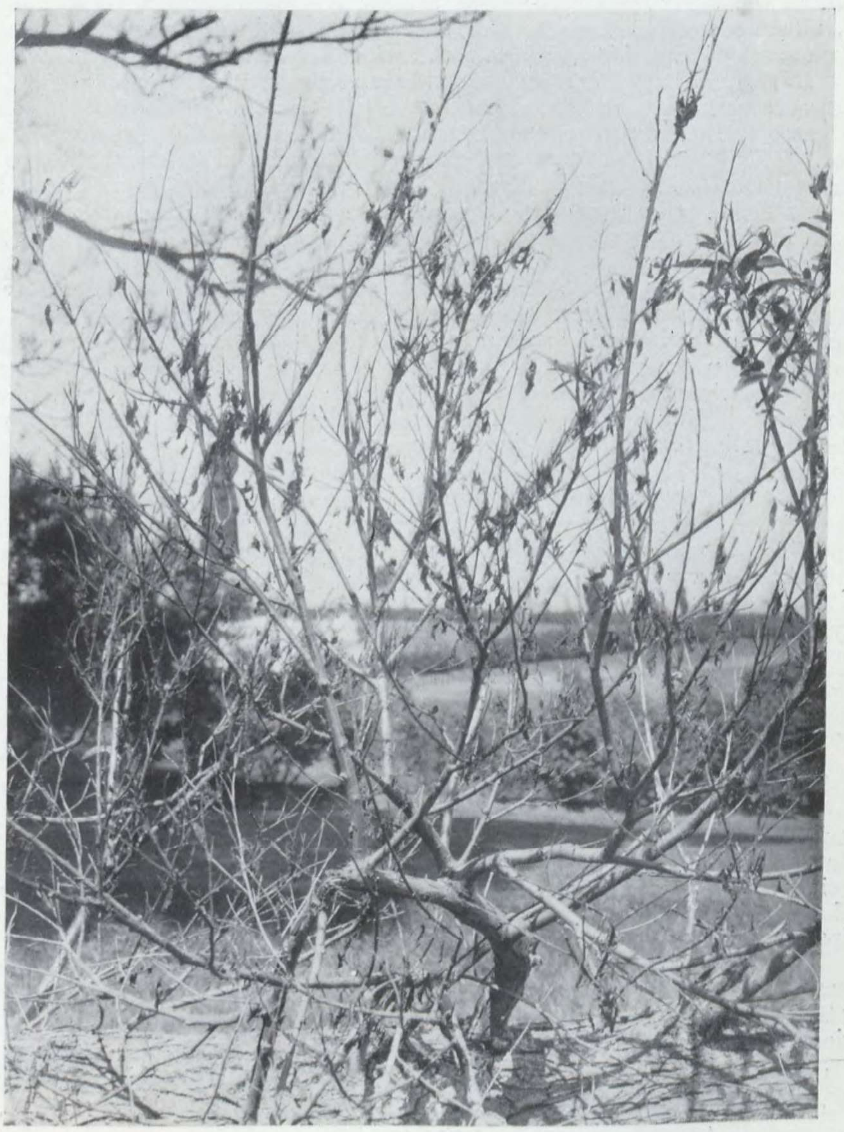


FIG. 2.—Current season's growth killed by willow blight.

WILLOW BLIGHT

(K. A. Harrison, Assistant Plant Pathologist, Kentville, N.S.)

The epidemic of willow blight has continued during the past season and a section apparently free from it before was found to be infected. This is the Gold River section of Lunenburg County that appeared to be free during the early part of the summer, but, in the early fall, a few blighted leaves were found that proved to be infected with the organism that is held to be responsible for this condition of willows in Eastern Canada. The disease was also found to be firmly seated in localities that were only lightly infected previously, and, where infection in 1927 was common, this year it was found to cause defoliation and, in one or two cases, the death of the trees under observation.

A serious feature of the outbreak is the firm foothold that has been established in the old "French" willows around Evangeline's Well at Grand Pré, and, unless a successful method of control can be inaugurated, it appears as though some of these historic landmarks will be doomed (see fig. 3).

The studies started in 1927 on the organisms associated with this destructive disease have been continued during the past season, and a constant association has been established with an organism of the genus *Gloeosporium* Desm. et Mont. This conclusion has been arrived at after repeated observations and isolations from collections of diseased willows from New Brunswick and Nova Scotia. Three collections have been secured from New Brunswick, one from Charlo in the northern part near the Quebec border and the others from Fredericton and Maugerville in the central part. In Nova Scotia collections have been made at Truro and Windsor as well as at five points outside of Kentville in the Cornwallis and Annapolis valleys. The largest number, of course, have been made in the immediate vicinity of Kentville, where a severe outbreak has developed. In every case this particular *Gloeosporium* has been found to be directly associated with the disease. The percentage of isolations from these collections yielding this organism has ranged from 10 to 70. A higher percentage of isolations was secured in the spring before secondary organisms gained a foothold.

The pure cultures thus obtained of this *Gloeosporium* were used for inoculations. Spore suspensions were made and applied to the young growing leaves of cuttings of various susceptible willows by spraying with an atomizer or applying with a platinum loop. The evidence of infection became apparent on the most susceptible varieties in from 40 to 48 hours. The organism was repeatedly re-isolated, and some of these re-isolations were used as a source of inoculum to reproduce the disease again. Monospore cultures from collections made at Charlo, N.B., and Greenwich and Grand Pré, N.S., with several special monospore cultures to be described below, were also used in these inoculations with identical results.

Three spore forms have appeared during the course of the investigation: First, a *Gloeosporium* stage which appears in nature, artificial inoculations, and rarely in cultures on sterilized willow twigs; second, a spore type, in the form genus *Ovulariopsis* Patouillard et Hariot, which was commonest on sterilized potato and bean plugs, but has not been observed in nature; and third, a perithecial stage of the *Glomerella* type which has been found abundantly in nature and on willow twig cultures. Single spore isolations established the relationships of these three types.

This disease is considered identical with Black Canker of Willow as described by R. M. Nattrass.[1] The causal organism was described and named by T. Fukushi,[2] *Physalospora Miyabeana* Fuk. The organism lives over in the lesions on the twigs.

[1] Nattrass, R. M. The *Physalospora* disease of Basket Willow. Trans. Brit. Mycol. Soc. XIII:286-304, 4 plates, 1928.

[2] Fukushi, T. A willow canker caused by *Physalospora Miyabeana* and its conidial form *Gloeosporium*. Ann. Phyt. Soc. Japan, I:1-12, 1921.

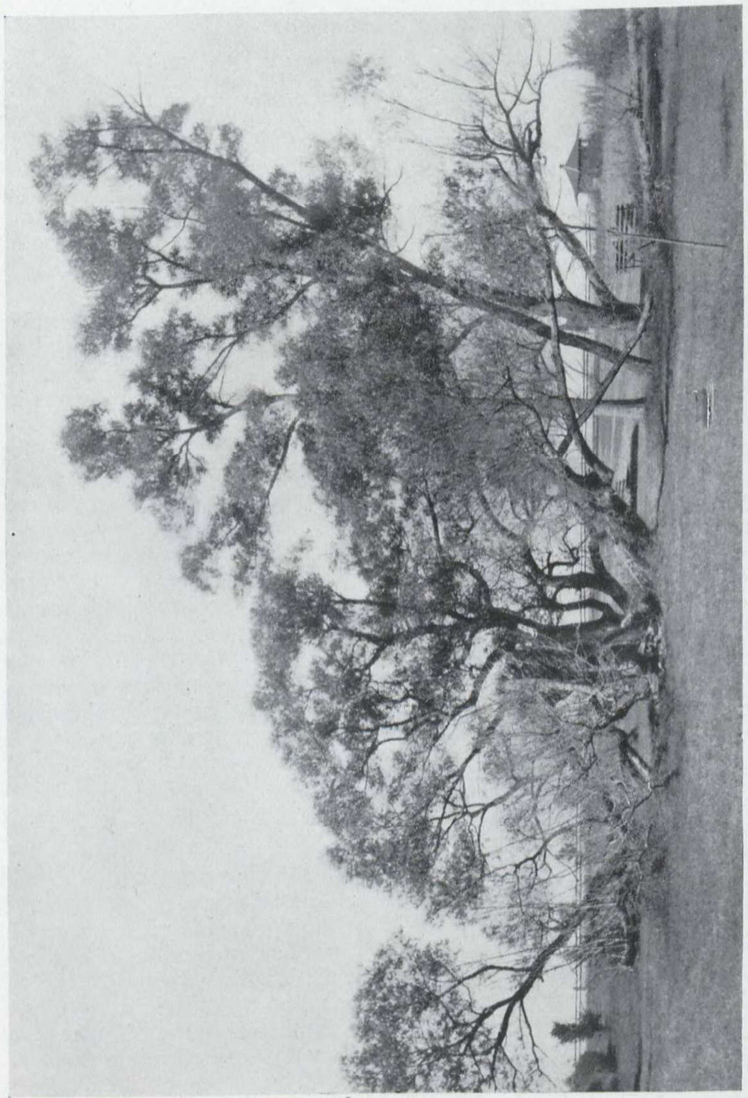


FIG. 3.—Typically diseased willows in Grand Pré Memorial Park, N.S.

Control measures that are being tried are late fall and winter pruning with an early spring spraying schedule of 4 to 5 applications of standard Bordeaux mixture.

Summer pruning and summer spraying have not proven effective in Nova Scotia.

FOREST PATHOLOGY

(A. W. McCallum, Forest Pathologist, Ottawa, Ont.)

In connection with the field studies of decay in balsam fir which have been made in Quebec, a bulletin[1] on this subject was published during the year.

During August an opportunity was afforded to visit the locality in New York where Woodgate rust—a gall-forming rust of Scotch pine—was first observed, and also to examine the outbreak of larch canker near Boston. The village of Woodgate is located in a section of the state which is very sandy, and Scotch pine has been used extensively in planting up many of the pure sand areas. The first plantation was made in 1870, and remarkable success has attended the use of this species. The early plantations are now fine stands of timber, and natural reproduction occurs freely in this district, taking possession of abandoned fields. The young trees are growing very rapidly. Under these conditions the gall rust becomes of economic importance and warrants the expenditure of time and money in an effort to combat it.

In Massachusetts larch canker was seen in several localities on a number of hosts, but most impressive and of special interest to this country was its occurrence on Douglas fir. One fine plantation of this species, in which the trees had reached a height of about 50 feet, was observed to be very badly infected with canker. While none of the trees was yet actually dead, the cankers were so numerous as to render the diseased trees worthless for lumber. The appearance of this stand gave some idea of the calamity which would result if larch canker ever spreads to the western part of this continent.

During September a short time was spent in the interior of Gaspé peninsula in company with Dr. J. H. Faull of Harvard University. One day was spent on the summit of Tabletop mountain, 4,000 feet, the highest point in eastern Canada. Some preliminary work was done on the decays of spruce, and a representative collection of the fungi of the district was made.

WOODGATE RUST IN CANADA

In 1925 Dr. H. H. York of the Conservation Department of the State of New York observed a gall-forming rust on Scotch pine near the village of Woodgate in New York State. As it seemed to be doing considerable damage, and as Scotch pine is an important species in that particular section of the State, an investigation in co-operation with the Federal Office of Forest Pathology was undertaken. It was found that this rust was not heteroecious as might have been expected, but that it spread directly from pine to pine. It was, therefore, not identical with either of the other two eastern gall-forming rusts on hard pines, i.e., *Cronartium cerebrum* and *C. fusiforme*, both of which have their alternate stages on oak. Upon the Pacific Coast there occurs a gall rust on hard pines which has been variously referred to as *C. coleosporioides*, *C. cerebrum*, *Peridermium Harknessii*. The interesting point about this western rust is that different workers have been successful in infecting hard pines using aeciospores from other naturally infected pines. However, the galls found in New York differed materially in appearance from these western galls so that,

[1] McCallum, A. W. Studies in forest pathology. I. Decay in balsam fir, (*Abies balsamea* Mill.) Canada, Dept. Agric. Bull. 104 (n.s.), pp. 1-25, 7 pl., 1928.

PLATE III.—Scotch pine branch showing galls of Woodgate rust, mostly on wood which is four years old. (Photo by J. B. MacCurry)

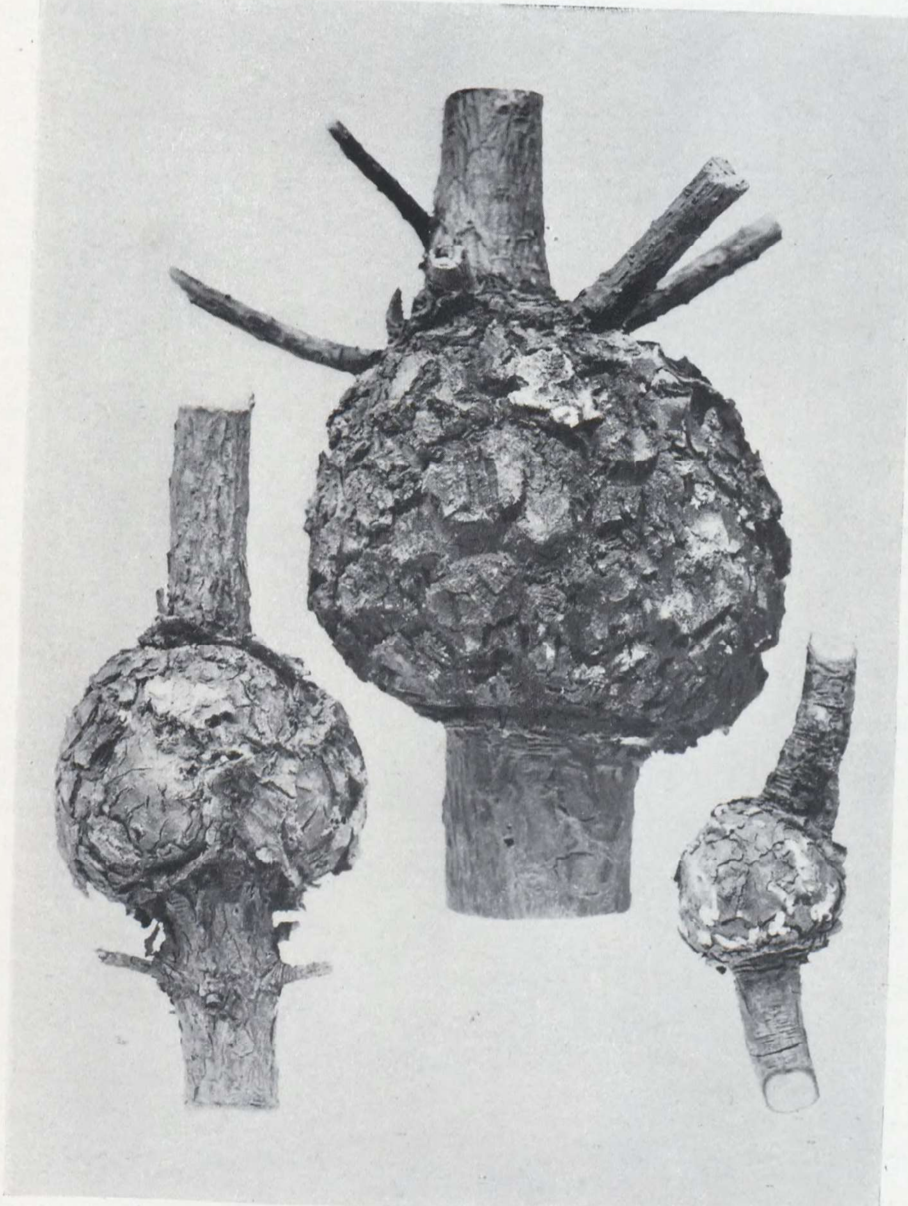


PLATE IV.—Galls of Woodgate rust on Scotch pine. The largest gall is on wood which is seven years old. (Photo by J. B. MacCurry) until further information in regard to the identity of this eastern rust could be obtained, it was designated "Woodgate rust" after the locality in which it was first found.

In 1918 a gall-forming rust on Scotch pine was collected on the grounds of the Experimental Farm at Ottawa. It had been observed by the Dominion Botanist for several years previously to this but, as it was thought to be the common *C. cerebrum*, no particular attention was paid to it. In 1918 specimens were submitted to Dr. J. C. Arthur, who pronounced it to be *C. cerebrum*. At the same time both oaks and Scotch pines were inoculated with the aeciospores of this rust but without success in either instance. When Dr. York's report of a gall rust on Scotch pine apparently new to the east came out it was believed that the Ottawa rust might be the same form, and this has proved to be the case. In New York the rust has been present for at least 30 years, and at Ottawa for about 40 years, or since the trees were first planted in 1888. It has not been possible to ascertain where the nursery stock used in planting at Ottawa was obtained, but it is known that it either came from France or from the State of Ohio. As there is no known similar rust in Europe, this form could not have been introduced from that source. In New York, the plantation in which the oldest galls of this rust occur originated from seed imported from Germany, so that the fungus was not brought in upon its present host. This rust may possibly be of Asiatic origin, or, what seems more probable, it may be from the western part of this Continent.

The more important plantations of Scotch pine in Ontario and Quebec have been examined and, apart from the Ottawa record, this rust has been found in Ontario at St. Williams in Norfolk county, and at Orono in Durham county. In Quebec it was present at Lachute and Berthierville, and specimens have been received from Nappan, Nova Scotia. Curiously enough all the infections found outside of Ottawa are quite recent, no galls having been found which are over 7 years old.

The effect of this rust upon its host is to stunt and deform the tree, and finally, if the infection is heavy, to kill it. Literally, thousands of these galls may occur upon a single tree.

Scotch pine is not a tree of very great importance at present in this country. It is most valuable in planting up waste land where the soil is so poor that other trees will not thrive. There seem to be several strains of this species, and the use of seed from some of the poorer of these has led to considerable prejudice against this tree.

THE EUROPEAN ELM DISEASE

While this disease which has proved to be very destructive to elms in Europe is not, as far as is known, present either in Canada or the United States, yet it has been thought advisable to include here a brief description of the symptoms so that, if it should occur in this country, it may be the more readily recognized and reported.

Elm blight was first noted in Holland in 1919, and subsequently was found to occur in Belgium, France, Germany, Norway, and England. The external symptoms of this injury are the wilting and discoloration of foliage in the crown or at the ends of branches. Following this the leaves die and drop off. The disease then gradually spreads until the whole tree is involved and killed. In small trees the injury progresses rapidly and death may occur within a few weeks from the time of infection. In large trees the process is much slower and may take several years. Dying trees frequently send out suckers on the main stem and from the bottom of branches. In this respect the disease resembles chestnut blight.

Perhaps the most characteristic symptom is observed when a transverse section is made of an affected branch. Usually in the last annual ring of growth, but sometimes in the second or third ring from the outside, there appears a brown ring which may or may not be complete. This discoloration appears too, of course, in longitudinal section, as two brown lines paralleling the bark on either side. It is generally present in the roots of affected trees. In several respects—the wilting and discoloration of the foliage, the rapid killing of small trees, and the staining of the wood—this disease of elm strikingly resembles that of maple caused by *Verticillium* sp. While the symptoms are very similar, the two diseases are quite distinct, as it has been shown that the elm blight is caused by *Graphium Ulmi* Schwartz. Another point of similarity between these two diseases is that nothing seems to be known as to the manner in which the causal fungi are distributed or how infection takes place.

All elm stock which has been imported in recent years has been examined but in no instance has this disease been found. There is some reason, therefore, to believe that the blight is not present in Canada, but this is a question which cannot be definitely answered for some time yet.

CULTURAL STUDIES OF WOOD-DESTROYING FUNGI

(Irene Mounce, Assistant Plant Pathologist, Ottawa, Ont.)

Stock Cultures of Wood-destroying Fungi

In the reports of the Dominion Botanist for 1926 and 1927 lists were given of the different species of wood-destroying and wood-inhabiting fungi included in the collection of stock cultures at Ottawa. Eight new species have been added during the year, namely:—

Coprinus atramentarius (Bull.) Fr.
Cytospora chrysosperma (Pers.) Fr.
Graphium Ulmi Schwarz.
Hexagonia discopoda Pat. et Heriot.
Physalospora Miyabeana Fuk.
Polyporus circinatus Fr.
Polyporus Tuckahoe (Güssow) Sacc. et Trott.
Trametes protracta Fr.

We are indebted to Dr. H. W. Wollenweber of Berlin for the culture of *Graphium Ulmi*, the causal agent of the destructive European elm disease; to Dr. Bose of Calcutta, for the culture of *Hexagonia discopoda;* and to Dr. Fritz, of the Forest Products Laboratory, Ottawa, for the culture of *Polyporus circinatus*. *Cytospora chrysosperma* was isolated several times from specimens of poplar canker received from Indian Head, Sask. Spore horns were produced abundantly both on malt agar cultures and on sterilized poplar twigs embedded in malt agar. The cultures of *Physalospora Miyabeana* were isolated by Mr. Harrison, Kentville, N.S., from infected willow trees.

Heterothallism in *Fomes pinicola* (Sw.) Cooke

For the last three years notes on heterothallism in *Fomes pinicola* have been included in this report. This study has been continued during the year, and the results obtained, together with those from earlier experiments, have been incorporated in Dominion of Canada Department of Agriculture bulletin No. 111 New series. This bulletin entitled "Studies in Forest Pathology II. The Biology of *Fomes pinicola* (Sw.) Cooke," is now available.

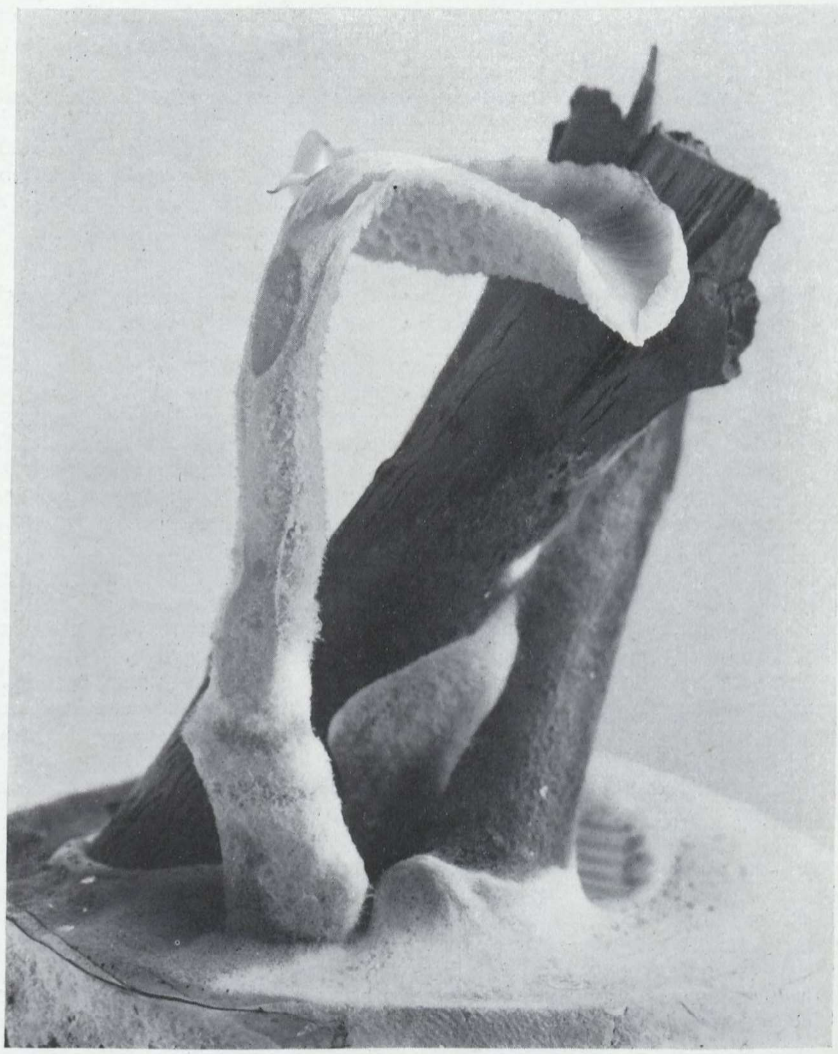


Plate V.—*Polyporus Tuckahoe.* A sporophore of *P. Tuckahoe* which developed in a culture of poplar twigs embedded in malt agar. × 1½. (Photo by J. B. MacCurry)

Fruiting of *Polyporus Tuckahoe* (Güssow) Sacc. et Trott.

This winter a large sclerotium of *Polyporus Tuckahoe*[1] was received by the Dominion Botanist from Grande Prairie, Alberta. Cultures were made from the interior of the sclerotium and mycelium obtained. Flasks containing sterile poplar twigs embedded in malt agar were inoculated and placed in the light at room temperature. The medium was covered rapidly with mycelium, and, six weeks later, a sporophore developed. The photograph (plate 5) shows the felted mycelium, the woolly stipe, smooth pileus, and rather large irregular tubes with dentate margins. The stipe and hymenium were a moist dull creamy white, while the upper surface of the pileus was tinged with pinkish and cinnamon buff.[2] Heavy white spore deposits were obtained, and the spores were germinated, but germination did not differ materially from that described and figured by Güssow. Monosporous mycelia were isolated, and pairings are being made to see whether this species is homothallic or heterothallic.

Heterothallism and the Clamp-connection Criterion for Identity of Species as applied to *Lenzites saepiaria* Fr. and *Trametes protracta* Fr.

Some writers consider *Trametes protracta* to be merely a pored form of *Lenzites saepiaria*, but Weir[3], Faull[4], and Snell[5], consider it a distinct and valid species. Snell has supported his contention by a comparative study of the growth of mycelium of the two fungi and concludes that " there is a pronounced difference in the temperature reactions of the two organisms, not as to optimum but as to rate of growth except at the lower temperatures. This fact supports the more commonly accepted view that *Trametes protracta* is a species distinct from *Lenzites saepiaria.* A test of growth upon a single agar at temperatures from 30° C. to 36° C. would serve to distinguish the fungi in culture." The results obtained so far in this laboratory with pairings of monosporous mycelia of *Trametes protracta* with monosporous mycelia of *Lenzites saepiaria* indicate that by this test, too, *Trametes protracta* is distinct from *Lenzites saepiaria.*

Sporophores of *Lenzites saepiaria* (No. 835 and No. 854) from two collections made at Timagami, Ontario, in 1927 were revived, spores were obtained, and monosporous mycelia were isolated. A series of all possible pairings of ten monosporous mycelia from one sporophore (No. 835) was made and the results are shown in table 3 where the plus sign (+) indicates the presence of clamp-connections on paired mycelia, the minus sign (—) indicates their absence. From the table it is evident that 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. Hence *L. saepiaria* is a heterothallic species, and, since the spores fall into two groups, and only two, it is bisexual. A similar series using nine monosporous mycelia from the second sporophore (No. 854) corroborated this result.

In the same way monosporous mycelia were obtained from a specimen of *Trametes protracta*, (No. 990) collected in British Columbia by Mr. Mielke, and from another (No. 903) collected in Timagami, Ontario. All possible pairings of eight monosporous mycelia from the first sporophore showed that this species, too, was heterothallic and bisexual; and a series of all possible pairings of ten monosporous mycelia from the second sporophore (No. 903) confirmed this result.

[1] Güssow, H. T. The Canadian Tuckahoe. Myc. 9 (3): 104-110, 1919. In this paper the fungus was named *Grifola Tuckahoe*, but the author concurs with the change to *Polyporus Tuckahoe* which was made in the Sylloge Fungorum, vol. XXIII, p. 375, 1925.

[2] Ridgway, Robert. Color standards and color nomenclature Washington, 1912.

[3] Weir, James R. Montana forest tree fungi I. Polyporaceae. Myc. 9 (3): 136. 1917.

[4] Faull, (in litt.)

[5] Snell, Walter H., W. T. Hutchinson, and K. H. N. Newton. Temperature and moisture relations of *Fomes roseus* and *Trametes subrosea*. Myc. 20 (5): 276-291. 1928.

835

835	1	2	3	4	5	6	7	8	9	10
1	−	−	−	−	−	−	−	+	+	+
2	−	−	−	−	−	−	−	+	+	+
3	−	−	−	−	−	−	−	+	+	+
4	−	−	−	−	−	−	−	+	+	+
5	−	−	−	−	−	−	−	+	+	+
6	−	−	−	−	−	−	−	+	+	+
7	−	−	−	−	−	−	−	+	+	+
8	+	+	+	+	+	+	+	−	−	−
9	+	+	+	+	+	+	+	−	−	−
10	+	+	+	+	+	+	+	−	−	−

TABLE 3

835

854	11	12	13	14	15
11	+	+	+	+	+
12	+	+	+	+	+
14	+	+	+	+	+
15	+	+	+	+	+
16	+	+	+	+	+

TABLE 4

990

835	1	2	3	4	5	6	7	8
1	−	−	−	−	−	−	−	−
2	−	−	−	−	−	−	−	−
3	−	−	−	−	−	−	−	−
4	−	−	−	−	−	−	−	−
5	−	−	−	−	−	−	−	−
6	−	−	−	−	−	−	−	−
7	−	−	−	−	−	−	−	−
8	−	−	−	−	−	−	−	−

TABLE 5

Then a series of all possible pairings of five monosporous mycelia of *Lenzites saepiaria* (No. **835**) with five monosporous mycelia of *L. saepiaria* (No. **854**) was made. The results are shown in table 4, from which it will be seen that clamp-connections were formed in every pairing. Similarly a series of all possible pairings of five monosporous mycelia of *Trametes protracta* (No. **990**, from B.C.) with five monosporous mycelia of *T. protracta* (No. **903**, from Ont.) was made. The results were identical with those shown in table 4, that is clamp-connections were formed in every pairing. This is the usual reaction when monosporous mycelia from fruit-bodies of the same species, but from different localities, are paired.

Next a series of all possible pairings of eight monosporous mycelia of *Lenzites saepiaria* (No. 835) with eight monosporous mycelia of *Trametes protracta* (No. **990**) was made. The results are shown in table 5, from which it is obvious that no clamp-connections were formed in any of the sixty-four pairings. Similar series were made pairing *L. saepiaria* (No. **835**) with *T. protracta* (No. **903**), and *L. saepiaria* (No. **854**) with *T. protracta* (No. **990**) and with *T. protracta* (No. **903**). The results in each case were similar to those shown in table 5, i.e., no clamp-connections were formed in any pairing.

A summary of the pairings made and of the results obtained is shown in table 6. Further work is in progress, but it has been shown that (1) both *Lenzites saepiaria* and *Trametes protracta* are heterothallic and bisexual, (2) sexual strains or geographical races which are perfectly cross fertile exist in each species, and the results obtained in crossing monosporous mycelia of *L. saepiaria* with those of *T. protracta* suggest that, judged by this criterion, too, *T. protracta* is a distinct and valid species.

Table 6.—*Lenzites saepiaria* and *Trametes protracta*. Summary of pairings of Monosporous Mycelia

Number of monosp. mycelia.	Culture No.	Species	Locality	Paired with	Number of monosp. mycelia	Culture No.	Species	Locality	Number of pairings	Fertile (+)	Sterile (−)
10	835	*Lenzites saepiaria*	Timagami, Ont.	x	10	835	*Lenzites saepiaria*	Timagami, Ont.	100	42	58
9	854	"	"	x	9	854	"	"	81	36	45
10	903	*Trametes protracta*	"	x	10	903	*Trametes protracta*	"	100	50	50
8	990	"	Appledale, B.C.	x	8	990	"	Appledale, B.C.	64	30	34
5	835	*Lenzites saepiaria*	Timagami, Ont.	x	5	854	*Lenzites saepiaria*	Timagami, Ont.	25	25	0
5	990	*Trametes protracta*	Appledale, B.C.	x	5	903	*Trametes protracta*	Timagami, Ont.	25	25	0
8	835	*Lenzites saepiaria*	Timagami, Ont.	x	8	990	*Trametes protracta*	Appledale, B.C.	64	0	64
5	835	"	"	x	5	903	"	Timagami, Ont.	25	0	25
5	854	"	"	x	5	990	"	Appledale, B.C.	25	0	25
5	854	"	"	x	5	903	"	Timagami, Ont.	25	0	25

SECTION III

INVESTIGATIONS OF THE DISEASES OF CEREALS AND GRASSES

REVIEW OF THE HISTORY AND PROGRESS OF STEM RUST RESEARCH IN CANADA

(H. T. Güssow, Dominion Botanist, Ottawa, Ont.)

Prior to 1916—the year of the most severe rust epidemic in Canada—comparatively slow progress was made in developing research work on rusts affecting grain in Canada. Even attempts at the compulsory eradication of the barberry throughout Western Canada did not meet with early success. To-day, Western Canada has no longer any barberries—they were finally completely destroyed—but rust is still with us. Immediately after the serious epidemic of 1916, events began to move very fast. If Canada to-day can be justly proud of its rust research laboratory, the credit is due to its present Minister of Agriculture, the Hon. Dr. W. R. Motherwell.

Soon after an exhaustive inquiry has been conducted in connection with the epidemic of 1916, the Dominion Department of Agriculture established two field laboratories to conduct rust research work, viz., one at Brandon, Man., and the other at Indian Head, Sask. The Department was fortunate in securing Prof. W. P. Fraser, (an outstanding authority on rust diseases generally), to take charge. To thoroughly organize this important work, the Department of Agriculture called a conference in August, 1917, at Winnipeg, inviting representatives from all agricultural colleges, the universities, and provincial departments, who finally agreed to make the eradication of the barberry compulsory, and to draw up a close co-operative program between all parties concerned. It was then that the Manitoba Agricultural College generously placed at our disposal laboratory and greenhouse accommodation at Winnipeg. Headquarters were established at Saskatoon, where the University of Saskatchewan contributed its share to the program by furnishing similar accommodation, still under the very able direction of Professor Fraser, who guided the destinies of these investigations for eight years, until 1925. During this period the scientific staff was materially increased by the appointments of Dr. D. L. Bailey and of Dr. Margaret Newton, both of whom are regarded as outstanding authorities on special phases of rust research, having been trained under Professor Stakman at the University of Minnesota.

In June, 1924, the Hon. Dr. Motherwell and his Deputy, Dr. J. H. Grisdale, instructed the Dominion Botanist, the principal officer in charge of the plant pathological work of the Dominion Department of Agriculture, to address the Select Standing Committee on Agriculture and Colonization of the House of Commons, on Wheat Rust. After a detailed discussion of the problem and a forceful plea for adequate support from Parliament, it is gratifying to report, that this committee agreed to the establishment of a special Rust Research Laboratory for Canada. It was moved by Mr. Gould, M.P., and seconded by Mr. Lovie, M.P., that this committee recommend to the House an appropriation of $50,000 for the purpose of special aid in research work in connection with grain rust. This gratifying result crowned our efforts of some eight years by placing our work on a more substantial and permanent basis.

In order to consider ways and means of spending this money most effectively, the Hon. R. Motherwell called a meeting soon after at his private residence in Ottawa. This occasion may really be regarded as the birthday of systematic rust research in the Dominion. It was then decided to locate our research laboratory at Winnipeg—the very heart of the grain country, and the centre of the wheat market of Canada. In September of the same year (1924), a second conference on wheat rust was held at Winnipeg under the joint auspices of the

Dominion Department of Agriculture and the National Research Council. This conference was representative of all national and international authorities on the subject, and a goodly number of United States experts were invited to confer with us. In speaking at this meeting the deputy minister reviewed the work done by the department for the past eight years and showed that at the end we knew infinitely more about rust than we had known seven years before. He also expressed himself as highly satisfied with the hearty co-operation and increased activity on the part of the various governments, especially now that there had been added to the forces of the Department the National Research Council. The Chairman of the Research Council explained that the attitude of the Research Council towards the wheat rust studies begun by the Department of Agriculture was the same as its attitude to all problems of scientific research in Canada. "We regard ourselves", the chairman explained, "as being able to assist in the co-ordination of scientific effort." There was established at this joint meeting the permanent Canadian Committee on Cereal Rust Research with six members representing the Department of Agriculture, and six the Research Council of Canada, of whom four at the same time represented the various universities and colleges materially interested. This committee unanimously agreed upon the continuation of all phases of research work started by the Department of Agriculture, which included epidemiology studies, biologic specialization, physiological and ecological studies, breeding for rust resistance, etc.

Events moved quickly after the inaugural meeting in Dr. Motherwell's residence and, as its share of the co-operation effort, the Dominion Department provided the entire funds for the building of the remarkably fine up-to-date Rust Research Laboratory on the grounds of the Manitoba Agricultural College, Winnipeg. This location was very generously placed at their disposal through the efforts of the President of the University of Manitoba.

The building, which was occupied on completion in 1925, then became the headquarters of co-operative Rust Research in Canada. At that time Professor Fraser, who was honoured by the University of Saskatchewan conferring on him the chair in Biology, resigned from our service. His successor was Dr. D. L. Bailey. Under his régime the experience gained from our years of previous work was used as a foundation, and remarkable progress has been made.

It was agreed that there should be held annually meetings of the Special Rust Research Committee to receive and consider progress reports on rust researches accomplished during the year. A third conference took place in April, 1926, a fourth in February, 1927, and the fifth and the last as yet held in April, 1928.

RESULTS SO FAR ACHIEVED

Brief reference may be made to the results achieved up to date. The work is substantially divided into pathological investigations and plant breeding. This latter phase is being carried on in closest co-operation with us by the very able geneticist, Dr. Goulden, on the staff of the Dominion Cerealist, L. H. Newman, who succeeded Dr. Charles Saunders.

The great problem of epidemiology of rust consisted in determining the origin and spread of stem rust in Western Canada. Thus the rôle of the barberry received first attention. I have already referred to the complete extermination of this shrub in Western Canada. In connection with the epidemiology studies inquiries were conducted into the possibility of overwintering of the rust, and consequent infection of the new crop from over-wintered spores. This investigation was concluded with the definite result that overwintering of the uredinial (summer) stage, if it occurs at all, is the exception rather than the rule.

The question then arose, since barberry eradication did not stay the rust, and since rust did not overwinter, where did the infection come from every year?

Investigators had long been suspicious of air-borne spores, and in close co-operation with the Royal Canadian Air force, largely through the interest of Mr. J. A. Wilson, Controller of Civil Air Service, our workers were enabled to critically examine the air above the wheatfields of Manitoba, by means of simple but very ingenious spore-traps, exposed at intervals for brief periods and at various altitudes from airplanes. These experiments, continued for three years or so, yielded many interesting and significant data. Each year a few spores were caught in these traps before any rust was found in the fields even after very careful search. The time at which the first spores were trapped bore a definite relationship to the stage of rust development farther south in the spring wheat areas of the United States. Furthermore, the spores were usually more numerous when southerly winds were blowing, so that, finally, it was indicated clearly that our incipient rust infections each year in Western Canada were caused by wind-borne spores from further south.

Once rust became established in a district in Canada, the rust spore content of the air increased remarkably until as many as 42,000 spores were caught in one day at Winnipeg on two square inches of exposed spore-trap surface, and 3,500 spores on the same area 5,000 feet up in the air near Winnipeg Beach. These observations were confirmed by a careful exposure of spore-traps on the ground. How far these spores may be carried in the air is not known, nor how long they may retain their germination power, but viable spores were caught 5,000 feet up near Norway House, Manitoba, and nearly 200 miles distant from the nearest wheat fields. The air above Western Canada, therefore, contains sufficient inoculum every year to start an epidemic, if conditions are otherwise favourable.

Now it will be realized that this determination, while clearing up the origin of our invasions and the lack of results from the destruction of barberries, at once rendered the exclusion of the inoculum impossible.

Before leaving the subject of airplanes, reference should be made to their experimental use in covering large areas of wheat fields in Western Canada with sulphur dust,—it having been proved from a series of experiments, conducted in a small way, that covering the growing grain with fine sulphur dust will effectively prevent rust attacks. For instance, in the experiments carried on at the Winnipeg Rust Laboratory in 1925, the yield of sulphur-dusted plots was increased from 15 to 55 bushels per acre, and the grade thus produced raised from feed to No. 1 Northern. In 1927 the yield was raised from 10 to 43 bushels per acre and the grade from feed to No. 1 Northern. In view of these results the effectiveness of sulphur dusting can no longer be doubted, but whether this method of control will answer under general practice is still open to question—being one largely of costs. Airplane dusting is still in its infancy, but has been used most successfully for the control of the cotton boll weevil in the Southern United States. Further work is being carried on along these lines.

As investigations of other likely methods for control of this important, if not the most important, plant disease in the Dominion and other grain producing regions, may be mentioned the studies of the effect of cultural methods, viz: summer fallowing versus stubble or new land, rate and depth of sowing, etc., etc., and their effect on the growth of wheat, aiming especially at the production of early maturing varieties of wheat, so that plants may thus escape injury from infection. It is, obviously, the duty of the plant pathologist and agronomist not to leave any factor to chance, and the duty of the plant breeder to secure valuable new and early maturing wheat varieties in order to escape serious damage from rust. Certain early maturing varieties were available already such as Ruby, Prelude, Reward, etc., but, while these varieties may not suffer from rust damage as Marquis wheat does, owing to early ripening or some other factor, they do not measure up to the latter in other respects such as quality and yield.

As another line of investigation may be mentioned the important problem of producing immune or resistant varieties of wheat. This is regarded as one of the most promising solutions, but as a problem is most complicated. It has been possible to demonstrate that susceptibility to rust differs materially within wheat varieties. Many tests were made, involving nearly all known varieties of wheat, which clearly showed that very promising resistant varieties existed. When interpreting these phenomena observers discovered a curious characteristic of the fungus causing this rust. It turned out not to be a simple species which is responsible for stem rust, but that this species, or linneon rather, consists of a large number of physiological forms or strains, geographically of wide distribution, and morphologically hardly distinguishable from each other, some of which show remarkable preference for certain varieties of wheat and their crosses or hybrids.

To put this more clearly, a certain variety of wheat may escape infection, while others nearby may show considerable infection. This, in the beginning, was looked upon as indicating tendencies towards immunity or at least resistance; yet, when grown for another year in the same locality, or when transferred to another locality, this same presumedly immune variety was observed to succumb to rust attack. Again the same variety showed desirable immunity in other years, and in localities where formerly it had been seriously attacked. This phenomenon remained a puzzle until the researches of Stakman furnished the most fundamental information indicating that, although the disease looked like common rust every time, there existed a large number of strains within the rust-causing species, some of them capable of causing serious injury to certain varieties, even while these varieties remained immune to attacks from other strains. It was this discovery which placed breeding for rust resistance upon a very concise and definite basis, and at the same time indicated that the problem of breeding a variety resistant to many, if not all strains, was one of the most difficult the plant breeder has to contend with. Some fifty and more such forms are now known, with every prospect that more exist. This curious phenomenon will indicate very strikingly that wheat breeding for resistance to rust is one of the most complicated problems, and explains at the same time why the process of elimination must be slow.

It is now up to the wheat breeder to produce a variety of wheat in all respects similar to the famous Marquis wheat, but without the susceptibility to rust which this important variety unfortunately possesses to a marked degree. To indicate that this phase of work is receiving every attention, it may be mentioned that, largely through the untiring efforts of Dr. Goulden, in charge of cereal breeding work and stationed at the Rust Research Laboratory at Winnipeg, there were, in 1927, in the hybrid wheat nursery, some 750,000 individual plants representing 20 different crosses. Among these were several lines which were very promising in regard to quality and resistance. I am assured that the progress which has been made during these past years in breeding for rust resistance has been exceedingly encouraging.

It would be an injustice to the modest discoverer of a most important scientific contribution to our knowledge of rust fungi were I to omit reference to the work of Dr. J. H. Craigie, who succeeded Dr. Bailey as officer in charge[1] of the Winnipeg Rust Research Laboratory. This work has attracted the attention of rust workers all over the world. Dr. Craigie's laborious and most intricate investigations have reference to sexuality in rust fungi. Sexuality studies have engaged a number of authorities in other countries (Kniep, Bensaude, etc.),

[1] Dr. D. L. Bailey had been offered and had accepted the professorship of Plant Pathology at the University of Toronto. It is gratifying to note that several of our Canadian Universities have drawn upon the technical personnel of our Division, even though their gain is our distinct loss.

and in Canada have made great progress under Miss Irene Mounce of the Central Plant Pathological Laboratory at Ottawa, herself also a student of that indefatigable research worker on fungi, Dr. A. H. Reginald Buller, through whose inspiration others of his students made fundamental contributions to our knowledge of sexuality in higher fungi. Now Dr. Craigie has established indisputably by his researches that certain organs, the so-called pycnia, which were always present in certain stages of the life history of many rusts affecting plants, and whose function had been hitherto a matter of speculation, in reality were concerned with sexual reproduction. This discovery is widely and rightly regarded as the outstanding one of recent years, and it is most gratifying that it emanated from our Canadian Rust Research Laboratory.

FLAG SMUT OF WHEAT

A Dangerous Disease Intercepted

(H. T. Güssow, Dominion Botanist, Ottawa, Ont.)

About ten years ago[1] attention was called, primarily as a note of warning, to certain wheat diseases prevalent and more or less seriously destructive in other countries, that might eventually find their way into Canada. There exists no longer any doubt that our suspicion that "Take all" or foot-rot of wheat caused considerable damage in the wheat crop around Scott, Saskatchewan, in **1916** was correct. At that time only one single fruiting body was discovered which looked so suspicious that it was considered advisable to direct the attention of investigators and farmers to the possible presence in Canada of this destructive disease. Careful surveys have since established that this trouble is widely spread throughout Western Canada and certain of the States of the Union to the South. Attention may again be directed to the opinion of C. C. Brittlebank, Government Botanist of the Department of Agriculture of Victoria, Australia, in regard to the economic importance of this trouble in Australia, which is as follows:

"Of all the fungous diseases affecting wheat 'Take all' is the most destructive, and the actual loss caused by it is far greater than by any other single disease, Rust included, or perhaps by a combination of all known fungous diseases affecting wheat. Rust, when present in epidemic form, causes more widespread loss for the one season, but fortunately it appears only once in a series of years, while 'Take all' is always with us" (in Australia), "destroying a few plants here, thousands there, and nearly the entire crop in other places."

The Divisional officers in our Plant Pathological Laboratories throughout the West are making a thorough study of "Take all" and related foot and root rots, and valuable recommendations have been the result, indicating that, with proper care and with the wholehearted support of our Western farmers, the disease may not become seriously established in Canada to the detriment of wheat growing.

It is interesting and instructive to note that the inspectional services of the Dominion and provinces perform exceedingly valuable services to the country in their endeavours to keep out destructive insect pests and plant diseases, likely to be carried by imported vegetation, plants, and plant products. Even though passengers of steamship lines and others may occasionally resent having their personal baggage inspected, and any plant and plant products affected by disease or brought into Canada in contravention of the regulations under the Destructive Insect and Pest Act confiscated, the faithful performance of these onerous duties has protected on many occasions the interest and prosperity of the entire popu-

[1] "Take all," "Flag Smut," and "Ear cockle" of Wheat, Agricultural Gazette of Canada, Vol. 6, No. 7, p. 615. 1919.

lace. People, either for sentimental or other reasons, will persist in bringing with them to Canada from foreign countries all kinds of vegetation which should at least be examined for diseases and pests.

One of the most striking instances of interception is to be credited to the vigilance of the Provincial Plant Pathologist of British Columbia, Mr. J. W. Eastham, which at the same time gives a clue to the manner in which diseases may find their way from one country to another. Likewise this particular case emphasized the advantage of the similarity of efforts and the benefits from co-operation with our neighbours to the South in the endeavour to protect the entire Continent of America from the invasion by diseases of foreign origin. Mr. A. C. Fleury, Senior Quarantine Supervisor of the State of California at Sacramento, advised Mr. Lyne, the inspector of imported and exported horticultural products of the Department of Agriculture for British Columbia, that he had occasion to reject at the ports of San Pedro and San Francisco a shipment of 1,500 bags of bran, wheat chaff, and oat chaff, brought from Australia, and intended as feed for polo ponies that were en route from Australia to California via Honolulu. The shipment was "duly accompanied" by an official health certificate. Since this shipment was refused entry in the U.S.A. under their regulation, the opinion was expressed that the consignment might proceed to a British Columbia port, possibly Vancouver, where the owners might expect to land same. This actually occurred and, on arrival at Vancouver, the shipment was held and carefully inspected by Mr. Eastham, who advised us that he detected evidence of heavy infection with flag smut, one of the very diseases mentioned in our note of warning in 1919, and one which is at present quite unknown in Canada. The spores of the disease were found in exceedingly large numbers—a condition which we were able to confirm from material and siftings forwarded to us promptly by Mr. Eastham. The landing of the material was forbidden and once more Canada's wheat areas were protected from the invasion of what might have proved to be one of the most undesirable and seriously destructive diseases, largely through the vigilance on the part of attentive officers performing these duties, and for which they are frequently ridiculed by unthinking people. Most fungous spores have an unusual vitality; they may pass through the intestinal tracts of animals and yet retain their powers of germination. "Flag Smut" of wheat is caused by the fungus *Urocystis Tritici* Koern., and, while its popular name indicates that it is of the nature of a smut, it is quite different from the ordinary smuts of wheat with which farmers are familiar. Its affects principally the leaf blade or "flag", causing long stripes or welts filled, when mature, with myriads of black spores. It resembles closely flag smut of rye which is occasionally found in Eastern Canada, but from which it is quite distinct, since it is confined to wheat alone. We are greatly indebted to the officials who have been responsible in preventing the landing of this material.

REPORT OF THE DOMINION RUST RESEARCH LABORATORY, WINNIPEG, MANITOBA

(J. H. Cragie, Officer in Charge)

The investigational work carried on by the Rust Research Laboratory during the year 1928 was, in general, a continuation of the projects reported on last year. In addition, some work has been undertaken on root rots of cereals. In this the laboratory is co-operating with the two Dominion laboratories at Saskatoon and Edmonton and with the three western universities.

Certain changes in personnel have occurred. Dr. D. L. Bailey, formerly officer in charge, resigned to accept a professorship in the University of Toronto. Dr. J. H. Craigie was appointed his successor. Three other appointments have been made to the staff, Dr. W. F. Hanna, as Senior Pathologist; Mr. Bjorn Peturson, as Assistant Plant Pathologist; and Mr. Ernest Mathews, as Clerk.

Additional facilities have been afforded by the erection of an isolation greenhouse. Certain additional equipment also has been installed.

RUST EPIDEMIOLOGY

(Wm. Popp)

(*a*) FIELD STUDIES

A comparison of the weather conditions which prevailed in Western Canada during the months of June, July, and even August, of **1927** and **1928**, might lead one to suspect that a rust epidemic might develop in one of these years just as well as in the other. That this was not the case is very well known. In **1927** rust caused very severe losses, whereas in **1928** the damage from rust was negligible. The average precipitation for June, **1928**, was over five inches, while that for June, **1927**, was a great deal less, being slightly over two inches. For July of both years the amounts were almost identical. In August, **1928**, however, almost one inch less of rain fell than in August the previous year.

It is well known that temperature profoundly influences the development of rust. As far as this factor is concerned, the months of July and August, **1928**, were even more favourable than the same two months in **1927**. In July of the present year the average temperature was two degrees higher than it was for the same month last year; and in August, a fraction of a degree higher. With respect, therefore, to humidity and temperature, there seems to be no reason why a heavy epidemic of rust did not occur this year.

In collecting field data in the various sections of Western Canada, the staff of the Rust Research Laboratory was very generously assisted by the three Dominion Laboratories at Saskatoon, Edmonton, and Vancouver; by the universities, and by the different Dominion and Provincial Experimental Farms and Stations throughout the West. This assistance is very gratefully acknowledged.

The first trace of rust was discovered at Winnipeg on July **9**, three days later than it was found last year, and at Morden, Man., on July **12**. Evidently the infections from which these first few pustules arose occurred at approximately the same time.

By July **21**, rust development had progressed somewhat. Secondary infections were becoming common on Garnet wheat in the Carmen-Morris-Morden district, although only a trace was yet present on Marquis and the other common wheats. Only traces of rust were found further west in Manitoba, through Treherne, Glenboro', and Killarney, to Deloraine. In the durum-growing area in southwestern Manitoba, no rust was found up to this time, and, in fact, the durum wheats remained almost free of rust all the season. Along the Winnipeg-Brandon line, scattered infections could be found. No rust was yet present on oats.

It was not until July **20** that any trace of rust was found in southeastern Saskatchewan. By this date also a few infections were found at Saskatoon. Secondary infection was found in a winter-wheat plot at the University at Saskatoon. This may possibly be a case of overwintering, but, more probably, it originated from an infection by early-arriving spores. The slides exposed by aeroplanes at Cormorant Lake in northern Manitoba on July **13** and **14** showed that spores were present in the air so far north in Manitoba, and this point is two degrees of latitude further north than Saskatoon. It is probable that, if earlier exposures had been made at Cormorant Lake, spores would have been found. There is, therefore, considerable likelihood that, as Saskatoon is less far north, the infection occurring there originated from spores which arrived early, although this cannot be proved.

An account of the subsequent development of rust in 1928 need not be long. The dull wet weather cleared up about the first of August, and the grain ripened fast during the next two weeks. By August 16, cutting was general in Manitoba, except in the northwestern section of the wheat-growing area. In both Manitoba and Saskatchewan the rapid ripening of the grain brought to a sudden ending the advance of the rust. Scarcely more than a trace of rust occurred anywhere in Alberta. A few late fields of oats in Manitoba and Saskatchewan and a little late wheat had a good deal of rust, but not enough to lower appreciably the yield or grade.

One feature of the rust development should be noted here; that is, the occurrence in a few scattered localities, both in Manitoba and Saskatchewan, of very small areas, perhaps only a small patch in a field, which were quite heavily rusted. Circumstantially this may appear as if rust had overwintered in these places, caused early infections, and multiplied sufficiently to produce this condition. It seems, however, more probable that early-arriving spores, even though few in number (as is shown by the slide exposure results), were successful in giving rise to a few scattered early infections, and that, during the very favourable conditions which obtained during the latter part of June and July, these were able to develop sufficiently to infect a small area in their immediate vicinity. Had these centres been numerous enough, so that later the infected areas coalesced, the condition would have simulated that of an ordinary epidemic. Fortunately this was not the case.

Any attempt to explain fully just why an epidemic occurred in 1927, and not in 1928, would be a futile endeavour. Sufficient information is not at hand for that purpose. But it seems worth while to draw attention to a few outstanding points. In 1927, owing to the excessive rainfall in May, particularly in Manitoba, seeding was done whenever and wherever the soil was dry enough. It, therefore, happened that all over the country there was great irregularity in the development of the crop. Moderately early fields lay side by side with ones which were very late. There was a good deal of rain during the months of August and September, and this condition, in conjunction with the heavy rust infection which developed, delayed the normal maturing of the harvest. Rust, therefore, suffered no check in its progress. Everywhere there were favourable conditions for its development and abundant green material on which it could multiply. The amount of inoculum present in Western Canada increased to enormous proportions, and spread to the farthest limits of the wheat-producing belt.

On the other hand, owing to the excellent weather during May, 1928, most of the seeding was done in a comparatively short time, and there was a very marked uniformity in the development of the crop. Although the months of June and July were wet, fine weather came early in August and hastened the maturing of the crop. The irregularity in ripening so noticeable last year was entirely absent this year. On account of these conditions the development of rust was brought to an abrupt termination, whereas in 1927 it continued on until late in the autumn.

Moreover, as indicated somewhat earlier, the amount of initial inoculum was smaller in 1928 than in 1927. Rust, therefore, began its invasion of Western Canada with too small a force for the rapid conquest of the prairies, and, before it had time to multiply there and increase its strength sufficiently to inflict severe damage, the crop had ripened, and thus escaped appreciable loss.

Leaf rust (*Puccinia Tritici*) was present as usual, but it appeared somewhat later than last year and was much less severe.

Crown rust (*Puccinia coronata*) of oats, which assumed epidemic proportions last year, was of little consequence during the present year. Fairly heavy local infections occurred at McDonald, Weymouth, and Boissevain, in Manitoba, but these infections very evidently originated from aeciospores which developed on neighbouring buckthorn hedges, which showed a considerable number of pustules of that rust. There was no general infection of oats in the prairie provinces.

Yellow stripe rust (*Puccinia glumarum*) was found in three places in Saskatchewan: at Alsask on Marquis wheat, and at Ponteix and Horizon on wild barley (*Hordeum jubatum*). In Alberta it occurred commonly, but not abundantly, throughout a large part of the province. On Vancouver island it was very severe and general. Here, as in Alberta, wild barley was the chief host.

(*b*) STATIONARY SLIDE EXPOSURES

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

A description of the methods employed in determining the spore content of the air will be found in the Report of the Dominion Botanist for 1927. It will be necessary here only to mention some of the features gleaned from the work this year.

Although spores of *Puccinia graminis* were found on the slides exposed at the different stations in Manitoba and Saskatchewan prior to June 24, there is good reason to believe that the first viable spores arrived in Manitoba on or about that date. The spores which appeared earlier on the slides were quite evidently produced in 1927. They were almost devoid of colour, and lacked entirely the characteristic appearance of viable spores. In fact this type of spore was found on slides exposed in southeastern Saskatchewan as early as the middle of May. It is inconceivable that these originated locally this year, as there were no hosts present at that time on which they could have developed. Moreover, through the courtesy of the United States Department of Agriculture, it is known that the first trace of stem rust occurred in the northern states of the Mississippi valley about June 20. Up to that time the development of rust in states farther south was so limited, that there is little or no justification for believing that sufficient inoculum was available there for dispersion northward to permit spores to appear so frequently on the slides. The evidence seems fairly conclusive that spores found on the slides during May, and the majority, possibly all, found during the first three weeks of June, were not produced this year, but were non-viable left-overs from last year.

During the last week of June and onward through July a new difficulty was encountered. Some of the spores on the slides were viable and were produced this year, but it is equally certain that many of them were not. Just where to draw a line of demarcation was a difficult matter, as spores produced comparatively early in the season, and thus subjected to weathering, might resemble very much in appearance spores produced the previous year. Germination tests for such spores were not conclusive, as many spores, even though freshly produced, frequently showed great irregularity in percentage of germination.

Why these left-over spores occurred so commonly on the earlier exposed slides this year may be attributed quite justly to the fact that, owing to the unusually wet autumn of 1927, a considerable portion of the crop remained unthreshed throughout the winter. In the early spring, 1928, the threshing was completed. As rust was exceedingly abundant last year, numerous rust spores must have been liberated during the spring threshing, and these, coming in contact with the slides, gave the results noted above. It would be hazardous to say that all the spores thus liberated were non-viable and, therefore, incapable of producing infection, for it is impossible to make exhaustive tests for the whole of Western Canada; but there is no doubt that such spores are not a significant factor in the initiation of rust epidemics in the prairie provinces.

There is no evidence yet to controvert the assertion that the earliest infections which occur in Western Canada arise from spores blown northward from rusted areas farther south, and that the rust development in the prairie provinces is accelerated by the subsequent arrival of spores. On the other hand, it is equally certain that the enormously high number of spores found on the slides, when rust gets well under way, are contributed to very largely by locally produced spores. It thus happens that there is only a limited period of time during which a comparison can be made of the number of spores carried northward into Canada in one year and another. This period for the present year would embrace approximately the last week of June and the first three weeks of July. During the last ten days of July the locally produced inoculum was becoming sufficiently abundant in Southern Manitoba to increase appreciably the number of spores on the slides. For the former period then, the number of spores intercepted by the slides indicate that, in Southern Manitoba, there was approximately only from one-sixth to one-eighth the amount of inoculum present in the air in 1928 that was present in that period in 1927. Of course, it must be borne in mind that the numbers of spores on the slides serve only as an index of the amount of inoculum actually present.

It would seem, therefore, that the relative scarcity of early-arriving spores was the chief factor operative in preventing a rapid development of rust during the month of July, as weather conditions for that month were very favourable for such development. Infections did occur, and on one of the early varieties rust made considerable progress before harvesting began, but, generally speaking, infections numerically throughout Manitoba and Saskatchewan were much less plentiful in July, 1928, than in the same month, 1927.

At the stations in Alberta, where slides were exposed, a few spores were present on the slides at various times during the latter part of July, but these were of the non-viable type referred to already. At Olds, particularly, these appeared to be more numerous than at the other stations. It was not, however, until about the first of August that viable spores appeared. These spores evidently caused the first field infections, as a few scattered infections were found about the 13th of that month.

Apparently two reasons account for the comparatively small number of spores present during the early summer in Western Canada. One, obviously, was that but a very limited development of rust took place in the States lying to the south; and the other, that frequent rains during the months of June and July undoubtedly washed the air more or less free of spores and kept the plants wet for long intervals, thus preventing the spores from being readily dislodged from the pustules and carried away by air currents.

(c) SLIDE EXPOSURES MADE DURING FLIGHTS

(Co-operative experiment between the Royal Canadian Air Force and the Dominion Rust Research Laboratory)

Slides were exposed during routine flights in northern Manitoba by patrols with base at Cormorant Lake, and in Alberta by patrols with base at High River; and during sulphur dusting operations, in southern Manitoba. The exposures were made at altitudes varying from 2,000 to 5,000 feet. As the methods employed have been already described in the Report of the Dominion Botanist for 1926, it is unnecessary to mention them here.

Owing to the limited development of stem rust this year either in the Mississippi valley or in the Prairie Provinces, the numbers of spores found on the slides were small; about half of the exposures registered no spores at all. Much space need not, therefore, be occupied with a discussion of the results.

One point, however, seems of interest. It is known that the first traces of stem rust in the fields began to appear in southern Manitoba between the 9th and 12th of July, but at this time the number of pustules was extremely low. It can be concluded that, as these few pustules were just breaking through the epidermis of the plants, they could have contributed no appreciable number of spores to the inoculum then present in the atmosphere. But at Cormorant Lake, on July 13, an exposure of 15 minutes' duration intercepted eight stem rust spores, and, on the following day, a similar exposure intercepted eighteen spores. These were viable-looking spores and were evidently produced this summer. If this was the case, and, judging from their appearance, it was, these spores must have originated several hundred miles distant from Cormorant Lake, as it is most improbable that rust had developed so far north, although, owing to the inaccessibility of this region, there is no opportunity of determining by over-wintering studies whether or not this rust persists there on native grasses from year to year. It is, however, not at all likely.

It may be said in general, that the results of this year confirm those of the three previous years, that rust spores are carried by air currents comparatively long distances from their place of origin; and, in addition, indicate that, in that northern region, there were only about one-eighth the number of spores floating about in the air that were present the previous year, thus supporting the evidence furnished by the stationary slides.

Physiologic Forms of Wheat Stem Rust in Canada

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

The work now reported on physiologic forms of wheat rust in Canada is a continuation of that given in earlier annual reports.

From tables 7 and 8 it will be seen that twenty-seven physiologic forms have been isolated in Canada during the period 1919 to 1927. The two physiologic forms 21 and 36, were the prevailing forms in 1925, 1926, and 1927, and were the most widely distributed of all the forms. (None of the 1928 results are being included in this report, as, at the date of writing, they are incomplete.)

TABLE 7.—DISTRIBUTION BY PROVINCES OF THE PHYSIOLOGIC FORMS OF *Puccinia graminis Tritici* IN CANADA IN 1927

Province	Forms																		
	9	14	15	16	17	19	21	29	30	32	34	36	38	49	50	52	53	56	57
Prince Edward Island	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	..	..	..
Nova Scotia	....	....	....	....	....	....	3	....	1	....	....	4	7	....	....	....	..	..	..
New Brunswick	....	....	....	....	....	1	....	....	....	....	....	1	2	....	....	....	..	..	..
Quebec	....	....	....	....	1	....	4	....	....	....	....	6	1	1	....	....	..	..	..
Ontario	....	1	....	....	1	....	7	....	1	2	....	7	3	....	1	....	1	..	..
Manitoba	4	10	5	....	7	....	52	2	4	4	7	81	5	4	1	11	..	1	1
Saskatchewan	3	1	3	1	7	....	50	3	4	....	5	81	5	3	1	2	..	..	..
Alberta	....	4	1	1	2	....	24	....	....	1	....	47	2	2	1	....	..	..	..
British Columbia	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	..	..	..
Total	7	16	9	2	18	1	141	5	10	7	12	228	25	10	4	13	1	1	1

Total number of forms, 19. Total number of cultures isolated, 511.

TABLE 8.—ANNUAL OCCURRENCE OF PHYSIOLOGIC FORMS OF *Puccinia graminis Tritici* IN CANADA FROM 1919 TO 1927, WITH A RECORD OF THE NUMBER OF TIMES EACH FORM WAS COLLECTED ANNUALLY

Form	Number of times form was collected								
	1919	1920	1921	1922	1923	1924	1925	1926	1927
1	2	1							
2					1				
3		4	3	10	10	16			
9	4	6	2	3				1	7
11	2	5	2	3	5	9			
12		2				5			
14								2	16
15	1							2	9
16									2
17	9	31	27	16	10	1		2	18
18	4	7	3	2					
19	1							1	1
21	4		4	24		1	44	86	141
24	1		1						
29		17	1				13	29	5
30		1					1	7	10
32		4	1				3	12	7
34				1	3	7	1	4	12
36				2			113	217	228
38								18	25
48								2	
49								3	10
50									4
52								1	13
53									1
56									1
57									1
Total number of forms....	9	10	9	8	5	6	6	15	19
Total number of collections made in year..........	28	78	44	61	29	39	175	387	511

All physiologic forms of rust collected in Canada up to 1926 were identified as one or other of the forms found in the United States. During 1926 and 1927, eight physiologic forms, different from any previously described in Canada or the United States, were discovered in Canada. In the 1927 report, mention is made of the discovery of six of them.

Dr. E. C. Stakman and Dr. M. N. Levine have assigned the following numbers to these forms: 38, 48, 49, 50, 52, 53, 56, and 57. Four of these were isolated only from uredinial material collected in the field, namely, forms 38, 48, 50 and 53. Two were isolated from both uredinial and aecial material, viz., forms 49 and 52; and two, forms 56 and 57, were isolated from aecial material only.

Form 38 is one of the prevailing physiologic forms of Eastern Canada, but occurs to a lesser extent in the prairie provinces. Forms 48 and 53 were each collected but once at Ottawa, the former in 1926, the latter in 1927. Form 50 was isolated once from each of the provinces, Ontario, Manitoba, Saskatchewan, and Alberta. Form 49 has been found in both Eastern and Western Canada, but form 52 has been found only in Manitoba and Saskatchewan. Forms 56 and 57 were isolated only from barberry infected in the greenhouse at Winnipeg.

These new physiologic forms have been discussed fully in Scientific Agriculture Vol. 9, No. 4, pp. 209-215, 1928.

GREENHOUSE EXPERIMENTS ON THE RELATIVE SUSCEPTIBILITY OF TWENTY-SIX VARIETIES OF WHEAT TO TWENTY-TWO PHYSIOLOGIC FORMS OF STEM RUST

One of the ultimate aims of all stem rust research is the production of a common wheat variety of satisfactory milling quality which at the same time possesses adequate resistance to stem rust. It is necessary, therefore, to know the exact reaction of many of the partially resistant common wheat varieties to the physiologic forms of rust which occur in Canada, and these reactions can be determined most exactly under controlled conditions in the greenhouse.

Since 1925, twenty-six wheat varieties have been tested in the greenhouse to twenty-two physiologic forms of wheat stem rust. An article, including the details of part of this experiment and the results obtained, will be found in the 1927 Annual Report, and in Sc. Agr. 7: 161-165, 1927. As all the results for the remainder have not yet been checked by duplicate experiments, it is deemed wise to hold over the final report until next year.

Physiologic Forms of Oat Stem Rust

(W. L. Gordon)

This project was carried on in a manner similar to that of previous years. Three hundred and forty-four collections of oat stem rust obtained in Canada were cultured in the greenhouse. Data concerning the number and distribution of collections from each province and the physiologic forms isolated from them are shown in fig. 4 and table 9.

TABLE 9—NUMBER AND DISTRIBUTION OF COLLECTIONS OF OAT STEM RUST

Province	Number of collections	Physiologic forms isolated
British Columbia	1	2, 5
Alberta	45	1, 2, 5
Saskatchewan	143	1, 2, 4, 5
Manitoba	115	1, 2, 4, 5, 6
Ontario	18	2, 5
Province of Quebec	9	1, 2, 5
New Brunswick	3	2, 5
Nova Scotia	9	2, 5
Prince Edward Island	1	4

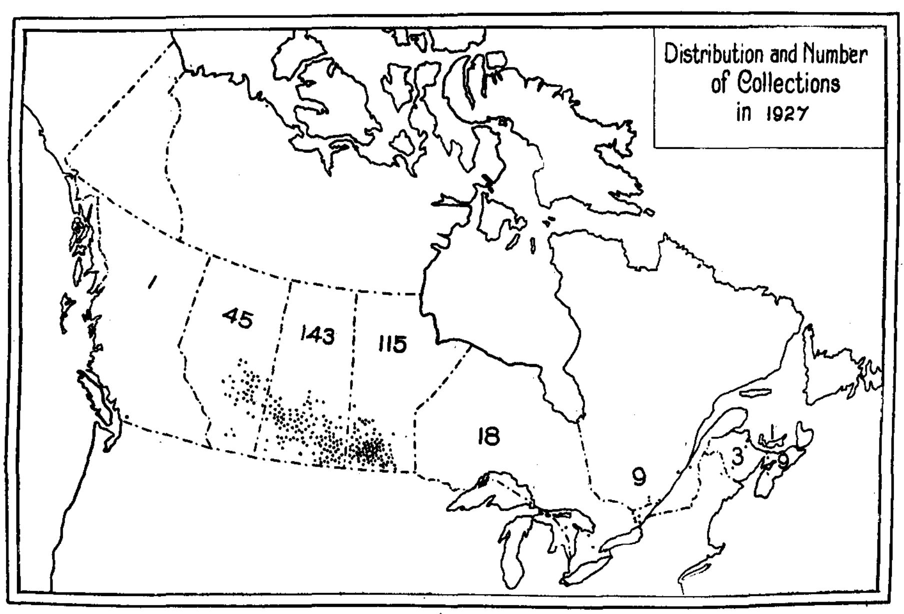


FIG. 4.—Collections of oat stem rust.

As in previous years, physiologic forms 2 and 5 were the most prevalent. Forms 1, 4, and 6 were isolated rarely. Form 6 is a new physiologic form which is capable of infecting heavily all differential hosts, as shown in fig. 5. It was collected for the first time at Paskwegin, Sask., in 1925. Physiologic form 4, previous to its first collection in Saskatchewan in 1925, was known to occur only in Sweden.

The number of isolations of each physiologic form is shown in table 10.

TABLE 10—NUMBER OF ISOLATIONS OF EACH PHYSIOLOGIC FORM OF OAT STEM RUST

Form	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	Total isolations
1	....	2	3	4	....	1	....	....	....	10
2	1	16	59	56	12	2	1	4	....	151
3	....	....	....	....	....	....	....	....	....	....
4	....	....	1	3	....	....	....	....	1	5
5	1	35	95	68	7	7	3	5	....	221
6	....	....	....	1	....	....	....	....	....	1

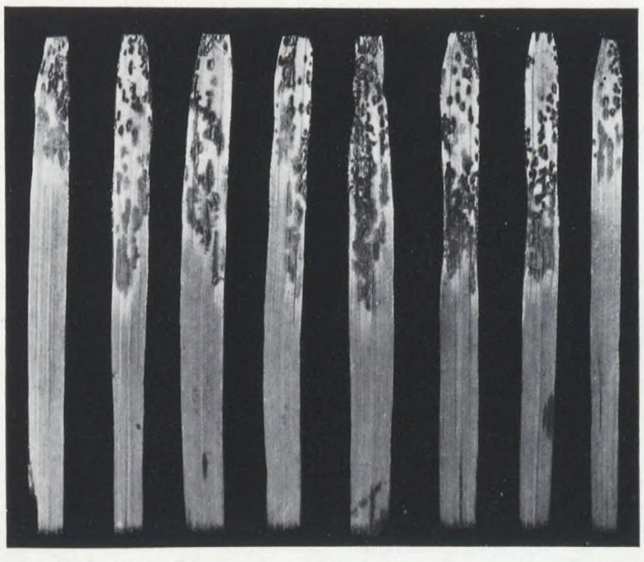


FIG. 5.—Typical reactions of the differential hosts to physiologic form 6.

SEEDLING TESTS OF OAT VARIETIES FOR RUST RESISTANCE TO PHYSIOLOGIC FORMS 4 AND 6

In connection with the physiologic form work, seedling tests of oat varieties for rust resistance were carried on in the greenhouse early in 1927, in the hope of obtaining a variety or strain resistant to form 6.

Some 230 varieties or strains of oats, obtained from various sources in Canada and the United States, were inoculated in the seedling stage. These varieties were tested also to form 4 at the same time. All appeared to be quite susceptible to both physiologic forms.

As none of the varieties available in America showed any resistance to these two forms, 100 additional ones were secured, through the courtesy of the Dominion Botanist, from France, Germany, Sweden, and Russia. It was discouraging to find that all were apparently susceptible to form 6, and only one variety, from France, showed any resistance to form 4.

Co-operative Uniform Rust Nurseries

(Margaret Newton and J. H. Craigie)

The co-operative uniform rust nurseries, installed in 1921, were continued as in previous years. The project was expanded in 1927 to include four new nurseries, one at each of the following places: Beaverlodge, Alta.; Guelph, Ont.; Nappan, N.S.; and Fredericton, N.B. In 1928, a nursery was placed on Vancouver island, at Sidney, B.C. At the twenty-two stations, in 1928, twenty-five varieties of wheat and eleven varieties of oats were tested for their relative resistance to stem rust.

Owing to the early date at which this report is being submitted, the physiologic forms have been isolated from only about one-half of the rust collections made in these nurseries. A full summary of this work, therefore, will appear in the next annual report.

Sulphur Dusting Experiments for the Control of Cereal Rusts

(F. J. Greaney)

During the last few years the problem of controlling rust by dusting with sulphur has been given considerable attention. The use of liquid fungicides for the control of rust diseases could not be made a practical method for treating large grain fields such as obtain in Western Canada. It would be impossible to spray large areas of crop, owing to the enormous amount of water required for the purpose. Dusting for the control of rust has much greater practical possibilities.

Successful attempts have been made to control rust with dust fungicides. Large fields have been dusted by means of horse-drawn and power-dusting machines. These field trials have given some remarkable results, and, more recently, applications by means of an aeroplane have also been successful. Nevertheless, considerable work has still to be accomplished before a completely successful dusting program for the control of rust can be developed. In attempting to make out a practical and efficient dusting schedule, it became apparent that the production of cheaper and more effective fungicides will be an extremely important factor in determining the practical and economic possibilities of the dusting method for the control of rust.

Field results in 1927 emphasized the importance of several factors, namely: the rate of dust application, the time of dust application, the thoroughness of the treatment, the weather conditions following the applications, and the rate of spread and development of the rust epidemic. In carrying out this season's experiment, particular attention was given to determine the influence of the various factors on the effectiveness of the treatment. The sulphur dusting studies for the control of rust were extended in 1928 to include three general lines of investigation. (1) Winnipeg, small plot experiments, (2) field dusting trials, and (3) laboratory and greenhouse studies on the toxicity and effectiveness of fungicidal dusts in the control of cereal rusts.

WINNIPEG PLOT EXPERIMENTS

A comprehensive series of small plot experiments was carried out in Manitoba during 1928 on the control of leaf and stem rust of wheat by sulphur dusting. Unfortunately, due to the occurrence of an exceedingly light infection of stem rust during the major part of the growing season, the season was not a very satisfactory one to test the efficiency of this treatment under field conditions.

One hundredth-acre plots of Marquis wheat were used to determine: (1) the effectiveness of various rates and frequencies of dusting, (2) the fungicidal efficiency of various commercial dusting sulphurs, (3) the influence of time of initial applications of the dust in relation to the stage of the rust epidemic, and (4) the influence of the addition of an oxidizing agent to the sulphur dust. An attempt was also made to discover the influence of direct and indirect methods of dust application. The purpose of another experiment was to find out the relative effectiveness of dust application just before and immediately after rains.

EXPERIMENTAL METHODS

A small field on the College Farm at Winnipeg was sown with Marquis wheat on May 19. After the plants had appeared above the ground, the field was divided into one hundredth-acre plots, which were separated from each other by three-foot pathways. The dusting was done with a small hand-duster of the blower-gun type. Kolodust, a finely divided sulphur dust, was used throughout the various experiments.

Dusting was begun on July 17. At this time a light infection of leaf rust was to be found in the plots. Stem rust had not been discovered in any part of the field. Final data on leaf rust infection were taken by Dr. Margaret Newton on August 8. Mr. T. Johnson recorded the final stem rust results on September 2.

Each treatment was replicated three times on four plots, systematically distributed throughout the field. A check plot series for each experiment was similarly distributed. No attempt was made this year to study the yield results statistically. In most cases differences between treated and untreated plots were extremely variable. Even in this late field of Marquis wheat, stem rust infection was unusually light during the major part of the growing period. Rust developed fairly rapidly after August 18, and by September 1 a fairly uniform and moderately severe epidemic of stem rust was prevalent. Unfortunately, an early frost on August 28 caused a marked reduction in yield and quality of these late plots of Marquis wheat. The threshed samples from the treated and untreated plots were graded according to the regular grain standards. All of the samples gave particularly low grades. Therefore, the quality of the threshed grain from the variously dusted plots could not be used as a criterion to determine the effectiveness of the different treatments.

Rust infection results were determined by using the average of the four plots in each treatment. Yield data were obtained by removing the outside rows and one foot from the ends of each plot, and then harvesting and threshing each one separately. The average of the four plots was used to compute the yield in bushels per acre. The weight per measured bushel was also determined from the average of four plots.

EXPERIMENTAL RESULTS

The Effectiveness of Different Rates and Frequencies of Dusting

The treatments used were 15, 30, and 45 pounds of sulphur dust per acre at each application, and the frequencies were once a week and twice a week. In this experiment, dusting was commenced on July 17 and was continued until August 29. The crop was harvested on September 8.

The results are summarized in table 11. It is evident that the best control was obtained by two applications of sulphur dust per week at the rate of 45 pounds per acre, from July 17 to August 20. The plot so dusted showed 6 per cent stem and 38 per cent leaf rust infections as compared with 56 and 70 per cent infections respectively in the check plots. In general, with any given frequency of dust application, the degree of control improved with the rate of sulphur dust applications. These results are similar to those obtained in the rate and frequency experiments of 1925 and 1927. The most perfect control was achieved when the heaviest applications were used at the greatest frequency.

TABLE 11—RESULTS OF DUSTING WITH SULPHUR. INFLUENCE OF THE RATE AND FREQUENCY OF APPLICATION ON RUST INFECTION AND YIELD OF MARQUIS WHEAT

Application of sulphur dust		Percentage infection			Yield results*	
Rate lb. per acre	Frequency number per week	Total number	Leaf rust	Stem rust	Weight per measured bushel	Yield per acre
			%	%	lb.	bush.
Checks	0	0	72	57	59	21·6
15	1	6	60	42	60	33·2
30	1	6	51	22	59	29·1
45	1	6	49	20	60	31·3
Checks	0	0	70	56	59	22·4
15	2	12	50	20	59	25·4
30	2	12	51	22	59	31·2
45	2	12	35	6	60	35·1

*Average of four, systematically distributed, one-hundredth-acre plots.

Owing to the conditions already mentioned, the differences in yield between the variously treated plots are not very significant. In the case of weekly application, a dusting frequency of considerable promise for practical purposes, stem rust infection was reduced from 57 to 20 per cent, and resulted in an increased yield of 7·4 bushels per acre, when the crop was dusted at the rate of 45 pounds per acre. Two applications per week of 45 pounds per acre significantly improved the degree of control. However, from a practical standpoint, weekly applications would seem to be approaching a feasible frequency for dusting large areas of crop. The cost of making more frequent applications would be almost prohibitive. For a bad rust year, however, semi-weekly applications of sulphur dust would be an extremely effective and profitable farming practice for the control of rust. It is apparent, however, that very heavy applications of sulphur are necessary to control leaf rust infection in the field, and it is important that the dust be applied before rust has appeared on the leaves. With the development of better spreading and more efficient fungicidal dusts the method will become a thoroughly practical one for the control of rust.

The Fungicidal Efficiency of Various Commercial Dusting Sulphurs

Five different commercial sulphur dusts were used in plot experiments to study their relative effectiveness. One hundredth-acre plots of Marquis wheat were dusted weekly at the rate of 30 pounds per acre from July 17 to August 29. Each dust treatment was replicated three times. The results of these treated and untreated plots are presented in table 12.

TABLE 12—FIELD RESULTS OF DUSTING WITH SULPHUR. EFFECTIVENESS OF VARIOUS DUST FUNGICIDES IN THE CONTROL OF LEAF AND STEM RUSTS OF WHEAT

Dust treatment	Percentage of rust infection		Yield results*	
	Leaf rust	Stem rust	Weight per measured bushel	Yield per acre
	%	%	lb.	bush.
Kopper Dust	59	20	60	30·8
Kolodust	58	23	60	29·3
Electric Sulphur	60	20	59	33·2
National Sulphur	64	30	58	27·0
Owl Sulphur	70	50	58	24·2
Checks	75	56	57	22·5

*Average of four, systematically distributed, one-hundredth-acre plots.

Some of the dusts were extremely efficient fungicides under field conditions. The degree of control obtained by the more finely divided materials, such as Kopper dust, Kolodust, and Electric Sulphur, was sufficient to influence significantly the yield. Under the conditions of the experiment, the coarser dusting sulphurs did not compare favourably with the finer and more expensive dusts. Still, in a season like the past one, the degree of rust control achieved by 30 pounds per acre, applied weekly, of such dusts as National Sulphur and Owl Sulphur, indicates the possible usefulness of cheaper grades of dusting sulphur for the most practical and economic control. Further field trials are essential to determine further the value of some of the most common commercial grades of sulphur dusts.

Influence of the Time of Initial Application on the Degree of Rust Control

Experiments were undertaken to determine whether the time at which dusting is begun, in relation to the development of the rust epidemic, influenced the degree of control. Dusting was commenced on July 25 in one series of plots, which was dusted subsequently at weekly intervals at the rate of 30 pounds per acre until August 28. On July 25 a trace of stem rust was present in the district, but leaf rust could be found on 80 per cent of the plants. One week later, similar treatments were started on another group of four plots. On August 8, dusting was begun on a third series. By August 8, 25 per cent of the plants were infected with from a trace to 5 per cent of stem rust. Leaf rust had developed rapidly and infection ranged from 10 to 20 per cent on all of the plants. Initial applications of sulphur were delayed until August 17 on another series of one-hundredth-acre plots, at which time a light trace of stem rust could be found on 75 per cent of the stems, and leaf rust infection ranged from 35 to 45 per cent on practically all of the plants.

The results of these experiments are presented in table 13. Owing to the effect of an early frost, the quality of the grain from the various treated and untreated plots was extremely poor. Weekly treatments of 30 pounds per acre, when dusting was begun on July 25, August 1, and August 9, gave approximately the same degree of stem rust control. Leaf rust infection was not influenced by any of the weekly dust treatments. Again, these results indicate the importance of very early dust application for the control of leaf rust.

TABLE 13—RESULTS OF DUSTING WITH SULPHUR. INFLUENCE OF TIME OF INITIAL APPLICATION ON LEAF AND STEM RUST INFECTION AND YIELD OF MARQUIS WHEAT

Date of initial application	Total number of 30 lb. per acre applications	Percentage of rust infection		Yield results*	
		Leaf rust	Stem rust	Weight per measured bushel	Yield per acre
		%	%	lb.	bush.
July 25	6	60	32	58	24·6
August 1	5	65	33	59	25·9
August 9	4	67	37	59	23·1
August 17	3	67	42	57	21·2
Checks†	0	75	55	57	20·0

†Average of eight untreated check plots.
*Average of four, systematically distributed, one-hundredth-acre plots.

The spread and development of stem rust was unusually slow during July and early August. It was not until the middle of August that any very appreciable amount of rust developed, and consequently it could hardly be expected that any marked differences in stem rust control would occur, when initial applications of sulphur were made on July 25, August 1, and August 9. However, a marked decrease in rust control was noticed when dusting was delayed until August 17. Although the differences in yield results are not outstanding, they emphasize the importance of having the plants well protected before much inoculum is present. Applications should be made according to the development and spread of rust, and the weather conditions prevailing during the critical period, and they should be continued until the crop is practically mature.

The purpose of another experiment was to determine whether or not the fungicidal activity could be increased by the addition of oxidizing agents to sulphur. Marquis wheat plots were dusted with Kolodust. These plots were compared with adjacent ones dusted with Kolodust to which 2 per cent of potassium permanganate had been added. A mixture of 5 per cent permanganate in sulphur was used in treating another series of one hundredth-acre plots. The plots treated were replicated three times with an adequate control series. Weekly applications of 30 pounds per acre were made from July 17 to August 29. None of the oxidized sulphur dusts gave any reduction in the disease in this experiment, when they were compared with weekly treatments of Kolodust, but, in other experiments mentioned in this report, a reduction is recorded.

An attempt was also made to determine the relative influence on rust control of applying sulphur dust just before and immediately after rains. Although the results were not very striking, there was a slight increase in degree of stem rust control when the dust was applied immediately after a rain. This treatment was very much more effective than the equally frequent weekly application which bore no relation to weather conditions. This phase of the problem deserves considerable attention. The results emphasize the influence of the weather conditions prevailing during the dusting season on the effectiveness of the sulphur treatment.

In another experiment, when two methods of applying the fungicide were used, the importance of applying the dust forcibly to the growing plants was clearly demonstrated. By allowing the dust to drift over the crop the efficiency of the fungicide was considerably reduced. Field experiments with power dusters have also demonstrated the value of dusting thoroughly the whole surface of the plants. Not only is the efficiency of the fungicide reduced, but a considerable waste of material occurs, when the finely divided dust is allowed to drift across the standing crop.

The tests for this year were not very satisfactory. The unusually late and rather light stem rust epidemic did not produce satisfactory conditions for testing the efficiency of the various treatments. Moreover, the occurrence of an early frost caused severe injury to the late plots of Marquis wheat and reduced the quality and yield of the crop to a significant degree. But the feasibility of the dusting method as a practical method of controlling rust was emphasized again by the increase in yield obtained by weekly applications of sulphur dust.

FIELD TRIALS

AEROPLANE DUSTING EXPERIMENTS

The use of the aeroplane for the application of dust fungicides and insecticides constitutes an advanced step in insect and plant disease control work. Experimental work in the control of the cotton boll weevil has been carried on at the Delta Laboratory at Tallulah, Louisiana, U.S.A., since 1922. Considerable success has been obtained in the practical control of the cotton boll weevil by the use of the aeroplane. A regularly organized commercial aeroplane dusting service has already been made available for this important work.

Aeroplane sulphur dusting experiments for the control of rust were carried on in Manitoba last year (see Report of the Dominion Botanist, 1927). The results obtained in these preliminary experiments were extremely promising, and thoroughly justified a continuation of this phase of the rust control work.

Profiting by the experience gained last year, the experiments of this season were outlined to determine the feasibility of aeroplane sulphur dusting for the control of rust. The results of the past three years at this laboratory have clearly demonstrated the effectivness of the sulphur dust treatment in the control of rust. With the effectiveness of the treatment no longer in doubt, it was essential to determine some means of distributing the fungicide efficiently and profitably over extensive areas. For the dusting of large areas of cereal crops, such as occur in Western Canada, the aeroplane is extremely well suited.

Since the cost of the fungicide is the chief factor in determining the practical serviceableness of this treatment, it is extremely important to determine the optimum rate and frequency of dust application for the most effective and profitable rust control.

From the results of the 1927 aeroplane dusting trials, it was evident that relatively heavy dust applications are necessary for the effective control of rust. In 1928, aeroplane dusting experiments were outlined to study the effectiveness of various rates and frequencies of dusting, and to determine the feasibility of the aeroplane dusting method for controlling rust over large areas.

Co-operative experiments between the Department of Civil Air Operations and the Dominion Rust Research Laboratory were continued this year. The Keystone Puffer, a specially designed plane for dusting work, and the one used in the experiments last year, was detailed by the Department of Civil Air Operations for this work.

One of the most important factors in determining the thoroughness of the dust treatment by aeroplane is the care and good judgment of the pilot. A slight error in judgment during a dusting flight means so much crop area improperly dusted, and results in a waste of dusting material. In a large measure the success achieved in the 1927 aeroplane dusting experiments was due to the pilot's skill in handling and manipulating the dusting plane under the most difficult air conditions. The laboratory was again fortunate in having the services of Flying Officer T. M. Shields for this work.

Early in the season a thorough search was made in Manitoba for satisfactory areas for the experiments. Although the acreage sown to common spring wheat was larger in 1928 than in 1927, nevertheless, considerable difficulty was experienced in locating large fields of common wheat suitable for the dusting experiments. However, selections were made in two localities in southern Manitoba. Two fields, comprising an area of 250 acres, were chosen near the town of Morden; and one field of 140 acres was selected at Morris, Manitoba. A small field at Graysville was also dusted.

EXPERIMENTAL METHODS

In Manitoba the spring of 1928 was favourable for the early sowing of grain crops, and subsequent weather conditions permitted a rapid, vigorous, and uniform development of the young plants.

Location of Dusting Areas

The fields selected for this year's trials consisted of Marquis wheat growing on summer fallow. These fields were conveniently near satisfactory landing bases. It is extremely important when selecting areas for aeroplane dusting operations to give considerable attention to the availability of desirable landing fields. In each dusting area a level pasture field comprising an area of approximately thirty acres was used for this purpose. In a field of this type the pilot was able to take-off, or land the machine, from any direction. Long smooth runways are particularly desirable when the plane has to take off with a 500-pound load of dust.

Dusting Methods

All the dusting was done with a "Keystone Puffer", a machine specially constructed for dusting work and used in the trials last year (Report of Dominion Botanist, 1927). In all of the aeroplane experiments, Kolodust, a finely divided sulphur manufactured by the Niagara Sprayer Company, was used.

The usual manner of treating a field consisted of flying back and forth over the growing crop, permitting the dust clouds to overlap very slightly. The aeroplane was loaded with 500 pounds of sulphur and was flown over the field at a height of from 10 to 20 feet and at a speed of from 100 to 110 miles per hour. When favourable air conditions prevailed, and with a hopper valve opening of 1¾ inches, the machine would put out a dust cloud which would cover a strip of wheat from 90 to 100 feet wide. Under these conditions the fungicide was applied at an approximate rate of 25 pounds per acre. In this work, with landing bases centrally and conveniently situated and with straightaway dusting flights from three-fourths to one mile long, it was possible to dust effectively 80 acres per hour. Fifteen minutes was the time required to load the machine, take off, distribute 500 pounds of sulphur, and return to the landing field for another load.

Check Plots

The most satisfactory control plots can be obtained when the fields under experiment are large and continuous. In order to avoid the effect of dust drifting, a difficulty so often encountered in aeroplane dusting experiments, a strip of crop from 150 to 200 feet wide was left between the treated and untreated portions of each field. This area acted as a satisfactory buffer plot and prevented significant quantities of the dust from drifting on to the areas which served as checks, during the progress of the dusting operations. In this way very satisfactory check areas were maintained throughout the entire dusting period.

Dusting Operations

Dusting operations were carried on when flying and air conditions were especially favourable for the most effective distribution of the fungicide. Successful aeroplane dusting can be done only when the air is calm, and its success is enhanced when there is sufficient moisture in the air to prevent excessive drifting of the finely divided fungicide.

In Western Canada, dusting wheat for the control of rust will probably always be carried on in the evening. The period from 6 to 9 o'clock seems to be the most suitable for this work. When dusting operations were done at this time, it was found that the prevailing air conditions were extremely satisfactory for efficient manipulation of the machine, and the distribution of the dust cloud was such as to give a uniform dust covering over a swath-width of 90 to 100 feet. On the prairies, early morning dusting operations were not satisfactory. Only under extremely rare conditions can satisfactory aeroplane dusting be carried out during the daytime. It is difficult to procure a uniform protective covering of sulphur dust, since excessive dust drifting occurs if even a wind velocity of 10 miles per hour prevails.

When the hopper valve is opened, the dust is drawn out beneath the plane by the suction of air, and is immediately caught in the "slip stream" and subjected to its influence. From the height of 10 to 20 feet it is forced down among the plants. The plane in flight is surrounded by a body of air, which, due to the movement of the machine and to the rotary motion of the propellor, follows a spiral course. The most effective and uniform distribution can be obtained when the dust is entirely under the control of the air movement set up by the plane. When the dust cloud is influenced by breezes, the efficiency of its spread and coverage is reduced. Careful observations have indicated that dust which drifts on to the standing crop affords it inadequate protection. In order to obtain the most effective dust covering, it is essential that the fungicide be applied forcibly to the growing plants.

Directing Dusting Flight

To ensure the most thorough treatment of the crop, arrangements were made to direct the dusting flights from the ground. When dusting operations were in progress, one man was always in the grain field to direct the dusting operation.

The dusting area was distinctly marked out with large red flags. By means of white flags the men on the ground could indicate to the pilot the path over which he was to traverse the field. After the machine had passed over, he would move a sufficient distance across the field to allow for the most efficient spread of the dust, and then take up a position for the next crossing. In this way a uniform swath-width was maintained over the entire area treated. When the pilot left the field for reloading, the ground man would take up the new position so that he could give the pilot the direct line of flight for laying down the next dust-swath, when the machine returned to distribute the new load.

Experimental Data

The development of rust in the dusted and undusted portions of the fields under experiment was carefully observed during the dusting period. Dusting operations commenced on July 17, at which time only a light trace of stem rust could be found in the fields. Final rust data were taken a few days after each field had received its final application of dust, and shortly before the crop was harvested. Rust infection was estimated on the percentage basis and according to the usual standards.

Yield results were obtained by harvesting from the dusted and undusted portions of the field, not less than 20 rod-rows being chosen at random throughout each area. The average of these samples was used in calculating the yield of each area in bushels per acre. Threshed samples were submitted to Government grain grading officials in Winnipeg, and were graded according to the Canadian Government standard.

Experimental Results

The results obtained in each of the fields treated with sulphur dust are discussed separately in the following paragraphs.

Morden, A.—This field consisted of 1,925 acres of Marquis wheat growing on summer fallow. It was one mile long and was well adapted for aeroplane dusting flights. The field was divided into three sections. Areas approximately 200 feet wide were left between each section for buffer plots. One section of 45 acres received but one application of dust at the rate of 25 pounds per acre. Another section comprising 110 acres was dusted four times, at weekly intervals, at the same rate. The third section was left untreated as a check.

As is well known, there was but a slight development of rust in southern Manitoba. The results presented in Table 14 show clearly that dusting had no marked effect on the percentage infection of stem rust. The result from the field dusted only once during the season does indicate the desirability of making more frequent dust applications for the most effective control of rust. However, where rust infection is so light and variable, it is very difficult to determine accurately small differences in the severity of the attack over such large areas.

In the section receiving four applications of dust, it was quite evident from field observations that rust was held in check in the treated area as compared to the untreated one. In this case, there was an increase in yield of six bushels per acre over the undusted check. It would be altogether unfair to consider that this increase was due entirely to reduced rust infection. Nevertheless, rust was significantly held in check in the treated plots. Part of this increase in yield might be accounted for by the control of other common leaf and stem diseases of wheat so prevalent in Manitoba this year. Careful observations indicate the value of sulphur against other diseases of wheat.

TABLE 14—RESULTS OF DUSTING MARQUIS WHEAT WITH SULPHUR BY MEANS OF AEROPLANE FOR THE CONTROL OF STEM RUST IN MANITOBA IN 1928

Area	Treatment	Acres	Application of sulphur dust			Percentage infection of stem rust		Yield results		
			Rate in lb. per acre	Frequency in days	Total number	Range	Average	Weight per measured bushel	Canadian Government grade	Bushels per acre
			lb.			%	%	lb.		
Morden A	Dusted	110	25	7	4	tr-15	10	62·5	3N	25·1
	Dusted	45	25	0	1	tr-30	15	62·	3N	19·0
	Undusted	40	0	0	0	tr-25	15	62·5	3N	19·3
Morden B	Dusted	30	30	7	3	tr- 5	tr.	62·	2N	24·6
	Undusted	20	0	0	0	tr-15	5	62·	2N	18·6
Morris	Dusted	115	20	7	3	tr-10	5	62·5	2N	30·1
	Undusted	25	0	0	0	tr-10	5	62·5	2N	29·5
Graysville	Dusted	15	30	7	2	tr-40	5	63·	2N	28·7
	Undusted	5	0	0	0	5-30	20	61·	2N	21·0

Morden, B.—This dusted area received three 30-pound applications of sulphur per acre at intervals of seven days. Rust infection was extremely light over the dusted and undusted portions of the field. Again, there was an increased yield of six bushels per acre, but this might not be due entirely to reduced rust infection. The difference might be caused by the many factors operating in the absence of large amounts of stem rust. However, the increase in yield is significant and interesting, and was in all probability brought about by plant disease control.

Morris.—The field at Morris was divided into two sections. The treated section of 110 acres received three applications of sulphur weekly at the rate of 20 pounds per acre. There was almost a complete absence of injurious amounts of stem rust in the dusted and undusted areas. The yields obtained from these treated portions of the field did not show any significant increase over the undusted crop.

Graysville.—A thirty-acre field of wheat was sown on the farm of Mr. Alex. Murray specially for dusting by horse-drawn, or self-propelled dusters. Extremely wet conditions in July prevented any treatment being made by means of ground machines. In order to protect the crop from damage by rust, it was deemed advisable to dust part of the field by aeroplane. Accordingly, 15 acres were dusted twice during the season. Sulphur dust was applied at the rate of 25 pounds per acre on July 19. Ten days later a similar treatment was made. Part of the same field remained untreated as a check. It is extremely interesting to notice the improvement in yield in the dusted area. Undoubtedly the increase of 7·7 bushels per acre shown in table 14 over the undusted check is due mostly to the control of plant diseases. However, owing to the exceedingly light and variable rust attack in this district, as in other parts of the province, the results cannot be interpreted as due entirely to the control of stem rust.

Discussion

The past season in Manitoba as far as rust development is concerned, was an exceptional one. It would be difficult to imagine more ideal conditions for the development and spread of rust than the conditions which prevailed during late June and early July. The amount of precipitation was unusually high and the weather over this period was moderately warm. However, a heavy rust epidemic did not occur.

It may be significant, as indicated by exposed spore trap records, that the relative absence of rust in Western Canada this year was correlated with the scarcity of early inoculum. The extremely patchy nature of heavily rusted spots in some districts did indicate that conditions were favourable for rust development, and that, in all probability, the absence of large quantities of early inoculum was a real factor in preventing a serious epidemic. However, in Manitoba, there was an almost complete absence of injurious amounts of wheat stem rust. As far as observations could ascertain the loss from stem rust was almost negligible.

Owing to the exceptionally light rust epidemic, the aeroplane dusting experiments were obviously of no great value in determining the fundamental question of what rates and frequencies of dust will effect the practical control of rust. It will require more significant results to indicate the limits of effectiveness of the treatment, as well as the economic and practical possibilities of aeroplane dusting. Such results can only be expected when fairly heavy rust epidemics occur. However, the results, as noted above, do indicate the effectiveness of this method of sulphur dusting.

As far as the yield results are concerned, any differences in yield between dusted and undusted fields in a given district may be due to many factors operating in the absence of significant amounts of stem rust. Nevertheless, the increase in yield is interesting, and from close observations it would seem that the differences in yield between dusted and undusted portions of the same field can be accounted for by the general effectiveness of sulphur in controlling rust of wheat and other common stem and leaf diseases. This is an extremely important point in favour of sulphur dusting. It will be noticed that in practically every case there was a decided increase in yield in favour of the dusted crop. However, as rust epidemics do not occur every year, and as the results of several years of heavy rust infestation are necessary before a dusting program can be laid down, it will be necessary to continue the experimental work until a definite schedule can be proposed.

From all of the results it is evident that this method has distinct practical possibilities. The experiments have shown that the aeroplane is well suited for dusting large acreages. It is extremely desirable to determine what constitutes practical, as opposed to absolute, control of rust, in order that the most economic system of dusting may be determined. The problem is one of tremendous economic imprtance, and should be given every attention, for the results thoroughly justify the continuance of this important phase of rust research work. Not only can rust be controlled, but, even in the absence of severe rust infection, the beneficial effects of dusting are evident.

Ground Dusting Experiments

From a practical standpoint this is one of the most important phases of the sulphur dusting investigations. Field trials in 1926 and 1927, in which horse-drawn traction dusters were used, gave a convincing demonstration of the great possibilities of this method of controlling rust. Undoubtedly, applying fungicides by means of horse-drawn, or self-propelled, power dusters is the simplest method of treating the smaller grain fields.

Field experiments were carried out in Manitoba this year with such dusters. An attempt was also made to determine the minimum rate and the frequency of dust applications necessary for the most practical and effective control of rust under conditions of a natural epidemic.

The question of obtaining a machine well adapted for dusting cereal crops arises here. At the present time there is not a wholly satisfactory machine available for this purpose. It is to be hoped that some of the mechanical difficulties incidental to the application of dust will soon be overcome. Indeed, during the last year or two, manufacturers of dusting machines have made considerable progress towards this desired end.

Through the courtesy of the Niagara Sprayer Company, of Middleport, New York, three horse-drawn power dusters, and, in addition, a specially designed, self-propelled power duster were made available for field dusting trials in Manitoba. The Shunk Manufacturing Company, of Bucyrus, Ohio, supplied one of their " Shunk " dusters.

Kolodust, a Niagara Sprayer Company product, was used throughout the experiments. In 1928, wheat dusting trials were carried out in Manitoba on the farms of Mr. Macauley, at Morden; Mr. F. Moody, at Morris; and at Graysville on the farms of Mr. Alex. Murray, Mr. P. Roth, and Mr. J. Gray. A small field of Victory oats was dusted on the Manitoba Agricultural College farm at Winnipeg.

Grateful acknowledgment is made to the Niagara Sprayer Company and to the Shunk Manufacturing Company for the loan of these machines, and to the farmers at Morden, Morris, and Graysville for their co-operation in carrying on these dusting trials, and particularly to Mr. Alex. Murray, of Graysville, for his assistance and advice.

Graysville Field Trials

Methods.—Experiments were carried out in three large fields of Marquis wheat, each on different farms. Approximately ten acres were dusted on each farm by means of the horse-drawn and self-propelled power dusters. The control consisted of a portion of each field which remained untreated.

Fields A and B received the first application of sulphur dust on July 9. At this time 75 per cent of the plants were headed out and not a trace of stem rust was found in the fields. Thereafter, weekly applications of the fungicide were made at the rate of 25 pounds per acre to Field A, and 15 pounds to Field B. As very little rust developed, only three treatments were given to Field A, and, as the crop in Field B matured early, dusting operations were discontinued after the second week.

The third dusting trial at Graysville was carried out on a late field of Marquis wheat. It was hoped that, owing to the lateness of this wheat, a heavier attack of rust would develop. Dusting was begun on August 6, at which time 20 per cent of the plants were very lightly infected with stem rust. Sulphur dust was applied at four-day intervals at the rate of 25 pounds per acre until August 22, when the crop was practically mature. Stem rust developed very slowly, and an unusually light and variable infection occurred, even on this late crop of susceptible wheat.

The Kolodust was applied with the same type of horse-drawn duster as used at Graysville last year (Report of Dominion Botanist, 1927), except that this year the machine was equipped with a special 30-foot boom attachment which proved to be an exceedingly valuable improvement. The fungicide was distributed uniformly over the entire 30-foot swath. For effective dust distribution this method is a step in advance over the previous one, in which the dust was distributed by means of an oscillating arm attached to the end of the main delivery pipe. The " boom " attachment is of value in that the dust cloud is forced down into the standing crop, and thus prevents an excessive amount of the dust from drifting.

In order to eliminate the mechanical injury done to the standing crop by the horses while drawing the dusters, an effort has been made to develop an efficient self-propelled power dusting machine. On several occasions this experimental traction duster was used in the Graysville fields. Unfortunately, the unusually heavy rains of late June and July made the ground too soft to permit its effective operation, although the machine proved entirely satisfactory as far as dust distribution was concerned. In a drier season its operation would have been much more successful.

Close observations on the spread and development of stem rust were made during the dusting period. Final data on rust infection were taken on the usual percentage basis. Due to the light and patchy nature of the rust epidemic, it was extremely difficult in some fields to obtain accurate estimates.

Yield results were obtained by harvesting at random 40 rod-rows from the dusted and undusted portions of each field. The weighted average of the forty threshed samples was used to calculate the yield of the dusted and undusted portions of the field in bushels per acre. The threshed samples were graded according to Canadian Government grades by official grain inspectors.

Results

The results of the Graysville field experiments are summarized in table 15. In all of the fields the average infection of rust was exceedingly light and variable. A yield difference of 4·6 bushels was obtained from the dusted plot in Field A. However, with such small differences in rust infection, it is hardly to be expected that this difference could be entirely due to the control of rust. It was, however, obvious that in Field A rust was significantly held in check by the dust treatment. Perhaps a better criterion of the control effected would be the percentage of rust infection which, as indicated in the table, was considerably higher in four of the checks than in the corresponding dusted parts. Other factors, such as soil heterogeneity, may have influenced the yield. There was some evidence also that a part of the difference in yield was brought about by the partial control of other common wheat diseases.

TABLE 15.—RESULTS OF DUSTING MARQUIS WHEAT WITH SULPHUR BY MEANS OF HORSE-DRAWN DUSTERS FOR THE CONTROL OF STEM RUST IN MANITOBA IN 1928

District	Field	Treatment	Acres	Application of sulphur dust			Percentage infection of stem rust		Yield results		
				Rate in lb. per acre	Frequency in days	Total number	Range	Average	Weight per measured bushel	Canadian Government grade	Bushels per acre
				lb.			%	%	lb.		
Graysville...	A	Dusted.......	10	25	7	3	5-20	15	63	2N	25·6
		Undusted.....	5	0	0	0	10-45	35	61	2N	21·0
	B	Dusted.......	10	15	7	2	tr-10	5	62	2N	28·4
		Undusted.....	10	0	0	0	tr-20	10	62	2N	27·3
	C	Dusted.......	14	25	4	4	5-20	10	57	4N	14·9
		Undusted.....	10	0	0	0	10-25	15	57	4N	14·6
Morris.......	A	Dusted.......	6	40	7	2	tr-10	5	61	2N	22·8
		Undusted.....	6	0	0	0	tr-10	5	61	2N	23·1
Morden......	A	Dusted.......	8	25	7	3	tr-20	5	62	2N	30·5
		Undusted.....	2	0	0	0	tr-30	10	62	2N	29·0

The average infection on the oats treated at the Agricultural College, Winnipeg, was 35 per cent, as compared with 65 per cent in the check, with an increase in yield of 6 bushels per acre. The increase may not be strikingly significant, but, in general, the results of the experiment indicate that practical control of oat stem rust can be effected by this means.

Precaution.—It may be unnecessary to mention that sulphur for dusting purposes should be kept dry, or that it should be stored in some place where there is no danger of ignition; but it may not be generally known that, in motor-driven dusting machines, the friction of the finely divided particles of sulphur in the delivery boom generates a considerable amount of static electricity which may be sufficient to ignite the sulphur. During dusting operations it is, therefore, necessary to " ground " the delivery boom by attaching a steel wire or chain to it, the lower end of which is allowed to drag along on the ground. As Lee and Martin have pointed out (see reference under Greenhouse Studies), this safe-guard should be employed, particularly when oxidized sulphur dusts are being used.

GREENHOUSE AND LABORATORY STUDIES

Studies of the Fungicidal Value of Sulphur Dusts in the Control of Cereal Rusts

Preliminary laboratory and greenhouse experiments to test the efficiency of two commercial sulphur dusts in the control of some cereal rusts have shown the importance of using finely divided dusts for the most effective control (Report of Dominion Botanist, 1927). Sulphur was also found to be extremely toxic to the germination of urediniospores of rust fungi. Greenhouse infection studies have yielded data of considerable practical importance. Extensive field experiments have clearly demonstrated the possibilities of the sulphur dusting method for the control of rust. Since the degree of rust control obtained by weekly applications of sulphur is not sufficiently satisfactory to be adopted as a general farm practice, a search was made for a more effective dust fungicide.

It soon became apparent that the cost and fungicidal effectiveness of any dust were extremely important factors in determining its status in the control of rust. It seemed advisable to determine by greenhouse and laboratory studies the fungicidal effectiveness of some of the available commercial dusting sulphurs, so that the most economic dust could be used for more extensive tests in the field.

In the winter of 1927-28 infection studies were made with ten different sulphur dusts. Experiments were also carried out to see whether the fungicidal action could be increased by the addition of oxidizing agents to sulphur. Greenhouse and laboratory studies are still in progress.

These dusts were obtained from several commercial firms in the United States and Canada, and were quite representative of the commercial grades of sulphur available for disease control work. Infection studies were made under controlled conditions in the greenhouse. In carrying out these studies, the procedure given in previously reported studies was followed. Four trials with an adequate check series, were run at different times for each dust.

The results are summarized in table 16. It will be noticed that all of the dusts gave a high degree of control. Under greenhouse conditions, some of the dusts were slightly injurious to young wheat and oat seedlings. When plants were dusted with "Canada Dust", severe etiolation occurred. It is extremely important to guard against the use of impure sulphur fungicides. The presence of light traces of other toxic substances in the sulphur may prove exceedingly injurious when applied to growing plants. In general, the finer dusts gave the highest degree of control. Under the conditions of the experiment the commercially prepared oxidized sulphur dusts, designated as Grade A and Grade B, were not as effective fungicides as ordinary 300-mesh sulphur.

TABLE 16.—THE RELATIVE EFFECT OF VARIOUS COMMERCIAL SULPHUR DUSTS IN REDUCING RUST INFECTION IN GREENHOUSE TESTS

Form of dust	Infection Results (a)					
	Marquis Wheat *Puccinia graminis Tritici* f. 21			Victory oats *Puccinia graminis Avenae* f. 3		
	Percentage of plants infected	Degree of infection (b)	Seedling injury	Percentage of plants infected	Degree of infection (b)	Seedling injury
	%			%		
Kolodust	0·6	tip	0	0·0	0	0
Kopper's Dust	0·3	tip	Slight	0·0	0	Slight
Gas Dust	0·3	tip	0	0·0	0	0
Electric Sulphur	0·0	0	0	0·0	0	0
Swan Sulphur	0·0	0	Slight	0·4	tip	0
Anchor Sulphur	2·1	tip	0	2·4	tip	0
Owl Sulphur	0·5	tip	Slight	1·4	light	Slight
Grade A Dust	4·7	light	0	2·8	tip	0
Grade B Dust	6·9	light	0	3·7	tip	0
Canada Dust	0·0	0	Severe	0·0	0	Severe
Check (undusted)	93·0	heavy	0	96·0	heavy	0

(a) Average of four tests run at different times. One hundred plants were inoculated in each test.
(b) Symbols for degree of infection:
tip—pustules at tip of leaf.
light—pustules scattered, light infection.
moderate—pustules numerous, general infection.
heavy—pustules very abundant, heavy infection.

The differences in the percentage rust infection were extremely small when such finely divided dusts as Kopper's Dust, Kolodust, Electric, and Gas Dust were used. These dusts were extremely efficient fungicides when applied to plants immediately after inoculation. It was found, however, that some of the coarser dusts, such as Owl and Anchor Dust, were effective fungicides, reducing rust infection markedly.

These results are only indicative of the possible value of the different fungicidal dusts. Extensive field trials are necessary to determine their practical value for the control of rust. Greenhouse infection results are valuable, however, for they indicate the fungicidal value of the dusts. Since it is of considerable practical importance to make use of the cheapest and most efficient fungicides for the control of rust, it would seem worth while to determine the value of the cheaper grades of sulphur under field conditions. A comparative test of these materials will be made in the field, under natural rust epidemic conditions.

Comparative studies were also made of the effect of five different fungicidal dusts in the control of crown rust of oats (*Puccinia coronata*), brown leaf rust of wheat (*Puccinia triticina*), and the dwarf leaf rust of barley (*Puccinia anomala*). The results are presented in table 17 and clearly demonstrate the effectiveness of sulphur in reducing infection caused by these leaf rust organisms. The ordinary 300-mesh sulphur was slightly less effective than the more finely divided Kolodust. Again, Grade A dust, a proprietary preparation of oxidized sulphur, proved to be less valuable than the 300-mesh sulphur. However, the addition of potassium permanganate to Kolodust gave an increase in the degree of control.

TABLE 17—THE RELATIVE EFFECTIVENESS OF VARIOUS SULPHUR DUSTS IN CONTROLLING CERTAIN RUSTS OF WHEAT, OATS, AND BARLEY IN GREENHOUSE TESTS

Dust treatment	Percentage of plants infected with*		
	Puccinia anomala	*Puccinia coronata*	*Puccinia triticina*
Kolodust	10·7	5·4	1·1
Kolodust plus 5 per cent potassium permanganate	5·4	3·8	1·0
Sulphur (300 mesh)	25·9	6·4	1·4
Grade A (Sulphur)	29·4	11·6	3·6
Controls (undusted)	100·0	100·0	86·3

*Average of four tests run at different times. One hundred plants were inoculated and treated in each test.

In the study of these three leaf rust diseases, it is seen that the addition of an oxidizing agent, such as potassium permanganate, to the finely divided sulphur increases significantly their fungicidal effectiveness. These studies demonstrated the efficient manner in which infection of leaf rust can be reduced by application of such oxidized dusts.

The success of sulphur, to which 5 per cent potassium permanganate was added, in preventing infection of the plants when heavily inoculated suggested experiments to determine the value of other concentrations of the permanganate in influencing the degree of control.

Influencing the Effectiveness of Sulphur by the Use of Oxidizing Agents

In their search for more effective dust fungicides against a *Helminthosporium* disease of sugar cane, called " eye spot ", Lee and Martin (Indus. & Engineer. Chem., Vol. 20, p. 23, 1928) found that the addition of oxidizing agents, particularly potassium permanganate, to sulphur increased its fungicidal action from 200 to 300 per cent. In an effort to determine the effectiveness of oxidized sulphur dusts in the control of stem rust, some experiments were carried out in which various concentrations of potassium permanganate combined with 300-mesh sulphur and Kolodust were investigated.

Experiment I.—Finely ground potassium permanganate (200-mesh) was mixed with sulphur in the following percentages, 1, 5 and 10, with 300-mesh sulphur, and 1, 5, with Kolodust, and tested in some infection studies with stem rust of wheat and that of oats. Five trials with this group of dust treatments were run at different times. Sufficient check plants were used in each trial.

According to the usual method, wheat seedlings were dusted immediately after inoculation and placed in incubation chambers for 48 hours. After their removal to the greenhouse benches, each series, dusted and undusted, was kept under comparable growing conditions.

The results of these treatments are given in table 18. In none of the treatments was there any injury to the seedling plants. The results show that the fungicidal efficiency of 300-mesh sulphur and Kolodust was increased by the addition of increased concentrations of potassium permanganate. However, it was found that the 10 per cent concentration of the oxidizing agent was no more effective than the 5 per cent concentration. With both rust pathogens, there is a decided increase in effectiveness of sulphur by the use of a 5 per cent concentration of potassium permanganate as an oxidizing agent. The results conform with those of Lee and Martin who found in their dusting work for the control of the "eye spot" disease of sugar cane, that the fungicidal activity of sulphur was markedly increased by the addition of 5 per cent of potassium permanganate.

TABLE 18—THE CONTROL OF STEM RUST EFFECTED BY SULPHUR DUSTS TO WHICH WERE ADDED DIFFERENT PERCENTAGES OF POTASSIUM PERMANGANATE

Treatment	Percentage of plants infected with*	
	Puccinia graminis Tritici f. 21	*Puccinia graminis Avenae*, f. 3
Sulphur (300 mesh)	10·3	32·8
Sulphur plus 1 per cent potassium permanganate	6·0	24·5
Sulphur plus 5 per cent potassium permanganate	3·5	7·0
Sulphur plus 10 per cent potassium permanganate	3·7	10·4
Controls (undusted)	97·2	97·2
Kolodust	7·4	15·9
Kolodust plus 1 per cent potassium permanganate	3·3	9·8
Kolodust plus 5 per cent potassium permanganate	0·3	7·6
Controls (undusted)	97·2	97·2
Grade A sulphur dust	9·2	27·0
Controls (undusted)	97·2	97·2

*Average of five tests run at different times. One hundred plants were inoculated in each test.

A commercially prepared oxidized dust, Grade A sulphur, was included in each test. Its efficiency as a fungicide was compared with that of 300-mesh sulphur, Kolodust, and of other oxidized dusts, prepared in the laboratory. The results given in table 18 indicate quite clearly that under the conditions of the experiment this proprietary preparation of oxidized sulphur was only slightly more effective than ordinary 300-mesh sulphur and did not give as good results as Kolodust. It did not compare in fungicidal value with the oxidized 300-mesh sulphurs and Kolodust.

Experiment II.—The purpose of the next experiment was to ascertain the effect upon stem rust infection of 1, 2, 3, 4, and 5 per cent concentrations of potassium permanganate in Kolodust. The various mixtures of Kolodust and potassium permanganate were prepared in the laboratory. Stem rust infection studies were carried out to determine the behaviour of these dusts.

Although the degree of control obtained by ordinary Kolodust was very satisfactory, some reduction in the percentage of plants infected was obtained when the oxidized materials were applied to inoculated plants. From the summarized results in table 19, it will be found that Kolodust with 2 per cent potassium permanganate was just as effective as with the higher concentrations, and gave slightly better results than the ordinary Kolodust. In this experiment the differences in the degree of control are extremely small, nevertheless, the results clearly demonstrate the possibility of increasing the fungicidal activity of sulphur by the addition of oxidizing agents. Further studies along this line are desirable.

TABLE 19.—THE EFFECTIVENESS OF DIFFERENT CONCENTRATIONS OF POTASSIUM PERMANGANATE IN SULPHUR FOR THE CONTROL OF STEM RUST

Form of dust	Infection results									
	Puccinia graminis Tritici f. 21					*Puccinia graminis Avenae* f. 3				
	Trials (a)				Average	Trials (a)				Average
	1	2	3	4		1	2	3	4	
Kolodust	3·6	1·3	1·4	0	1·6	2·0	1·7	1·0	1·2	1·47
Kolodust plus 1 per cent potassium permanganate	2·3	0·0	0·0	0	0·57	0·8	1·7	0	1·4	0·97
Kolodust plus 2 per cent potassium permanganate	1·1	0·0	0·0	0	0·27	0·0	0·0	0	0	0·0
Kolodust plus 3 per cent potassium permanganate	0·0	1·4	1·1	0	0·62	0·8	1·5	0	0	0·57
Kolodust plus 4 per cent potassium permanganate	1·3	1·3	0·0	0	0·65	3·6	0·0	0	1·6	1·3
Kolodust plus 5 per cent potassium permanganate	1·1	0·0	0·0	0	0·27	0·0	1·3	0	0	0·32
Check (undusted)	100·0	100·0	97·3	80·8	94·5	100·0	95·2	97·0	98·7	97·7

(a) One hundred plants were inoculated and dusted in each trial.

Experiment III.—In order to determine whether or not the potassium permanganate had of itself any toxic effect on the rust organism, an experiment was conducted in which potassium permanganate was mixed with an inert non-sulphur carrier, talc ($H_2Mg_3Si_4O_{12}$). Previous experiments (Report of Dominion Botanist, 1927), have shown that talc is ineffective in reducing the amount of infection by the organisms causing leaf and stem rust. A mixture of talc and 5 per cent permanganate was dusted on Marquis wheat seedlings immediately after they were inoculated with stem rust (*Puccinia graminis Tritici,* f. 21). Another series of inoculated plants was dusted with ordinary finely divided talc. In similar experiments, Kolodust plus 5 per cent of potassium permanganate, and Kolodust alone were employed. An adequate control series, consisting of inoculated but untreated plants was used in each trial. Five separate tests were made.

A similar experiment was carried out with Victory Oats inoculated with *Puccinia graminis Avenae* f. 3. Potassium permanganate used with talc had but a very slight effect in reducing the amount of stem rust infection, and possibly the slight difference in favour of the plants treated with talc and permanganate may be due to other causes. The addition, however, of 5 per cent of permanganate to Kolodust increased the fungicidal action of the sulphur to a significant degree.

Discussion

These experiments, carried on in the greenhouse, give an idea of the fungicidal value of the dusts used in controlling certain rust diseases. Their ability to control rust in the field requires field tests.

The toxicity of sulphur to rust organisms was considerably enhanced by the addition of one per cent of potassium permanganate, but in a greater degree by the addition of two per cent. Higher percentages, up to 10 per cent, gave no appreciably better result than the two per cent mixture. The increased fungicidal action seems to be due to an oxidizing effect on the sulphur and not to any inherent toxic principle in the permanganate. The results of additional experiments dealing with this phase of the problem will be given in a subsequent report.

Yellow Stripe Rust in Canada

(T. Johnson and Margaret Newton)

A survey was made to determine the spread of stripe rust (*Puccinia glumarum*) in the prairie provinces during the summer of 1928. This was conducted largely through the co-operation of the Dominion Laboratories of Plant Pathology at Saskatoon, Sask., and Edmonton, Alta. Twenty-four collections were obtained from twenty-two localities. The rust was most prevalent in Alberta, nineteen of the twenty-two localities where it was found being in that province. It was found in three localities in Saskatchewan, but has never been found in Manitoba. The survey shows that its distribution is general throughout Alberta from Edmonton south to the international boundary. It seems to decrease progressively eastward until its eastern limit is reached in south central Saskatchewan. The easternmost point at which it has been collected is Horizon, Sask., which is about 220 miles east of the Alberta boundary.

In British Columbia, stripe rust occurs commonly in the south end of Vancouver Island, but no extensive survey has been made of that province.

The hosts on which stripe rust was found in 1928 include wheat, barley, and *Hordeum jubatum*, the latter being the one most commonly found infected.

The reason for the localization of the rust in Alberta and southern Saskatchewan is not clear. Since it was thought, however, that climatic conditions might be responsible for this, a survey was made of meteorological records for several points in the three prairie provinces for the summers of 1925, 1926, and 1927. These data seem to suggest a correlation between low mean temperatures for a district and the occurrence there of stripe rust.

A number of wheat varieties were tested out in the greenhouse for their reaction to stripe rust. It was found that some of the varieties susceptible to stem rust were highly resistant to stripe rust. Quality and Huron were highly resistant, while Marquis and Little Club were moderately resistant. On the other hand, Hope and H—44—24, which are fairly resistant to many physiologic forms of stem rust in the seedling stage, were found susceptible to stripe rust. The varieties Reward, Prelude, and Acme were susceptible, but Iumillo and Black Persian, which are highly resistant to stem rust, were likewise found resistant to stripe rust.

Sexual Behaviour of *Puccinia Graminis*

(J. H. Craigie)

Experiments carried on in 1927 established the parallelism in sexual behaviour of the stem rust of wheat, *Puccinia graminis*, and of *P. Helianthi*, the rust of sunflower. As experimentation is more difficult to carry out with *P. graminis* than with *P. Helianthi*, especially when a large number of plants are required, the results reported in the first experiment were obtained with *P. Helianthi*, and as identical results were secured in a similar, but much more limited, experiment with *P. graminis*, it seems fairly safe to conclude that the numerical results would have been more or less identical, had the experiment with the latter been co-extensive with that carried on with the former.

In earlier work (see Dominion Botanist's Report, 1927), it was found that the majority of pustules of monosporidial origin never produced aecia, but that a minority of them, in the course of four or five weeks, developed aecia. Later, when it was found that insects carried the pycnospore-containing nectar from pustule to pustule and thereby induced the production of aecia in these pustules, the suspicion arose that possibly the production of aecia in the earlier monosporidial pustules might have been induced by the transference of the nectar from one pustule to another by insects or other agencies. An experiment with the sunflower rust (*P. Helianthi*) was carried out to determine whether or not pustules of monosporidial origin would produce aecia, when the possibility of transferring nectar from one to the other was, as far as possible, precluded.

By inoculating sunflower seedlings in the greenhouse, a large number of monosporidial pustules were secured on the first two true leaves of the plants. As soon as the pustules were visible, the plants bearing them were covered with screen-wire cages to exclude insects. Each plant was in a separate flower pot and a separate cage covered each plant. Seventeen days from the date on which the plants were inoculated, there were 228 monosporidial pustules, in none of which were there any aecia evident. Of these, 93 were borne singly, one to a plant; of the remaining 135, usually two, but sometimes three or even four, occurred on the same plant. None of the pustules which developed on the cotyledonary leaves were considered, as these leaves became chlorotic and died comparatively early in the experiment.

Not all the pustules persisted for the same length of time. Some became necrotic during the fourth week; most of them died before the end of the sixth week; but a few were still living and exuding nectar in their peripheral region when seven weeks old. The final data were taken at the end of the seventh week. Within that time aecia appeared in only 11 of the 228 pustules.

It should be pointed out that, although each plant was covered by a screen-wire cage, small insects, such as white flies (*Aleyrodes*) and thrips (*Heliothrips*), were not thereby excluded. The former were rarely seen in contact with the pustules, but the latter showed a decided preference for nectar as a diet. Each day the plants were examined and any insects found on them were destroyed, but, in spite of these precautions, there was the possibility, especially on those plants which bore more than one pustule, that, during the seven weeks over which the experiment extended, nectar was carried, to a small extent, from one pustule to another. But the fact that so few pustules developed aecia (11 out of 228) indicates that, if the experiment were carried out under absolutely controlled conditions, possibly none of the pustules would have produced aecia. Even though this might not have been the case, it is quite evident that under the conditions of the experiment a very small percentage of the pustules produced aecia.

During the summers of 1927 and 1928 several species of rust, developing under natural conditions, were observed to ascertain whether or not any evidences of heterothallism could be noted in them. The rusts selected were *Puccinia graminis* (on barberry), *P. coronata* (on buckthorn), *P. Pringsheimiana* (on gooseberry, and a *Gymnosporangium* species (on *Amelanchier,* the common Saskatoon).

It was known at the time the observations were made that *P. graminis*, the stem rust organism, was heterothallic, but, as the discovery of this phenomenon was made through experimentation in the greenhouse, it was desired to observe the rust under natural conditions in order to compare its behaviour under such conditions with that under greenhouse conditions. In addition, a comparison of the behaviour of the three other species with that of the stem rust organism might afford some indications as to the sexual behaviour of these organisms. Particularly was this desired in the case of *P. coronata*, the crown rust of oats.

Leaves of these hosts, bearing young and apparently monosporidial pustules were marked by a small tag as soon as the pustules were noticed. When the pustules were 14 or 15 days old, those which showed no evidence of aecia were selected for further observation. From time to time during the succeeding three or four weeks these pustules were examined. Within that time some of the pustules produced aecia, but others did not. Within that time also, all those pustules which produced aecia and most of those which did not produce aecia became necrotic, but a few of the latter type persisted for a week or more longer. The results of these observations are given in table 20.

TABLE 20—SUMMARY OF OBSERVATIONS MADE IN 1927 ON THE OCCURRENCE IN NATURE OF AECIA IN MONOSPORIDIAL PUSTULES

Name of rust	Number of pustules 14 days old	Period observed in weeks	Number of pustules at end of period	
			with aecia	without aecia
Puccinia graminis	50	4½	37	13
Puccinia coronata	60	2½	45	15
Puccinia Pringsheimiana	60	3	16	44
Gymnosporangium sp	60	3	52	8

It should be noted that none of these pustules was protected in any way from the visitation of insects; and there is little doubt that, through their agency, the transfer of nectar from one pustule to another of the same rust took place, as insects of various kinds were seen flying about or crawling over the leaves of the host plants; some even were observed in contact with the pustules. For each rust, however, a considerable number of the pustules failed to produce aecia, thus indicating that they were unisexual and that the organism in each case was heterothallic.

In the summer of 1928, observations were made on the same rust species, only in this case the majority of the pustules, when 14 days old, were covered with one ply of white cheese-cloth, in order to intercept as far as possible the visitation of insects, and consequently prevent the transference of nectar from pustule to pustule by their agency. This protection excluded fairly effectively most of the winged insects, but not so well ants and small spiders, so that the possibility of such transference was not wholly eliminated.

The results showed that a much smaller percentage of the covered pustules produced aecia in 1928 than of the uncovered ones in 1927, or of those that were left uncovered in 1928. It seems, therefore, that, by excluding the insects, or at least some of them, from the pustules, the opportunities for carrying nectar from one pustule to another were reduced and, consequently, fewer of the pustules were induced to produce aecia. It is not probable that the cheese-cloth covering intercepted sufficient sunlight to inhibit or retard materially the formation of aecia. This supposition is supported by the fact that a few of the covered pustules produced aecia. Possibly the development of aecia in these pustules was induced by the transfer of nectar to them before the covering was applied.

From the fact that pustules of *P. coronata*, of *P. Pringsheimiana*, and of the *Gymosporangium* species behave under natural conditions as do similar pustules of *P. graminis*, and as *P. graminis* has been shown by experiments in the greenhouse to be heterothallic, it may be inferred that these other rusts also are heterothallic.

These results are of interest in the study of cereal rusts, for if, as the observations indicate, *P. coronata* is heterothallic, there exists, as in *P. graminis*, the possibility of hybridization occurring between two forms of rust, and consequently the multiplication of new physiologic forms of the crown rust of oats.

OCCURRENCE OF AECIA IN ONE SECTION OF PUSTULE

While the data recorded above were being collected, it was noticed that, in some of the pustules, aecia occurred only at one side or in one section of the pustule. This phenomenon was observed in what were evidently monosporidial pustules of *P. graminis* (fig. 6), of *P. coronata*, and of *P. Pringsheimiana*. A plausible explanation of this condition was that the nectar from pustules of opposite sex had been deposited on the upper surface of those sections only of the pustules, and as a result aecia had developed.

In order to ascertain the correctness of this interpretation, the nectar from a number of pustules was drawn off and deposited in one drop on a glass slide. By this means it was hoped that some nectar would be gathered from pustules of opposite sex and that consequently, when this composite nectar was applied to the upper surface of a portion of a monosporidial pustule, of either sex, it would induce the development of aecia in the section thus treated. The experiment was carried out on pustules three to four weeks old of the stem rust and the sunflower rust. With both rusts the results were similar. Aecia appeared within a few days in the section receiving the nectar (figs. 7 and 8).

The occurrence in nature of aecia in one section of a pustule and the duplication of the phenomenon by experimental methods in the greenhouse are of interest in themselves, but they are mentioned here chiefly to lend additional support to the evidence already given that *P. coronata* and *P. Pringsheimiana* are heterothallic. In appearance and behaviour these two rusts simulate the two rusts which have been shown experimentally to be heterothallic.

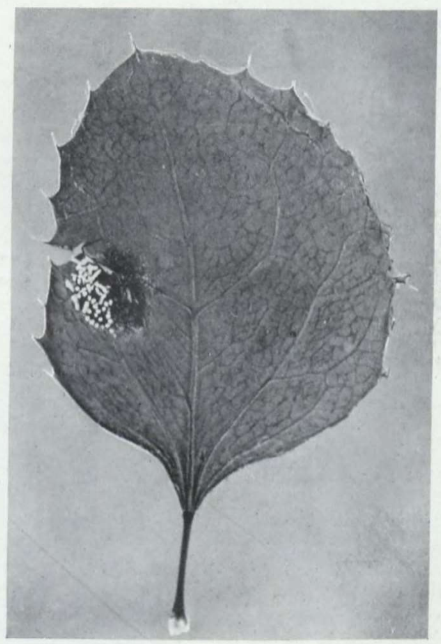


FIG. 6.—Under side of a barberry leaf, showing aecia present on the left-hand side, but not on the right-hand side, of a pustule of *P. graminis* which arose from an infection by natural inoculation. × 2.

FIG. 7.—Under side of a barberry leaf which was inoculated artificially in the greenhouse, showing aecia present on the right-hand side, but not on the left-hand side of a pustule of *P. Graminis* arising from an infection of monosporidial origin. When the pustule was twenty days old, a small amount of composite nectar was applied to the upper surface of the section which now bears the aceia. The photograph was taken seven days after the nectar was applied. × 2½.

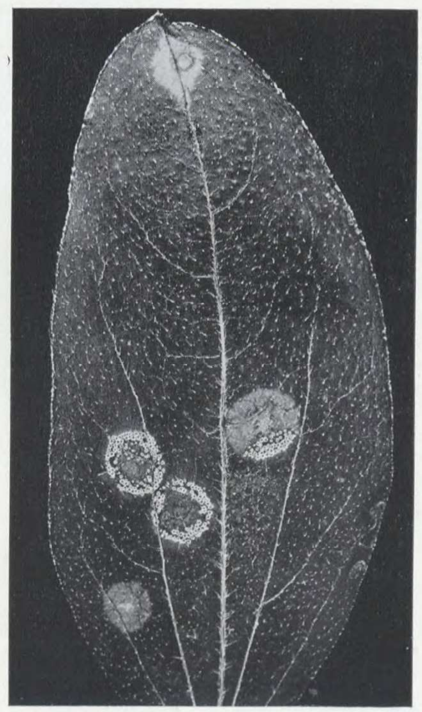


FIG. 8.—Under side of a sunflower leaf showing five pustules of *P. Helianthi*, of monosporidial origin. When the pustules were three weeks old, composite nectar was applied to the upper side of the two closest together and to the upper side of that portion which now bears aecia in the third. No nectar was applied to either the pustule at the tip or the small one nearest the base of the leaf. They remained without aecia. Photographed eight days after the nectar was applied. × 1½.

The Dwarf Leaf Rust of Barley in Western Canada

(A. M. Brown and Margaret Newton)

The dwarf leaf rust of barley (*Puccinia anomala*) was first collected in Western Canada in 1922, but was not again found there until 1927 when it was collected throughout southern Manitoba and southeastern Saskatchewan. On account of the prevalence of dwarf leaf rust during that year, a study of this rust was undertaken with the object of discovering, if possible, why this sudden outbreak of leaf rust had occurred on barley, and whether physiologic specialization existed in this rust.

Six different collections of dwarf leaf were made in the field, one at each of the following places in Manitoba: Morden, Brandon, Bird's Hill, and Winnipeg; and two at Indian Head, Saskatchewan.

As no study had been made of physiologic specialization in dwarf leaf rust of barley, suitable barley differentials had to be secured. Over sixty varieties of barley were each inoculated with these six collections of rust. Three of these barley varieties, Success, Harsford, and Chinese, proved to be very resistant to these six collections of rust; one of them, Gold, was resistant to one collection; and the remaining barley varieties were all very susceptible. It was clear, therefore, since Gold was fairly susceptible to one collection of rust and resistant to another collection, that at least two physiologic forms of *P. anomala* must be present in Western Canada. A summary of the reactions of three of the barley varieties to these two physiologic forms is given in table 21.

TABLE 21—THE REACTION OF DIFFERENTIAL HOSTS OF BARLEY TO PHYSIOLOGIC FORMS OF *P. anomala*

Physiologic form	Infection on differential hosts		
	Chinese	Gold	Odessa
1	resistant	resistant	susceptible
2	resistant	fairly susceptible	susceptible

SPORE GERMINATION

An attempt was made to determine the optimum temperature for germination for the urediniospores of *Puccinia anomala*. The spores were germinated in hanging drops of distilled water in Van Tieghem cells, when the uredinia were from ten to twelve days old. From table 22, it will be seen that the spores germinated quite readily from 11°C. to 17°C. At 19°C. there is a decided falling off in germination, at 23°C. very poor germination. As *P. graminis Tritici* gives an optimum spore germination at a temperature of from 18-20°C., *Puccinia anomala* must be regarded as a lower temperature organism than *Puccinia graminis*.

TABLE 22—PERCENTAGE GERMINATION OF UREDINIOSPORES OF DWARF LEAF RUST OF BARLEY AT FIVE DIFFERENT TEMPERATURES

Date of test, 1927	11°C.	15°C.	17°C.	19°C.	23°C.
	%	%	%	%	%
November 25	92	96	95	75	25
November 29	0*	92	95	60	0
December 13	93	90	92	85	3

*Dried up.

The urediniospores remain viable for at least one month. Material, gathered in the field at Indian Head on September first, and kept at ordinary room temperature in the laboratory, gave good germination at the end of a month. At the end of three months, however, no germination could be observed. The above study is being continued and further results will be available at a later date.

SUMMARY

1. Physiologic specialization in *P. anomala* Rostr. has been established for the first time.
2. By infection experiments, two physiologic forms have been isolated in Canada, forms 1 and 2.
3. To form 1 the barley variety Gold is resistant; to form 2, it is fairly susceptible.
4. Optimum temperature for urediniospore germination in *P. anomala* varies from 11°C. to 17°C. It is a lower temperature organism than *P. graminis*.

Colour Mutations in *Puccinia graminis Tritici*

(T. Johnson and Margaret Newton)

In the annual report for 1927, two colour mutants of physiologic forms of *P. graminis Tritici* were discussed, an orange coloured mutant of form 9, and a greyish-brown mutant of form 36. These colour abnormalities were manifested in the uredinial stage. The orange mutant arose in the uredinial stage, while the greyish-brown mutants arose on several occasions in the first generations of uredinia which resulted from inoculating wheat with aeciospores from barberry.

Since the previous report, greyish-brown mutants of form 52 have arisen several times in a manner similar to that described for the greyish-brown mutant of form 36.

Although these mutants had been studied in the uredinial stage, nothing was known about their behaviour or appearance in the aecial stage. Hence, telia of the orange mutant of form 9, and of the greyish-brown mutant of form 36, were developed, and these, after having passed through the stage of dormancy, were employed to infect barberry. The aecia resulting from these inoculations were then studied.

The aeciospores of the orange mutant did not differ visibly from normal aeciospores, but the aeciospores of the greyish-brown mutant of form 36 were strikingly different. Normal aeciospores have cytoplasm of a brilliant orange colour, due largely to the presence of carotinoids. The cytoplasm of the aeciospores of the greyish-brown mutant contains no yellow colour, but appears light grey. The aeciospores, in mass, appear almost hyaline, in contrast to the yellow colour of normal aeciospores.

Root Rots and Foot Rots of Cereals in Manitoba

(W. L. Gordon)

Reports of injury to cereals in Manitoba apparently due to root rotting organisms have increased in recent years. In order to get more exact information concerning the distribution and severity of these diseases, particularly those affecting wheat, a more extensive survey of the province was made this year. The area surveyed is shown in Fig. 9, which includes the greater part of the grain growing area in the province.

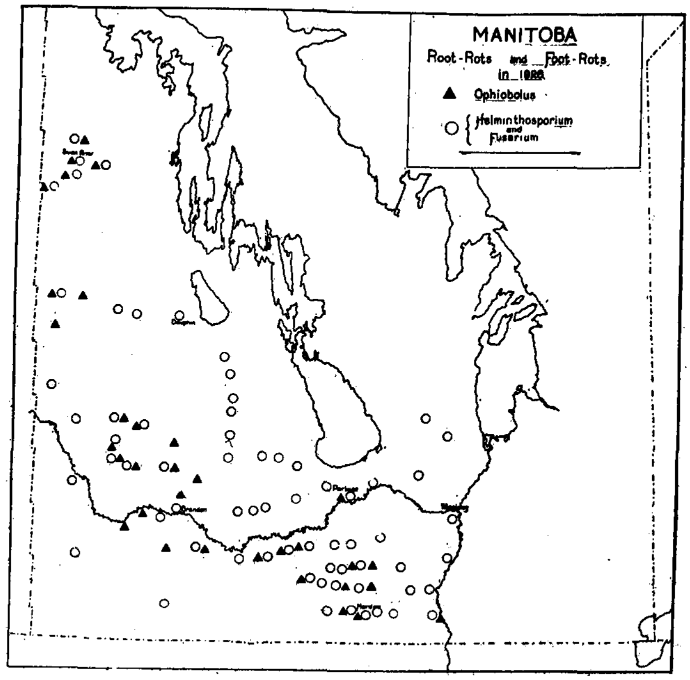


FIG. 9

This survey was carried on in conjunction with the stem rust survey during July and August by members of the Dominion Rust Research Laboratory staff. In most cases, collections were made of diseased specimens, and, at this time, notes were taken on the severity of the disease, general condition of the crop, soil conditions, and such factors. On going over the data with regard to the severity of the disease, it was readily noted that some uniform method of estimating the damage to the crop was greatly to be desired.

A preliminary survey of the province carried out by Greaney and Bailey (Can. Dept. Agric. Bul. 85, N.S., 1927), in 1925, showed that the pathogens, *Helminthosporium* and *Fusarium,* were widely distributed and destructive to wheat. "Take-all" of wheat (*Ophiobolus graminis* Sacc.) was collected at eight points in the province. Only a mere trace was present in some cases, while in others it caused serious injury.

The survey this year again showed that *Helminthosporium* and *Fusarium* were widespread (fig. 9), but, in addition, *Ophiobolus graminis* was also widely distributed. Collections of diseased plants from sixty-six points in the province showed injury due to the attack of *Helminthosporium* or *Fusarium.* Isolations made from a number of the collections indicate that these fungi were most often associated with the diseased condition of the roots of wheat and barley. *Ophiobolus graminis* was collected at thirty-three points (fig. 9). It was found to be more widely distributed than was previously thought to be the case. All the collections of this fungus were made on wheat.

There was a wide variation in the degree of infection by these organisms. In the majority of the collections, in which the diseased condition was attributed to *Helminthosporium* and *Fusarium,* only a trace was observed. In others, infection up to one hundred per cent was reported, both wheat and barley being severely injured. The usual amount of infection with *Ophiobolus graminis* was a trace on a small percentage of the plants. However, in a few cases, the infection ranged from forty to eighty per cent, and resulted in decided injury to the crop.

Only results of the survey can be given at this time, but, during the winter, pathogenicity studies with the organisms isolated are to be carried on.

The origin of the collections of the fungi mentioned are given in tables 23 and 24.

TABLE 23.—*Ophiobolus graminis*

Alexander	Hamiota (2)	Portage (2)
Asessippi	Holland	Rapid City
Basswood	Jordan	Roblin (4)
Benito	Kenville	Shoal Lake (2)
Bowsman (2)*	Lavinia (2)	Shortdale
Carman	Letellier	Somerset
Carroll	Miami	Strathclair
Cypress	Minnetonas	Swan River (5)
Forrest	Morden	Thornhill
Graysville	Moorepark	Treherne
Griswold	Oak River	Wawanesa

* The number denotes the number of collections made.

TABLE 24.—*Helminthosporium* and *Fusarium*

Altamont	Kelwood	Rapid City (2)
Benito	Kemnay	Riding Mountain
Binscarth	Kenville	Roblin
Birtle (2)	Keyes	Rosebank
Boissevain	Lavinia (2)	Roseisle (2)
Bowsman	Laurier	Ste. Agathe (2)
Brandon (4)	Letellier	St. Claude
Carberry	Lowe Farm	Shoal Lake
Culross	Macdonald (6)	Sidney
Cypress River	Macgregor (2)	Somerset
Darlingford	McCreary	Sperling
Dauphin (3)	Melbourne	Stephenfield (2)
Eden	Miami	Swan River (6)
Gilbert Plains	Minnetonas	Teulon
Gladstone	Morden (3)	Thornhill
Glenboro' (2)	Morris	Treherne (2)
Grand View (2)	Neepawa	Two Creeks
Graysville (4)	Oak River	Warren
Hamiota	Pipestone	Wawanesa
Haywood	Plum Coulee	Winkler
Holland	Poplar Point	Winnipeg
Inwood	Portage (3)	Woodside

Smut Investigations

(I. L. Conners)

The problems under investigation this year were as follows: (1) The prevalence and distribution of wheat bunt in the Prairie Provinces. (2) The control of wheat bunt, covered smut of oats, and covered smut of barley, by seed treatment. (3) The varietal resistance of oats to loose and covered smuts of oats.

THE PREVALENCE AND DISTRIBUTION OF WHEAT BUNT IN THE PRAIRIE PROVINCES

The prevalence and distribution of wheat bunt in the three prairie provinces were determined by examination of the grain inspection records, which were made accessible through the kindness of the Chief Inspector of the Western Division, Mr. J. D. Fraser. From these records a separate record of the "smutty" cars was made. As only part of the data has been collected and analyzed, a full report can only be made later. However, certain findings are worth reporting here.

The most striking fact is the prevalence of bunt in durum wheat. Approximately 5 per cent of all the durum wheat produced in 1927 and 1928 was graded smutty. Moreover, 75 per cent of the crop showed at least traces of bunt. Not only have the monetary losses been considerable, but, with so much grain infected with bunt, greater losses still may be expected, unless the grain used for seed is carefully and regularly treated for bunt. The results of an experiment to control bunt in durum wheat are given in the next section.

In comparison with durum wheat, common wheat is relatively free from smut; only 0·5 per cent of the cars of common wheat were reported smutty in 1927, but these cars came from all parts of the three provinces. The presence of bunt in all parts of the country shows clearly that seed wheat should be carefully treated every year, if bunt is to be avoided. Although a crop appears to be free of bunt, when treated seed is used, it usually happens that some bunt spores were not killed and a few smutted plants develop. These few plants affect the seed slightly and slowly, but inevitably the smut increases until a smutty crop results.

THE CONTROL OF WHEAT BUNT, COVERED SMUT OF OATS, AND COVERED SMUT OF BARLEY BY SEED TREATMENT

The experiments in the control of smut by seed treatment were conducted in co-operation with the Dominion Experimental Farms situated at Brandon, Man., and Indian Head, Sask. The seed was treated at the Dominion Rust Research Laboratory. The smut notes were taken by a member of the laboratory. The planting of the seed and the care of the plots, etc., were mostly taken care of by the members of the Dominion Experimental staff at these Farms. The seed was sown in rod-row plots, each treatment being in quadruplicate. Two hundred heads in each row were examined for smut and the number of smutted heads was recorded. As four rows were sown of each treatment the percentage of smut was estimated from the examination of 800 heads.

CONTROL OF BUNT IN DURUM WHEAT.—Naturally smutted Mindum wheat, grown at Miniota in 1927, was used for seed in the experiment to control bunt in durum wheat. The seed contained a goodly number of bunt balls. An examination of 100 bunt balls taken from the sample showed that the wheat was infected with *Tilletia Tritici*, the rough-spored species. In the dust treatments, the seed was shaken with the dust in a stoppered Ehrlenmeyer flask, the dust being applied at the rate of 3 ounces per bushel of seed. The seed was sown at the rate of 16·8 grammes per rod-row. The bunt balls were not removed from the seed, except in the formalin steep treatment as reported below.

The treatments were as follows:—

(1) Formalin sprinkle: The seed was sprinkled with formalin solution of standard strength (1 pint of formalin to 40 gallons of water). The seed was stirred till every kernel was thoroughly moistened, covered for 4 hours, and then spread out to dry.

(2) Formalin steep: The seed was poured into the formalin solution and stirred. Bunt balls which floated to the surface were skimmed off. The excess solution was drained off and the seed was covered for 4 hours, and then spread out to dry. The formalin used in the two treatments was manufactured by the Standard Chemical Co., Montreal, Que. It analyzed 38·3 per cent formaldehyde by weight, and a formalin solution of proper strength for use was made from this formalin.

(3) Dusts:

(*a*) Deloro copper carbonate, containing 20 per cent copper, manufactured by Deloro Chemical Co., Deloro, Ont.

(*b*) Beaver, also containing 20 per cent copper, manufactured for the Beaver Soap and Chemical Co., Winnipeg.

(*c*) Mococo, a copper carbonate containing 50 per cent copper manufactured by Mountain Copper Co., San Francisco, Cal.

(*d*) Kolodust, a sulphur dust which has been used successfully in experiments to control wheat stem rust.

(*e*) Du Pont No. 12, an organic mercury dust.

(*f*) Du Pont No. 68, which contains a copper compound.

The last two dusts are manufactured by I. E. du Pont de Nemours Co., Wilmington, Delaware.

Seed in this experiment was sown at Brandon, Man., and Indian Head, Sask. The results of the experiment are given in Table 25.

TABLE 25—THE CONTROL OF WHEAT BUNT IN DURUM WHEAT BY SEED TREATMENT

Treatment	Percentage of bunt	
	Brandon, Man.	Indian Head, Sask.
Formalin sprinkle	0	1·3
Formalin steep	0	0·3
Deloro copper carbonate dust	0	4·6
Beaver copper carbonate dust	0·1	3·5
Mococo copper carbonate dust	0·1	2·1
Kolodust	0·8	13·5
Untreated	1·4	22·5
Du Pont No. 12 dust	0	0·3
Du Pont No. 68 dust	0	1·4

It will be seen from Table 25 that bunt development was very poor at Brandon in comparison with Indian Head. However, some very definite conclusions may be drawn from the Indian Head Experiment, where 22·5 per cent of bunt developed in the untreated plots. Copper carbonate dust, which has given such excellent results in the control of bunt in common wheat, cannot be recommended for the control of bunt in durum. The formalin treatments reduced the bunt to small amounts, the formalin steep treatment being particularly effective. It is, therefore, recommended that the bunt balls be fanned out of the grain and the usual formalin treatment be applied, or, if the bunt balls cannot be removed by fanning, that the durum wheat be treated by the formalin steep method, in which the bunt balls may be floated out and removed. The apparent ineffectiveness of formalin in the hands of some farmers to control bunt in durum wheat has probably been due to the failure to remove the unbroken bunt balls.

Other experiments were conducted for the control of bunt in common wheat, but no results were obtained, as bunt failed to develop even in the untreated plots.

COVERED SMUT OF OATS.—An experiment on the control of covered smut in oats was successfully concluded at Indian Head and Brandon this year. The seed used was Longfellow oats of the 1927 crop, lightly infected with smut under natural conditions. To insure more positive results the seed was artificially smutted, one part of spores being mixed with each 1,000 parts of seed, by weight.

The treatments were as follows:—

1. Formalin sprinkle: 1 pint of formalin to 40 gallons of water, seed sprinkled with solution, covered for 4 hours, and spread out to dry.

2. Formalin steep: Seed steeped 5 minutes in a standard formalin solution, excess solution drained off, seed covered for 4 hours, and then dried.

3. Formalin spray: 1 pint of formalin to 2 quarts of water, solution sprayed on seed from an atomizer-sprayer at the rate of one quart of solution to 20 bushels of seed, covered for 4 hours, and then dried.
4. Deloro copper carbonate dust.
5. Mococo copper carbonate dust.
6. Kolodust.
7. Fine dusting sulphur.
8. Monohydrate copper sulphate dust.
9. Copper acetate dust, crystals of copper acetate were finely powdered in a mortar.
10. Dust composed of 2 parts of Mococo copper carbonate and 1 part of common salt ground together in a mortar.
11. Dust composed of 2 parts of monohydrate copper sulphate and one part of common salt similarly prepared.
12. Dust composed of 5 per cent of iodine in infusorial earth ground together in a mortar.
13. Dust composed of 2·5 per cent of iodine in infusorial earth.
14. Deloro copper carbonate 1927 and 1928. Seed from the row treated in 1927 was treated again in 1928.
15. Deloro copper carbonate in 1927, untreated in 1928.
16. Mococo copper carbonate 1927 and 1928.
17. Kolodust 1927, untreated in 1928.
18. Bayer dust No. 488.
19. Bayer dust No. 195. These two dusts were manufactured by the Bayer Co. Inc., New York, N.Y. The results of the experiment are given in table 26.

TABLE 26—CONTROL OF COVERED SMUT OF OATS BY SEED TREATMENT

Treatment	Percentage of smut	
	Brandon, Man.	Indian Head, Sask.
Liquid treatments—		
Formalin sprinkle	0	0
Formalin steep	0	0
Formalin spray	0	0
Dust treatments—		
Deloro copper carbonate	2·6	3·4
Mococo copper carbonate	0·6	2·4
Check (untreated)	12·1	19·8
Kolodust	3·1	4·1
Dusting sulphur	2·0	3·5
Monohydrate copper sulphate	0·8	0·3
Copper acetate	1·3	2·6
Mococo copper carbonate and common salt	2·1	3·9
Check (untreated)	11·1	18·1
Monohydrate copper sulphate and common salt	0·6	0·4
Iodine 5 per cent in infusorial earth	9·8	20·3
Iodine 2·5 per cent in infusorial earth	10·5	19·1
Deloro copper carbonate 1927 and 1928	0·4	0·5
Deloro copper carbonate 1927 only	0·8	0·5
Mococo copper carbonate 1927 and 1928	0·4	0·1
Kolodust 1927 only	....	0·8
Check (untreated)	8·8	16·5
Bayer No. 488	2·3	1·4
Bayer No. 195	2·1	0·8

Smut development in the untreated plots was very good at both Brandon, Man., and Indian Head, as table 19 shows. The formalin treatments demonstrated again their effectiveness in the control of covered smut of oats. No smut appeared in any of the plots sown with formalin treated seed. Although the copper carbonate dusts appear capable in most seasons of greatly reducing the infection of covered smut in oats, they failed to eliminate smut from the crop grown from seed of a previously treated crop containing only a small amount of smut. Kolodust hardly appears to be as effective as a pure sulphur dust of good quality. The iodine dusts which were reported on favourably by Sayre and Thomas[1] in 1928, appear to be of little value. The great difficulty is that the iodine is volatile and, if the seed is treated some time before sowing, a large portion of the iodine evaporates. The seed was treated 8 days before it was sown and kept in small envelopes. Smut control was nil. It was noticed that in the infusorial earth containing 5 per cent iodine, the iodine tended to separate from the infusorial earth when it was kept in a tightly stoppered bottle at room temperatures. From our experiments we would recommend the formalin treatments for control of covered smut of oats. If the copper carbonate dust treatment is used, the smut may be reduced to a small amount, but it cannot be completely eliminated by the treatment.

COVERED SMUT OF BARLEY.—An experiment for the control of covered smut of barley by seed treatment was conducted at Brandon, Man. Naturally infected barley seed was used in the experiment. Of the six treatments four have already been described in the experiment with oats. The two remaining treatments were with dusts: Agfa, a German preparation, and Bayer H.T. 3, manufactured by Bayer Co. Inc., New York. The results are given in table 27.

TABLE 27—THE CONTROL OF COVERED SMUT OF BARLEY BY SEED TREATMENT

Treatment	Percentage of smut
Formalin steep	0
Du Pont No. 12 Dust	0
Deloro copper carbonate dust	0·5
Iodine, 5 per cent in infusorial earth	1·5
Agfa dust	0
Bayer H. T. 3 dust	1·2
Untreated	2·0

Although the seed was heavily smutted, very little smut developed in the plots. The formalin steep treatment was one of three which completely eliminated smut from the resulting crop. The two dust treatments, Du Pont No. 12 and Agfa, are promising, but until further experiments are conducted, we would recommend the use of formalin for the control of barley covered smut.

THE VARIETAL RESISTANCE OF OATS TO LOOSE AND COVERED SMUTS

Forty-seven varieties or strains of oats were tested this year to one strain each of loose and covered smuts of oats. Eleven varieties of common oats (*Avena sativa*) proved immune or highly resistant to both smuts. Of these eleven varieties Black Mesdag, Markton, and two lines of a cross, (Minota x White Russian) x Black Mesdag, produced by Dr. H. K. Hayes, University of Minnesota, are now being used by the Plant Breeding staff of the laboratory in crosses to produce a rust and smut resistant oat suitable for our conditions. The testing of the progeny of these crosses for smut resistance will begin next year.

Most of the forty-seven varieties that were tested this year have now been under test for three years to one strain of each smut, and a full report of these experiments will soon be published. The resistant varieties, especially those of common oats, are to be tested further to several strains of the two smuts from different parts of Canada to establish more fully the resistance of these varieties.

[1] See abstract of paper presented at the Nashville, Tenn., meeting of the American Phytopathological Society, in Phytopathology 18:1, p. 139. Jan., 1928.

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

(P. M. Simmonds, Officer in Charge)

INTRODUCTION

This report is a brief account of the progress for the past year. The investigations have centred around cereal foot-rot disease problems. Besides the work reported here, some attention has been given to other projects, such as barberry survey, buckthorn survey, and stem rust epidemiology investigations in co-operation with the Dominion Rust Research Laboratory. The plant disease survey records were forwarded to Mr. J. B. MacCurry for compilation. The *Helminthosporium* studies and the investigations of the take-all disease reported herein were summarized by Mr. G. A. Scott and Mr. R. C. Russell respectively. Messrs. B. J. Sallans and W. G. Sallans, seasonal assistants, assisted in all of the work. We wish to thank all others who co-operated with us in any way.

Fusarium STUDIES

Up to the present most of the work with the genus *Fusarium* has revolved around a pre-emergence and seedling blight of oats caused by *Fusarium culmorum* (W. G. Smith) Sacc. The results of this work were embodied in a bulletin which appeared in the autumn of 1928 as Bulletin No. 105 N.S. of the Dominion Department of Agriculture.[1]

During this time, however, hundreds of isolations have been made from various parts of apparently diseased cereal plants collected chiefly in Western Canada; these have been tested in preliminary pathogenicity tests. In this manner, along with due consideration of types brought out by cultural studies, the isolations have been brought down to a workable number. From cultural studies an effort is being made to determine the prevalent species, after which an intensive study of the diseases produced will be carried on. This phase of the work will not be reported upon in detail until later. Two species of quite different characters and habits were tried out in field tests at Saskatoon and Indian Head on wheat and oats. *F. culmorum* (W. G. Sm.) Sacc. of the section *Discolor*, representing the cortical invading type, and *F. orthoceras* App. et Wr., v. *longius* Sherb. of the section *Elegans*, species of which are associated with vascular invasions, were tested side by side. The inoculum consisted of cultures grown on ground, oat-hull mash. Besides a good mycelium development there was an abundance of conidia. Such cultures were broken up finely and added at the rate of 25 grammes to a row. The plots were of three rod-rows and 200 seeds were sown to a row. The plots were duplicated. A total of 1,200 seeds each of wheat and oats were inoculated separately with each culture at the two places. Twice these numbers were run as checks. The varieties used were Marquis 70 Sask., and Banner oats, both being obtained from the Field Husbandry Department, University of Saskatchewan. Notes were taken on the emergence and seedling blights only. The Saskatoon plots were sown on May 10 and the Indian Head plots on May 16. The results are summarized in the following table:—

[1] Simmonds, P.M. Studies in Cereal Diseases—III. Seedling Blight and Foot-rots of Oats caused by *Fusarium culmorum* (W. G. Sm.) Sacc. Bull 105 N.S Dept. of Agr. Dominion of Canada.

TABLE 28—EMERGENCE AND SEEDLING BLIGHT CAUSED BY *Fusarium* SPECIES

Saskatoon Plots

Inoculations	Wheat		Oats	
	Emergence	Seedling blight	Emergence	Seedling blight
	%	%	%	%
F. culmorum	74·1	0	49·7	0
F. orthoceras, v. *longius*	80·7	0	69·7	0
Check (no inoculations)	81·0	0	72·4	0

Indian Head Plots

Inoculations	Wheat Emergence	Wheat Seedling blight	Oats Emergence	Oats Seedling blight
F. culmorum	55·1	0	26·7	·5
F. orthoceras, v. *longius*	81·7	0	82·5	0
Check (no inoculations)	80·2	0	81·1	0

When the plants were well headed, isolations were made from a representative number from each plot. The *F. culmorum* type was recovered to the extent of approximately fifty per cent, which would indicate that the inoculation was successful. Isolations for *F. orthoceras* v. *longius* gave a few true to type from the Saskatoon wheat, but none from the other plots, although other types of *Fusarium* appeared. The checks gave odd types, with a few similar to *F. culmorum,* which was to be expected, as this form is quite common. It seems that the inoculations with *F. culmorum* were successful in every case, and that it was very virulent. *F. orthoceras,* v. *longius,* on the other hand, was not pathogenic when pre-emergence and seedling blight are considered. The poor emergence in the plots inoculated with *F. culmorum* was caused by the seedlings being blighted before reaching the surface (pre-emergence blight). Because of the very dry spring seedling blight was difficult to determine, so these figures are somewhat meagre, as only definite cases were recorded. Oats were more severely affected than wheat, which is the usual result.

Helminthosporium STUDIES

For some years *Helminthosporium sativum* P. K. et B., causing a foot rot of cereals, has been under study at this laboratory. The progress made in the study has been outlined in this report for the years 1925, 1926, and 1927. Special attention was paid to field and greenhouse experiments on methods of inoculation; relative virulence of strains of the fungus on wheat, oats, and barley; resistance of wheat varieties to attacks of the fungus; dates of seeding; seed treatments; and infection phenomena.

During the current year experiments have again been undertaken in the field and greenhouse, the results of which are outlined below.

Seed Treatments

The results of the seed treatments carried on in the greenhouse (see Report of the Dominion Botanist, 1927) indicated that a marked protection resulted when wheat seed was treated with Dupont No. 12, and that formalin and sulphur gave no protection to the seedling against artificial inoculation with *H. sativum.* A small field test was undertaken this summer to ascertain whether similar results could be obtained under field conditions.

Two sulphur dusts (Kolodust and flowers of sulphur), Dupont No. 12 (a mercurial dust), and formalin soak, were used. The dusts were applied in the usual way and care was taken to see that the seed was evenly coated. In the formalin treatment the seed was soaked in a solution of formalin (1-320) for five minutes, the solution was then poured off, the seed covered for four hours, allowed to dry, and then sown.

Ten plots, three rod-rows per plot, were sown on May 2. The rows were one foot apart, with three feet between plots. Artificial inoculum of *H. sativum*, consisting of a month-old growth of the fungus on ground oat-hulls, was sprinkled in the inoculated rows at seeding time. Table 29 shows the effect of the above treatments on Marquis wheat.

TABLE 29—SEED TREATMENTS OF MARQUIS WHEAT IN A FIELD TEST AGAINST ARTIFICIAL INOCULATION OF *H. sativum*

Treatments	Plots	Number of seeds sown	Emergence
			%
Kolodust	Check	300	84·3
Kolodust	Inoculated	300	41·6
Sulphur	Check	300	88·0
Sulphur	Inoculated	300	30·0
Formalin	Check	300	89·3
Formalin	Inoculated	300	23·0
Dupont No. 12	Check	300	96·6
Dupont No. 12	Inoculated	300	85·0
Check	Check	300	92·3
Check	Inoculated	300	31·0

The emergence, as indicated above, gives a correct interpretation of the plants throughout the entire period of growth. Formalin and sulphur gave no protection to the seedling from fungous attack, while in the case of Dupont No. 12 a distinct protection was seen. These field results correspond with those obtained in greenhouse tests.

Infection phenomena on wheat

It has been known for a long time that *H. sativum* is carried on seed wheat. In order to find out at what time infection takes place, some greenhouse tests were undertaken. The primary reason for carrying on the tests was to discover, if possible, the time when the artificial inoculation would damage the ripened grain to the greatest extent.

Several six-inch pots were sown with Marquis wheat on February 27. When the plants emerged the number in each pot was reduced to five. Inoculation consisted of spraying on the foliage, from an atomizer, a heavy spore suspension of the fungus. After inoculation the plants were placed in a moist chamber for 48 hours, then removed, placed on the greenhouse bench, and allowed to grow to maturity. Inoculations were done at approximately monthly intervals from the seeding stage until maturity, as follows:—

1st inoculation—March 8, wheat in seedling stage.
2nd inoculation—April 4, wheat nearing shot blade.
3rd inoculation—May 11, wheat heading.
4th inoculation—May 23, wheat flowering.

A number of plants were allowed to grow to maturity, without inoculation, to act as checks.

The results of the inoculations were quite evident in each case. In the first inoculation the plants, within two days after removal from the moist chamber,

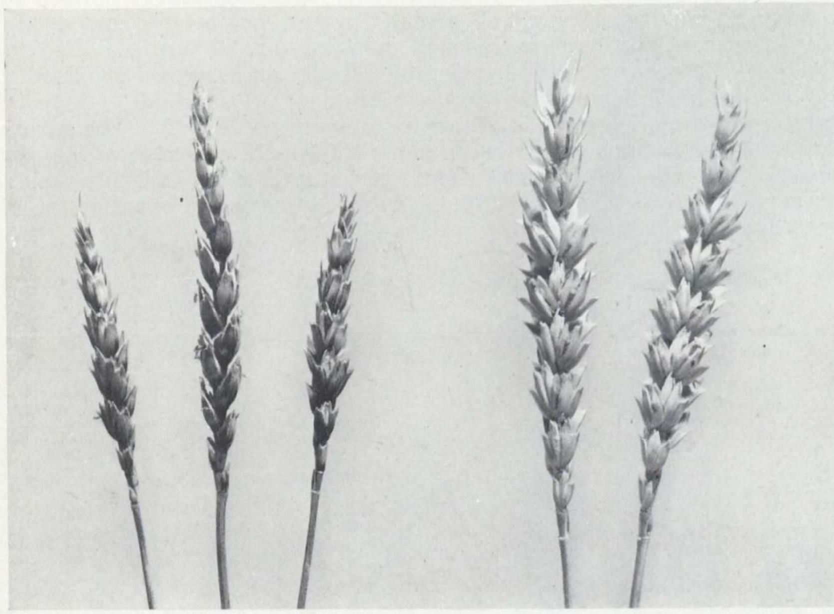


FIG. 10.—The result of inoculation with *Helminthosporium sativum* P.K. et B. of three heads of wheat at flowering time compared with two normal heads.

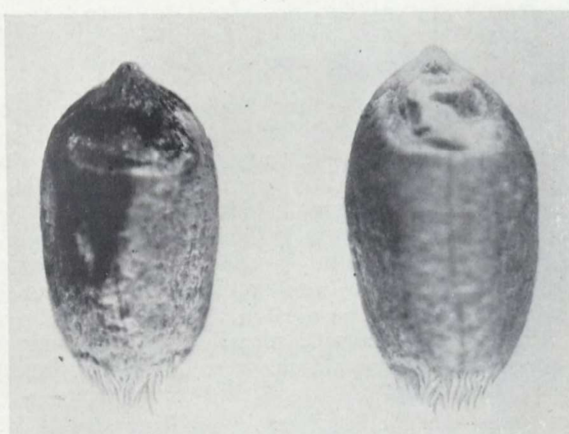


FIG. 11.—A representative, diseased kernel of wheat showing the dark discoloration caused by the fungus *Helminthosporium sativum* P.K. et B. as compared with a normal kernel.

showed typical *Helminthosporium* lesions on the leaves. These leaves eventually dried out and withered, although in no case was the plant killed outright. The second inoculation resulted in a similar way to the first. After the third inoculation, at heading time, besides the leaf-spotting and dying of the leaves, the gumes of the heads also showed lesions. After the last inoculation the heads showed still more numerous lesions than in the previous inoculation (fig. 10).

All the heads were harvested on July 10, allowed to dry, and threshed on August 22. On examination ninety per cent of the kernels from the last inoculation showed a distinct blackening at the germ end, and in the majority the blackening extended to other parts of the kernel (fig. 11). The part of the kernel where no blackening was evident seemed somewhat bleached, and in a few cases the kernels were distinctly shrunken. Only four per cent of the kernels from the third inoculation showed any evidence of blackening, and none was evident in the kernels from the check plants or the first and second inoculations.

In order to make sure that this discoloration was caused by the fungus, platings were made of a representative number of discolored kernels and positive results were obtained in every case.

Greenhouse tests were also carried on in sterile sand to check up on germination and lesioning of the seedlings. The lesions from the seedlings were surface sterilized and plated out on slightly acidified potato dextrose agar. Table 30 shows the results.

TABLE 30—GREENHOUSE TEST IN STERILE SAND FOR GERMINATION AND LESIONING OF WHEAT KERNELS PREVIOUSLY INOCULATED WITH *H. sativum*

—	Number of seeds sown	Germination		Lesioned	Number of lesions plated	*Helminthosporium* colonies produced
		Strong	Weak			
		%	%	%		
Check	50	100	0	6	3	3
1st inoculation	50	98	0	16	8	8
2nd "	50	98	0	0	0	0
3rd "	50	92	6	62	31	31
4th "	50	34	38	66	29	29

While the above results point strongly to the fact that the most damage done by *H. sativum* to the mature kernel occurs during the period of flowering, yet it must be borne in mind that these are only preliminary experiments conducted on a small scale, and the results should not be given wide application. Further tests are under way at the present time in the greenhouse, and it is hoped to supplement these tests by field experiments next season.

Prevalence of Helminthosporium sativum on seed wheat

Sixty samples of seed grains, consisting of forty-five samples of wheat, thirteen of oats, one of flax, and one of barley, were tested out in this laboratory during the current year for germination and prevalence of seed-borne diseases. These samples were sent in from farmers in widely separated parts of Saskatchewan and Alberta, so that they give a fair representation of the class of seed sown.

The method adopted for testing these samples was to choose three hundred seeds at random from the sample and sow them in sterile sand in greenhouse flats. At the end of ten days the seedlings were harvested and notes recorded on strong and weak germination and lesioned seedlings. Uniform conditions of moisture and temperature were maintained as far as possible during the growth of the seedlings. The lesioned seedlings were then immersed in a solution of mercuric chloride (1-1000) for five minutes, washed four times in sterile water, and the lesions cut off with sterile scissors and plated out on slightly acidified potato dextrose agar.

Of the forty-five samples of wheat tested only three produced seedlings that were entirely free from lesions, the remainder showed an average of four per cent of the seedlings lesioned, the percentage varying from zero to eleven. *H. sativum* was isolated from forty of the forty-two lesioned wheat samples. It was not isolated from any of the oat, barley, or flax samples. Judging from the above tests the fungus under consideration is a very common impurity in seed wheat, and the sowing of such wheat would naturally aid in the spread of the foot rot disease. Since these tests were done it has been discovered that the treating of the lesioned seedlings for five minutes in a (1-1000) solution of mercuric chloride, before plating out, tended to kill some of the fungi which may have caused the lesions. The platings showed that only about fifty per cent of the lesions produced fungi, while a direct microscopic examination of the lesions showed mycelium present in every lesion examined. The failure to isolate a larger number of fungi is attributed to the fact that the mercuric chloride was responsible for the death of the mycelium.

TAKE-ALL STUDIES

CULTURAL STUDIES.—During the winter months repeated attempts were made to reisolate *Ophiobolus graminis* Sacc. from infected plants produced in the greenhouse. These attempts met with very little success despite the fact that an abundance of heavily infected material was available, although fruiting bodies were absent. At the same time the organism was reisolated quite easily in plugged tubes on plant nutrient agar from similarly infected plants produced under aseptic conditions. Possibly this was due to the inability of *O. graminis* to compete on potato dextrose agar with the other organisms present in the diseased tissues. This emphasizes the difficulty in trying to isolate *O. graminis* from field material bearing no perithecia.

Mature perithecia were produced in cultures on oat hull mash. These cultures, after becoming well established under ordinary conditions, were placed outside for eight days, and were exposed to freezing temperatures during the night. They were then brought into the laboratory; and, when examined later, well developed perithecia were found. The low temperatures appeared to have furnished the necessary stimulus for the formation of fruiting bodies. The cultures were from a single ascus origin. This is the first time in these investigations that perithecia have been produced in cultures.

A number of single spore isolations were made late in the summer from perithecia produced on wheat stubble collected at Cudworth, Sask., and from a perithecium which developed on an infected specimen of *Hordeum jubatum* collected at Rama, Sask. We have now made isolations of *O. graminis* from four different localities in Saskatchewan.

HISTOLOGICAL STUDIES.—A start has been made on a histological study of wheat parasitized by *O. graminis*. So far this has been confined to a study of the penetration of the coleoptile of the wheat seedling by the fungus. It has been found that characteristic callosities are often formed where the fungus penetrates the epidermis and also where the hyphae pass from cell to cell within the tissues. The hyphae lose the brown colour which they exhibit when growing externally and become hyaline when they pass into the normal host tissue.

GREENHOUSE EXPERIMENTS.—One-gallon earthenware crocks have been adopted to replace flower pots in these experiments. It has been found that more uniform results are obtained than was the case when flower pots were used. This is largely due to the fact that greater uniformity in soil moisture can be maintained, the crocks being weighed and watered at regular intervals. The method of recording the disease rate was a modification of that used by McKinney (J.A.R. 26: 5, p. 199), and it proved very satisfactory. The method of inoculation and so forth have been explained in previous reports.

Experiment 1.—To determine the relative virulence on wheat of six isolations of *O. graminis*. The results are given in table 31.

TABLE 31—THE RELATIVE VIRULENCE ON WHEAT OF SIX ISOLATIONS OF *O. graminis*

Culture No.	Source	Disease rate
		%
1	Saskatchewan	55
2	"	91
10	Kansas	94
11	New York	55
31	Australian	27
58	"	31
Check		14

These isolations showed a marked and fairly consistent difference in virulence.

Experiment 2.—To determine the susceptibility of a number of selections of Marquis wheat which survived inoculation in greenhouse tests.

FIG. 13.—Left—progeny of supposedly resistant plants after attack of *Ophiobolus graminis;* right—checks from uninoculated plants.

In comparison with the bulk seed of the variety there was no distinct evidence of resistance. It is more probable that the plants which survived had escaped infection than that they had some innate resistance (fig. 13).

Experiment 3.—To determine the influence of depth of seeding upon pre-emergence and seedling blight caused by *O. graminis.*

FIG. 14.—Effect of depth of seeding upon the pre-emergence and seedling blight caused by *Ophiobolus graminis*.. Left—check and inoculated wheat plants sown at a depth of 1 inch; centre—the same sown at 3 inches; right—the same at 5 inches.

There was a proportionate increase in the amount of disease as the seeding depth was increased (fig. 14).

Experiment 4.—To determine the influence of compacting the soil upon pre-emergence and seedling blight, caused by *O. graminis.*

Apart from the fact that heavy compacting interfered with the emergence of the checks and still more with the emergence of the inoculated seedlings, the results did not show any marked influence.

Experiment 5.—To determine the rate of spread of take-all in pot tests.

It was found that the disease did not spread from inoculated seedlings in the centre of eight-inch crocks to seedlings sown closely around them. The neighbouring plants reached maturity without showing the characteristic symptoms.

Experiment 6.—To determine the influence, if any, on the development of perithecia when inoculum made from a mixture of *O. graminis* cultures is used.

Although wheat plants were infected no perithecia were produced.

FIELD EXPERIMENTS.—In the field experiments *Ophiobolus* isolation No. 2 was used instead of No. 1 which was used last year. A very heavy infection resulted in the seedling stage. This is shown by the following table, summarizing the notes taken on the one hundred wheat varieties in the seedling stage.

TABLE 32—SHOWING THE AVERAGE EMERGENCE, PRE-EMERGENCE BLIGHT, SEEDLING BLIGHT AND TOTAL NUMBER OF SEEDLINGS KILLED IN THE ST. GREGOR AND MELFORT PLOTS DURING THE SEEDLING STAGE

Plots	Emergence	St. Gregor Plots			Melfort Plots			
		Pre-emergence blight	Seedling blight	Total killed	Emergence	Pre-emergence blight	Seedling blight	Total killed
		%	%	%		%	%	%
Check........	125	0	4·8*	0	143	0	0·4	—
Inoculated....	89	29	51·8	62	103	28	50·0	63·6

*Much of this was due to cutworm and wireworm injury.

Notwithstanding the fact that the Melfort plots were sown three weeks later than the St. Gregor plots, the results obtained were almost identical. The coefficient of correlation between the percentage of each variety which died in the seedling stage at St. Gregor and the percentages of the same varieties which died at Melfort was $0 \cdot 5008 \pm 0 \cdot 0505$.

During the remainder of the season a further mortality occurred at St. Gregor, so that the average percentage dead at maturity averaged sixty-five of all the plants which emerged. At Melfort conditions were much drier and very few of the survivors of the seedling stage died during the summer. They behaved more like the survivors do under greenhouse conditions. At the time the checks were mature, the diseased plants were nearly as tall as the checks, but they were considerably retarded.

Besides the wheat varieties several varieties of oats, barley, and rye were tested again this year. Three different dates of seeding were tried, and yields were taken on these plots (5 x 5 feet in size) to get an accurate idea of the reduction in yield and grade resulting from artificial inoculation. Also four patches, three feet in diameter, were inoculated artificially to see if the disease would spread noticeably during the summer. Apparently it did not, for these patches were still of the same size at harvest time. The results of the date of seeding test are shown in table 33.

TABLE 33—SHOWING THE YIELD, GRADE, AND REDUCTION IN YIELD OF PLOTS SOWN ON DIFFERENT DATES AT ST. GREGOR

Date	Plots	Yield in grammes	Grade	Reduction in yield
				%
April 25..	Check......	688	3	
	Inoc........	96	Feed	86
*May 17..	Check......	650	5	
	Inoc........	134	Feed	79·4
*June 9..	Check......	366	6	
	Inoc........	42	Feed	88

*Samples were frozen by early fall frosts.

The main plot at both places was quite evenly and heavily diseased this year, so that rotation plots may be laid out on them next spring.

FIELD SURVEY.—Take-all was found more widely distributed throughout the province than in any previous year. Traces were found in almost every district inspected, except the southwestern corner of the province. Moderate infections were reported from several districts where only a trace had been found previously. This is not considered an indication that take-all is spreading in the province, but merely that the heavy rainfall in certain of these districts brought out the symptoms more clearly, and that a more comprehensive survey was made for root rots than in previous years. In the past few years a marked correlation has been noticed between the amount of rainfall during the summer and the prevalence of take-all. See table 34. The total rainfall listed is the average for six places in northeastern Saskatchewan for June, July, and August.

TABLE 34—THE EFFECT OF RAINFALL ON THE PREVALENCE OF TAKE-ALL

Year	Rainfall in inches	*Remarks
1923	10·24	First reported; probably quite prevalent.
1924	3·01	Not easy to find; only one case was prevalent.
1925	8·72	Found in other districts for the first time; quite prevalent.
1926	3·84	Not prevalent in northeastern Saskatchewan.
1927	8·81	Quite prevalent throughout northeastern Saskatchewan.

*See also reports of the Dominion Botanist for these years.

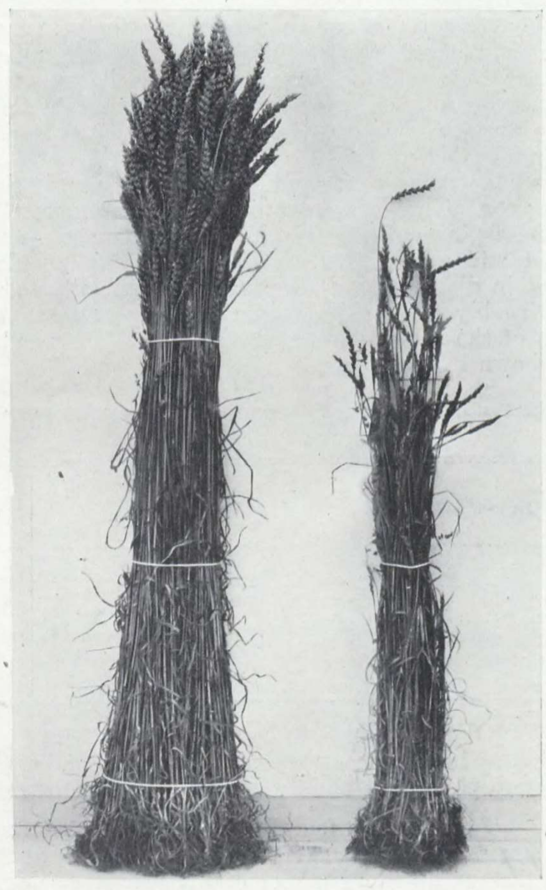


FIG. 12.—Reduction in yield from take-all of wheat. Left—yield of 100 healthy plants; right—yield from 100 representative diseased plants.

The diseased patches are far more noticeable and the blackening of the stem bases is far more pronounced in comparatively wet seasons. Even in the wet years, however, the only fields in which much take-all has been found, (i.e., more than 1 per cent of the plants noticeably diseased), have, with very few exceptions, been comparatively new fields which have raised one or more crops of wheat in succession before the crop which was inspected; or they have been fields of wheat following western rye grass or brome grass. Fields of wheat sown immediately following summerfallow or a crop of oats seldom show more than a trace of the disease even though they were heavily infested previously.

The results of this year's field observations tend to increase our faith in crop rotation as the most practical method of controlling take-all. In this connection we would recommend that farmers adopt the following rotation on new land in districts where this disease is prevalent: *breaking, wheat, oats, wheat, summerfallow,* instead of sowing wheat for three or four years in succession. It would probably be well to sow oats instead of wheat for the first crop following western rye grass or brome grass. In handling fields with a view to ridding them of take-all, care should be taken at all times to prevent the growth of creeping rooted grasses and volunteer wheat. Other crops which may safely be used in rotation on such fields are flax, sunflowers, sweet-clover, and potatoes.

In order to get a more accurate idea of the damage caused by the disease under natural field conditions, samples of healthy and diseased wheat were collected from ten fields in northeastern Saskatchewan. These were compared as to grade and weight. A sheaf of one hundred healthy plants was collected and another of one hundred representative plants affected with take-all (fig. 12). Table 35 shows the data secured.

TABLE 35.—SHOWING, IN COMPARISON OF DISEASED AND HEALTHY FIELDS, THE REDUCTION IN YIELD, VALUE, ESTIMATED PERCENTAGE OF PLANTS AFFECTED, AND COMPUTED LOSS IN PERCENTAGE FOR EACH FIELD.

Sample number	Weight in grammes		†Grade		*Percentage reduction		Plants diseased	Loss
	Healthy	Diseased	Healthy	Diseased	Weight	Value		
	grms.	grms.			%	%	%	%
1	222	32	2	4	85·5	13·5	12	10·26
2	152	28	4	5	81·5	9·5	2	1·63
3	277	34	4	4	87·5	0	3	2·62
4	83	16	6	Feed	80·5	10·5	5	4·02
5	192	16	5	6	91·5	5·5	20	18·30
6	120	15	5	Feed	87·5	15·5	10	8·75
7	185	15	3	Feed	92·0	30·0	8	7·31
8	155	18·5	Feed	6	88·0	10·5	3	2·64
9	122	19	6	6	84·5	0	8	6·76
10	95	9	5	6	90·5	5·5	5	4·52

†Grading was done by Mr. Rose of the Robin Hood Mills, Saskatoon.
*The computation of loss only takes into consideration the reduction in yield, as the amount of poor quality wheat in the total crop would not likely be enough to affect the grade except in fields 1, 5, 6, and 7

In table 35 it is seen that the yield from affected plants was reduced approximately 85 per cent. The grade was also reduced in most cases. By multiplying the estimated percentage of plants affected in the field by the reduction in weight of the diseased samples a fairly close approximation of the actual damage is obtained.

FUNGOUS FLORA OF WHEAT CROWNS AND ROOTS

This investigation was carried forward after the manner of last season, when it was initiated. Instead of using bichloride of mercury for surface sterilization the pieces were given a vigorous washing in sterile water. With such a large number of isolations it was not practicable to record the *Fusarium* types separately, so they are presented as a group. The results of the Saskatoon isolations gave some indication of seasonal variation. These are shown in tables 36 and 37.

TABLE 36.—RESULTS OF ISOLATIONS FROM MARQUIS WHEAT GROWN AT SASKATOON

Date	Stage of growth	Crowns					Roots				
		Total fungi	*Hel.*	*Fus.*	*Alt.*	*Rhiz.**	Total fungi	*Hel.*	*Fus.*	*Alt.*	*Rhiz.**
May 21......	2nd leaf......	82	12	52	0	0	92	0	88	0	0
June 21......	3 tillers.......	176	36	120	2	0	126	6	98	8	0
Aug. 3......	Milk..........	100	18	52	0	0	102	0	50	0	0
Aug. 24......	Dough........	112	14	54	0	0	88	9	42	0	0
Sept. 21......	Stubble.......	112	18	70	0	0	98	8	52	0	0

TABLE 37.—RESULTS OF ISOLATIONS FROM KUBANKA WHEAT GROWN AT SASKATOON

Date	Stage of growth	Crowns					Roots				
		Total fungi	*Hel.*	*Fus.*	*Alt.*	*Rhiz.**	Total fungi	*Hel.*	*Fus.*	*Alt.*	*Rhiz.**
May 21......	2nd leaf.......	90	12	56	0	0	104	4	88	0	0
June 21......	6 tillers.......	124	10	98	8	0	152	12	126	4	0
Aug. 3......	Milk..........	108	26	50	0	0	102	10	48	0	0
Aug. 24......	Dough........	98	8	62	0	2	102	8	64	0	2
Sept. 21......	Stubble.......	94	4	46	0	0	100	8	54	0	0

*The abbreviations denote *Helminthosporium*, *Fusarium*, *Alternaria*, and *Rhizoctonia* respectively.

The total numbers of *Fusaria* and *Helminthosporia* isolated from plants grown at the various locations show a possible regional variation. The results are given in Tables 38 and 39.

TABLE 38.—TOTAL PERCENTAGE OF *Helminthosporia* AND *Fusaria* ISOLATED FROM MARQUIS WHEAT GROWN AT THE VARIOUS STATIONS

Station	Crowns		Roots	
	Hel.	*Fus.*	*Hel.*	*Fus.*
	%	%	%	%
Morden..........	4·6	8·6	0·6	12·0
Winnipeg..........	30·0	45·5	10·0	38·5
Indian Head..........	26·5	44·5	3·5	38·5
Saskatoon..........	19·6	69·6	5·0	68·7
Swift Current..........	25·0	62·0	3·0	20·0
Edmonton..........	5·7	31·0	0	14·5

TABLE 39.—TOTAL PERCENTAGE OF *Helminthosporia* AND *Fusaria* ISOLATED FROM KUBANKA WHEAT GROWN AT THE VARIOUS STATIONS

Station	Crowns		Roots	
	Hel.	*Fus.*	*Hel.*	*Fus.*
	%	%	%	%
Morden..........	3·0	11·0	0	12·0
Winnipeg..........	23·0	42·0	9·3	45·3
Indian Head..........	18·6	42·6	3·3	35·3
Saskatoon..........	14·0	66·5	8·4	76·0
Swift Current..........	21·3	54·6	3·0	16·0
Edmonton..........	10·0	32·5	1·5	11·5

In the Saskatoon isolations the greater number of fungi were obtained from the early collections. This could not definitely be correlated with rainfall or soil temperatures. The results for the other stations were variable. There is generally a high peak for *Fusarium* isolations early in the season. *Helminthosporium* isolations from Winnipeg, Swift Current, and Indian Head, on the other hand, appear to increase towards harvest time. The increase early in the season comes at about the time the plant is tillering and putting out new crown roots. No definite conclusions can be drawn until further results are obtained. In comparing the various locations it is found that Saskatoon stands foremost for the number of *Fusaria* isolated. Similar results were obtained last season. Most *Helminthosporia* were obtained from the Swift Current specimens last year, whereas, in the present data, Winnipeg is about equal with Swift Current in this respect. In most cases Morden and Edmonton specimens revealed fewer fungi than any of the other stations. *Rhizoctonia* types were obtained from all stations except Morden. A few *Alternaria* were isolated. A sclerotial fungus was isolated from the Edmonton specimens.

WHEAT SEED DISCOLORATIONS

In our studies of root rot diseases we have been confronted with the problem of what constitutes disease-free seed. This necessitates a study of the various discolorations and abnormalities of wheat kernels as well as of normal and healthy-appearing grains. The following types were selected:—

TABLE 40.—TYPES OF WHEAT KERNELS SELECTED FOR STUDY

Type of discoloration, etc.	Variety	Produced in year	Source
Piebald	Preston	1927	Bruno, Sask.
Basal glumerot	E. Red Fife	1925	Duck Lake, Sask.
Frozen	Marquis	1927	Bruno, Sask.
Green	"	"	St. Gregor, Sask.
Normal	"	"	Moose Jaw, Sask.
Rusted	"	"	Saskatoon, Sask.
Smudge (*Helminthosporium*)	"	"	Mossbank, Sask.
Scab (*Fusarium*)	"	"	Saskatoon, Sask.
Pink	"	"	Munson, Alta.

It was quite impossible to get sufficient grain showing all types from one locality and of the one variety, which makes comparisons less valuable. As it is expected that a more detailed account of this work will be available later, it is not necessary to endeavour to define the types here.

About 2,000 kernels of each type were selected from a large sample, along with the same number for checks. These were tried in the greenhouse for germination and the presence of lesions. The tests were made in sterile sand. Isolations were made from the lesions which appeared. In the greenhouse tests 1,600 kernels of each type of discoloration, along with a similar number from the same source, as checks, were compared. The results are given in Table 41.

TABLE 41.—RESULTS OF EMERGENCE, GERMINATION, BASAL LESIONS, AND DISEASE RATE OBTAINED IN GREENHOUSE TESTS WITH VARIOUS WHEAT SEED DISCOLORATIONS

Type of discoloration	Weight of 1,000 kernels	Emergence	Basal lesions	Weak germination	Non-germination	Disease rate
	grms.	%	%	%	%	%
Piebald	32·431	94·12	6·37	2·50	3·37	11·90
Check	30·280	96·75	5·50	1·02	2·25	8·12
Basal glumerot	27·408	97·87	7·37	1·00	1·12	8·15
Check	34·849	97·87	10·87	1·12	1·00	10·84
Frozen	26·633	84·50	15·00	4·00	11·50	28·75
Check	27·242	86·25	17·25	4·50	9·25	28·93
Green	8·259	58·37	7·37	11·75	29·87	53·03
Check	29·185	92·12	9·62	2·87	5·00	16·53
Normal	26·623	95·55	9·25	2·30	2·25	12·53
Rusted	16·376	95·87	4·62	1·12	3·00	8·15
Check	30·702	95·87	6·00	1·37	2·75	9·31
Smudge	21·068	65·62	4·37	8·75	25·62	42·03
Check	28·642	97·62	3·37	1·25	1·12	5·53
Pink	18·981	97·25	1·80	·75	2·00	4·47
Check	32·134	96·25	6·25	·87	2·87	8·89

Field tests were run at Saskatoon and Indian Head. The plots consisted of two rod-rows with one hundred seed to a row. These were duplicated. The Saskatoon plots were severely damaged by sparrows. Only the results from the Indian Head tests will be given. The smudge sample sown at Indian Head was not from the same lot as the greenhouse test, but was of the same type. The notes for the field test are given in table 42.

TABLE 42—RESULTS OF EMERGENCE, YIELD, AND GENERAL NOTES OBTAINED IN A FIELD TEST WITH VARIOUS WHEAT SEED DISCOLORATIONS

Sample	Emergence	Average plot yield	General appearance on July 31
	%	grms.	
Smudge	42·7	641	Poor
Check	72·0	1,098	Good
Pink	78·0	1,065	"
Check	81·7	1,184	"
Piebald	84·0	1,197	Fair
Check	84·2	1,245	"
Frozen	71·0	881	"
Check	72·2	1,054	"
Normal	78·5	1,101	Good
Rusted	80·2	922	Fair
Check	79·7	1,093	"
Basal glumerot	83·7	1,064	Good
Check	85·0	1,076	"
Green	48·5	593	Late
Check	82·7	1,132	Good

The diseased kernels of the basal glumerot, smudge, and scab types are all due to parasites, *Bacterium atrofaciens* McC., *Helminthosporium sativum* P.K. et B., and *Fusarium* spp., respectively. The remaining abnormalities were caused by various conditions which will not be dealt with here. Progress has been made in histological studies of these discolorations. In greenhouse tests the emergence of frozen, green, and smudge was low. The disease rate, determined on the emergence, presence of lesions, and weak germination, gave from highest to lowest in the following order,—green, smudge, frozen, and normal, the remaining ones in this respect being lower than kernels selected as normal. Severe cases of scab were not included as they do not germinate. With the exception of basal glumerot, the kernel diseases caused by parasites appeared to be significant in this method of examination. Of the non-parasitic conditions, green and frozen show a high disease rate. The rusted, pink, and piebald types were not far from normal. The field tests were not particularly good this season for comparisons. In yields, smudge, green, and frozen were distinctly lower. When the histological work and further miscellaneous tests are completed, it is hoped that some useful information on wheat seed diseases will be available.

CO-OPERATIVE SURVEY FOR ROOT ROT DISEASES IN WESTERN CANADA

At a conference in April between members of the Associate Committee on Field Crop Diseases of the National Research Council and members of the Federal Department of Agriculture it was decided that a survey should be made to determine the prevalence of root rot diseases in Western Canada.

The staff of this laboratory in conjunction with the plant pathologists of the University of Saskatchewan made such a survey in the province of Saskatchewan.

Generally speaking the federal men surveyed the northeast, east, and south, while the provincial men did the west, and northwest. There was, however, an interchange of men, whenever possible, to assure uniformity in note-taking; and most fields were appraised by two men. The federal workers examined a total of 313 fields and the provincial workers 211. A detailed account of the survey will be given when the complete data for the three provinces are compiled. Only summary tables of the Saskatchewan survey will be given here.

To facilitate recording, the general root rot condition was divided into five types,—take-all, pre-maturity blight, browning, *Helminthosporium* and cortical invading *Fusaria,* and doubtful.

Total number of fields examined	524
" " " wheat fields examined	447
" " " oat fields examined	47
" " " barley fields examined	23
" " " rye fields examined	6
" " " corn fields examined	1

TABLE 43.—ESTIMATED INJURY IN THE WHEAT FIELDS EXAMINED

Type	Number of fields showing				
	Trace	Slight	Medium	Severe	Total
Take-all	62	56	28	4	150
Pre-maturity blight	28	6	0	0	34
Browning	21	31	19	13	84
Helminthosporium and *Fusaria*	86	37	4	0	127
Doubtful	4	10	4	0	18
No disease	....	....	....	....	41

Estimated damage when all types are considered of 454 cases in wheat (some fields having more than one type).

Trace	44·3	per cent.
Slight	30·8	"
Medium	12·1	"
Severe	3·8	"
No injury	9·0	"

TABLE 44.—ESTIMATED INJURY IN FIELDS OF THE OTHER CEREALS

Crop	Type	Number of fields showing					
		Trace	Slight	Medium	Severe	No disease	Total
Oats	Pre-maturity blight	7	3	2	0	35	47
Barley	*Helminthosporium* and *Fusaria*	5	0	0	0	18	23
Rye	Doubtful	0	1	0	0	5	6
Corn						1	1

Root Rot Field Study

This work was done in conjunction with the regular co-operative root rot survey. Fields which appeared to show a chronic root rot condition were selected for investigation. The history of such fields was obtained in as much detail as possible. Notes were then taken regarding the present situation—as to the seed source, type of cultivation, weather conditions, amount of damage, and so forth. After the threshing period was over a questionnaire was sent to the co-operating farmers to obtain information on the yield and grade of the wheat. A sample of this wheat was requested for laboratory work. An attempt was made to visit these locations at least twice during the season, at the seedling stage, and just prior to maturity.

Nineteen fields were selected this season. Eleven in the southern part of the province and eight in the northern. Sixteen of these fields showed the type of root rot commonly called " browning ". Two fields were listed as affected with take-all, and one with a doubtful condition. All of the " browning " fields had been in summer-fallow the previous season. They were all sown to Marquis, except one which was in a durum variety. Most of the fields ranged in age of cultivation from a few years to twenty or thirty. Very few fields had had any other crop except one of the cereals over this period. Crop rotation and changes in methods of cultivating are coming in and their influence on root diseases is one of the objects of this work. In the two fields selected as being severely affected with take-all one had followed wheat and the other brome grass. The " browning " trouble was most characteristic and appeared to be most severe this season. It is most commonly found on the summer-fallow crop. From eleven questionnaires relative to fields affected with this disease it was learned that there was an average reduction in yield of eight bushels per acre—the range being from five to ten bushels; and in " days late " the variations were from three to fourteen, averaging approximately ten days. These figures are in part only estimates, but were arrived at in a comparative manner by observant farmers. The effect of frost interfered with the comparing of grades. A characteristic of this disease appears to be a notable retardation in development. If this is true and consistent, the economic importance cannot be overlooked.

Methods of Inoculation

The most satisfactory method of inoculating seedlings under greenhouse and field conditions in our work has been to use cultures grown on ground oat hull mash. It is not as satisfactory under field conditions as one would desire. Experiments have been carried out to see if some more effective method could be developed. *Fusarium culmorum* and *Helminthosporium sativum* were used, the former against wheat and oats, and the latter against wheat and barley. Cultures of these fungi were mixed with various proportions of soil and sand, then such mixtures were tried out as an inoculum. Also, ground oat hulls were mixed with soil and sand in different proportions, and the mixture used as a culture and inoculation medium. After the mixture was made up it was kept on the greenhouse bench for two weeks. It was found that the pure oat hull mash culture could be diluted with soil two or three times and still give infections equivalent to the pure inoculum. With the sand mixtures there was some irregularity in the case of wheat inoculated with *Fusarium*. In the test with oats the pure inoculum was superior. All of the mixtures of *Helminthosporium* with sand were more effective than the pure culture inoculum. *Helminthosporium* mixtures kept in a cool cellar instead of on the greenhouse bench were more effective for inoculations. It was found that cultures should be used as soon as they are taken from the flasks, as, under ordinary conditions, they lost disease-producing qualities after being broken up, or mixed and allowed to stand.

A culture medium made of mixtures of ground oat hulls and soil or sand was not superior to the pure cultures for inoculation purposes.

Field tests were run, but a prolonged dry spell and some alkali patches made reliable comparisons impossible.

GENERAL NOTES

In an effort to obtain some information from a pathological standpoint in regard to seed wheat, many samples were tested in various ways during the winter of 1927 and the summer of 1928. Eleven samples, including select seed and commercial grades of 1926 wheat, were tested in the first series. One thousand kernels of each sample were germinated in sterile sand. All of the regular seed samples gave good emergence. In the commercial grades there was a steady downward trend from No. 4 to feed. For the amount of lesioning and presence of fungi there was no consistency, some of the better samples revealing a fair percentage of fungi. *Helminthosporium sativum* was rather commonly isolated. Thirty-two samples of the 1927 seed were tested in a like manner. Some samples distinctly showed more fungi than others. This was not correlated with poor emergence. Centrifuge tests and examinations of the pericarp for mycelium were also made. These investigations were of an exploratory nature; the detailed results are of interest and will serve as a foundation for future work, which is contemplated.

Each season for the last few years tests with wheat for moisture content and the presence of fungi have been made. This season the plots set aside for this work were severely injured by sparrows so that the tests are very incomplete. The work, however, will be reorganized and extended for next season. Some preliminary tests on artificial injuries to the root system of wheat were carried out in the greenhouse and field. Some very interesting results were obtained. This work will be continued.

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, EDMONTON, ALBERTA

(G. B. Sanford, Pathologist in Charge)

Following the decision of the department to establish a federal plant pathological laboratory in Alberta, in 1927, at the Dominion Experimental Farm, Lacombe, arrangements were made between the federal and provincial departments for this laboratory to be located at the University of Alberta. The laboratory is now housed on the campus in a new structure, which accommodates both federal and provincial plant pathological staffs. The building of the new laboratory was begun in July, and the quarters were occupied in December. The laboratory is a three-story structure, containing about eighteen rooms, supplemented by two large greenhouses, each 75 feet by 22 feet. These greenhouses are each divided into three separate compartments, and in each compartment the temperature is automatically regulated. When completed, the laboratory will have an ammonia refrigeration plant. These advantages of construction and equipment will greatly assist the work to be done in investigating the foot rot and root rot diseases of our field crops. The expense ot constructing the building, and the greenhouses, and the permanent fixtures in these; the heat, light, and certain other advantages, including experimental plots, have been generously provided by the province through the university. The laboratory is co-operating with the University Department of Field Crops.

Mr. W. C. Broadfoot joined the stuff of the laboratory in August as pathologist. Mr. Broadfoot, formerly a resident of Saskatchewan, received his B.S. and M.S. degrees, and carried out further work toward a doctorate, at the University of Minnesota. The position of Assistant Pathologist has not yet been filled. Mr. M. W. Cormack, Plant Disease Investigator, on a temporary appointment, assisted during the summer period.

Owing to the unsëttled conditions existing since July, 1927, and to the lack of laboratory facilities to date, very little laboratory work could be undertaken in the foot rot studies. However, certain field studies and root rot surveys have been made. The first extensive plant disease survey in Alberta was made in 1927, and a similar survey was made again in 1928. The main purpose of the survey each year was to determine the severity of the foot rot and root rot of wheat in Alberta.

The cultural and crop rotation studies for the control of the foot-rot diseases, begun co-operatively with the Dominion Experimental Stations in 1927 at Morden, Man., and Indian Head, Swift Current, and Scott in Saskatchewan, were extended this year to include the Dominion Experimental Stations at Lethbridge and Lacombe, and the Provincial School of Agriculture at Vermilion. A project for studying the take-all disease was begun this year on the farm of A. M. Sanders near Duhamel in the Camrose district. The Sander's project was laid down on soil infested with *Ophiobolus graminis*. Included in the study is a susceptibility test of about 91 varieties of wheat to the take-all disease. A field test was made at the University of Alberta of the relative susceptibility of these varieties of wheat to *Helminthorsporium sativum* and *Ophiobolus graminis*. The test was made in soil artificially infected with inoculum. To date it has not been possible to complete the analysis of the material collected from the field studies, and, therefore, the results cannot be included in this report.

FOOT ROTS OF SPRING WHEAT

In continuing the survey in 1928, the same methods were employed in recording the occurrence and severity of foot rot and root rot as were used in the 1927 survey. In 1927 this laboratory recorded the results from 1,467 fields distributed throughout the main wheat growing areas of Alberta, with the exception of the Peace River area, and a summary of the results was included in the Annual Report of the Division of Botany for 1927. In 1928 the severity of foot rot and root rot was obtained in 914 fields of wheat. Roughly, every sixth field was visited where the survey led. In evaluating the loss from foot rot the yield was first estimated on a disease-free basis. An estimate was then made of the loss due to the foot rots, and this was expressed as a percentage of the estimated yield. While only approximately correct, it is believed that this method expresses the actual conditions more closely than such general terms as " trace ", " slight ", " medium ", and " heavy ". The terms " foot rot and root rot " refer to damage caused by any of the important foot-rotting and root-rotting fungi, including *Ophiobolus graminis, Helminthosporium sativum,* and *Fusarium* spp., or other fungi which may be associated. From the appearance of the diseased plants in the field, verified by gross microscopic observations. the great majority of the cases of root rot, recorded from our survey, were caused by *Ophiobolus graminis*. A brief summary of the results from the survey of 914 fields is listed in table 45. For convenience the estimated severity of the disease has been grouped into classes. The percentage of the fields in each class of severity is given for the preceding crop or cultural practice listed.

The following loss-classes in percentage were found suitable: 0; 0-0·9; 1-2·9; 3-5·9; 6-9·9; 10-14·9; 15-20·9; 21-27·9; 28-35·9; 36 and above. The preceding crop or practice includes the first or second crop after breaking the virgin sod; the second, third, and fourth successive crops of wheat; a stubbled in crop after wheat; wheat after sweet clover, alfalfa, peas, oats, summer fallow, brome sod (breaking and backsetting), timothy sod, and field rye. The preceding crop was not determined for 65 fields. In table 45 it will be noted that no mention has been made of a third crop following breaking, and only a few cases of four successive crops of wheat. However, it is believed that a number of such fields are included in the column headed "2nd crop following wheat". In other words, this column includes all the definite cases of wheat for two years, and also many cases of the third or fourth successive crop of wheat, whether following breaking of the virgin sod or on old land.

In table 45, it is clear that where wheat follows breaking, the 0·9 loss-class was not exceeded, and a few of the fields have no recorded loss. These observations corespond with the data from surveys made in 1927 and earlier. However, there is a marked increase of the severity of the disease on the second crop

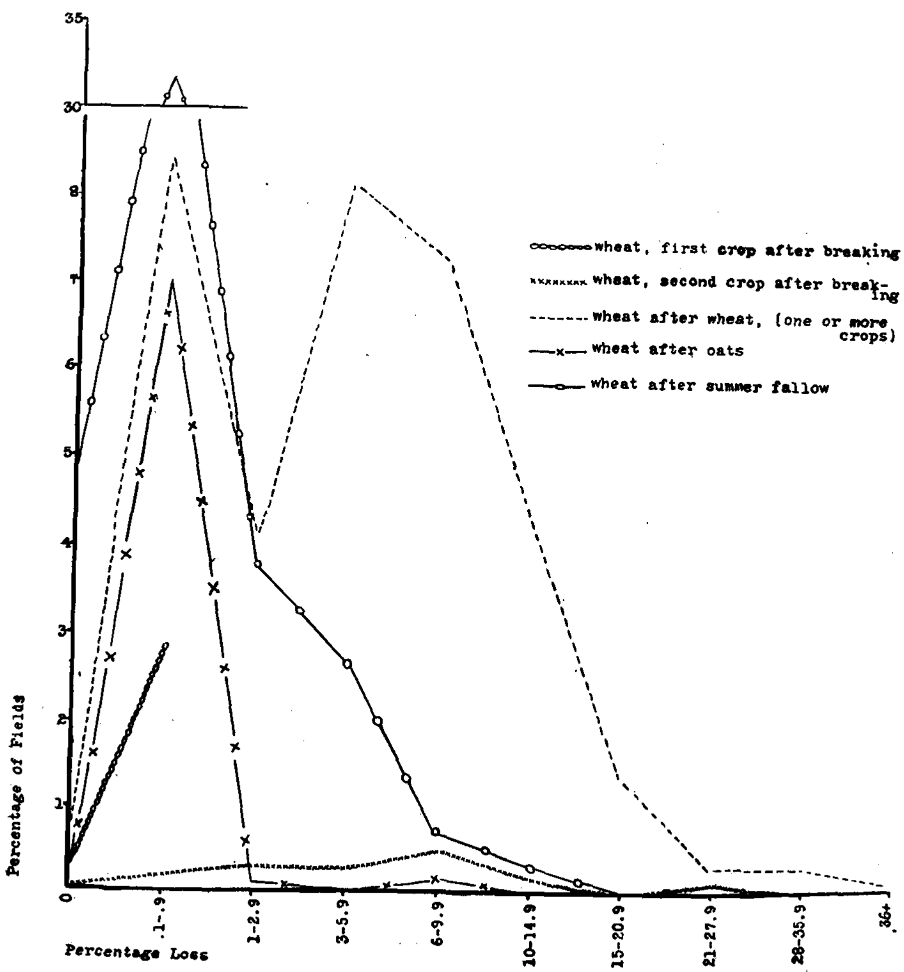


FIG. 15.—A comparison of the effect of preceding crops on the development of foot rot of wheat.

TABLE 45—THE EFFECT OF THE PRECEDING CROP OR CULTURAL METHOD ON THE DEVELOPMENT OF FOOT-ROT OF WHEAT IN ALBERTA IN 1928. THE PERCENTAGE OF FIELDS FOR THE PRECEDING CROPS IS GIVEN, AND THESE ARE ARRANGED FOR EACH LOSS-CLASS

Estimated loss-class in percent	Number of fields	Breaking		Wheat				Legumes			Oats	Summer-fallow	Brome Sod		Timothy	Rye	Not known	Total fields per loss-class
		1st crop	2nd crop	2nd crop*	3rd crop	4th crop	Stub-bled in	Sweet clover	Alfalfa	Peas			Break-ing	Back-setting				
%		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0	59	0·3		0·8							0·3	4·7			0·1		0·2	6·4
0·1–0·9	495	2·9	0·2	7·7	0·1	0·1	0·4	0·1			6·5	31·3			0·2	0·1	4·7	54·3
1– 2·9	91		0·3	3·8	0·1		0·2	0·1	0·1	0·1	0·1	3·7					1·3	10·0
3– 5·9	107		0·3	7·0	0·6		0·4	0·1				2·6		0·1			0·4	11·7
6– 9·9	89		0·5	5·5	1·2		0·7	0·1	0·1		0·2	0·6					0·7	9·7
10–14·9	47		0·2	1·4	2·2	0·4	0·4					0·3					0·1	5·1
15–20·9	16			0·8	0·7			0·3										1·7
21–27·9	6		0·1		0·3							0·1	0·1					0·7
28–35·9	3				0·3													0·3
36+	1				0·1													0·1
	914																	

*Many of the fields in this column probably belong in the 3rd crop column since in many cases it was difficult to ascertain further than the preceding crop.

following breaking. The severity of foot rot on the third or fourth successive crop of wheat following breaking of the virgin sod is frequently very marked, and the distribution of the disease is usually fairly general.

Where wheat follows wheat on old land, the data show that there is a definite increase in the severity of foot rot disease for the second and third years, in fact this tendency is often very marked in the third successive crop. Where wheat has been stubbled in, the disease is usually more severe than where the crop has been seeded on ploughed land. Unfortunately, the data on this point in table 45 are not sufficient to warrant conclusions. The amount of foot rot found in certain fields of wheat which followed legumes was unexpected, because the legumes mentioned are not known to be hosts of the foot-rotting fungi. Possibly certain grass hosts grew in the legume sod, or the additional nitrogen and crop residue favoured the development of the foot rotting fungi. Very little loss was observed where wheat followed oats, and this is in accordance with common observation. Where more than a slight loss occurred it is possibly due to the presence of wheat or other grass hosts of the foot rotting fungi in the oat crop. The cases listed of foot rot following brome, timothy sod, and common rye are too few for comment. However, severe take-all foot rot has been observed several times where wheat followed brome sod.

The data in table 45 are presented graphically in figure 15. The distribution of the various loss classes is given of wheat following the first year and the second year, respectively, of breaking virgin sod; wheat for two or more successive years; wheat following oats; and wheat following summer-fallow. It is evident there is a distinct tendency for the foot rot disease to be relatively unimportant the first year following breaking, but to increase quickly the second year. Of the 495 fields of wheat following summer fallow, inspected, only a few were damaged more than three per cent. In these cases it is considered unlikely that the summer-fallow was free from grass and volunteer wheat. Considering the loss in the fields of wheat following wheat for one or more years, only 0·8 per cent of these are in the zero loss-class; 8·3 per cent of them are in the 0·1-0·9 (trace) loss-class; 4·1 per cent are in the 1-2·9 class; 8 per cent are in the 3-5·9 class; 7·4 per cent are in the 6-9·9 class; 4·4 per cent are in the 10-14·9 class; 1·4 per cent are in the 15-20·9 class; 0·3 per cent in each of the 21-27·9 and 28-35·9 classes, and 0·1 per cent above 36 per cent loss. These data show that very significant losses occurred where wheat followed wheat on old land. The question of the take-all disease tending to disappear on old land is not supported by our observation. On the contrary, there is evidence that the take-all disease may develop on normal Alberta soils regardless of age. For example, a field of wheat at Mirror following a clean summer-fallow (under observation) had about 8·3 per cent loss from the take-all. In 1926 the wheat in this field was severely injured by take-all. The field has been cultivated for over twenty years. This example would also indicate that in certain cases it requires at least more than one year of clean summer-fallow to free the soil of the take-all fungus.

The chart in fig. 16 shows the distribution of all the fields surveyed in the various loss classes. Of the 914 fields, the loss in about 61 per cent of them is less than one per cent. About 10 per cent of the fields are in the 1-2·9 loss class. In the remaining 29 per cent the loss was significant. Of these fields 11·7 per cent fall in the 3-5·9 loss-class; 9·6 per cent in the 6-9·9 class; 5·1 per cent are in the 10-14·9 class; 1·7 per cent in the 15-20·9 class; and in the remaining one per cent, the percentage loss was between 21 and 36 per cent.

Granting that the figures for the estimated loss are only approximately exact, the data supplied in table 45 indicate clearly that the loss in fully 30 per cent of the fields was very significant. The data also indicate that the severity of the foot rots tends to increase with two or more crops of wheat, and that the loss is usually very slight in a wheat crop sown after oats. Finally there was no indication that the take-all foot rot tends to decrease on old cultivated land.

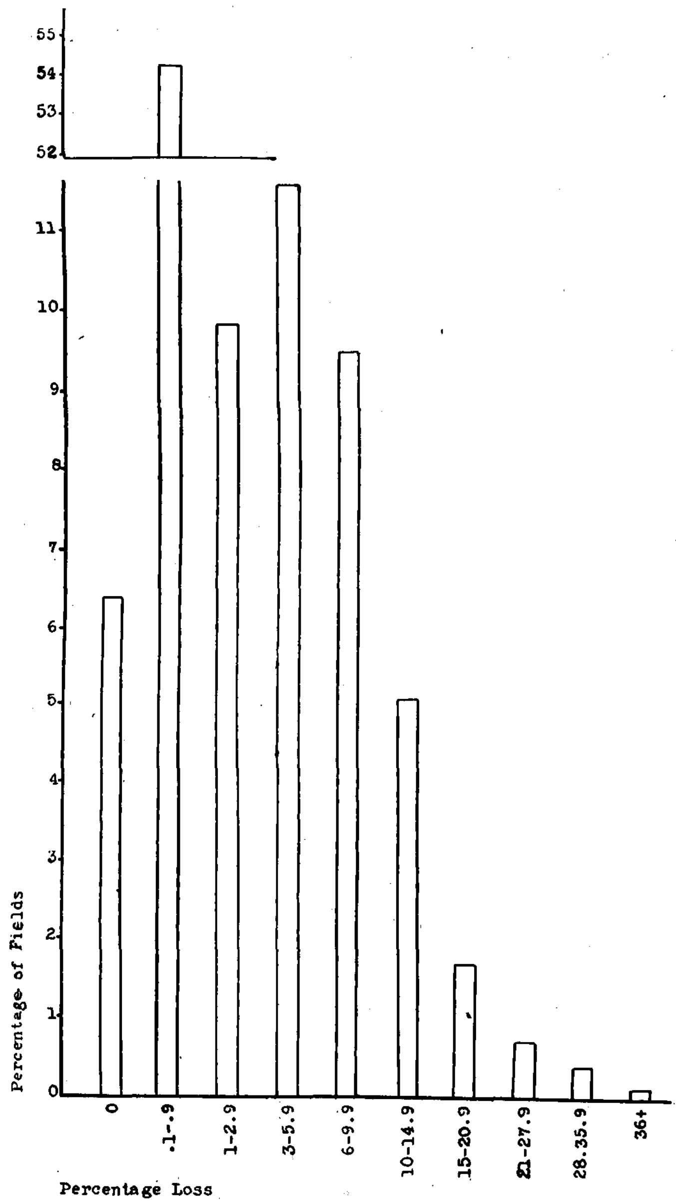


FIG. 16.—This chart shows the distribution of the 914 wheat fields inspected, according to the estimated loss from foot rots.

FOOT ROT AND ROOT ROT OF WINTER WHEAT

A number of fields of winter wheat in southern Alberta were inspected in May and later for evidence of foot rot and root rot. Many fields of wheat had apparently wintered well, but in others there was considerable winter killing. The basal parts at this time appeared to be in a reasonably good condition, and apparently free from evidence of foot rot. In July reports came to this laboratory of winter wheat dying. These reports were investigated, and the evidence obtained showed that much of the injury was, without doubt, associated with foot rot and root rot diseases. Platings from the diseased plants commonly gave *Helminthosporium sativum* and *Fusarium* of the *culmorum* type. However, microscopic examination showed that *Ophiobolus graminis* was present, and in

PLATE VI.—Representative heads and kernels of winter wheat from plants injured by *Ophiobolus graminis* in the field at Cowley.

many cases appeared to be the principal pathogene concerned. The injured plants were bleached and stunted, and many of the heads were empty, or contained only shrivelled grain, as is characteristic of the take-all disease.

In the Cowley district a twenty-five-acre field of Alberta Red winter wheat was practically destroyed by the take-all disease, and gave a negligible yield, which graded poor feed. Mature perithecia of *O. graminis* were fairly abundant on the basal parts throughout the field, and every plant was badly diseased. Plate 6 shows some of the heads and shrivelled grain from the field. The crop history of the Cowley field, since breaking the virgin sod in 1918, is as follows: winter wheat; summer-fallow; winter wheat; oats; summer-fallow; winter wheat; oats; spring wheat; summer-fallow in 1927; and winter wheat in 1928. The summer-fallow in 1927 was said to have been a clean one. If so, foot rot of winter wheat in Alberta apparently presents a somewhat different problem from that associated with spring wheat, for the amount of foot rot on spring wheat following a clean summer-fallow is rarely very important.

A field experiment was begun at the Dominion Experimental Station at Lethbridge, where this laboratory will observe the effect of early versus late seeding, and deep versus shallow seeding, on the development of foot rot of winter wheat.

STRIPE RUST, *Puccinia glumarum*

The finding of stripe rust in Alberta on *Hordeum jubatum,* and on varieties of wheat in 1926 and 1927, is included in the annual reports of the Division for these years. During the season of 1928, the first intensive search was made in this province for stripe rust, and it was found without difficulty on a number of varieties of spring wheat, on winter wheat, *Hordeum jubatum,* common barley, *Agropyron Smithii,* and *A. dasystachyum.* Of the 64 varieties of wheat exposed to infection by stripe rust only one variety, (Chagot), was severely rusted, one variety had medium infection, and 53 varieties showed a trace. These results indicate that the commonly grown varieties of wheat are fairly resistant to the form of stripe rust in Alberta.

On May 12, at Claresholm, the first, second, and third leaves of fall sown wheat (Kharkov) were found to be heavily infected with yellow stripe rust. The rust was not found on the leaves belonging to the 1928 growth. The urediniospores which had overwintered were found to be highly viable. This is the first definite case observed of the overwintering of stripe rust in Western Canada (plate 7).

Before the middle of August stripe rust was found only in low, cool, damp places on *H. jubatum,* but subsequently it was found almost anywhere until the end of the season. Specimens of this rust, including samples of the rust which had over-wintered at Claresholm, were sent to the Dominion Rust Research Laboratory at Winnipeg. A complete report of stripe rust in Alberta in 1928 has been accepted for publication, and will appear in an early issue of *Scientific Agriculture.*

STEM RUST OF WHEAT AND OATS

Puccinia graminis Tritici, and *P. graminis Avenae*

The 1928 wheat and oat crops of Alberta were remarkably free from rust of any kind. In wheat fields throughout the north-central and southern parts of Alberta, occasional primary or localized secondary infections could be found, but usually with difficulty. Traces of stem rust on wheat and oats in Alberta developed simultaneously during the first ten days in August. Apparently there was no indication of a tendency for the rust to become more plentiful in one section than in another. This condition is in marked contrast to the way stem rust developed in 1927, when it assumed epidemic proportions in certain late maturing wheat fields from Wetaskiwin northwest and eastward. The first collection of stem rust was obtained on *Hordeum jubatum,* July 29, about 30 miles east of Edmonton. This infection was severe but local, and easily traceable to a hedge of rusted barberry only four feet distant. Eight days later stem rust was collected at Wetaskiwin on *H. jubatum* and on wheat the same day. The following day it was collected at Olds, on wheat. Two days later primary and secondary infections were found on several plants of winter wheat at the School of Agriculture, Claresholm. There is the possibility that these infections came from a rusted barberry about 40 rods distant. Following this, stem rust in the

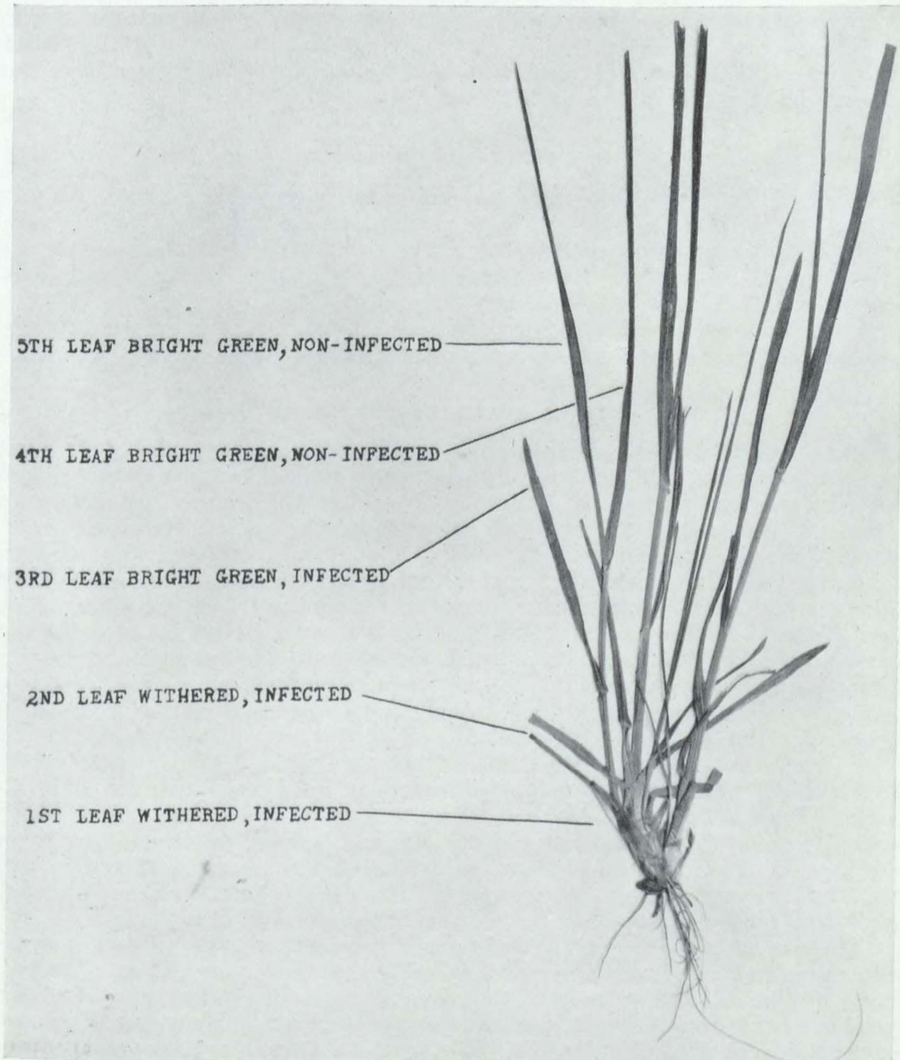


PLATE VII.—This wheat seedling was taken May 12, 1928, from a field of Kharkov M.C. 22, sown August, 1927, at the School of Agriculture, Claresholm, Alberta. The first and second leaves were withered and heavily infected with stripe rust. The third leaf was green, succulent, and also heavily infected. The urediniospores on these leaves were found to be strongly viable.

secondary stage was collected on *H. jubatum* at the Dominion Experimental Farm, Lethbridge, and a trace was observed on one plant of Little Club wheat at this station. The next day one pustule was obtained on Garnet wheat at the Dominion Experimental Station, at Lacombe. Following August 12, collections were made throughout the north-central and southern parts of the province. This continued until late September when it was found on fall sown wheat in southern Alberta.

The first collection of stem rust of oats was made at Lougheed, August 16, and following this, traces were obtained at various points in Alberta in the territory in which the stem rust of wheat was found. Weather conditions during the crop season were considered fairly favourable for the development of rust. The wheat crop ripened fully ten days earlier than it did in 1927. Many collections of both kinds of stem rust were forwarded to the Dominion Rust Research Laboratory, Winnipeg.

BARBERRY AND BUCKTHORN

Thirty-three shrubs of *Berberis vulgaris* were destroyed in Alberta this year. Twenty-five of these, which were large shrubs bearing fruit, were taken from a nursery 30 miles southeast of Edmonton, and one from the Provincial School of Agriculture at Claresholm. These were all slightly rusted. The remaining seven were located at Lethbridge, but were not rusted.

Three hundred and seventy-five feet of *Rhamnus cathartica* were located. Rust was not found on common buckthorn in Alberta this year.

GENERAL PLANT DISEASE REPORT

Puccinia Phlei-pratensis was common on *Phleum pratense*. *P. dispersa* occurred on spring and fall sown rye at many places, but it was not severe. This rust was collected at the Dominion Experimental Station at Beaverlodge. *P. triticina* occurred in Alberta from late July to the end of the season. Only a trace appeared in wheat fields throughout the north-central and southern parts of the province. Leaf rust was found during late September on fall sown wheat. Specimens of the take-all disease of wheat were collected in the Peace River block of British Columbia and Alberta. The findings for British Columbia were reported to H. R. McLarty, Pathologist-in-Charge of the federal laboratory at Summerland, British Columbia. Glume blotch, *Septoria glumarum,* was more common in southern Alberta than further north, but the disease was not as severe as in 1927. Basal glume rot of wheat, *Bacterium atrofaciens,* was collected from many wheat fields, but never more than a trace was observed. Black chaff of wheat, *Bacterium transluscens,* var. *undulosum,* was not found this season. Ergot, *Claviceps purpurea,* did not appear to be more plentiful than usual. In some fields of spring and fall rye and isolated patches of *Agropyron* and *Bromus,* there was much ergot. Blast of oats was common, and in some fields the loss was apparently significant. The covered and loose smuts of oats, wheat, and barley did not appear to be more severe than usual.

The mortality of *Populus tremuloides* is very extensive in Alberta, and particularly so in the Edmonton district, where entire groves are dying. The older trees suffer most, but frequently the younger trees die. Nearly all the older trees have heart-rot. According to Schmidt and Jackson (" Heart-rot of Aspen ", Minnesota Technical Bulletin No. 50) there was good evidence that *Fomes igniarius, F. applanatus,* and *Armillaria mellea* were probably the cause of almost all the heart-rot of aspen in Minnesota, and that the most important of these is *F. igniarius*. They state that they had been unable to find sporophores of *F. applanatus* in Minnesota. Sporophores of *F. igniarius* were found on aspen in Alberta, but not those of *F. applanatus*. A species of *Polystictus* (probably *pergamenus*) is frequently abundant on fallen aspen and about the butts of diseased trees. *Cytospora chrysosperma* is rather generally distributed, and apparently the cause of severe lesions and frequently the killing of both old and young aspens.

The foot rot and root rots of wheat were, by far, the most important plant diseases in Alberta in 1928.

SECTION IV

INVESTIGATIONS OF THE DISEASES OF FRUITS AND VEGETABLES

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

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

The season of 1928, like that of 1927, was favourable for the development of fungous diseases. Apple scab, though not so prevalent as in 1927, was, nevertheless, quite general. Cherry leaf spot again caused serious defoliation in many sections, particularly in unsprayed orchards, or orchards where one or more applications of the usual spray schedule were omitted. On the other hand leaf spot was present to quite an extent in some orchards which had received the recommended number of applications. In some of these cases the explanation might readily be that the sprays were not applied thoroughly enough or at the correct time. In our demonstration orchards, which were practically free from leaf spot, lime sulphur and Bordeaux were equally efficient in controlling it. As a result of the severe defoliation caused by the leaf spot fungus during the last two years, it is thought advisable to pay particular attention to this disease next year.

Black knot on plums was brought to our attention on many occasions during the season. This is the first time in years that black knot has been so apparent. During the last few years the dormant spray on plums has not been applied to the same extent as formerly, and this no doubt accounts in part for the increase of black knot.

Grape mildew and black rot caused considerable damage in many graperies in widely separated sections of the district.

On October fifteenth, we moved from our old quarters at 204 St. Paul street to our new experiment station on Niagara street. Our new quarters are first class in every respect, comprising, as they do, an office, three private laboratories, photographic room, dark room, chemical laboratory, sterilizing and media room, and a large general laboratory, all under one roof. Attached directly to the laboratory proper is a greenhouse 93 feet long by 22 feet wide, divided into three compartments of 25 feet each and a potting room 18 feet long. The entrance to the greenhouse is either from outdoors or directly from the laboratory.

The farm property, consisting of about thirty acres, is situated at the corner of Niagara and Carlton street, on the highway to Port Weller, an ideal situation. This spring 755 fruit trees of various kinds were planted for experimental purposes. Small fruits such as raspberries, gooseberries, currants, strawberries, etc., have also been planted.

Our equipment is now of the best and makes it possible for us to attack many problems which formerly we were unable to give any attention to, due to lack of proper facilities.

However, the acquiring of the new property, the alterations made thereto, and the moving into our new quarters interfered considerably with research work. This was particularly true in the case of the officer in charge, who found very little time during the past year for research problems.

Mr. A. B. Jackson resigned from our staff last May; Mr. Chamberlain was promoted to Mr. Jackson's position, but as yet no one has been appointed to succeed Mr. Chamberlain. In other words for the last eight months our staff has been below its usual strength. This weakening of our staff, coming at the same time that we were preparing to move to our new quarters, has seriously interfered with the research program of this laboratory.

SPRAY SERVICE

The fifth year of the spray service, which furnishes to growers spray information pertaining to all tree fruits, was again successfully conducted. The membership the past year was 200, being practically the same as previous years. The service started the last week of March and continued till the end of July. Seventeen different notices, giving detailed instructions regarding the various spray applications, were sent out to the members of the service. The time of one man was wholly occupied in the supervision and the necessary extension work arising from this service. One feature of the service which was greatly appreciated this season was the demonstrations in seven different localities of the method of making up oil emulsion sprays. Two hundred growers attended these demonstrations.

Bordeaux Spraying of Sour Cherries

The experiment of spraying sour cherries with Bordeaux mixture vs. lime sulphur to determine the effect of the Bordeaux spray on the size of the fruit was again conducted on the farm of Morris Udell, Grimsby. Three applications of each spray were applied. The following are the results obtained this year:—

TABLE 46.—RESULTS FROM SPRAYING SOUR CHERRIES

Spray	Average weight of 1,000 cherries.	Total crop of 7 trees. 6 qt. baskets.	Average diameter of cherries, 32nd inch.
	lb. oz.		
Lime sulphur, 1-40	6 6	68¼	23·20
Bordeaux, 4-6-40	6 1	63	22·21
Difference	5	5¼	·99

These results bear out those obtained in previous experiments, showing that sour cherries sprayed with Bordeaux mixture are slightly smaller in diameter and lighter in weight.

Spraying Experiment to Test the Fungicidal Value of Wettex for the Control of Apple Scab

During the early part of the season inquiries were received regarding the value of the new sulphur spray called Wettex, in controlling fungous diseases, particularly apple scab. Having had no experience with this spray material, it was decided to test the material in a commercial orchard against the regularly recommended lime-sulphur. This demonstration was carried out in an orchard near St. Catharines on Duchess and McIntosh apples. The spray schedule for this orchard was as follows:—

April 19	Sprayed orchard with oil to control red mite—insect dormant spray.	
May 1	Sprayed with Bordeaux mixture and arsenate of lead—the dormant spray.	
May 14	10 rows Wettex 5 rows lime sulphur and arsenate of lead 5 rows Bordeaux and arsenate of lead	pink spray.
May 29	10 rows Wettex 10 rows lime sulphur and arsenate of lead	calyx spray.
June 20	10 rows Wettex 10 rows lime sulphur and arsenate of lead	three weeks cover spray.
July 4	Sprayed all orchard with Wettex.	

The following tables give the results obtained from the above schedule:—

TABLE 47—PER CENT CLEAN AND SCABBY APPLES—McINTOSH VARIETY

Spray	Clean	Light scab	Severe scab	Insect injury
	%	%	%	%
Lime sulphur	70·0	12·8	5·4	11·8
Wettex	14·7	27·7	49·1	8·5
Check trees (no spray)	14·7	32·7	47·1	5·5

TABLE 48—PER CENT CLEAN AND SCABBY APPLES—DUCHESS VARIETY

Spray	Clean	Light scab	Severe scab	Insect injury
	%	%	%	%
Lime sulphur	53·0	26·5	8·2	12·3
Wettex	62·2	22·6	7·6	7·6
Check trees (no spray)	14·7	32·7	47·1	5·5

NOTE—There was only one check block of Duchess variety, there being no trees of the McIntosh variety available as a check block.

In the case of the Duchess apples, satisfactory results were obtained with Wettex. With the McIntosh variety, however, Wettex did not give good control. Almost 50 per cent of the fruit was so severely scabbed as to be unmarketable, compared to the low percentage of 5·4 per cent severely scabbed in the lime sulphur block.

INSPECTION AND CERTIFICATION OF RASPBERRY STOCK

Inspection and certification of raspberry stock was again carried on from this laboratory. Three hundred and fifty inspections of raspberry plantations were made, with the result that approximately 60 acres of raspberries were certified as being free from mosaic, after roguing had been done and second inspections made. Special aid and assistance were given to the plantations of the commercial nurseries. Inspections were made in answer to requests from this service. Requests were received from growers in outlying districts such as London, Waterford, Port Burwell, Port Elgin, Goderich, St. Thomas, Cooksville, and Brampton. Mosaic disease was found present in all raspberry growing sections. During the past season, however, there appeared to be less spread than in 1926-1927. Leaf curl was also quite general in plantations, but the percentage present was very small.

Apple Scab Studies

(G. C. Chamberlain)

Progress report of the work being carried on to determine the effect of temperature and leaf fall on the development of the perfect stage of *Venturia inaequalis*.

This work was commenced in the fall and winter of 1926-27. Since then progress has been very slow indeed, due to the fact that little time has been available for this problem owing to pressure of the outside work connected with the spray service.

In the fall of 1926 two lots of McIntosh apple leaves were gathered, the first October 15, and the second November 15. This latter date approximated to the time of normal leaf fall for that year. These leaves were placed at various temperatures in controlled incubators through the kindness of Dr. W. H. Burkholder of Cornell University. Commencing on January 1, 1927, material from the leaves was prepared and embedded in paraffin for sectioning. A portion of this work has been done and is reported herewith.

In recording the perithecial development from the various temperatures and groups, the size of the ascocarp and the stage of development, as marked by the grosser characters, were noted. For this purpose the excellent plates of Wilson* were helpful. At first there was some confusion arising from the presence of perithecia and pycnidia of other leaf invading fungi, but on becoming acquainted with certain definite stages in the development of *Venturia* the difficulty was largely overcome. The terms used in the following tables in recording the stage of development are based on the stages as shown by Wilson* in plates V and VI.

D—Represents the early stages in the formation of the ascogonium.
E—Stage where indications of trichogyne are apparent.
F—Little later stage.
H—Stage where ascogonium begins to break up and disappear.
I—Stage where ascogenous hyphae begin to appear.
J—Stage where ascogenous hyphae are prominently lined.
K—Stage where asci are definitely present.
L—Stage where ascospores are mature.

The following tables show the number, size, stage of development, etc., of perithecia found in the different groups of leaves studied.

TABLE 49—PERITHECIAL DEVELOPMENT IN LEAVES, BASES ON WILSON'S PLATES IN "PHYTOPATHOLOGY"

Group 1—Prepared for Sectioning on January 1

Date leaves collected	Temperature centigrade	Number of sections	Perithecia Number	Perithecia Size microns	D	E	F	H	I	J	K	L
October 15	3°	1,069	18	39·8 x 35·3	6	7	1	4	....	....	....	....
November 15	3°	1,131	4	43·3 x 38·0	1	3	....	....	....	....	....	....
October 15	6°	1,278	8	54·4 x 48·6	1	7	....	....	....	....	....	....
November 15	6°	1,199	1	44·0 x 32·0	1	....	....	....	....	....	....	....
October 15	9°	1,532	....	....	....	....	....	....	....	....	....	....
November 15	9°	1,107	....	....	....	....	....	....	....	....	....	....
October 15	12°	552	1	42·0 x 40·0	....	1	....	....	....	....	....	....
November 15	12°	592	....	....	....	....	....	....	....	....	....	....
November 15	20°	1,458	21	39·9 x 30·9	19	1	....	1	....	....	....	....
Group 2—Prepared for Sectioning on February 1												
November 15	0°	448	4	41·0 x 38·0	1	3	....	....	....	....	....	....
October 15	3°	1,413	34	49·2 x 43·1	11	11	1	10	1	....	....	....
November 15	3°	1,342	282	61·2 x 54·6	2	71	1	95	28	26	39	15
October 15	6°	733	14	65·6 x 55·1	3	4	....	7	....	....	....	....
November 15	6°	570	15	59·7 x 53·0	2	3	....	6	....	....	....	....
October 15	9°	445	3	46·0 x 42·6	....	3	....	....	....	....	....	....
November 15	9°	449	63	79·8 x 71·6	....	6	....	17	26	11	5	....
October 15	12°	362	5	58·7 x 48·2	3	2	....	....	....	....	....	....
November 15	12°	225	43	66·8 x 60·5	5	3	2	11	....	17	5	....
November 15	20°	247	45	51·7 x 45·7	8	9	4	13	8	3	....	....

* Wilson, E. E. Studies of the Ascigerous Stage of *Venturia inaequalis* (Cke.) Wint. in Relation to Certain Factors of the Environment.—Phytopathology XVIII:5, pp. 375-418. May, 1928.

Group 3—Prepared for Sectioning on March 1

Date leaves collected	Temperature centigrade	Number of sections	Perithecia Number	Perithecia Size microns	D	E	F	H	I	J	K	L
November 15.........	0°	611	4	56·0 x 51·0	3	1	....	....	....	....	....	....
October 15...........	3°	511	18	46·7 x 38·7	2	3	....	....	....	....	....	....
November 15.........	3°	458	3	42·0 x 38·0	....	....	....	3	....	....	....	....
October 15...........	6°	578	....	....	....	....	....	....	....	....	....	....
November 15.........	6°	587	22	60·4 x 49·3	4	4	5	7	1	1	....	....
October 15...........	9°	561	12	65·4 x 48·4	....	5	1	4	2	....	....	....
November 15.........	9°	578	14	55·7 x 51·1	....	9	....	4	1	....	....	....
October 15...........	12°	848	....	....	....	....	....	....	....	....	....	....
November 15.........	12°	609	5	54·0 x 50·6	....	5	....	....	....	....	....	....
November 15.........	20°	682	97	65·2 x 46·6	3	16	3	27	19	28	1	....

Group 4—Prepared for Sectioning on April 1

October 15...........	3°	360	3	50·2 x 46·0	1	....	2	....	....	....	....	....
November 15.........	3°	287	1	36·0 x 32·0	....	....	1	....	....	....	....	....
October 15...........	6°	105	....	....	....	....	....	....	....	....	....	....
November 15.........	6°	180	1	68·0 x 56·0	....	....	....	....	....	....	....	1
October 15...........	9°	257	....	....	....	....	....	....	....	....	....	....
November 15.........	9°	126	....	....	....	....	....	....	....	....	....	....
October 15...........	12°	270	....	....	....	....	....	....	....	....	....	....
November 15.........	12°	286	29	64·4 x 57·1	3	3	2	16	5	....	....	....
November 15.........	20°	211	24	63·9 x 50·5	....	3	5	9	5	2	....	....

NOTE.—The temperature 20° C. in the above tables represents leaves held under natural conditions outdoors.

TABLE 50—STAGE OF DEVELOPMENT OF PERITHECIA IN RELATION TO TIME OF LEAF FALL

Group	Date	D	E	F	H	I	J	K	L	Total Number of perithecia
B Group............................	(Oct. 15th).....	26	44	3	39	4	0	0	0	116
C Group............................	(Nov. 15th).....	18	107	10	160	68	44	42	15	464
Check material.....................	(Nov. 15th).....	30	29	12	50	32	33	1	0	187

TABLE 51—NUMBER OF PERITHECIA ACCORDING TO GROUP
B Group collected October 15, 1926
C Group collected November 15, 1926

Date	Temperature of Incubation								
	3° C. group		6° C. group		9° C. group		120° C. group		20° C.
	B	C	B	C	B	C	B	C	
January 1................................	18	4	8	1	0	0	1	0	
February 1................................	34	282	14	15	3	43	5	63	202
March 1................................	18	3	0	22	12	14	0	5	
April 1................................	3	1	0	1	0	0	0	29	

NOTE.—In the above tables 20° C. refers to leaves under natural conditions, outdoors.

From the above tables it is seen that perithecial development takes place at various temperatures. In the material examined so far a larger number of perithecia developed in the C Group comprising leaves gathered November 15. The stage of development in this group was for the most part more advanced.

Particularly interesting in this regard was the material sectioned from the leaves held at 3°C. and brought in for examination February 1, 1927. Fifteen perithecia were found containing mature ascopores and thirty-nine with the asci formed. In none of the other material examined were perithecia found with such advanced development.

Fewer perithecia have been found in the older material brought in the first of March and first of April. This may be due to the fact that, owing to shortage of space in the controlled incubators, it was not possible to keep the leaves separated from one another. It has been observed in the field that fewer perithecia are formed in leaves which lie covered by other leaves or debris than in those which are exposed.

Last year (1927) experiments were started to ascertain the possibilities of preventing perithecial formation in over-wintering leaves by means of fall, winter, and early spring applications of various spray materials. These experiments have been repeated this year. The whole question of the over-wintering stage (perithecial stage) is being studied from several angles in the hope of gaining information that may be of use in controlling apple scab. As yet these investigations have not progressed far enough to warrant drawing any conclusions. It is hoped that some definite results may be reported soon.

Raspberry Spur Blight

(L. W. Koch)

The work on raspberry spur blight was continued during 1928. Positive results from inoculations made into healthy raspberry canes with ascospores of *Mycosphaerella rubina* were obtained. Inoculations made directly into growing tips, buds, and on leaves gave positive results also. Spur blight on raspberries causes not only the usual lesions associated with the cane, but, under certain conditions, lesions on petiole and leaf blade tissue as well. During the past season leaf blade lesions were quite common on the Herbert variety.

Spur blight produces its greatest injury to the buds. It has been observed that buds on spur blight areas are dwarfed and discoloured. Some are killed outright. Since these buds are destined to produce the fruit for the following year, it is quite apparent that, if they have been injured by spur blight attack, it is going to have some effect on next year's crop. Just to what extent injury of the buds by spur blight affects the following year's crop, under Ontario conditions, is one of the points still to be investigated in connection with our spur blight studies.

CONTROL DEMONSTRATIONS

Spraying experiments were begun on May 30, 1928, in an attempt to control spur blight injury. In this work Bordeaux mixture—3 pounds copper sulphate, 5 pounds hydrated lime to 40 gallons of water, with the addition of 2 pounds laundry soap—was used. Spraying was done at a pressure of 250 pounds, with as fine a mist as possible.

Four adjacent rows of berries, each 103 yards long, were chosen for the experiment. One of these was of the Herbert and the other three of the Cuthbert variety. One half of each row was left as a check.

TABLE 52—RESULTS OF SPRAYING WITH BORDEAUX

Variety	Number of canes counted	Unsprayed number of lesions	Sprayed number of lesions	Percentage control %
Herbert	100	550	42	92·4
Cuthbert	100	614	Sprayed once	
			19	96·5
			Sprayed twice	
			13	98·0
			Sprayed three times	
			13	98·0

The above results, it will be noticed, are figured out according to the number of lesions. The above results indicate at least that under the above set of conditions spur blight was successfully controlled by even a single application of Bordeaux. However, it is realized that several years' work with control demonstrations are essential before any definite control measures for Ontario can be formulated.

Strawberry Mosaic

The so-called mosaic disease in strawberries was described in last year's annual report and the results of some inoculation experiments given. The results of an experiment, conducted in 1926, were described which tended to show that this trouble was infectious. However, because of the fact that the check plants were lost through freezing, no definite conclusions could be drawn. During the past year, however, inoculation studies were carried out on a much larger scale (200 inoculations), with negative results in all cases. Inoculations were made by means of macerated tissue, and transfers of insects from mosaic plants to healthy plants. Results so far obtained are, therefore, inconclusive and unsatisfactory. Further experimentation will be necessary to ascertain the true nature of this trouble.

During the past year the variety Van Dyke, originated at the Vineland Experiment Station, has shown this trouble. So far the following varieties have been found in Ontario affected with this mosaic-like disease, namely: Eaton, Waites Everbearer, Grand Prize, Minnesota No. 3, and Van Dyke.

Strawberry Root Rot

(A. R. Walker)

The investigation on the strawberry root rot for the season of 1928 was a continuation of work commenced during the previous summer. Hence, it was possible to keep the experiments set up in 1927 under observation for another entire season. Further experiments of a similar nature were set up, as well as work started on other aspects of the problem.

The work was resumed the third week in May which, as in the previous season, proved to be early enough for the first appearance of root rot in the strawberry patches. The earliest appearance of this trouble, and its period of greatest severity for 1928 in the Niagara Peninsula, corresponded very closely with those reported for last year in that district. Thus the first evidence of the trouble appeared during the last week in May, and its severity increased, slowly at first, and then rapidly to a maximum in the last week of June. By that time it was to be found fairly general throughout the strawberry districts of the Niagara Peninsula. Some fields, however, were quite free, but others suffered losses as heavy as 50 per cent. In general the losses were rather heavier than during the previous year.

The results of work in 1927 suggested that, although an organism was perhaps responsible for the trouble, the general vigour of the plants was in all probability a very important factor. For these reasons the investigation of 1928 was divided into two main groups which, with their subdivisons, are as follows:

A. *Study of Organisms*

1. Results from overwintered plants inoculated the previous year.
2. Isolation of organisms from diseased plants.
3. Inoculation of healthy plants with suspected organisms obtained by isolation.

B. *Cultural Studies*

1. Depth of planting in relation to general vigour.
2. Survey of strawberry patches, collecting data on cultural practices, and health of plantation.
3. Relation of soil to spread of the disease.
4. Influence of mulching on the general vigour and susceptibility to root rot.

RESULTS FROM OVERWINTERED PLANTS INOCULATED THE PREVIOUS YEAR

During the season 1927 between June 1 and August 15, twenty-one isolated groups of Glen Mary strawberries had been inoculated in the field. Eleven different types of inoculum were used. These included filterable extracts from diseased plants and organisms, mostly *Bacteria, Fusaria,* and one *Ramularia* sp., all of which had been isolated from stricken plants. One of the patches which had been inoculated with the *Ramularia* sp. towards the end of June, gave positive results. Many of the plants in this patch died, and several of these gave positive re-isolations. Hence, other patches were inoculated with this organism early in August.

These experimental plants were all allowed to winter over without protection. On May 25, 1928, these plots were examined. They all showed quite a number of casualties. However, this was much more marked in the plots which had been inoculated with one of: a couple of types of bacteria, two forms of *Fusarium,* and one of *Ramularia.* In two of the plots in which the plants had been inoculated with the *Ramularia* sp. the plants were nearly all dead. This was the more striking because runners had been sent out before the plants died. (In these plots, inoculated later in the season, many runners had been produced before inoculations were made. These runers were left attached to the parent plant which was inoculated.) These runners formed a border of healthy plants around the almost bare patch where the inoculated plants had been.

However, these results were not as reliable as could be desired, owing to a disturbance of the stakes used to mark these plants over winter. In some cases it was difficult to ascertain, with certainty, all the experimental plants. Then too, some of the check-plants died during the winter, so that one could not say with any degree of certainty how many of the plants had died as a result of the inoculation.

The plants which were set in pots in sterile soil the previous season and overwintered in the greenhouse were not much of a success. Many of these were inoculated and some died. One of these weakened plants gave a positive re-isolation. However, these plants were generally of such low vigour that they could not be considered very fit subjects for experiment.

ISOLATION OF ORGANISMS FROM DISEASED PLANTS

The practice of making isolations from diseased plants, which was begun during the 1927 season, was continued throughout 1928. Again a great many different organisms appeared, but species of *Fusarium* and *Ramularia* predominated. Species of *Coniothyrium, Ozonium,* and *Verticillium* appeared frequently. Eelworms were present in many cases, but were rarely found in an isolation which also contained fungus. They appeared to be contaminations.

On account of the preponderance of *Ramularia* and *Fusarium* in isolations, and because such results agreed with the work of the previous year, these types were used for inoculation work.

INOCULATION OF HEALTHY PLANTS WITH SUSPECTED ORGANISMS OBTAINED BY ISOLATION

Apparently healthy strawberry plants were inoculated under ordinary field conditions with the organisms which had given some positive results during the previous season. The plants were all spring planted and were of either Glen Mary or Wm. Belt varieties.

Only six plants out of fifty-four inoculated early in the season showed symptoms of the root rot trouble. Four of these developed unmistakable evidence and were removed. Isolations from these gave positive results in all four cases. Two of these plants had been inoculated with the *Ramularia* sp. and the other two with the *Fusarium* sp. These plants were removed on July 27, and, as no other evidences of casualties appeared up to September 1, it was considered that these few would perhaps be all the inoculated plants which would develop the malady this year. Other inoculations were made somewhat later in the season—well after the cropping period. These had not had a very long period for development of symptoms before the termination of the work for the season.

All of these experimental plants, both inoculated and checks, were staked so that observation can be made on them again next season.

DEPTH OF PLANTING IN RELATION TO GENERAL VIGOUR

A patch of 500 Wm. Belt strawberry plants was set out on June 11, varying the depth of planting. This experiment was undertaken not for the purpose of questioning the well established method of planting, but because observations indicate that growers show wide differences in this respect; and it was considered important to determine if discrepancies of this nature might alter the vigour of the plants sufficiently to influence their susceptibility to root rot.

The plants were set in at three different depths. Approximately one-third of them were planted *normal depth* or the depth recommended for planting, i.e. with the crown about on a level with the surface of the ground. The second lot of one-third, which we will call *deep planting,* were set in with the crown about $\frac{1}{2}$ inch below the surface of the ground. In the other one-third, which we will call *shallow planting,* they were set in with the crowns about $\frac{1}{2}$ inch above ground level.

In preparation for planting, the ground was made as level as possible so that the planting could be done at a uniform depth for each series. This was accomplished by first working the ground up well with the harrows and then running over it with a hand lawn roller to break down all lumps. The holes were dug with a garden trowel, water was placed in each hole and before this soaked away the plants were set in. Each plant was held at the desired level with the one hand and the soil was carefully packed around with the other hand. Alternate rows were set out leaving room for similar rows to be set in between. However, this second lot could not be procured.

These plants all received the same treatment subsequent to planting. They were watered occasionally during the first week after setting, and they were scuffled and hoed occasionally.

The general vigour of these plants was estimated on July 27 after runner production had become quite general. This was done by counting the number of plants which had produced runners four inches long or more. This length was arbitrarily chosen in order to avoid the unnecessary work involved in searching among the leaf petioles for very young runners. In addition to determining the number of plants producing runners, the total number of runners produced by all the plants was also counted, and the average calculated.

The results were as follows:—

TABLE 53—DEPTH OF PLANTING IN RELATION TO GENERAL VIGOUR

—	Number healthy	Number sending runners	Total number of runners	Number sending runners per 100 healthy plants
				%
Normal planting	103	59	105	57·3
Deep planting	111	54	101	48·6
Shallow planting	109	49	97	45·0

The table of results shows that normal planting produced the most vigorous plants judged by runner production and the shallow planting the least vigorous. These results agree very favourably with those obtained from general observation with one exception, i.e. for a few weeks after the plants were set out the deep planted ones looked about the same as the normal. Both of these groups looked much healthier than the shallow planted ones.

These rows will be watched next season to see if any variation occurs in their susceptibility to root rot.

SURVEY OF STRAWBERRY PATCHES, COLLECTING DATA ON CULTURAL PRACTICES, AND HEALTH OF PLANTATION

A measure of success had marked the attempts of the previous season to associate an organism with the root trouble. However, the results were not altogether convincing, so it was decided to make a survey of a good many patches in the district in an attempt to trace all or a part of the trouble to some other source.

This work was undertaken some time after the crop had been harvested. This time was chosen so that a better estimate on the crop could be obtained by getting figures from the grower and, at the same time, a better idea could be obtained of the ability of a patch to withstand the strain of a crop. In this connection it may be recalled that last year's work showed that the patches suffered heaviest at cropping time.

The principal points investigated were: variety of strawberry plants used, age of patch, source of stock, type of soil, fertilizers used, crop rotation, mulching practices, yield per acre, and the amount of root rot present. The observations made indicate that there is a strong probability that several factors other than parasitic organisms enter into the problem which, therefore, becomes more complex. The most important of these factors suggested by the survey are:

1. SOURCE OF STOCK USED FOR PLANTING.—Plants which did not have good healthy roots when planted usually showed heavy casualties by the time the first crop was harvested. In several instances it was noted that weak patches had been obtained from a common source, while other patches, obtained from a common good patch, produced healthy plantations in spite of adverse conditions.

2. MULCHING.—Many of the growers do not produce sufficient straw for mulching and have to buy. They complain that the last few years it has been difficult to obtain suitable mulching manure in any quantity without incurring a great risk of filling their soil with noxious weed seeds. The result has been that many growers do not mulch as regularly as formerly, and when they do mulch they use an insufficient quantity. In some cases where the plants had a particularly heavy foliage the previous autumn, the patches without mulch came through

the winter almost as well as mulched patches. However, the mulched patches, if well mulched, usually showed a marked superiority over the unmulched patches.

3. Crop Rotation.—Other factors being equal a long period between strawberry plantings gave better results than a short one. It was found that a wide variation existed in this respect. Some growers plant a plot of strawberries with only one intervening crop. Some practise a three- or four-year rotation, others a five- or six-year rotation. Several patches observed had not had strawberries planted thereon for many years, while a few represented a first crop on virgin soil. Many of the growers on smaller farms, or on farms largely given over to tree fruits, find it difficult to secure a long rotation. However, a five- or six-year rotation was found to be about the shortest period compatible with healthy root development.

RELATION OF SOIL TO SPREAD OF DISEASE

Runners were set in flower pots containing soil from various sources. The three main groups of soil were (*a*) sterilized garden soil, (*b*) soil taken from around the roots of plants which showed root rot, (*c*) soil taken from around the roots of plants which appeared to be sound.

The pots were placed in the soil to the collar beside rows of healthy plants of last spring's setting. The young runners were placed over the pots, and held there by means of small stakes in such a way that a young runner was immediately over the pot. These potted plants were left in position in the field to enter the resting period under conditions as nearly normal as possible. They are to be under observation up to the end of the next cropping season.

INFLUENCE OF MULCHING ON THE GENERAL VIGOUR AND SUSCEPTIBILITY TO ROOT ROT

One half of each row of the experimental plot has been heavily mulched with straw while the other half of each row is left unmulched. Some of these rows were planted normal depth, some deep and some shallow. Hence, the mulching experiment will take in plants of each type of planting.

The results of the mulching experiment will be followed up until the end of the next crop in order to determine if the winter protection increases the vigour of the plants sufficiently to render them more resistant to root rot.

SUMMARY OF RESULTS OF THE PAST TWO YEARS' WORK WITH RECOMMENDATIONS FOR PREVENTION

The work of the past two summers indicates that the cause of the strawberry root rot as it occurs in the Niagara District is a composite one. Several factors are perhaps involved, the exact importance of which have not yet been demonstrated. Three possibilities seem to exist. (1) The trouble is the result of several factors acting jointly. (2) Each of several factors is capable, under certain conditions, of causing the trouble. (3) One factor is primarily the cause while the others are only secondary.

The indications are that while soil organisms, especially *Ramularia* and *Fusarium* may be responsible for the actual disease, the general vigour of the plant is important as a predisposing factor.

Pending further research in this field, the following recommendations are given for the control measures:—

1. In setting out a new patch use only plants which have good healthy roots. If possible select these from a field which showed no indication of the trouble last season.
2. Avoid, if possible, strawberries on a field which has not had a 5- to 6-year rotation.
3. Protect the plants during the winter with a 2- to 3-inch mulch.

Studies on *Verticillium*

During the past summer the work with different strains of *Verticillium* was continued. Slow progress was made, however, due to the resignation of Mr. A. B. Jackson, who had been working on this problem for the last two years. Some inoculation experiments were carried out on raspberry, snapdragon, chrysanthemum, peach, barberry, potato, tomato, and cucumber, with the various strains of *Verticillium* under study.

It is hoped that the work planned for the completion of the study of Verticillial strains can be completed in the near future. This problem has been under way for the last five years and is now nearing completion.

Tomato Streak

(C. Perrault)

The work with tomato streak has been continued with three main questions in mind, namely: (1) Is streak carried in the seed or soil? (2) Can streak be produced from the juice of healthy potato alone, or is either, or both tomato mosaic and potato mosaic necessary? (3) Can streak be produced from certain environmental conditions, such as soil and greenhouse management? These questions have, of course, been suggested by the different theories now put forward as to the cause of streak of tomatoes.

As to streak being carried in the seed, our experiments so far give negative results. Over 500 plants from streak seed were set out and grown to maturity. Of these 500 plants, two hundred were grown in the greenhouse. Out of the 500 plants only four showed streak symptoms. As these plants were not protected in any way this small number of streak plants can be easily accounted for.

Healthy tomato plants have been inoculated with various juices such as (1) healthy potato juice of different varieties, (2) healthy tomato juices of different varieties, (3) the juice from solanaceous weeds such as *Physalis peruviania, Saracha edulis, Datura Stramonium, Nicandra physaloides,* and *Solanum nigrum.* The results so far indicate that streak is produced in tomato when apparently healthy tomato plants of Bonny Best or Grand Rapid varieties are inoculated with juice from either healthy Green Mountain or Irish Cobbler potatoes. Streak was not produced, however, when tomato plants of Chalk's Jewel or Sunrise varieties were inoculated. Similar results were obtained last year. These experiments have been repeated several times during the present year with the same results. Streak was not produced when the above solanaceous weeds were used as a source of inoculum. The same is true for juice from healthy tomato plants of other varieties.

Is streak carried in the soil? A preliminary experiment to ascertain this fact indicates positive results. Tomato plants 3 inches to 6 inches high were placed in four types of soil as follows:

(1) Soil in which streak plants had grown.
(2) Soil in which streak plants had grown and to which macerated streak pulp was added.
(3) Soil in which healthy tomato plants from streak seed had grown.
(4) Fresh compost.

The results tabulated below indicate that streak is carried in the soil.

TABLE 54—DATA ON STREAK INFECTION AS CARRIED IN THE SOIL

Soil No.	Number of plants used	Number of streak plants	Number of healthy plants
1	18	5	13
2	18	17	1
3	18	2	16
4	20	0	20

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

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

APPLE SCAB (*Venturia inaequalis*) (CKE.) WINT.)

Observations on the seasonal development of this fungus have been continued during the past year under the same general methods as described in the reports of the Dominion Botanist for the years 1925, 1926, and 1927. The number of observation points has been increased to obtain as complete records as possible in each district where orchard spraying and dusting experiments have been conducted. During 1928 spore traps were located at eight centres in the province. At six of these centres meteorological records on temperature and rainfall were taken. The two remaining centres were used chiefly as observation points for the use of extension services working in those localities.

Generally speaking, ascospore inoculum was scarcer during 1928 than in any of the three previous years. There was sufficient to cause severe injury in many sections, but in some experimental orchards the scabby fruit on unsprayed trees did not exceed 30 per cent, in comparison with the previous three seasons when unsprayed trees yielded from 90 to 100 per cent scabby fruit, much of which was cracked and worthless.

At Kentville, perithecia began enlarging towards the end of March. A few days of very mild weather were experienced at this time, and asci developed in some of the favourably located leaves. On March 27 the air temperature in the orchard reached 63° F. On the surface of leaves lying exposed on the ground the temperature averaged 61° F., whereas that of the surface soil, immediately below the mat of leaves, averaged 46° F. These temperatures all fall within the range of temperatures for the development of the fungus, and the higher ones approach the optimum. The leaves were damp and conditions favourable for perithecial growth.

Ten days later it was found that asci had increased in length considerably, and were approximately one-half normal size. By the middle of April several days with temperatures above 50° F. had been recorded and considerable rainfall. These conditions encouraged development of the fungus to such an extent that a few leaves in favourable environments were collected exhibiting a few well differentiated spores. The general development of asci seemed to be retarded. Perithecia were abundant, but conditions did not appear to favour general growth of the fungus to its perfect stage. Several days with mean temperatures above 43° F., but with rainfalls not exceeding 0·28 inches on any day, were experienced from the time that mature spores were first found until the first light spore discharge was recorded on May 3. The first general discharge of ascospores was recorded on May 12 and 13, and a very heavy and general ejection took place from May 23 to 26. At this latter date the trees were in the late pink stage of development, and some of the early varieties opening into bloom.

In making a summary of the total number of days on which ascospore ejections were recorded at the eight observational stations in the apple growing sections of the province this past season, it was found that there were thirty-nine days on which discharges took place.

TABLE 55.—SUMMARY OF ASCOSPORE DISCHARGES, 1928

Location	Total number of days	Number between green tip and pink	Number between pink and petal fall	Number after petal fall
Middleton	21	4	13	4
Berwick	11	2	9	0
Kentville	21	9	8	4
Starr's Point	16	5	10	1
Wolfville (2)	25	4	21	0
Gaspereaux	27	5	21	1
*Falmouth	7	1	5	1
Summary for district	39	10	23	6

*Records taken only after moderate rains

The records in table 55 indicate that there were approximately six spore ejections before petal fall for every one after. This emphasizes the relative importance of the pre-blossom and calyx sprays. The same general condition prevails annually, although in some seasons the proportion may be slightly greater or less than six to one. However, it is now well established that three pre-blossom sprays are necessary in the average season and two or three advisable after petal fall to give adequate protection. The average period from the time the fruit buds commence to show green tips to full bloom is between five and six weeks and it is necessary to have adequate fungicidal protection on the trees throughout this period. There are doubtless seasons when two sprays will give sufficient protection for this period, but the local orchardist must expect from 10 to 15 days on which rain will fall and cause liberations of ascospores. In seasons when rainfall exceeds normal during this period and temperatures are favourable very heavy spore discharges are experienced. The past four years have given ample evidence of this, as the rainfall has been from one-half to one and three-quarters inches above the 12-year average each year at this critical time, and spore ejections have been frequent and heavy.

The first infections bearing conidia were found in the open on May 28, twenty-five days after the first recorded discharge and fifteen days after the first general discharge of ascospores. A month later, unsprayed trees showed up to 85 per cent spotted foliage in many of the orchards.

The after blossom ejections of ascospores were of comparatively minor importance in 1928. The last severe discharge was recorded at the time of petal fall, and for the ten days following no discharges were recorded. Those which were subsequently determined were very small, and the last discharge occurred on July 3, when a few spores were located on the traps. Examination of many perithecia at this time failed to reveal any viable ascospores. A few desiccated spores were found but none capable of germinating.

OBSERVATIONS ON APPLE SCAB IN EXPERIMENTAL ORCHARDS AT MIDDLETON AND BERWICK

The two experimental orchards at Middleton and Berwick are used cooperatively with the Entomological Laboratory, Annapolis Royal. Observations in the Middleton orchard have been carried on for two years. Each year a record of the seasonal development of the scab fungus has been obtained by means of perithecial examination, spore traps, and observations on foliage and fruit infection under natural conditions. Approximately one hundred plots have been used in each of the two years, for applications of different spray mixtures and solutions. A variety of toxic substances has been employed to determine their effect under field conditions compared with their toxicity under laboratory conditions to the spores of the fungus. The experimental data on control will not be reported in detail at this time.

Ascospore ejections started at Middleton in 1928 when the trees were in the green tip stage, i.e., before the leaves had expanded appreciably. The first discharge was recorded following two days of wet, dull weather, on May 3. Ten days later a general discharge was observed. The trees were in the late mouse-ear stage with leaves approximately one-half inch in diameter. No further discharges were recorded for another ten days until the trees were in the pink stage, and early varieties coming into bloom. On May 25 the heaviest ascospore ejection of the season was experienced. More ascospores were ejected on May 25 and 26 this year at Middleton than on all the other days on which ejections took place. Intermittent spore discharges of decreasing intensity took place until June 29, when the last spores were observed. Following another week's exposure the leaves were gathered and examined for mature ascospores. All perithecia examined revealed either no formation of asci or complete discharge. No mature viable spores were found.

The first primary infection was found May 28 on unsprayed trees in this orchard. Three weeks later foliage infection counts were taken on the plots to ascertain the degree of control of foliage spotting obtained by the various spray materials. In making these observations, individual leaf counts were made on 100 leaves in each of 10 different parts of each plot on terminal and lateral foliage. This gave a total of 2,000 leaves per plot, a number calculated to give a fair indication of the amount of scab present. The relative amounts of spot on lateral and terminal foliage are of interest in these observations. Similar counts on foliage infection on lateral and terminal shoots were made in three other orchards in the province.

At Middleton, foliage counts were made on 100 plots, composed of 90 treated plots and 10 scattered check plots. The mean of the average infections on treated plots showed that foliage on laterals had 2·34 per cent scabby leaves and terminal foliage had 3·14 per cent scabby leaves. Seventy-one per cent of all treated plots contained more scab on terminal foliage than on lateral. The check plots did not reveal a consistent difference. The number of unsprayed plots having more scab on lateral foliage was slightly greater than corresponding plots with scab predominating on terminal foliage. The average for all untreated plots would not exceed the experimental error. Hence it is concluded that the predominance of scab on the terminal foliage of the treated plots is the result of more fungicidal protection at the time the lateral foliage was at its period of greatest susceptibility. The terminal foliage, being later in development, was proportionately protected to a lesser extent when most susceptible. From a study of the spraying dates, ascospore discharges, and stage of development of the host, this seems the logical conclusion.

The seasonal development of the scab fungus was studied in the experimental orchard at Berwick as at Middleton. The first ejection of ascospores occurred on May 3, followed seven days later by a discharge of slightly greater consequence. The first heavy liberations of ascospore inoculum occurred immediately before bloom and during the early blooming period, May 25 to 26 and May 28 to 31. Another fairly heavy liberation of spores took place on June 10 and 11. The other recorded ejections were light and of minor importance.

Considering the stage of development of the trees, we find that, immediately before bloom and during the early part of the blooming period, inoculum was greatest and the chances of infection higher than at any other time in the season. At this time the lateral leaf clusters are normally becoming resistant and the quickly growing terminal leaves very susceptible. This is best demonstrated by the leaf counts taken between June 15 and 20 on twenty-two dusted plots and one untreated. The average number of scabby leaves on the lateral foliage of the twenty-two plots was 4·72 per cent compared with 8·36 per cent as the average number of scabby leaves on the terminal foliage in a total count of over 43,500 leaves. The untreated plot had 9·92 per cent scab on lateral leaves and 28·01 per cent scab on terminal leaves on a total count of over 1,800 leaves. From these data it is quite evident that the foliage on terminal growth was either the least protected or at a period of great susceptibility during the season when infection was most probable. The treatments were applied to the entire tree with as uniform distribution of materials as possible, with not more than ten days between applications at this critical time. It must be concluded that the rapid growth and extreme susceptibility of the younger terminal leaves, coupled with the presence of heavy inoculum, were the factors causing a greater amount of scab on these than on the older and slower growing lateral foliage in this experimental orchard.

OBSERVATIONS ON SCAB CONTROL IN DEMONSTRATION ORCHARDS

The two orchards under consideration were treated, with slight modifications, according to the recommendations of the Nova Scotia Spray Calendar, and under the direction of Dr. W. H. Brittain, Provincial Entomologist. Data on apple scab were collected by members of the laboratory staff, who also assisted in collecting data for the department operating the experiments.

Records of ascospore discharges were taken in these orchards, and some of those data used in an earlier part of this report. Foliage infection counts were made after bloom to determine the amount of scab present on the foliage and also to observe what difference there might be between the amount of scab present on the two sides of the tree rows. The same information was gathered from some of the plots at harvest to see if there were correlations between the amount of foliage scab and fruit scab under the different treatments.

SPRAY APPLICATIONS AND ASCOSPORE EJECTION

The following data (table 56) show which were the most important sprays in 1928, in the two orchards under observation:—

TABLE 56.—SPRAYS IN RELATION TO SPORE DISCHARGES

——	Orchard A	Orchard B
Delayed dormant spray	May 3	May 4–5
Recorded spore discharges	May 13	None
	May 14	
	May 15	
Pre-pink spray	May 16	May 16
Recorded spore discharges	May 16	May 17
	May 17	May 29
Pink spray	May 26	May 30
Recorded spore discharges	May 28	June 4
	May 30	June 8
	May 31	June 9
	June 1	June 11
	June 2	
	June 3	
	June 6, 7, 8, 9	
Calyx spray	June 10	June 13
Recorded spore discharges	June 14	June 16
Ten-day spray	June 26	June 26, 27
Recorded spore discharges	None	None

From the above it can be seen that in Orchard A of a total of sixteen days when ascospores were ejected, twelve days were following the pre-pink and pink sprays. The heaviest ejections of the season took place the last few days of

May while the trees were coming into bloom. In Orchard B, where the spore traps were examined only after moderate rainfalls, seven ejections were recorded, six of which occurred following the pre-pink and pink sprays. From these observations it can be seen that the sprays immediately before bloom were of primary importance for protection during the past season in the districts of which these orchards were representative.

Records of foliage infections were taken immediately before the final applications of spray. The observations included leaf counts on the north and south sides of trees and were confined to typically lateral and terminal growth of foliage. The objects of these counts were to determine which side of the tree had the greatest amount of scab, and whether the terminal or vegetative growth, or the lateral or fruiting growth carried the most summer inoculum. Approximately two hundred thousand leaves were examined in taking these records.

Eighty-seven and one-half per cent of the observations indicated that there was more scab on the foliage on the north sides of the trees, and eighty per cent of the observations indicated a greater leaf infection on lateral growth foliage than on foliage on terminals. These are contrary to the observations at Middleton and Berwick, where similar data were collected. The same variety was used in two of the three orchards and in both the observations were different. It would seem, therefore, that the amount of scab on lateral and terminal foliage is dependent on the stage of development, or in other words, stage of susceptibility at the times of spraying and of spore discharges.

The foliage on lateral growth is the first to develop in the spring and therefore the first exposed to infection. Protection to this foliage is of extreme importance because of its immediate proximity to the developing fruit. It is also apparent that the sheltered side of the tree requires more fungicide or greater thoroughness in application to supply protection equal to that afforded on the exposed side.

In taking the records of fruit blemishes at harvest, the north and south sides, approximately, of the tree rows from some plots were picked and examined separately, to note what difference existed in the amount of scab that had developed on the two sides of the trees. In these counts sixty per cent showed more spot on the north sides, exceeding the amount of spot on the south sides by an average of **104** per cent, whereas in the remaining forty per cent the excess of scabby fruit on the south sides of the plots averaged only **20·1** per cent.

These observations support the conclusions arrived at above in the discussion of scab on the foliage. Further observations of more detailed nature will be necessary to find an explanation for these conditions.

Having obtained records of the amount of scab on the foliage of the spray plots soon after set and after the last recorded ascospore discharge, a comparison of these data with the data at harvest should give an indication of the protective value of the fungicides used. The following brief summary presents a comparison of this for scab control. The control of all pests is indicated by the mean percentages of clean fruit. These latter data are possibly a truer indication of the commercial value of the respective treatments for the season under the conditions prevailing.

TABLE 57.—PROTECTIVE VALUE OF FUNGICIDES

Averages of four varieties	Bordeaux	Lime sulphur	L. sulphur Al. sulphate	Check
Foliage scab	2·24%	2·20%	2·40%	17·72%
Fruit scab	7·59%	10·28%	11·82%	44·61%
Mean ratio of foliage- fruit scab	1:3·39	1:4·67	1:4·92	1:2·53
Average percentage of clean fruit	56·69%	63·10%	61·68%	25·89%

Considering these data purely from the scab control point of view, the Bordeaux mixture plots permitted the smallest increase in the disease. The ratio of increase in the check plot is obviously smaller than that of the controlled plots, on account of the greater foliage infection in the early season, and the drop of young fruit on account of severe scab, which is not indicated by these data. In taking harvest records it was noted that the majority of spotted apples in sprayed plots were affected with comparatively late infections of scab, whereas those from check trees had both early and late lesions on the affected fruit. The plots received only one spray after the calyx application. No actual comparison of the relative values of the three spray calendars will be made at this time, as the data obtained will be considered by another department in full reference to orchard spraying.

STUDIES ON APPLE SCAB CONTROL

The most economical control of apple scab is the object of continuous experimental work with fungicides of various types. Scores of experimental plots are devoted to spraying or dusting annually in Nova Scotia, and each has as one of its objectives the better control of apple scab. In 1928 the growers were given a new spray schedule using lime-sulphur as the basic fungicide but with the addition of aluminium sulphate. This spray is the result of work done largely under the direction of A. Kelsall, Dominion Entomological Laboratory, Annapolis Royal, N.S.

Kelsall* found that aluminium sulphate had some fungicidal properties. These were not sufficiently strong to warrant its use along as a fungicide so lime-sulphur in varying concentrations was added to obtain a precipitated sulphur spray. Laboratory studies were made on various dilutions of lime-sulphur, both alone and in combination with aluminium sulphate and hydrated lime, on the toxicity of these materials to conidia of *Venturia inaequalis*.

The lime-sulphur concentrate used tested approximately 1·24 specific gravity. Finely ground crystalline aluminium sulphate was employed with the hydrated lime, and the calcium arsenate had a very low percentage of water soluble arsenic.

The following table, No. 58, gives the materials used and their concentration. Each percentage represents counts on over 500 spores. The materials were sprayed on microscope glass slides and drops of a spore suspension placed on the slides. The slides were kept in a moist chamber at room temperature. The 36-hour count included only spores with germ tubes above 30μ in length.

TABLE 58.—TOXICITY OF LIME-SULPHUR DILUTIONS

No.	Materials and Concentration	Germination: 12 hours		Germination: 36 hours
1	Lime-sulphur 16:480 (1·008 sp. gr.)	0·49		0·00
2	Lime-sulphur 4:480 (1·002 sp. gr.)	1·29		0·45
3	Lime-sulphur 2:480 (1·001 sp. gr.)	3·03		1·18
3A	Lime-sulphur 1·500 (1:00048 sp. gr.)	5·32		1·47
4	Al. sulph. 4: hyd. lime 8: water 400	2·29		0·40
5	Al. sulph. 4: hyd. lime 8: water 400: Ca. ars. 1	0·33		0·93
6	Al. sulph. 4: hyd. lime 8: water 400: L. s. 15	1·95		0·00
7	Al. sulph. 4: hyd. lime 8: water 400: L. s. 15, Ca. ars. 1	1·63		0·00
8	Al. sulph. 4: hyd. lime 8: water 400: L. s. 3·75	2·66		0·45
9	Al. sulph. 4: hyd. lime 8: water 400: L. s. 3·75 Ca. ars. 1	1·91		0·64
10	Al. sulph. 4: hyd. lime 8: water 400: L. s. 1·87	1·47	partially dry	0·00
11	Al. sulph. 4: hyd. lime 8: water 400: L. s. 1·87 Ca. ars. 1	1·11	partially dry	0·00
12	Check	20·98		19·77

* Kelsall, A. The use of aluminium sulphate in place of copper sulphate in insecticide-fungicide combinations. Proc. Acad. Entom. Soc. for 1922:8-17, 1923.

The 36-hour count must be taken as the final result for summary purposes, as the spore suspension was between two and three hours old when used, and slight germination may have taken place. The full inhibiting effect of the materials is best determined after 36 hours. Germ tubes in the check drops for this period were very long. From the above table it will be seen that all materials had some toxic effect on the spores. The three tests, Nos. 1, 6, and 7, in which lime-sulphur at a concentration of 1·008 specific gravity was used, inhibited all spore germination in 36 hours. Lime-sulphur at decreased concentrations became less effective, but the fungicidal effect was still very pronounced at concentrations in which the specific gravity was 1·001 or greater.

Corresponding field plots in the experimental orchard at Middleton, N.S., were treated with a series of sprays identical with those used in laboratory studies, with the exception that 3A above was omitted. Three pre-blossom and two post-blossom applications were made. Plots 6 and 7 had the lowest percentages of scabby fruit at harvest, averaging 6·0 per cent and 8·5 per cent respectively. Plot 1 had no apples but an adjacent series of plots sprayed similarly and at approximately the same dates gave 14·0 per cent scabby fruit at harvest. The three plots 2, 8, and 9, in which lime-sulphur at the rate of 1 quart of commercial concentrate to 40 gallons of water was used, averaged 18·67 per cent scabby fruit. The three plots, 3, 10, and 11, containing lime-sulphur at the rate of 1 pint of commercial concentrate to 40 gallons of water, averaged 29·06 per cent scab at harvest. The untreated trees yielded 69·4 per cent scabby fruit.

In the table on germination studies above, it will be seen that plots 1, 6, and 7 had no germinations at 36 hours and that, as the concentrations of lime-sulphur decreased, the percentage germination of conidia increased. The same relative condition existed at harvest in the control of fruit spotting. It, therefore, appears that, while concentrations of lime-sulphur weaker than 1 to 40 (sp. gr. 1·008) can be used with fair success, either alone or with aluminium sulphate and hydrated lime, the standard recommendation of a 1-40 spray gives the most efficient control of scab.

APPLE SCAB RESISTANCE

Four varieties of apples were used in making reciprocal crosses during 1928—Belle de Boskoop, Gravenstein, McIntosh, and Wagener. Two and sometimes three blossoms per cluster were emasculated. Pollen was applied by means of a camel's hair brush and the viability tested before use. That from Boskoop and Gravenstein was weak compared to Wagener and McIntosh, which invariably gave a high percentage germination. All crosses in which pollen from Boskoop or Gravenstein was used in 1928 failed to make a satisfactory set of fruit.

Boskoop was used as the female parent with the other three varieties, and a few blooms were selfed. Reciprocal crosses using Boskoop on the three varieties were also made. Table 59 shows the crosses made and the results obtained. The fruit was harvested and placed in storage until spring. The seed will be removed and planted in the spring for subsequent use in scab resistance studies. Boskoop is moderately resistant to apple scab. It is slightly susceptible in the very early stages of growth but, from July to harvest, is quite resistant under local conditions. No secondary infection or late spot has been observed on this variety here. Open pollinated seed of other resistant varieties is also being used in these studies.

TABLE 59.—APPLE CROSSES, 1928

Varieties	Number of blooms used, May 29 to June 1, 1928	Set June 16, 1928	Fruit harvested
Boskoop selfed	188	131	0
Boskoop x Gravenstein	677	15	0
Boskoop x Wagener	567	548	181
Boskoop x McIntosh	679	600	97
McIntosh x Boskoop	238	3	0
Wagener x Boskoop	38	3	0
Gravenstein x Boskoop	718	17	0

SPY INJURY

A peculiar injury on Northern Spy apples in storage was brought to the attention of this laboratory by Mr. G. E. Hutchinson, Berwick, N.S. The injury was first observed in the warehouse. The fruit had been picked and left in the orchard in new barrels for some days before being placed under cover. Only a small percentage of affected fruits was found.

The injury was in the form of light, brownish-green, depressed areas with wavy margins, as illustrated in fig. 17. In cross section the injury extends less than one-eighth inch below the epidermis. There were no indications of cells ruptured by insect attacks or invaded by fungi. The trouble appeared to be the result of some chemical injury.

FIG. 17.—Injury on Northern Spy apple.

Two sources of injury were possible, namely, the sulphur fungicides and pitch or exudations from new barrels. The latter condition is occasionally found, but heretofore no injury to apple fruit has been associated with secretions from barrel wood. It was therefore decided to try to duplicate the injury by using some of the spray solution constituents or products. It was not possible to duplicate the injury, but the effects of some chemicals are worthy of record in view of the typical injuries they produced.

With all liquid treatments the solutions were applied with an atomizer, and the specimens of fruit placed in a moist chamber in the light at room temperature. The dusts were applied to both wet and dry specimens, which were placed in moist chambers as above. The treatments included the following materials:—

Lime-sulphur at different concentrations.
Sulphur dust.
Hydrated lime.
SO_2 and H_2S fumes.
Sulphurous acid.
Sodium thiosulphate (hypo).
Pentathionic acid.

Lime-sulphur caused no injury except where the fruit was exposed to the sun's rays in a moist chamber. In such cases a soft breakdown developed. Hydrated lime was harmless. The fruit subject to fumes of sulphur dioxide or hydrogen sulphide for varying intervals developed sunken, bleached lesions one-eighth inch or more in diameter. This spotting eventually coalesced. Hypo gave similar lesions of less intensity. Sulphurous acid caused small, sunken, bleached spots which did not enlarge as did those caused by sulphur dioxide. Figure 18 shows this injury.

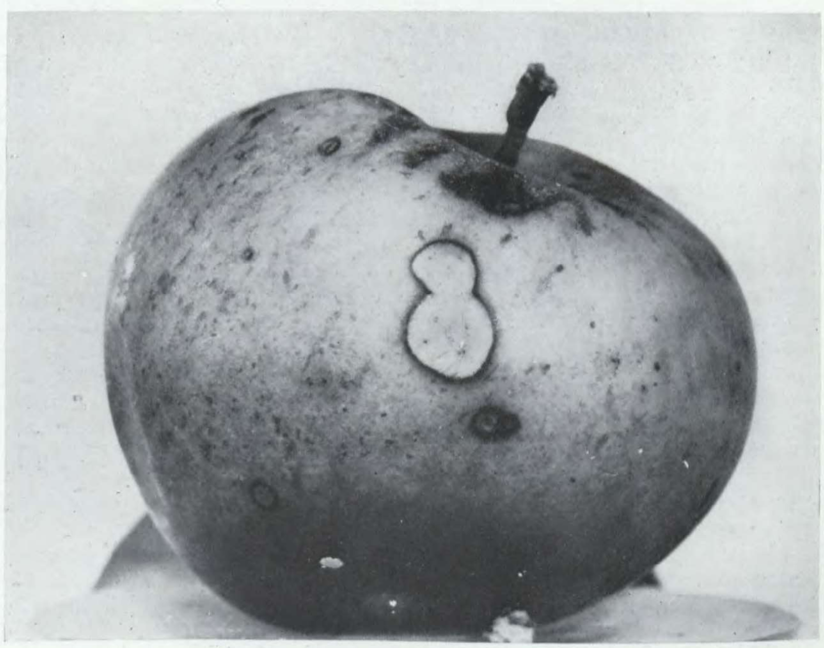


FIG. 18.—Injury to fruit caused by spraying with sulphurous acid or being in an atmosphere of sulphur dioxide.

Pentathionic acid was made by bubbling hydrogen sulphide into a solution of sulphurous acid at 0° C. This resultant solution contained free sulphur and part of it was filtered until clear. A portion of this filtrate was aerated for 2 hours to eliminate free SO_2 or H_2S by bubbling air through the solution. The aerated solution and unaerated but filtered solution were both sprayed on fruit, but neither produced injuries. The original solution, previous to filtering, caused the formation of bleached spots resembling those produced by sulphur dioxide.

From these observations it was concluded that the injuries produced by probable constituents of the fungicides used in the orchard were not comparable to the observed injury. No further work has been done to establish a possible connection between this injury and wood saps or secretions.

REMOVAL OF SOOTY BLOTCH FROM FRUIT

A brief laboratory experiment was conducted to determine if the lesions of sooty blotch caused by the fungus *Gloeodes pomigena* (Schw.) Colby could be readily removed by dipping the apples in various solutions for varying lengths of time. A limited amount of material was available for this work. The variety used was Northern Spy, and other than sooty blotch there were very few blemishes present on the specimens.

Apples were dipped in solutions of known concentrations at room temperatures. Commencing at the end of five minutes and at subsequent intervals up to four hours, a few specimens were removed and wiped. Notes were taken on the ease of removal of the blotched areas and the various lots put in storage for later observations.

The chemicals used included 10 per cent ammonia water, 2 per cent sulphuric acid, 2 per cent ethyl alcohol, 2 per cent boric acid, 1 per cent potassium permanganate, 2 per cent sodium hydroxide, and 2 per cent washing soda. Comparative lots were dipped in water, wiped, and stored as checks on the treatments.

Ammonia did not loosen the fungus and, after a few days' storage, much brown, lenticel-spotting and burning around scab spots were apparent.

Sulphuric acid did not affect the fungus until after three hours' dip, when the blotches were readily removed. However, after a few days' storage, pronounced sunken, bleached areas developed around scab spots and mechanical injuries. After another month's storage the injury became more pronounced. See fig. 19.

Treatments using alcohol, boric acid, and potassium permanganate were no better than dipping in water. The potassium permanganate caused severe discoloration of the tissue.

Sodium hydroxide gave good results in blotch removal, but caused severe injury to the fruit. Dipping in the hydroxide solution followed by an acid bath did not decrease the injury sufficiently. The hydroxide dips caused severe pittings which subsequently coalesced, as in fig. 20.

Washing soda gave the best results of all treatments. After a 30-minute dip the blotch was readily removed, and no subsequent injury developed after six weeks' storage.

It is believed that fruit severely affected with sooty blotch could be successfully treated so as to remove this superficial fungus, and permit the sale of the fruit on local markets. It was impossible to proceed further with these tests on account of lack of material and the lateness of the season. Little or no evidence of the disease was found on this season's crop, hence these observations are reported at this time in order that they may be available to anyone interested.

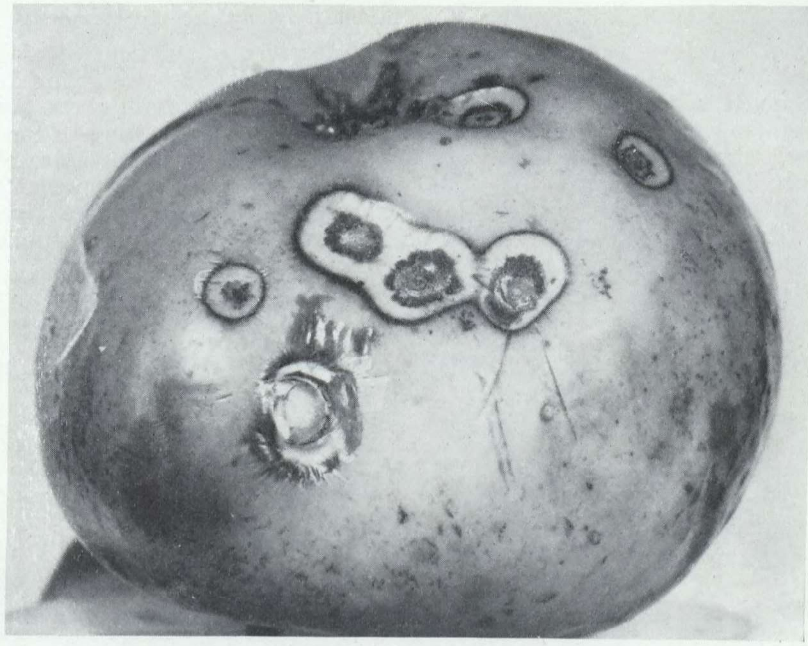


FIG. 19.—Injury produced by dipping fruit in 2 per cent sulphuric acid solution.

FIG. 20.—Injury produced by dipping fruit in sodium hydroxide.

CURRANT RUST

For the last three years field experiments have been conducted to determine a satisfactory control of white pine blister rust on currants. Defoliation of black currants has been prevented by four applications of sulphur dust at ten to fourteen day intervals, commencing when the leaves are about one-half inch in diameter. The first application has been timed according to the stage of development of aeciospores on nearby white pines. When these are mature and first breaking open, the dust is applied. Defoliation can be prevented by this method, but there is sufficient inoculum left to re-infect white pines. A more detailed account of these experiments has been prepared for publication in "Scientific Agriculture."

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

(H. R. McLarty, Plant Pathologist, Officer in Charge)

Report on Investigational Work

EFFICIENCY OF ZINC CHLORIDE IN THE CONTROL OF FIRE BLIGHT

Success in controlling or checking a severe fire blight epidemic in the summer by means of cutting out cankers is extremely difficult. Moreover, the procedure is an arduous one, and one for which the growers would gladly have a better substitute. A new method of control, appearing in a popular periodical, developed by Prof. L. H. Day of the University of California, in which cankers might be painted with zinc chloride, created, therefore, considerable interest among local growers and many requests were received at the laboratory for further information. Accordingly, the laboratory, in conjunction with the Provincial staff, carried out several tests on the efficiency of this means of control in this section. Results, however, were somewhat conflicting, and it is felt that no recommendation can at present be given.

IS FIRE BLIGHT SPREAD IN WINTER PRUNING? RESULTS OF SIXTH YEAR

Although the season of 1927 completed the five-year period during which it had been originally planned to carry on this experiment, further tests have been made during the past season. As in past years, the procedure followed was to cut with pruning shears or saw into living fire blight cankers, and then to use the tool immediately in pruning off a twig or branch of the pear tree being tested. On March 17 a total of 339 inoculations were thus made. Careful observations were made throughout the season, but no cases of resulting fire blight infection occurred.

THE RESISTANCE OF CERTAIN PEAR SPECIES AND VARIETIES TO FIRE BLIGHT

Inoculations were continued on the resistant pear stocks which have been collected together by this laboratory. In table 59 are presented the results of three years' tests. The stocks represented by letter and number, as S.P.I. 49489, are those developed by M. B. Waite of the United States Department of Agriculture. These have been distributed for testing purposes only. The "lih" pears are from scions imported direct from interior districts in China.

TABLE 59—RESISTANCE OF PEAR SPECIES AND VARIETIES TO FIRE BLIGHT ORGANISM

Species or variety	1924			1927			1928		
	Number of inoculations made	Number of inoculations taking	Remarks	Number of inoculations made	Number of inoculations taking	Remarks	Number of inoculations made	Number of inoculations taking	Remarks
Patten	16	15	13 took freely.	6	6	Took freely.	2	2	1 took moderately, 1 took freely, several free-running, natural infections.
Flemish Beauty	12	5	1 took very slightly. 4 too moderately.	28	28	1 took slightly. 27 took moderately.	6	6	Took freely.
Rimes Pineapple	25	21	Took slightly.	27	12	Took slightly.	8	4	Took slightly.
S.P.I. 49489	4	1	Took slightly.	19	4	Took slightly.	6	5	Took slightly.
S.P.I. 49490	...	...	...	4	0	No infections.	6	4	Took moderately, 2 cases of moderately running natural infections.
S.P.I. 49492	3	0	No infection.	39	25	Took moderately.	3	0	No infections.
S.P.I. 49494	4	4	Took freely.	6	6	Took moderately.	5	5	Took freely, several free-running natural infections.
S.P.I. 49495	2	0	No infection.	3	0	No infection.	6	6	Took freely. 5 cases of free-running natural infections.
S.P.I. 52461	...	...	...	14	1	Took slightly.	4	3	Took slightly.
S.P.I. 52462	...	...	...	4	2	Took slightly.	4	2	Took slightly.
S.P.I. 52464	...	...	...	15	2	Took slightly.	6	0	No infections.
Muh Kush Lih	...	...	...	3	3	Took fairly freely.	5	5	Took freely, 2 free-running natural infections.
Ruh Shiang Lih	...	...	...	4	3	Took slightly.	4	3	Took freely, several free-running natural infection.
Ta Huang Lih	...	...	...	3	0	No infections.	4	3	Took freely, there are several natural infections.
Siao Huang Lih	...	...	...	...	...	...	6	3	Took freely, 2 cases of natural infection.
Suan Lih	...	...	...	...	...	...	6	6	2 took slightly, 4 took freely, 3 cases of natural infection.
Pyrus ussuriensis	...	...	...	...	...	...	6	4	Took slightly.
Seedling pear from Sicamous	...	...	...	...	...	...	6	6	Took freely.

CONTROL OF ANTHRACNOSE IN SALMON ARM DISTRICT

During past years the recommendations, which are generally given growers in Salmon Arm, as to the kinds and times of sprays to be applied for anthracnose, have not given satisfactory control. Such control suggestions as have been given were based on a careful series of experiments carried out some years past in the coast sections of the province where a much more humid condition prevails. As a means of bettering this condition, and in an attempt to get at the root of the trouble, this laboratory has undertaken to keep a check on the dates of spore dissemination, and to work out a spray program suitable for this section.

Examinations made from time to time in different orchards in Salmon Arm disclosed the fact that spores of anthracnose were disseminated early in August, a date considerably in advance of that recorded in the fruit districts of the coast, where the control measures for this disease had been worked out.

Experiments with sprays were begun on the Norton orchard. The experimental plot was divided into four sections, each for different treatment. Check plots were provided for each section.

Plot No. 1.—This plot was sprayed with Burgundy mixture on August 15, which is a month earlier than the usual recommendations. This spraying was followed on October 10 by Bordeaux 4-4-40 after the apples were harvested.

Plot No. 2.—This plot was sprayed with Bordeaux oil emulsion on August 12. The formula used was a 3-5-40 Bordeaux, to every 40 gallons of which were added 2 quarts of a 77 per cent oil emulsion.

Plots Nos. 3 and 4.—These were dusted on August 14 with colloidal sulphur dusts from two different sources.

Results on the efficiency of each spray will not be available until the spring of 1929.

PERENNIAL CANKER

In our study of this problem we have obtained this year further information on the following points:—

A. Spore germination for the season 1928.

B. Value of wound dressings in keeping out woolly aphis.

C. Further proof for the belief that the disease is dependent for its spread on the presence of woolly aphis.
   1. By wrapping cankers with cloth.
   2. By marking on large cankers the position of woolly aphis colonies.

D. Rot in the fruit.

E. Cultural characteristics.

F. The occurrence of the disease in the southern Okanagan.

A. SPORE GERMINATION—SEASON 1928

A series of tests to determine percentage spore germination was made during the season. Spores were germinated in 2 per cent sugar solution. The results are presented in table 60. We have noticed that spores collected after November germinate much more slowly than those collected earlier in the season.

TABLE 60—SPORE GERMINATION TESTS, 1928

Place	Date material was collected	Date of test	Percentage germination
			%
Okanagan Centre	June 28, 1928	June 30, 1928	100
Winfield	July 10, 1928	July 12, 1928	75
Okanagan Centre	Aug. 30, 1928	Sept. 1, 1928	50
Winfield	Sept. 12, 1928	Sept. 20, 1928	100
Okanagan Centre	Oct. 11, 1928	Oct. 31, 1928	100
"	Oct. 23, 1928	Oct. 29, 1928	100
"	Nov. 9, 1928	Nov. 15, 1928	90
"	Dec. 10, 1028	Dec. 11, 1928	25
Penticton District	Dec. 28, 1928	Dec. 31, 1928	10
Okanagan Centre	Jan. 7, 1929	Jan. 9, 1929	10

B. VALUE OF WOUND DRESSINGS IN KEEPING OUT APHIS AND THUS PREVENTING SPREAD OF CANKER

Considerable attention has been given during the last three years to a study of such wound dressings as might prevent the spread of infection in cankers. Before the relationship of woolly aphis to the spread of the disease was understood, attempts were made to control the infection by use of fungicides. These proved futile. With our present information, gained from further study, as to the influence of the aphis, our efforts have been directed to finding a material that will effectively and lastingly exclude all aphids from wounds. Many materials have previously been tested, but only three were retained this year for further tests. These were rapeseed oil, castor oil, and pine tar. In making applications with these materials, an attempt was made to paint only cankers where woolly aphids were already present,—a number of check cankers being left on each tree. The materials were applied on the 8th and 22nd of July, 1927, and results were read on the 15th of May, 1928, the time at which any new spread was most easily discernible. In making the examination total reliance was not placed on the visible signs of spread, but the edge of each canker was carefully cut around with a knife so that even slight infection would be noticed.

In the table presenting the results, the cankers are classified into three groups—first, those with no spread of infection; second, those having slight spread; and, third, those having severe spread. By slight spread is meant the killing confined to a thin line in the area around the edge of the callus which had apparently been fed upon by the aphids before the time of applying the materials. This thin line was never more than one-eighth inch in depth. Severe spread is where the killing has penetrated beyond all limits of aphis attack and has run back into healthy tissue a distance usually of one-quarter to one-half inch in depth. In estimating the percentage of cankers free from aphis it was necessary to remove all old bark around the edge of the cankers. In doing this, considerable wounding of the callus was unavoidable. So much injury was done that it was considered inadvisable to use these same cankers for counts of spring infection. Accordingly, 50 cakes each, of those receiving different treatments, were examined, and the percentage of freedom from aphis determined. This practice, therefore, gave only the approximate efficiency in each case, and gives room for the apparent discrepancy in the table where rapeseed oil is shown as giving 100 per cent freedom from aphis in the fall with five severe infections in the spring.

Table 61—Efficiency of Wound Dressings in Preventing Spread from Aphis Infestation

Tree No.	Material	Date	Number of cankers treated	Cankers free from aphis	Spread			Check		
					Bad	Slight	No spread	Bad	Slight	No spread
		1927		%						
14	Pine tar..........	July 8	57	93·3	......	9	48	14	5	1
15	Rapeseed oil.....	July 22	68	100	5	10	53	17	9	5
16	Castor oil........	July 22	39	93·8	1	2	36	23	5	3
					6	21	137	54	19	9

C. FURTHER PROOF FOR THE BELIEF THAT THE DISEASE IS DEPENDENT FOR ITS SPREAD ON THE PRESENCE OF WOOLLY APHIS

1. *By Wrapping Cankers with Cloth.*—In continuance of our investigation further to prove or disprove our suspicion, previously reported,* that woolly aphids were associated with the spread of perennial canker, a number of live cankers were carefully wrapped with factory cotton early in the season before the woolly aphids were yet present in the trees (figure 21). Each live canker was tightly wrapped with the cotton, and tied above and below with a stout string, in the middle of which was inserted a small steel coil spring. This spring always insured a tight band in the cotton, and also provided for expansion in the limb during the growing season. In all, one hundred and thirty cankers were so wrapped, some on the 19th and some on the 27th of May. On the 9th of November, after all woolly aphis activity had ceased for the season, the cankers were unwrapped and examined for the presence of aphis, after which the coverings were again replaced, and marked with either one or two dots of red paint to record the presence or absence of the insect.

In the following spring the wrappings were removed, and examination made for the occurrence of new spread in the cankers. The results are presented in the following table. In each case where aphids were present there resulted spread of infection; in each case where no aphids were present there was no resulting spread (figs. 22, 23, and 24).

Table 62—Influence of Aphids on Spread of Perennial Canker. Effect of Wrapping with Cotton

Tree No.	Number of Cankers wrapped		Number of Cankers showing	
	With aphids present	With no aphids present	No infection	No new infection
1..	8	2	8	2
2..	10	0	10	0
3..	6	4	6	4
4..	6	4	6	4
5..	7	2	7	2
6..	10	0	10	0
7..	6	4	6	4
8..	5	6	5	6
9..	5	5	5	5
10..	6	4	6	4
11..	7	3	7	3
12..	4	6	4	6
13..	6	4	6	4
	86	44	86	44

*Report of the Dominion Botanist, H. T. Güssow, for the year 1926, page 138.

FIG. 21.—A close-up picture of a wrapped canker. This method was used during the 1928 season. In 1927 the cankers were tied top and bottom as described.

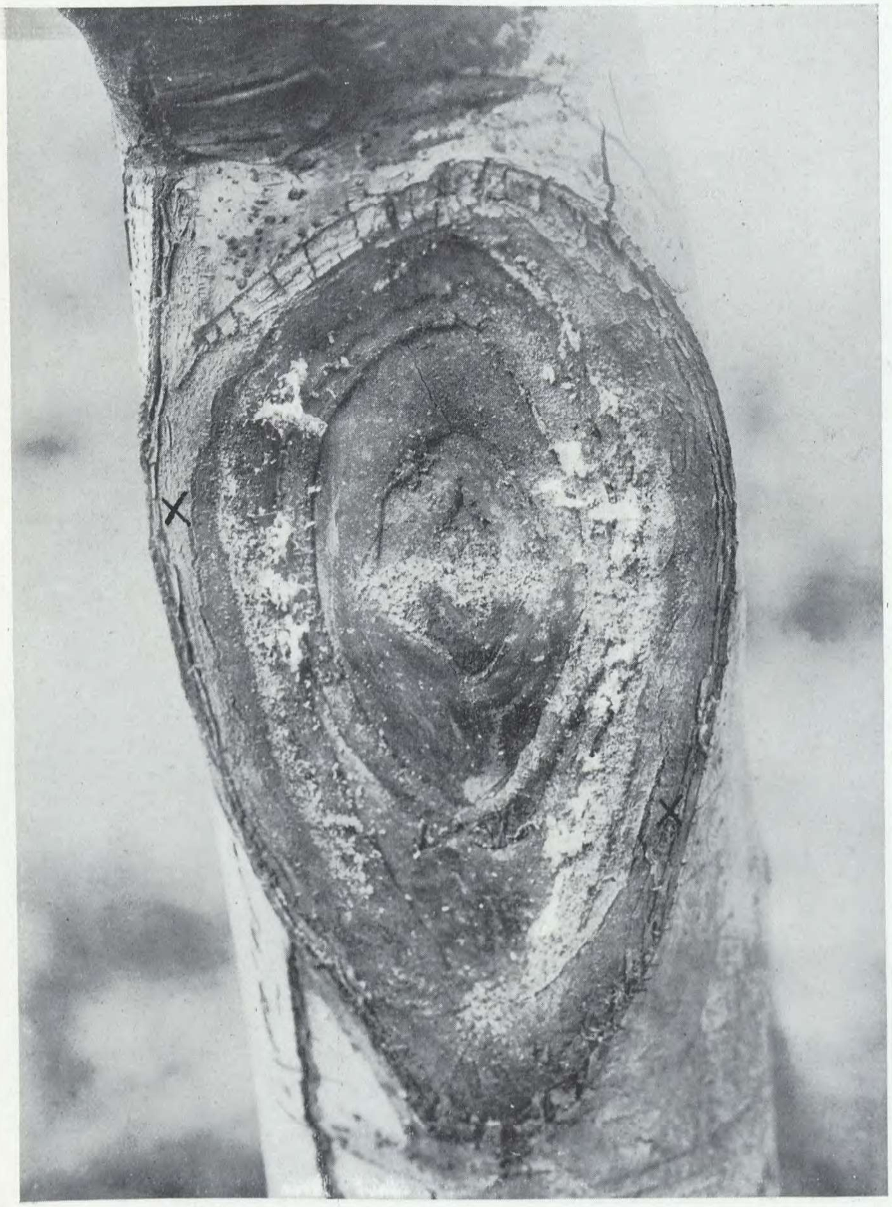


FIG. 22.—A wrapped canker in which aphids were present. Photographed in the spring of 1928. A crack marked x denotes the limits of this year's infection.

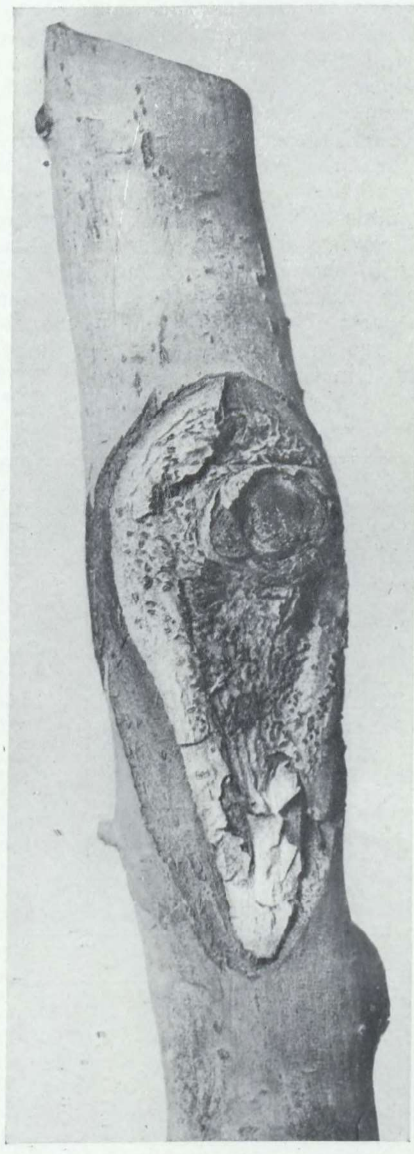


FIG. 23.—A wrapped canker in which no aphids were present in 1927. The dead bark in the centre was caused by the spread made in the spring of 1927. In this canker no new spread occurred in the spring of 1928. (See Fig. 24.)

FIG. 24.—Same canker as in Fig. 23, with dead bark removed showing no spread in this canker in the spring of 1928.

2. *By Marking Position of Woolly Aphis Colonies on Large Cankers.*—In a certain orchard, where, previously, a great deal of cutting out of cankers had been done, making them very large and open, we found excellent opportunity for the carrying out of this experiment. In these large cankers, a vigorous callus formation had taken place making a very suitable situation for aphis attack. On several such cankers we noticed in the fall distinct and separate colonies of the insect. In some of the cankers, especially the very large ones, we might find four or five of these colonies, while in the smaller ones there might be only one or two. The position of several of these colonies was marked with a daub of red paint on the heart wood just behind the aphis colony. In marking these colonies, reasonable care was taken to mark all that were visible in that canker. One could not be certain, however, that aphids had not fed on other portions of the canker at an earlier date, and had disappeared by the time the observations were made. Of 38 colonies so marked 37 showed spread of infection, and in only one case was there no spread where an aphis colony had been established. The spread which occurred in eleven other parts of cankers is quite reasonably explained by the fact that aphids might have been feeding there before the marking was done. The results are presented in the following table:

TABLE 63—APHID INFESTATION AND SPREAD OF PERENNIAL CANKER

Tree No.	Canker No.	Colonies marked 1927	M.C. showing spread, 1928	M.C. showing spread, 1928	Spread in cankers not marked
2	1	3	3	0	0
	2	1	1	0	2 s
	3	1	1	0	0
3	1	1	1	0	1 s
4	1	1	1	0	1
5	1	2	2	0	0
	2	2	2	0	0
	3	3	2	1	0
	4	2	2	0	1
	5	2	2	0	1
	6	1	1	0	0
	7	9	9	0	0
	8	2	2	0	1
	9	2	2	0	0
	10	1	1	0	0
	11	2	2	0	0
	12	1	1	0	1
6	1	1	1	0	2
7	1	1	1	0	1
		38	37	1	11

s=slight spread. M.C.=marked colonies.

D. ROT IN THE FRUIT

Besides producing a canker in the tree, the fungus is capable of causing serious losses by rotting the fruit during the storage period. This particular phase of the injury has, up to the present, not been so acute in the Okanagan as in Washington and Oregon, by reason of the fact that we do not store such large quantities. As we comply with the ever increasing demand on the part of our consuming public, that we store more of our own fruit, this problem will become more serious. The rot has occasionally been found in such fruit as is stored in the valley, but up to the present this loss has not been serious.

The rot-producing ability of the fungus on different varieties was tested out and results are presented in the table. The method of inoculation was to puncture the flesh with a needle that had just previously been drawn through a sporulating pure culture of the fungus. Apples were inoculated on the 2nd and 8th of November, and an examination was made on the 19th of December, making incubation periods of 46 and 40 days. Apples during this period were stored in the common storage cellar at the laboratory.

TABLE 64.—ROT IN THE FRUIT

Variety	Number of apples	Inoculation period	Average size of rot	Characteristics on fruiting structures	Colour and characteristics of rot
		days	inch		
Winesap	20	46	9/16 dia.	Greyish white pustules observed breaking through epidermis—few spores found.	Colour, deep brown around outer edge shading to light yellowish brown in centre; rot fairly firm, centre sunken.
Wealthy	20	46	16/16 "	Pustules few—few spores found	Rot deep brown around outer edge shading to slightly lighter brown in centre—rot fairly firm, rotted area was distinctly sunken.
Jonathan	20	46	9/16 "	Greyish white pustules common, breaking through epidermis at centre of rot; some indication that they occur in concentric rings. Spores plentiful.	Deep brown at outside, shading to light yellowish brown in centre. Rot fairly firm, somewhat sunken in centre.
Wagener	22	46	12/16 "	Greyish white pustules common in distinct concentric rings, older pustules toward centre. Spores plentiful.	Deep brown at outside, shady and light yellowish brown in centre. Rot firm, slightly sunken in centre.
Rome Beauty	19	46	14/16 "	Pustules found plentiful in concentric rings. Few spores found.	Deep brown throughout, in some cases slightly lighter in colour at centre—slightly sunken in centre. Rot fairly firm. Rot is lighter brown inside than on surface.
Spitz	17	46	13/16 "	Spores and pustules plentiful	Deep brown for most part, with small area in centre shading to light yellowish brown. Rot was much sunken or shrivelled—fairly firm.
Newtown	21	46	12/16 "	Pustules plentiful, sometimes in concentric rings; spores plentiful.	Colour deep brown over most of the rot with a small light yellow centre. Rot is fairly firm, sunken in centre.
Winter banana	17	40	9/16 "	Pustules plentiful, sometimes in concentric rings; spores fairly plentiful.	Colour deep brown shading to light yellow, brown in centre. Sunken rot firm and dryish.
Delicious	19	46	13/16 "	Greyish white pustules plentiful, somewhat in concentric rings. Spores plentiful.	Deep brown except for small, light yellowish-brown centre. Centre somewhat sunken. Rot firm and lighter in colour in interior than on surface.

E. CULTURAL CHARACTERISTICS

During the year considerable study has been made on the general characteristics of the causal fungus when grown in culture in the laboratory. Our purpose is to perfect a ready and sure means of distinguishing this fungus from all others for our diagnostic work. In the past, for example, much difficulty has been experienced in distinguishing *Gloeosporium perennans,* the perennial canker fungus, from *Neofabraea malicorticis,* the fungus causing anthracnose. On potato agar, and several other media, the growth is so similar that one can never be certain just which fungus he has. In this study we have found, however, that very distinct and distinguishing characteristics are shown on certain other media. The media on which these two fungi have shown these distinguishing differences are, mature sweet clover stem, potato agar plus 5 per cent dextrose, potato agar plus 10 per cent dextrose, Czapec's agar, corn starch agar, and an agar to which has been added a complete nutrient solution (Duggar's synthetic liquid medium No. 1," "Fungus Diseases of Plants," page 26).

On mature sweet clover stem the distinguishing characteristic is the production, on 15-day-old cultures, of a sweet smelling odour by *Neofabraea malicorticis*, and the complete absence of any from *Gloeosporium perennans*. With the remaining media the general distinguishing features are the tawny colour occurring in cultures of *Gloeosporium perennans*, and the greyish-black colour in the cultures of *Neofabraea malicorticis*. While colour reactions in fungi are now considered to be of doubtful value in classification studies, owing to their ability to change colour according to the hydrogen ion concentration of the media, such a distinctive colour variation between these two fungi, when grown on media of the same acidity, will serve, at least, as a ready means of distinguishing between them.

F. OCCURRENCE OF THE DISEASE IN THE SOUTHERN OKANAGAN

Casual observations and reports from provincial inspectors have, up to the present, led us to believe that this disease is not present or, at least, not at all prevalent in orchard sections from Westbank south. The verification of this supposition is considered important, in view of the fact that it is now considered possible to keep a district free from the ravages of this disease by the immediate removal of all affected trees. Should this district prove to be sufficiently free from infection to make eradication feasible, it is hoped that we can keep it so indefinitely, by taking the necessary corrective steps now. This fall, therefore, this laboratory, in conjunction with the Provincial Horticultural staff, is carrying out a tree-to-tree survey throughout this territory. Up to the time of writing, when most of Penticton district and a large part of Summerland district have been covered, we have found the disease present in several places in each territory covered, but, fortunately, when found it is usually confined to one or two trees in the orchard and is not widespread. The indications are, that the trouble is not yet so prevalent in these sections as to render infeasible a system of control through tree eradication.

CROWN ROT

Under the caption of "crown rot" we are generally accustomed to associating practically all forms of rot on the crown and upper root system of the apple. The causes, as most generally accepted by the majority of investigators, are attributed to parasitic organisms, to arsenical poisoning, or to low temperatures, although current literature also shows there exists a feeling that other causal factors, not as yet understood, may be responsible.

In the Okanagan there has appeared a type of this trouble which is insidiously advancing from year to year, and which is now taking a toll sufficient to cause genuine concern to the growers. A fair instance of crown rot's possibilities, if not checked, is to be found in one orchard of average soil, which received attention above the average, and yet which, in four years, has shown a total loss of 24 per cent of the trees, a damage to 35 per cent more, and a consequent loss in production of almost 50 per cent. In view, therefore, of the steady, annual advance of this disease, it seems imperative that the investigation, already begun, of the nature, extent, and cause of the trouble be carried forward as rapidly as possible.

Possibility of the Trouble Being Due to

A. *Fungi or bacteria.*—Since investigators commonly associate *Bacillus amylovorus* (Burr.) Trev. and *Armillaria mellea* (Vahl.) Sacc. with crown rot, we began the collection of material from diseased areas in an endeavour to isolate any organism. In some cases we have found cankers caused by fire blight, in several of which we could discern the point of infection, and material taken from such trees has produced *B. amylovorus* in culture. In the vast majority of cases, however, where material has been collected, extending over a two-year period, we can obtain no parasitic organism whatever in culture. We sometimes find that trees which have been healthy in the spring (as determined by careful investigation) have become severely diseased by fall, and yet in material collected from these new centres of rot, no fire blight organism can be isolated. Again, we have collected oozing drops which sometimes occur on these cankers and which are similar in appearance to those produced by fire blight (fig. 25), and although the fire blight drops of ooze give *B. amylovorus*, the drops collected from these crown rot cankers appear under the microscope merely as drops of ooze and from them we can culture no organism. A further reason to suspect

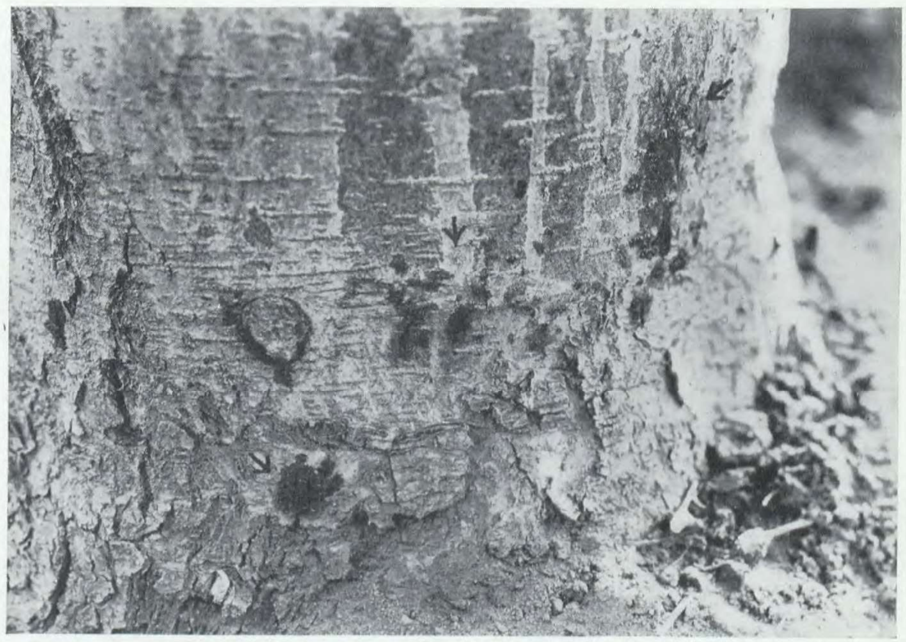


FIG. 25.—Shows apple tree girdled half way around with crown rot. Photo taken in September, 1927. All the bark in the area below the brownish ooze marked with an arrow was found to be killed right to the heart wood although there is no noticeable outward difference between the diseased and healthy bark.

that *B. amylovorus* is not necessarily associated with our local rot is that there are, in the Okanagan, districts where fire blight has never been known, and yet where crown rot has taken a very considerable toll of the apple trees.

As regards *Armillaria mellea* in only one tree in all our examinations has this organism been found.

In our isolation work a variety of bacteria and fungal growths appeared, but, so far, with none of these have we been successful in reproducing our typical crown rot.

B. *Arsenical poisoning.*—Since a commonly recognized cause of crown rot is to be found in arsenical poisoning, we considered the possibility of this as a primary cause. The symptoms described in literature, however, are so at variance with our condition that this cause, we feel, cannot apply. Moreover, the severity of the disease shows no marked difference in orchards, which have never received arsenical sprays, from those which receive several applications annually.

C. *Low Temperature.*—It is possible that low temperature may have a bearing on the presence or severity of crown rot. This would not seem to be a primary cause, however, for, although the normal winter shows a temperature 15 or 20 degrees colder in the north end of the valley than in the south, and although winter injury generally occurs in the north and is rarely severe in the south, yet there is no corresponding variation in the severity of crown rot in the two sections. Typical winter injury, moreover, is quite distinct from crown rot in its characteristics and the two may be easily differentiated.

Distinctive Characteristics

Since the causes generally associated with crown rot seem to be inapplicable to our local condition, we have been forced to the conclusion that the disease here is of a different nature from that generally classed as crown rot. A comparison of the crown rot indigenous to the Okanagan and those forms described in literature has shown distinct differences. From observations, our typical rot seems to present three different aspects.

One form of appearance might be termed a powdery dry rot. When the roots and crown are exposed, one sees greyish white patches of varying sizes on either roots or crown or on both. When these are rubbed with the finger, a dry powder or flakes rub off. This diseased area is almost entirely a surface one, for only occasionally does the rot penetrate to the cambium.

The second aspect of the rot is a slimy condition. Diseased spots appear on the crown and roots, and when the outer surface is broken with the hand, the tissue rubs away in a slimy pulp and a watery excretion follows the line of the finger. When this is cleaned away, it, too, is found to be more or less of a surface trouble, for although it extends into the cambium in a larger percentage of cases than does the powdery type, yet it is not commonly found to any great depth.

The third and most serious type from the standpoint of extent and severity in our orchards is somewhat different from the two foregoing types. When affected trees, which were perfectly healthy in the spring, are uncovered in the fall, there is no sign to the naked eye of an unusual condition of crown or roots. But a scratching through the surface below the outer bark (which looks and feels just like healthy bark) reveals that the tissue beneath is completely dead. Only patches of the crown or of the roots may be so affected, but often the tree may be completely girdled in this way. There may be small live rootlets out in the soil, and the main root from which they emanate may be dead at the crown. This is the epidemic type (fig. 25). From material taken again and again in these dead areas, cultures have been set up and microscopic examinations have been made, but no success has so far attended our efforts to find a causal organism.

Temporary Control

Since the time seems very indefinite when recommendations for any permanent control of this disease may be given, a program of experimentation for obtaining some temporary relief has been under way for the past two years. These relief measures consist mainly of an attempt to provide a connection for the part of the tree above the diseased areas with the tree's source of food supply from the roots. Where only diseased spots occur, bridge grafting has been tried, i.e. grafts have been inserted with one end in good roots and the other in the tree trunk above the disease area, so forming a bridge, as it were, over the dead tissue. Where the rot is too extensive on the roots and crown for successful bridge grafting, seedlings have been planted around the tree and their tips grafted into the tree at a point above the crown. This is known as "inarching."

Observations on these phases of control are, however, as yet quite incomplete, and any tabulation of results would be premature and of little significance.

Meanwhile there is under way a comprehensive investigation of this problem, so vitally important to the fruit industry of the Okanagan. The plan as laid out consists first, of a general survey of conditions, second, a search for the cause from the angles of pathology, physiology, and zoology, and finally, an attempt at permanent control.

PHYSIOLOGICAL DISEASES IN APPLE

(a) *Investigation of the Causes of Corky Core, Drought Spot, and Die-back*

Investigations on this problem have been continued along lines similar to those outlined in the 1927 report. The information obtained further verifies our opinion, as expressed in that report, that there is a close relationship between rootlet injury in the late summer and autumn, and the subsequent occurrence of physiological diseases, such as corky core, drought spot, and die-back in apple.

Observations of some interest were made in two of our experimental plots, numbers 9 and 10, with respect to rootlet injury and its effect as shown many months later. Soil in these plots is of a light sandy type and the rootlets of the trees lie almost entirely in the top two feet of soil. The plots belonged to a most careful grower who had always practised the best cultural methods. Unfortunately, however, on one occasion in August, 1927, when water was unobtainable, too long a period was allowed to elapse between two irrigations, and a severe killing occurred of the light coloured, succulent root tips. Rootlets which had formed a cortex were apparently unaffected, but so severe was the tip root killing that it was estimated that the trees had lost about 90 per cent of their total absorbing surfaces. The trees themselves, however, did not flag or in any other way give any indication above ground of any untoward occurrence, and, as water and soil conditions from that time forth were optimum for root growth, and as a normal fruit crop was taken off, it was not considered that the tip root killing would create more than a very slight check in the normal growth of the trees.

Meanwhile, careful observations were kept on the root development, and, where it was expected that recovery would be rapid, the anticipated return to normal failed to materialize. A few new tips were produced here and there, but throughout the entire fall, only a few new tips could be found on any single root, whereas before the drought there had been from 75 to 100 succulent, absorbing tips.

With the renewal of growth in the spring of 1928, the expected return to normal development again failed to appear. As in the fall, new rootlets were put out, but again only a very few appeared where there had been 75 to 100 before. This condition persisted throughout the summer, although soil conditions were optimum for rootlet development. It seemed as if the trees had practically lost their ability to put out new roots. During this time the trees carried a fairly heavy crop of apples, produced a fair to medium coloured foliage, and put on 15 inches terminal growth. This past fall, however, the apples showed a large increase in the amount of corky core over the amount normally occurring previous to the drought injury. Late in the season, too, the leaves of the trees were showing a bronzing similar to that which often appears on collar-rotted trees. The further development of these trees is being watched with interest.

(b) *Practical Control of Physiological Diseases in Apple*

Upon direct requests received from individual growers for suggestions concerning the management of their orchards to control physiological disorders, there has been established by this laboratory an advisory service. The orchards to which this service is given are, in the future, to serve as demonstration plots in the districts concerned. This service aims to direct all those cultural practices, including irrigation, which tend to promote a uniformly healthy rootlet development throughout the entire growing season, and thus to check the development of corky core, drought spot, and die-back. These orchards are widely separated, being fairly representative of the various districts of the valley, and are grown on varying types and conditions of soil. Records are kept of all the cultural methods employed in each orchard, and it is hoped that these records and the orchards themselves, serving as demonstration plots, will be of much service in promoting better cultural conditions in all orchards which are now suffering from these diseases.

Orchard No. 1.—Five acres—varieties, chiefly McIntosh and Jonathan. Recommendations first made in 1926. Soil, sandy loam; water supply, a private irrigation system from a spring arising on the property. Originally orchard was 10 acres, but this was cut down to 5 acres to ensure a sufficient water supply. Orchard was previously seriously affected with corky core owing to a super-drought situation in late summer and fall. Suggested correction was to cut down acreage; apply water oftener, and continue longer in summer, at least until fall rains started. General results excellent. No commercial loss during the season 1928. Visited three times per year.

Orchard No. 2.—Fifteen acres—varieties, chiefly Wealthy, Delicious, Jonathan, and Spy. Soil, silt loam. Situation, super-drought, no irrigation being used. In 1922 an experimental plot was established with a water supply available from the city main. Results in the plot, where water and cover crop of vetch were used, very satisfactory, there being no commercial loss on this plot since that date. Encouraged by these results the grower in company with neighbours put in an irrigation system. The whole orchard came under water in 1926; general recommendations have been given since on proper use of the water and cover crop. Results, very satisfactory. Season 1928 no commercial loss from corky core, drought spot or die-back. Visited three times per year.

Orchard No. 3.—Ten acres—Variety, McIntosh. Super-moisture situation. Soil, black loam. Recommendations first made in 1926, at which time corky core was extremely severe, also die-back on some trees. Work in this orchard has been carried on in co-operation with the Assistant District Horticulturist. At the time of first examination super-moisture was found. Suggestions on putting in of drains, and directions given on use of water were accepted. Result, season 1928, heavy crop of clean, healthy fruit. Visited three times per year.

Orchard No. 4.—Five acres—varieties, McIntosh and Jonathan. Soil consists of layers of clay and sand to depth of 6 feet. Super-moisture condition. Experimental work commenced in 1925. In this location the super-moisture has been difficult to overcome. A drain to cut off water coming from higher levels failed to remove the excess water. Preliminary experiments on water control also failed. This past season, water has been withheld from various sections of orchard for various lengths of time, and in one section super-moisture was eliminated this fall. Up to the present we have not been successful in reducing the amount of disease, as corky core, drought spot, and die-back are still all severe. Visits are made every two weeks throughout the growing season.

Orchard No. 5.—Fiften acres—varieties, McIntosh and Jonathan. Soil, gravelly loam, very shallow, most of the roots within one foot of the surface of the ground. Super-drought situation. Experimental work commenced in 1924. Definite recommendations on control since 1926. Inability always to obtain water when needed has interfered somewhat with success of control measures. Improvement in orchard has been satisfactory, and the amount of disease has been brought to a minimum.

Orchard No. 6.—Ten acres. McIntosh, Snow, Ontario, Spy, and other varieties. Soil, heavy silt of good depth. Super-moisture condition. Recommendations first made in 1927. In this particular orchard the problem was to apply only sufficient moisture for the needs of the trees. In past, an excess amount was being continually applied, and as a result no commercial crop was obtained from this orchard for several years. Correction of water supply since July, 1927, has greatly improved colour and vigour of growth in 1928, but did not eliminate all corky core and drought spot. No die-back was present. Visited every second week throughout the growing season.

Orchard No. 7.—Seven acres. McIntosh, Snow, Gano, Salome, and other varieties. Soil, heavy silt. Super-moisture situation. First recommendations were made in fall of 1928. Drought spot, corky core, and die-back have practically ruined the orchard, many trees being now dead; practically all are affected with one or the other of these diseases. To be visited every second week.

Orchard No. 8.—Twelve acres. Newtown, Jonathan, Winter Banana, Delicious, and other varieties. Soil very variable, from a very shallow gravelly type to a deep soil composed of layers of sand and silt. A combination in same orchard of super-drought and super-moisture conditions. First recommendations made in 1927. During season of 1928 decided improvement in colour on trees growing in deep type of soil. To hold off water on this soil, however, it was necessary to dry out other soils, and as a result there was not a general improvement, as some small sections of the orchard suffered. A relaying of the irrigation flumes for next season will largely remedy this trouble. Visited every second week.

Orchard No. 9.—Ten acres—Newton, McIntosh, Wagener, Cox Orange, and other varieties. Soil, deep silt. A super-moisture situation. Excess moisture has arisen not from seepage but from too heavy and too frequent irrigations. Recommendations first made July, 1927. Water was at once corrected. In season of 1928 splendid improvement in colour occurred, and trees put on an average of 9 to 10 inches growth where previous average was 2 to 3 inches. The presence of corky core and drought spot was not entirely eliminated during the first season, as they were present in a certain number of trees. Approximately one-quarter of the amount of water is now applied to what was previously used. Visited every second week during the growing season.

Investigational Work on Vegetable Diseases

(G. E. Woolliams, Assistant Plant Pathologist)

CLUB ROOT OF CABBAGE

The presence of club root of cabbage (*Plasmodiophora Brassicae* Wor.) in the coast regions of the province, has been known for several years, but its occurrence in the Okanagan valley had not been noticed prior to the past season. During the summer at Armstrong the disease was found on the Danish Ballhead, which is the main variety grown there.

The disease was found in nearly one-half of the acreage, and appeared in a severe form, causing 90 to 100 per cent infection in about three-fourths of the acreage affected. It is possible that the causal fungus has been present in the locality for several years, but previously caused infections that were so slight as to fail to attract attention.

Much of the cabbage is grown in low-lying peat soil, where the disease was most serious. Owing to an unusual, heavy, snow fall during the winter these lands were flooded for a short time during the spring, and, as wet soils, especially to the saturation point, are favourable to the development of the organism,* the moisture conditions probably aggravated the severity of the disease. The majority of the soils, where the disease was found, had an acid reaction which is also conducive to the growth of the pathogene.

It is rather interesting to note that the disease caused a total loss to a small patch of Chinese cabbage (*Brassica pekinensis*). The plants were stunted and showed a wilted condition in the leaves, some of which turned yellow. The typical swelling was found on the roots, but the galls were not as large as those found on the common cabbage. The swellings occurred on any part of the root system and often produced wartlike growths on the side of the tap roots. Cracks commonly appeared on the surface of the roots, which were brittle and easily broken, disclosing a cheesy, white tissue within. The histological appearance of the roots was quite similar to that of affected roots of common cabbage, and many cells were filled with the characteristic resting spores of *Plasmodiophora Brassicae.*

AN EXPERIMENT TO CONTROL TOMATO LEAF-MOULD

For several years tomato leaf-mould (*Cladosporium fulvum* Cke.) has been present in the Okanagan valley, and has been causing losses to some growers of the greenhouse tomato crop. Although the ordinary method recommended for the control of the disease, namely, that of keeping the humidity of the greenhouse as low as is consistent with good growth of the tomato plant, was carried out as much as possible, the disease was not held in check. Since no attempt had been made to control the disease by the use of fungicides, an experiment was started to find out their efficiency in controlling the disease, when tried out under local conditions.

The tests were made in a local grower's greenhouse with young tomato plants of the Sunrise variety. When the tests were begun, the plants were about to produce their first bloom. At that time the disease had already become firmly established in nearby greenhouses, but in the one under test only a slight amount of infection was found. The planted area was divided into four sections of approximately equal size; two sections were used for sprays, one for a dust, and the fourth for a check (no treatment). The two sprays used were, Bordeaux mixture (5-5-40), and soda Bordeaux (1 pound copper sulphate, 1·5 pounds sodium carbonate, 40 gallons of water), and the dust, copper-lime (20-80). The applications were made at weekly intervals for seven weeks.

At the conclusion of the tests, in no case was there complete control, but the results indicate that the use of sprays may be of some benefit. Both of the sprays held the disease in check. Bordeaux mixture gave the best control, since it reduced the amount of infection to a considerable extent without injury to the plant. Although the soda Bordeaux spray gave control similar to the Bordeaux mixture, it did not appear to be satisfactory since it produced considerable injury to the fruit, causing brown lesions on the surface wherever the spray residue accumulated. The copper-lime dust was unsatisfactory, as it failed to give any appreciable control. Like the Bordeaux mixture, it was not injurious to the plant.

FUNGICIDAL TREATMENTS FOR THE CONTROL OF *Botrytis* NECK-ROT OF ONIONS

The occurrence of *Botrytis* neck-rot of onions (*Botrytis Allii* Munn) in certain sections of the benchlands at Kelowna has caused difficulty in the production of the crop. The disease appears in the field on the growing bulbs

*Monteith, J. Relation of soil temperature and soil moisture to infection by *Plasmodiophora Brassicae.* Journ. Agr. Research 28:549-561. 1924.

and, later, on the mature bulbs, while they are being cured. The crop is grown also on the low-lying land of the district, but here no trouble with the disease is experienced in the field.

In order to determine whether the use of fungicide might be of value in controlling the disease under field conditions, sprays and dusts were experimented with in a field in which the disease had been severe for four of the five years during which the crop had been grown there. For the major portion of the growing season, sprays and dusts were applied at fortnightly intervals on plots of one twenty-fourth of an acre. The sprays were applied with a "Brown" knapsack sprayer, and the dusts with a "Niagara Blower-Type Gun." The fungicides used in the tests were as follows:—

TABLE 65—RATES OF APPLICATION OF FUNGICIDES

Plot No.	Treatment	Rate of application per acre
1	Bordeaux mixture (5-5-40)	100 gallons
2	Lime sulphur (1-30)	100 "
3	Soda Bordeaux (1 lb. copper sulphate, 1·5 pound sodium carbonate, 40 gallons water)	100 "
4	Check (no spray)	....
5	Copper-lime dust (20-80)	72 pounds
6	Kolodust (regular preparation) (90 per cent colloidal sulphur)	72 "
7	Kolodust (special preparation) (73 per cent colloidal sulphur)	72 "
8	Copper carbonate dust (20-80)	72 "
9	Check (no dust)	....
10	Thylox (colloidal sulphur dust)	72 "
11	Ferrox (colloidal sulphur dust, containing iron)	72 "

Results indicate that the use of these fungicides is of no value in controlling the neck-rot disease of the growing bulk. The presence of the disease in the field was first found on August 14, and from that date until the crop was pulled on September 15, affected plants were found. The disease was just as severe on the treated plots as on the checks.

The soil, in which the crop is grown, is a heavy, rich, black loam and, as it is situated on the northern side of a hill, from which there is a certain amount of seepage, it does not dry out rapidly. Formerly the soil kept very moist through excessive irrigation. This season, however, the amount of water was materially reduced so that the soil had, to some extent, an opportunity to dry out.

During the past season, the higher portion of the field remained moist, due to a certain amount of seepage, but the lower portion dried out considerably towards the latter part of August. The disease appeared fairly severely on the moist soil, but little was found on the dry. On August 21, the average amount of infection found in the upper part of the field (the moist) was 22 per cent, but that on the lower part (the dry) was only 3 per cent. These results indicate that, under local conditions, the occurrence of the disease on immature bulbs may possibly be kept in check by keeping the soil moisture as near the minimum as is required for good growth. It would seem that the use of fungicides, either as a spray or as a dust, does not give effective control of the disease.

Fusarium BULB-ROT OF ONIONS

In studying the natural development of *Fusarium* bulb-rot of onions, it was decided to visit a selected field every ten to fifteen days to watch for symptoms of progress of the disease. The first visit was made on May 28, when the plants were about 6 inches high, and although no decay was found on any of the plants that were examined, some plants were found with one or two pink-coloured rootlets. As pink rootlets are often found on older plants that show decay, it is possible that this root discoloration is caused by incipient infection. The plants were still small, having a diameter of only one-eighth of an inch, and bulb formation had not yet begun. However, ten days later on June 7, the typical rot was found on some of the plants at the base of the stem. They had made considerable growth during this period; bulb formation had begun, and the diameter just above the stem plate had increased to one-quarter of an inch. During June, the outer leaf of diseased plants often turns yellow, beginning at the tip, but usually such leaves remain turgid.

Although the disease was slowly developing in the bulbs during the month of June, the symptoms could not be readily distinguished in the foliage until the first part of July, when the plants had formed fairly good-sized bulbs with a diameter of three-quarters to one and one-quarter inches. From July 5, when the typical symptoms, shown by the wilting and yellowing of the foliage, had developed, and until the crop was harvested, the disease progressively appeared.

During the past season an experiment was incepted for the purpose of studying the effect of soil treatments on the development of the disease. A field in which the disease had been severe in recent years was chosen for the tests. For about twenty years onions had been grown successfully on this land, but the disease has now become so severe that rotation of crops, a practice which is not generally followed in this district, is being adopted.

In order to avoid inoculation of the soil with spores of the causal organism, the plots, which were of one-sixtieth of an acre, were so arranged, beside a flume, that the irrigation water could not come in contact with infected soil prior to application, and so that it was not carried from one plot to another. The treatments consisted of the application of (*a*) fertilizers, to determine whether by their use the onion plant might be stimulated to a rapid growth that will aid it in resisting the disease, and (*b*) chemicals, to determine their effect on the growth of the fungus. Just prior to seeding, the soil was treated with the various fertilizers and chemicals. Throughout the growing season, all the diseased plants were pulled, and counted, as they appeared in the plots, and the final count was made when the crop was harvested in September. The treatments were made as follows:—

TABLE 66—TREATMENTS OF ONION PLOTS

Plot No.	Treatment	Rate of application per acre
1	Horse manure	10 tons
2	Cow manure	10 "
3	Check—no treatment	....
4	Nitrate of soda	120 pounds
5	Sulphate of ammonia	120 "
6	Muriate of potash	135 "
7	Superphosphate	480 "
8	Check—no treatment	....
9	Flowers of sulphur	1,200 "
10	Hydrated lime	1,000 "
11	Check—no treatment	....
12	Copper sulphate	200 "
13	Copper sulphate	100 "

The results of the tests, showing the percentage of diseased bulbs found in each plot are presented in table 67. As no conclusions can be drawn from one year's tests, further experiments will be made next year.

TOBACCO LEAF-DROP

As tobacco leaf-drop was found to occur usually on low-lying soil that had a high water table, an experiment was initiated in 1927 for the purpose of determining whether the height of the water table had any influence on the occurrence of the disease (see Report of the Dominion Botanist for the year 1927). The water table in a field of tobacco was lowered by growing plants in a wooden frame, 20 feet square and 10 inches high, that was filled with top soil from the field. At the end of the season, 40 per cent of the plants in the frame were affected with the disease and those in the adjoining part of the field showed about the same percentage of disease.

During the past season a similar test was conducted in the same field. As it was possible that the water table had not been lowered sufficiently to affect the occurrence of the trouble, it was lowered still further, from 10 inches to 24 inches, by raising the frame to a height of 2 feet.

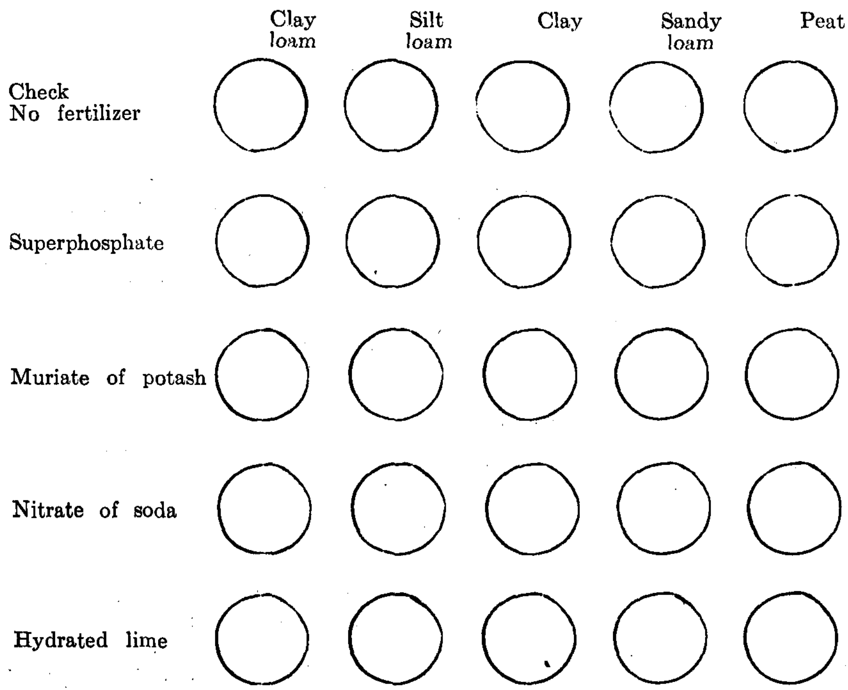
On June 6 eighty-eight plants of the Connecticut Havana 38 variety were set out in the frame, and 25 plants were set out in the adjacent part of the field to serve as checks. As the frame was filled up to the new height a short time before the plants were set out, the soil in the frame was not in good tilth for normal plant growth. The tobacco plants in the frame did not make very good growth, but those set out in the field grew well.

During the past season, there was a reduction in the amount of disease present. At the end of the season, on September 13, ten of the 88 plants in the frame or 11·4 per cent were affected with the trouble and, at the same time, 8 of the 25 check plants, or 32 per cent, were affected. The disease was not severe, as on most of the affected plants not more than one or two leaves dropped off.

TABLE 67—NUMBERS OF AFFECTED PLANTS AND DISEASED BULBS

Plot No.	Treatment	Counts of diseased bulbs removed from the field						Total number of affected nts	Number of healthy bulbs on Sept. 4-5	Percentage of diseased bulbs
		July 5	July 16	July 31	Aug. 13	Aug. 22	Sept. 4-5			
1	Horse manure	6	94	70	70	39	125	404	1,136	26·23%
2	Cow manure	25	65	64	68	46	136	404	1,484	21·40
3	Check—no treatment	32	115	145	110	85	166	653	1,560	29·50
4	Nitrate of soda	41	117	109	78	82	130	557	1,422	28 15
5	Sulphate of ammonia	44	105	75	61	67	126	478	1,591	23·10
6	Muriate of potash	57	78	73	69	46	135	458	2,251	16·91
7	Superphosphate	24	69	85	56	43	140	417	1,775	19·02
8	Check—no treatment	23	84	93	68	46	157	471	1,742	21·28
9	Flowers of sulphur	34	73	110	71	65	119	472	2,036	18·82
10	Hydrated lime	17	47	53	67	18	105	307	2,283	11·85
11	Check—no treatment	18	70	52	48	30	114	332	2,374	12·27
12	Copper sulphate	14	32	56	47	15	70	234	2,186	9·67
13	Copper sulphate	8	40	27	32	12	....	119	....	....
		343	989	1,012	845	594	1,523	5,306	21,840	

An experiment was also made this year to determine whether, without changing the level of the water table, the type of soil or the use of certain chemical fertilizers might have an effect on the malady. In order to grow the plants under the same moisture conditions and yet in different types of soil, the tobacco was grown in clay pots. Twenty-five 10-inch pots were buried in the soil beside the raised frame, and were filled with the following kinds of soil—peat, sandy loam, silt loam, clay, and clay loam, which is found in the field where the tests were being made. Liberal applications of hydrated lime, nitrate of soda, muriate of potash, and superphosphate, were made to the different soils. One pot of each kind of soil, to which no fertilizer was added, was used as a check. The arrangements of the pots with the different treatments was as follows:—



On June 6 one tobacco plant of the same variety as was used in the other test was planted in each pot. Good growth was obtained in each pot, although the plants were not quite as large as those set out in the field.

The results of this test were inconclusive. The trouble appeared to a slight extent, on two plants only. The leaf drop was found on the plant growing in silt loam to which nitrate of soda had been added, and on the plant growing in clay loam which contained superphosphate.

Raspberry Inspection at Ste. Anne de la Pocatière, Quebec

(H. N. Racicot, Officer in Charge)

Only 40 inspections were made and 30 plantations certified during 1928. This is a smaller number of inspections, but a higher percentage of certified fields. The certified fields are much freer from disease on the whole than in previous years.

SECTION V

INVESTIGATIONS OF THE DISEASES OF POTATOES AND FIELD CROPS; POTATO CERTIFICATION SERVICE

90946—11½

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, CHARLOTTETOWN, PRINCE EDWARD ISLAND

(R. R. Hurst, Officer in Charge)

INTRODUCTION

Work in connection with the laboratory has shown satisfactory advances during the past year as indicated by the progress made towards solving some of the more serious plant disease problems, the study of potato diseases ranking first in importance. Laboratory research has been extended to better meet the needs of research development. Many enquiries relating to plant diseases were answered by correspondence, personal calls at farms, and attendance at farmers' meetings. In addition, lectures were given at all the Illustration Station Field Days. Numerous press articles have been published for the purpose of advising the public of the latest approved methods of plant disease control. This service is exceedingly popular. A demonstration of certified seed and potato diseases was prepared for the provincial exhibition, and practical information was given out to the farmers on this occasion.

In addition to the field experiments, a potato virus disease demonstration was established. This not only proved of inestimable value as a training ground for inspectors of certified seed but was used freely by farmers as a means to acquaint themselves with the symptoms of leaf roll and mosaic.

Valuable laboratory assistance was rendered by Mr. J. L. Howatt, Plant Disease Investigator, who was able to devote full time to research.

The plant disease survey has been continued and several diseases new to the province have appeared. Important among these were *Alternaria* tuber rot of potatoes, *Phoma* rot in association with powdery scab of potatoes (figure 26), *Sclerotinia* blight of hollyhock, leaf spot of hollyhock, and crinkle of potatoes. Spindle tuber was found, but fortunately was confined to a small area from which the sale of seed potatoes was restricted, and into which new seed will be introduced in 1929.

Striking evidence was obtained giving an additional explanation of missing hills in potato fields through the agency of late blight rot in the sets. Six fields were examined in which these conditions were reported, and in each case it was apparent that late blight rot was alone responsible. Sets from missing hills invariably showed late blight rot development in the region of the eyes. To eliminate any doubt on this point more than one thousand sets thus affected were washed and placed in moist chambers, and each, without exception, produced the typical conidiophores and conidia of *Phytophthora infestans*. Figure 27 illustrates a field of potatoes having many missing hills as a result of late blight infection of the seed piece.

It will be recalled that late blight rot was abundant in 1927. As a consequence it commonly occurred that tubers developed an incipient growth of blight rot which remained inactive throughout the winter. When cut into sets for the 1928 plantings this rot, which escaped notice, developed in the seed-piece in the ground. Cases were noticed where sprouts were produced but the set decayed before the plant became established. The practical application suggested by this observation is to take all the precautions necessary for the production of seed potatoes free from late blight rot. Furthermore, the exclusive use of Government Certified Seed cannot be too strongly urged.

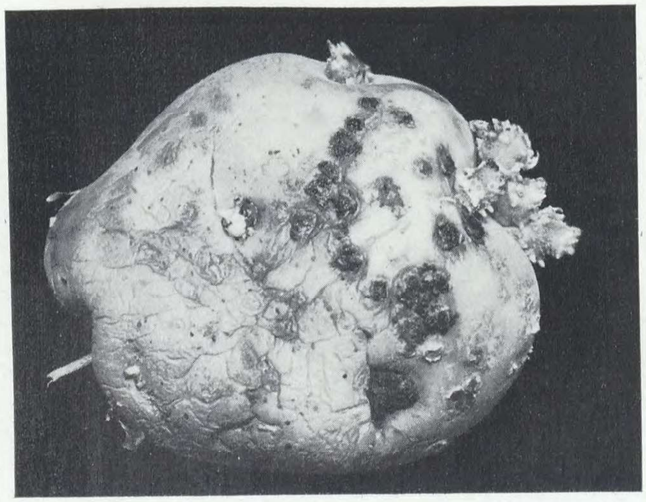


FIG. 26.—*Phoma* rot in association with powdery scab of potatoes.

FIG. 27.—A field of potatoes having missing hills as a result of late blight infection of the seed-piece.

SIZE OF POTATO SEED-PIECE

A Continuation of the Project to Determine Whether Small Sets Can Be Used Economically for Certified Seed

This project is now in its fifth year of investigation. As stated previously the primary object of the experiment was to determine whether or not there is any merit in using small tubers for seed purposes, when obtained year after year from the same source. A further consideration was the matter of using, for seed purposes, small tubers, or culls, from the crop of the previous year on occasions when the marketable tubers had been sold and the price of seed was high. This procedure involves the question of virus disease development, since it is generally accepted that there is a tendency towards the production of small tubers from plants infected with leaf roll and mosaic.

Investigations of this problem covering a period of four years revealed a yearly decrease in the yield obtained. However, it was pointed out that repetition on the same land no doubt accounted for this difference in no small measure. In 1928 the land used had not been in potatoes for several years. Grain stubble was ploughed down in October, 1927. Manure was applied previously at the rate of 15 tons per acre. In 1928 fertilizer was applied broadcast at the rate of 1,560 pounds per acre, the chemicals being supplied as follows:—

Nitrate of soda	260 pounds
Sulphate of ammonia	400 "
Muriate of potash	300 "
Superphosphate	600 "

Culls graded from Certified Seed of the Irish Cobbler variety were used in these tests, and the progeny culls from this source have been used continuously for five years.

In 1928, the experiment was duplicated, using Green Mountains. As this variety is more susceptible to mosaic, the culls are accordingly more likely to be contaminated with the virus responsible for this disease. The history of this strain records a trace of mosaic. The weights and nature of the seed-pieces used were as follows:—

Seed-piece.	Weight in ounces
Whole	3, 2, 1½, 1, ½
Cut	1½, 1, ½

The sets were spaced 12 inches in the rows, which were 36 inches apart. The plan of the experiment comprised 4 replications, including buffer rows and ends. Roguing was accomplished as the diseased plants appeared. These were not replaced, but the loss in yield was calculated and adjusted, according to the estimated average yield of a hill for each size of seed-piece involved. At cutting time all possible precautions were taken to have the sets of correct weights. Seeding was done by hand in furrows opened and covered by a hoe. The plants were hilled when they appeared above the ground and again two weeks later. The crop was harvested by hand, graded, and weighed before leaving the field. The weights were checked one month later in the laboratory. Tubers below three ounces in weight were considered as culls.

TABLE 68.—YIELDS FROM SIZE OF SET FIELD TESTS IN 1928

Variety: Irish Cobblers

Kind of set	Seed used per acre in bushels	Yield per acre in bushels			Per-centage culls	Yield with seed deducted	Average stems per plant	Order of merit
		Total	Market-able	Culls				
oz.	bush.	bush.	bush.	bush.	%	bush.		
3 whole..........	56¼	425	290	135	31·76	368·75	5·20	3
2 "	37½	406·50	286·75	119·75	29·45	369·00	4·00	2
1½ "	28	401·75	273·25	128·50	31·98	373·75	3·65	1
1 "	19¾	331·75	237·55	94·20	28·39	312·00	1·75	5
½ "	9¼	290·25	217·69	72·56	25·00	281·00	1·72	6
1½ cut.............	28	388·75	280·25	108·85	28·00	360·75	3·58	4
1 "	19¾	279·75	205·62	74·13	26·50	260·00	1·80	7
½ "	9¼	268·50	191·38	77·12	28·72	259·25	1·68	8

Results

The figures tabulated in tables 68 and 69 show a general agreement with the results from the experiments of previous years. While the data obtained in 1928 did not conform, in each instance, to previous findings, it will be seen that the total crop return varied directly with the weight of seed-piece used, both with Irish Cobblers and Green Mountains.

The calculations in table 68[1] show that yields in 1928 were greater than for the average of the previous four consecutive years, when the tests were made on land used for potatoes only. It is apparent that the change to new land promoted better yields. The results obtained with Green Mountains are shown in table 69.

TABLE 69.—YIELDS FROM SIZE OF SET FIELD TESTS IN 1928

Variety: Green Mountains

Kind of set	Seed used per acre in bushels	Yield per acre in bushels			Percentage culls	Yield with seed deducted	Order of merit
		Total	Marketable	Culls			
oz.	bush.	bush.	bush.	bush.	%	bush.	
3 whole......	56¼	354·87	235·25	119·62	33·71	298·62	5
2 "	37½	448 00	312·84	135·16	30·17	410·50	1
1½ "	28	429·00	299·06	129·94	30·29	401·00	3
1 "	19¾	321·58	225·98	95·60	29·73	301·83	4
½ "	9¼	219·26	158·75	60·51	27·60	210·01	8
1½ cut.........	28	434·63	304·98	129·65	29·83	406·63	2
1 "	19¾	283·85	212·69	71·16	25·07	264·10	6
½ "	9¼	226·33	156·72	69·61	30·76	217·08	7

The smaller seed-pieces gave the most economical yields in proportion to the weight used. However, the yields are comparatively small from seed-pieces one ounce and lighter, and the disadvantage in obtaining a poor crop is not consistent with economy or good farming practice.

In 1928, in the case of Irish Cobblers, whole tubers weighing 1½ ounces gave the best total returns when the amount of seed used was deducted, while the 2-ounce whole tubers came next. Green Mountains gave the best returns from 2-ounce whole tubers with 1½ ounce cut sets in second place. The proportion of marketable tubers to culls for each size set represented in the test with Green Mountains is illustrated in fig. 28.

[1] See also Dominion Botanist's Annual Report 1927.

The advisability of using culls in the production of Certified Seed depends upon the controlling circumstances, namely price and availability of seed, and the extent to which virus diseases were present in the field the previous year. In these investigations the virus disease factor has been negligible as will be seen from the inspection records shown in table 70.

TABLE 70.—OCCURRENCE OF VIRUS DISEASES IN SIZE OF SET EXPERIMENT USING CULLS FROM SAME STOCK FIVE CONSECUTIVE YEARS

Variety: Irish Cobblers

Kind of set	Percentage estimate of virus diseases. (Total 400 plants per estimate)					
	Mosaic			Leaf roll		
	1926	1927	1928	1926	1927	1928
oz.	%	%	%	%	%	%
3 whole	....	·50	·25	....	....	....
2 "	0·50	0·50	....	....	0·25	0·25
1½ "	....	·50	·50	·25	....	·25
1 "	·50	1·50	1·00	....	·25	....
½ "	· 50	1·00	1·00	....	·25	·50
1½* cut	....	·25	·50	....	....	....
1 "	1·00	·50	1·00	....	....	....
½ "	1·00	·50	1·50	·25	....	·25

*3 oz. tuber halved.

In the year 1926, after the same seed had been used for two years traces of mosaic were found in each size of set represented with the exception of 3-ounce whole, 1½-ounce whole, and 1½-ounce cut. Figures for 1927 and 1928 show a trace of mosaic in these three sizes, and a slight increase in the case of 1-ounce whole and ½-ounce whole in 1927, and, in 1928 in the three weights of cut sets, namely 1½, 1, and ½ ounces. In general there appeared to be a tendency towards the development of mosaic where sets of lighter weights were used. This lends support to the belief that mosaic is more likely to occur where culls are used for seed continuously. However, the increase has not been sufficiently marked to confirm this; yet there is no doubt that both mosaic and leaf roll would have shown greater increase had it not been for consistent roguing each year.

FIG. 28.—Experiment on sizes of seed-pieces, illustrating proportional yields of marketable tubers and culls in 1928. Numbered from left to right. (1) 2 oz. whole; (2) 1½ oz. cut set; (3) 1½ oz. whole; (4) 1 oz. whole.

THE VIRUS DISEASE SITUATION IN THE PROVINCE OF PRINCE EDWARD ISLAND

Economic Importance

Virus diseases are known to occur generally in uncertified potatoes and, while figures are not available, it is conceded that mosaic and leaf roll effect an important reduction in yield in the province. The situation in the case of the Certified Seed potatoes merits consideration as indicated in the inspection records for the year 1928. The average amount of mosaic in the total fields inspected was 0·568 per cent, 0·065 per cent in the total fields passed, and 2·411 per cent in the total fields rejected. The average amount of leaf roll in total fields inspected was 0·017 per cent, 0·009 per cent in total fields passed, and 0·043 per cent in total fields rejected. Nine fields were rejected for leaf roll and 608 fields for mosaic, representing 0·143 and 9·72 per cent respectively. Twenty-three and one-half acres were rejected on account of leaf roll and 2,875 acres for mosaic. The Green Mountain variety constituted much the greater acreage. It will be seen from these records that mosaic, at least, is a factor worthy of serious consideration in the production of seed potatoes.

Transmitting Agents

While investigational information is not available it is obvious that potato aphids are largely responsible for the spread of mosaic from plant to plant. Failure to control this insect complicates efforts to check the spread of mosaic.

Other Hosts

A survey has been made of virus disease hosts and it is proposed to investigate the infecting possibilities upon potatoes of each virus recorded. The following is a list of hosts which showed virus disease symptoms and were, therefore, classified as harbouring a disease-producing virus. In each instance the plant was examined carefully to ascertain the possibility of insect trouble.

TABLE 71.—PLANTS OBSERVED TO BE AFFECTED WITH VIRUS DISEASES

Cultivated hosts	Wild Hosts
Potato: Leaf roll	
Potato: Mosaic	*Plantago major.*
Potato: Spindle tuber	
Potato: Crinkle.	
Tomato	*Chrysanthenum Leucanthemum.*
Beet	*Matricaria suaveolens.*
Parsnip	*Leontodon autumnalis.*
Celery	*Rubus spp.*
Spinach	*Rubus strigosus.*
Lettuce	
Sugar beet	Ornamentals.
Cucumber	Sweet pea.
Strawberry	Petunia.
Garden pea	Nicotiana.
Bean	Delphinium.
Corn	Aster.
Alfalfa	Dahlia.
Red clover	
Tobacco	
Wheat	
Raspberry	

Control Measures

Investigation of this phase has been limited to two projects. One is an attempt to procure disease-free strains of all the potato varieties grown in Prince Edward Island. The other deals with the question of maintaining potatoes free from virus diseases when culls are used for seed purposes. In the latter instance consistent early roguing has held mosaic and leaf roll in check over a period of five years, when culls from the same source were used in consecutive years. The utilization of tuber units was not involved in these tests.

In the attempt to procure disease-free strains of the varieties grown in the province the tuber unit method has been applied over a period of two years. In 1927 the varieties were isolated in relation to other potatoes to determine the extent to which virus diseases were present.

In 1928 these varieties were included in the general test plots. They were, however, well isolated from the plots devoted to virus disease demonstrations. By this method we have obtained twenty varieties apparently free from virus diseases. Included in these are all the varieties in the province known to be certified, namely: Green Mountain, Irish Cobbler, MacIntyre, Spaulding Rose, and Bliss Triumph.

The question of control of virus diseases by the introduction of disease-free potatoes from other localities applies only in so far as potatoes are circulated in the province. Seed potatoes are not commonly brought into the province. The original strains have been maintained reasonably free from diseases and are used to supply local needs.

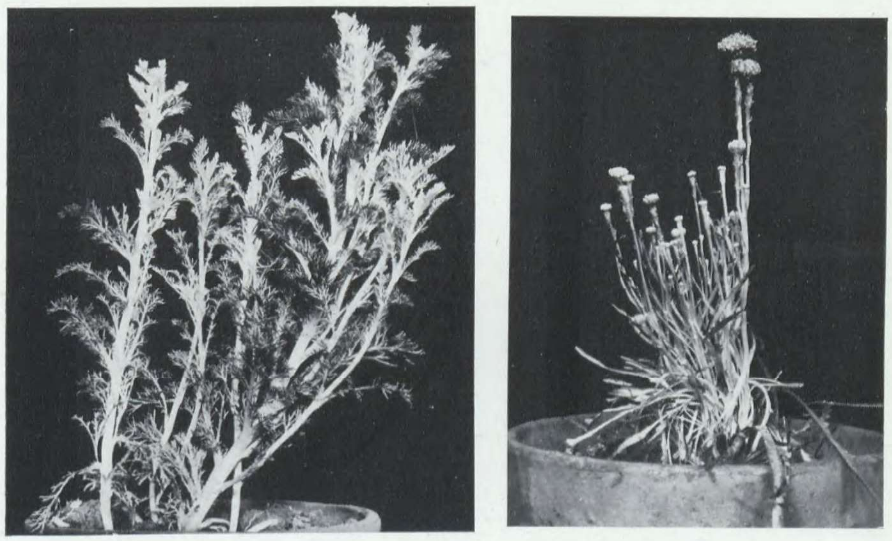


FIG. 29.—A. *Matricaria suaveolens.* This plant is suspected of virus disease infection. Note the marked chlorosis and lack of flower development. B. *Leontodon autumnalis.* The effect of mosaic is clearly indicated by the stunted character, chlorosis, and lack of flower development.

One particular strain of Green Mountains has enjoyed an exceptional record of freedom from disease, inasmuch as it has maintained this unbroken record over a long period of years.

The most effective method in our experience for developing and maintaining potatoes free from virus diseases has been the consistent use of the seed plot, where the tuber unit system has been applied.

Investigations of Seed Potato Treatments

(In co-operation with the Fredericton Laboratory)

While treatment of seed potatoes is an accepted feature in the production of this crop, there has been much to be desired in the methods and disinfectants employed. In the past, corrosive sublimate and formalin have shared equal honours as controls for surface-borne diseases of potatoes. However, the time consumed and the labour involved have been the basis of objections to their use. In recent years new and promising chemicals have reached the market, and it is with these that the investigations recorded herein are concerned.

This report represents the results of investigations carried on over a period of two consecutive years. In 1927 the experimental plots at Charlottetown were on land known to be heavily contaminated with the organism whose control was sought. Hence an opportunity was afforded to study the behaviour of each organism under these conditions, and the effect of seed treatment as a control measure.

The plan followed in 1928 was essentially the same as in 1927. However, organic mercury compounds were not used as dusts, these having been replaced by calomel. Two compounds of organic mercury were used as dips, namely, Bayer Dipdust and Semesan Bel. Tests were seeded in duplicate plots with the exception of checks, which consisted of 15 plots each of infected seed untreated and disease-free seed untreated. Individual plots comprised 20 plants, 13 inches in the rows, which were spaced 36 inches. In the case of organic mercury compounds the sets were cut before treatment. In all other tests whole seed tubers were treated, dried, and then cut.

Seed pieces embodied one eye, and were 2 ounces in weight. All tubers intended for treatment were presoaked for two hours in tap water.

The various disinfectants were employed as follows:—

TABLE 72.—SEED POTATO TREATMENTS

(*a*) Improved Semesan Bel. (dip), (1:20) 1 lb. to 2½ gals. of water before cutting.
(*b*) D.D.D. No. 77 Bel. (dip), (1:20) 1 lb. to 2½ gals. of water before cutting.
(*c*) D.D.D. No. 76 Bel. (dip), (1:40) 1 lb. to 5 gals. of water before cutting.
(*d*) Bayer Dipdust (dip), (1:20) 1 lb. to 2½ gals. of water before cutting.
(*e*) Formalin (cold) 1 pint to 30 gals. of water for 1½ hours before cutting.
(*f*) Formalin (hot) 2 pints to 30 gals. of water for 3 minutes before cutting.
(*g*) Mercuric chloride (cold) 4 oz. to 30 gals of water for 1½ hours before cutting.
(*h*) Mercuric chloride (hot) 4 oz. to 30 gals. of water for 3 minutes before cutting.
(*i*) Mercuric chloride (dip), (1:10) 16 oz. to 5 qts. of water before cutting.
(*j*) Mercurous chloride (dip), (1:40) 16 oz. to 5 qts. of water before cutting.
(*k*) Mercurous chloride (cold) 8 oz. to 5 qts. of water before cutting.
(*l*) Mercurous chloride (cold) 8 oz. to 30 gals. of water before cutting.

RESULTS

(*Rhizoctonia* Investigations)

One of the merits generally disregarded in the practice of treating seed potatoes is control of underground stem infection. In localities where early growing conditions favour the development of *Rhizoctonia*, the young shoots are invaded by this fungus to the extent that misses may occur, or plants will sustain injuries which leave them in a weakened condition which may exist throughout the season. With a view to comparing the values of the chemicals in this respect, percentage counts were made of underground stem infection from sets representing each of the disinfectants used. Sprouts and underground stems were examined 9 days and 16 days, respectively, after seeding date. Sprout infection was rare and was accordingly considered of no consequence. It is shown in table 73 that there was a minimum of infection of underground stems where Bayer Dipdust and Semesan Bel were used. Where cold formalin was used there was an apparent increase of infection. Corrosive sublimate gave practically equal benefit as compared with the other chemicals, inasmuch as there was a reduction of lesions in the treated sets over checks. In view of the limited opportunity to make these observations on the growing shoots the results are not conclusive. Five plants were examined in each plot, the earth being removed carefully and the plant recovered when counts were made.

TABLE 73.—EFFECT OF SEED TREATMENT ON UNDERGROUND STEM INFECTION

Disinfectant	Per cent free	Per cent infected
	%	%
Corrosive sublimate (1-1000) (cold)	98·0	2·0
Corrosive sublimate (1-1000) (hot)	98·4	1·6
Corrosive sublimate (1:40) (dip)	99·2	0·8
Calomel (1-1000) (cold)	98·4	1·6
Calomel (1-1000) (hot)	99·4	·6
Calomel (1:20) (dip)	99·2	·8
Formalin (cold)	96·4	3·6
Formalin (hot)	99·2	·8
D.D.D. No. 76, Bel (dip)	97·2	2·8
D.D.D. No. 77 Bel (dip)	97·8	2·2
Bayer Dipdust (dip)	100·0	....
Semesan Bel (dip)	100·0	....
Disease free seed untreated	99·4	·6
Infected seed untreated	96·2	3·8

Field observations showed that plant vigour during the early growth period was favoured by the use of organic mercury compounds. No appreciable difference was noticeable in the tops after mid-season. The percentage stand was higher where organic mercury compounds and corrosive sublimate were used, there being no distinction between these two disinfectants in this regard (table 74).

It must be pointed out in connection with the experiments at Charlottetown that tuber infection by *Rhizoctonia* in 1928 was never severe. It is obvious, therefore, that the results obtained cannot be interpreted as conclusive and definite recommendations must of necessity be based upon further investigations.

Experimental work in 1927 yielded little information of value, except that it was demonstrated conclusively that seed treatment cannot be expected to prevent scab or *Rhizoctonia,* when the crop is produced on land harbouring the organism responsible for the disease sought to be controlled.

In studying the results shown in table 75, it will be seen that the organic mercury compared favourably with corrosive sublimate and hot formalin at Charlottetown. From the standpoint of the effect of treatment upon sclerotial development, as indicated by tuber counts, corrosive sublimate and formalin were slightly superior to the organic mercury compounds. However, the most satisfactory yields were obtained where the latter were used. Excellent results were obtained from sets treated with calomel (hot and cold), both from the point of yield and of *Rhizoctonia* control. *Rhizoctonia*-infected seed, untreated, gave the lowest percentage stand as well as the poorest yield.

The seed treatment investigations at Fredericton yielded results which agreed in a general way with the findings at Charlottetown. Hot calomel gave the best control of *Rhizoctonia,* but the yield of marketable tubers was noticeably lower than in the case of cold corrosive sublimate which gave satisfactory control. Calomel used as a dip and hot corrosive sublimate gave excellent control of *Rhizoctonia.* Yields also were satisfactory. The best yields on the whole were obtained where hot and cold corrosive sublimate were used, when considered on the basis of the percentage weight of tubers. The two compounds designated D.D.D. Nos. 76 and 77 Bel effected slightly better control than did Semesan Bel. However, the last named gave a higher percentage of marketable tubers (see tables 76 and 77).

TABLE 74—RESULTS OF SEED POTATO TREATMENTS (CHARLOTTETOWN, P.E.I.), 1928

Rhizoctonia

Treatments	Date of emergence	Per cent stand	Disease Content			Number of Tubers			Weight of Tubers		
			Free	Slight	Severe	0-3 oz.	3-12 oz.	12 + oz.	0-3 oz.	3-12 oz.	12 + oz.
		%	%	%	%	%	%	%	%	%	%
Corrosive sublimate (cold)	June 9	100	100·0	0	0	44·5	55·5	0	22·6	77·4	0
Corrosive sublimate (hot)	" 9	100	98·4	1·6	0	43·7	56·3	0	21·2	78·8	0
Corrosive sublimate (1 : 40) dip	" 9	100	92·0	8·0	0	39·3	60·7	0	19·8	80·2	0
Calomel (cold)	" 8	99	90·2	9·8	0	43·2	56·8	0	21·7	78·3	0
Calomel (hot)	" 8	94	88·5	11·5	0	38·3	61·7	0	8·3	91·7	0
Calomel (dip.)	" 8	97	84·8	15·2	0	37·2	62·8	0	16·4	83·6	0
Formalin (cold)	" 9	99	87·0	13·0	0	42·7	57·3	0	14·5	85·5	0
Formalin (hot)	" 9	98	100·0	0	0	40·1	59·9	0	18·2	81·8	0
D.D.D. No. 76, Bel (dip.)	" 8	100	86·2	13·8	0	35·4	64·6	0	14·1	85·9	0
D.D.D. No. 77, Bel (dip)	" 8	100	91·5	8·5	0	42·2	57·8	0	19·0	81·0	0
Semesan Bel (dip)	" 8	100	92·6	7·4	0	43·4	56·6	0	14·4	85·6	0
Bayer Dipdust (dip)	" 8	100	92·1	7·9	0	34·8	65·2	0	18·4	81·6	0
Rhizoctonia-free seed untreated	" 8	99	98·4	1·6	0	36·9	63·1	0	16·9	83·1	0
Rhizoctonia-infected seed untreated	" 8	93	83·1	16·9	0	47·4	52·6	0	21·7	78·3	0

TABLE 75—RESULTS OF SEED POTATO TREATMENTS (CHARLOTTETOWN, P.E.I.), 1928

Rhizoctonia

Treatments	Disease Content			Number of Tubers			Weight of Tubers, in pounds		
	Free	Slight	Severe	0-3 oz.	3-12 oz.	12 + oz.	0-3 oz.	3-12 oz.	12+ oz.
							lb.	lb.	lb.
Corrosive sublimate (cold)	240	0	0	107	133	0	13·4	45·7	0
Corrosive sublimate (hot)	241	4	0	107	138	0	14·0	52·0	0
Corrosive sublimate (1 : 40) (dip.)	229	20	0	98	151	0	14·7	59·5	0
Calomel (cold)	238	26	0	114	150	0	13·5	48·7	0
Calomel (hot)	238	31	0	103	166	0	7·7	84·0	0
Calomel (dip)	228	41	0	100	169	0	11·2	57·0	0
Formalin (cold)	231	34	0	113	152	0	8·5	50·3	0
Formalin (hot)	247	0	0	99	148	0	12·4	55·6	0
D. D. D. No. 76 Bel (dip)	251	40	0	103	188	0	11·6	70·5	0
D. D. D. No. 77 Bel (dip)	248	23	0	109	162	0	14·3	61·1	0
Semesan Bel (dip.)	252	20	0	118	154	0	11·0	65·4	0
Bayer Dipdust (dip)	257	22	0	97	182	0	12·7	56·2	0
Rhizoctonia-free seed untreated	1,521	25	0	570	976	0	60·6	298·1	0
Rhizoctonia-infected seed untreated	1,320	264	0	751	833	0	75·1	270·7	0

TABLE 76—RESULTS OF SEED POTATO TREATMENTS (FREDERICTON, N.B.), 1928

Rhizoctonia

Treatments	Disease Content			Number of Tubers			Weight of Tubers in Pounds					
	Free	Slight	Severe	0-3 oz.	3-12 oz.	12 + oz.	0-3 oz.		3-12 oz.		12 + oz.	
							lb.	oz.	lb.	oz.	lb.	oz.
Corrosive sublimate (cold)	224	1	0	85	139	1	5	10	44	0	0	15
Corrosive sublimate (hot)	203	5	0	88	117	3	7	3	39	8	2	7
Corrosive sublimate (1 : 40) (dip)	229	12	0	128	109	4	10	3	39	8	3	7
Calomel (cold)	200	35	0	117	117	1	10	0	41	0	0	13
Calomel (hot)	240	0	0	105	135	0	11	10	34	0	0	0
Calomel (dip)	227	1	0	95	130	3	7	11	43	8	2	9
Formalin (cold)	239	11	0	122	123	5	8	10	42	0	4	8
Formalin (hot)	143	40	0	91	90	2	7	0	31	8	2	6
D. D. D. No. 76 Bel (dip)	226	2	0	112	114	2	8	8	40	0	1	14
D. D. D. No. 77 Bel (dip)	178	2	0	83	93	4	6	10	33	0	3	8
Bayer Dipdust (dip)	204	10	0	95	119	0	8	0	36	0	0	0
Semesan Bel (dip)	211	4	0	88	122	5	7	3	41	0	4	1
Rhizoctonia-free seed untreated	1,782	204	0	1,041	945	0	80	9	316	0	1	5
Rhizoctonia-infected seed untreated	1,497	133	0	782	837	11	60	14	275	0	12	10

TABLE 77—RESULTS OF SEED POTATO TREATMENTS, (FREDERICTON, N.B.), 1928

Rhizoctonia

Treatments	Disease Content			Number of Tubers			Weight of Tubers		
	Free	Slight	Severe	0-3 oz.	3-12 oz.	12+ oz.	0-3 oz.	3-12 oz.	12 + oz.
	%	%	%	%	%	%	%	%	%
Corrosive sublimate (cold)	99·5	0·5	0	37·7	61·7	0·6	11·7	86·2	2·1
Corrosive sublimate (hot)	97·6	2·4	0	42·3	56·3	1·4	14·0	86·0	0
Corrosive sublimate (1:40) (dip)	95·1	4·9	0	53·6	45·2	1·2	18·5	74·1	7·4
Calomel (cold)	85·2	14·8	0	49·0	49·0	2·0	19·2	78·9	1·9
Calomel (hot)	100·0	0	0	43·7	56·3	0	26·0	74·0	0
Calomel (dip)	99·6	0·4	0	41·6	57·0	1·4	14·5	80·0	5·5
Formalin (cold)	95·6	4·4	0	48·8	49·2	2·0	16·0	75·0	9·0
Formalin (hot)	78·2	21·8	0	49·9	49·1	1·0	17·0	78·2	4·8
D.D.D. No. 76 Bel (dip)	99·2	0·8	0	49·2	50·0	0·8	15·6	80·5	3·9
D.D.D. No. 77 Bel (dip)	98·9	1·1	0	46·1	51·6	2·3	15·9	75·0	9·1
Bayer Dipdust (dip)	95·3	4·7	0	44·3	55·7	0	18·1	81·9	0
Semesan Bel (dip)	98·1	1·9	0	40·9	56·7	2·4	13·4	78·8	7·8
Rhizoctonia-free seed untreated	89·7	10·3	0	52·4	47·6	0	20·2	79·3	0·5
Rhizoctonia-infected seed untreated	91·8	8·2	0	49·5	49·7	0·8	17·4	78·8	3·8

SCAB INVESTIGATIONS

Experimental results of seed treatment as applied to scab control at Charlottetown were of little value and are omitted in this report. The land devoted to tests was unfavourable to the development of scab, and infection failed even in the checks of untreated diseased seed.

Future tests will be made on land having a soil reaction known to be more favourable to the occurrence of the organism responsible for common scab. It is intended also to investigate the possibilities of scab control by the addition of soil disinfectants in combination with fertilizer applications.

At Fredericton, cold corrosive sublimate gave 100 per cent control of scab (table 78). Semesan Bel and D.D.D. No. 77 Bel dips gave practically full control.

Compared with untreated scab-infected seed, hot formalin appeared the least effective. Hot corrosive sublimate gave excellent control and returned the most satisfactory yield. The lowest percentage of marketable tubers occurred in this instance. The greatest percentage weight of marketable tubers was obtained from sets treated with hot calomel (table 79).

CONCLUSIONS

While it is difficult to render an intelligent analysis of the foregoing results and designate the most efficient method of treatment, it is apparent, nevertheless, that the compounds containing organic mercury can be looked upon favourably. Corrosive sublimate undoubtedly is effective in controlling scab and *Rhizoctonia*, and has much to recommend its continued use as a seed potato disinfectant, provided the matter of compensating deterioration in solution is given due consideration.

TABLE 78—RESULTS OF SEED POTATO TREATMENTS, (FREDERICTON, N.B.), 1928

Scab

Treatments	Disease Content			Number of Tubers			Weight of Tubers		
	Free	Slight	Severe	0–3 oz.	3–12 oz.	12 + oz.	0–3 oz.	3–12 oz.	12 + oz.
	%	%	%	%	%	%	%	%	%
Corrosive sublimate (cold)	100·0	0	0	37·4	61·4	1·2	11·1	82·6	6·3
Corrosive sublimate (hot)	98·6	1·4	0	40·1	58·5	1·4	13·0	82·7	4·3
Corrosive sublimate (1:40) (dip)	95·7	4·3	0	26·0	71·3	2·7	6·7	85·0	8·3
Calomel (cold)	96·8	3·2	0	47·3	52·3	0·4	11·8	86·4	1·8
Calomel (hot)	98·6	1·4	0	27·5	69·7	2·8	5·6	87·4	7·0
Calomel (dip)	97·8	2·2	0	37·7	61·0	1·3	11·6	84·0	4·4
Formalin (cold)	89·0	10·0	1·0	35·8	62·8	1·4	10·4	83·5	6·1
Formalin (hot)	84·4	13·4	2·2	42·1	57·9	0	16·6	83·4	0
D.D.D. No. 76 Bel (dip)	93·5	5·7	0·8	43·8	55·8	0·4	13·7	84·6	1·7
D.D.D. No. 77 Bel (dip)	99·6	0·4	0	36·0	63·2	0·8	12·6	84·1	3·3
Bayer Dipdust (dip)	94·3	5·7	0	40·5	58·1	1·4	12·5	82·1	5·4
Semesan Bel (dip)	99·2	0·4	0·4	40·8	58·0	1·2	12·5	82·9	4·6
Scab-free seed untreated	96·7	3·1	0·2	38·9	60·3	0·8	13·1	84·1	2·8
Scab-infected seed untreated	78·6	18·1	3·3	37·3	61·4	1·3	11·8	83·3	4·9

TABLE 79—RESULTS OF SEED POTATO TREATMENTS, (FREDERICTON, N.B.), 1928

Scab

Treatments	Disease Content			Number of Tubers			Weight of Tubers		
	Free	Slight	Severe	0–3 oz.	3–12 oz.	12 + oz.	0–3 oz.	3–12 oz,	12 + oz.
							lb. oz.	lb. oz.	lb. oz.
Corrosive sublimate (cold)	235	0	0	88	144	3	7 2	51 8	3 13
Corrosive sublimate (hot)	270	4	0	110	160	4	9 2	57 0	3 3
Corrosive sublimate (1:40) (dip)	176	8	0	48	131	5	4 7	50 8	4 10
Calomel (cold)	239	8	0	117	129	1	12 3	42 0	0 13
Calomel (hot)	215	3	0	60	152	6	4 5	62 0	4 15
Calomel (dip)	230	6	0	89	144	3	8 1	58 0	2 12
Formalin (cold)	204	23	2	82	144	3	7 12	56 0	3 0
Formalin (hot)	232	37	6	116	159	0	8 14	44 8	0 0
D.D.D. No. 76 Bel (dip)	228	14	2	107	136	1	8 6	48 8	0 14
D.D.D. No. 77 Bel (dip)	229	1	0	83	145	2	7 11	53 0	1 13
Bayer Dipdust (dip)	219	13	0	94	135	3	7 3	45 8	2 10
Semesan Bel (dip)	245	1	1	101	143	3	8 2	52 8	2 8
Scab-free seed untreated	1,440	47	1	579	898	11	43 9	281 0	8 15
Scab-infected seed untreated	1,292	298	55	625	998	22	50 3	350 3	21 0

Summary of the Experiments in Connection with the Size of Potato Seed-Piece conducted at the Field Laboratory of Plant Pathology, Charlottetown, Prince Edward Island

This project was undertaken with Certified Irish Cobblers (from healthy, vigorous, and productive plants) to determine whether small sets could be used economically and with safety in the production of Certified Seed. Particular attention was paid to the presence or absence of virus diseases, it being known that plants thus affected are influenced to produce small potatoes.

The results obtained over a five-year period clearly indicate that small tubers (culls), weighing not less than 1½ ounces and planted whole, will return good crops. Whole tubers weighing 1½ ounces gave the best returns. Whole tubers weighing 2 ounces also gave satisfactory yields.

Yields were comparatively small from seed-pieces weighing 1 ounce and less. This disadvantage is not consistent with economy and good farming practice.

Virus diseases were not a limiting factor in these tests, despite the practice of selecting the culls for each year's seeding from the crop grown from culls the previous year.

In general there appeared to be a tendency towards the development of mosaic where sets of lighter weights were used, thus lending support to the belief that mosaic is more likely to occur when culls are used for seed continuously. However, the increase has not been sufficiently marked to confirm this. Undoubtedly, leaf roll and mosaic would have shown greater increase, had it not been for consistent roguing each year.

The Deterioration of Corrosive Sublimate in Solutions as applied to Treatment of Seed Potatoes in Prince Edward Island[1]

(R. R. Hurst and J. L. Howatt)

INTRODUCTION

Treatment of seed potatoes is considered essential in Prince Edward Island and is practised as a matter of routine by the great majority of potato growers.

Corrosive sublimate has been the standard disinfectant for many years, and, in spite of the recent introduction of some very promising compounds, continues in popular demand. Familiarity with the method involved and confidence in its fungicidal efficiency leave the farmers reluctant to accept new methods until we have shown to their satisfaction that the new compounds are better than the bichloride of mercury.

While it has been generally conceded that deterioration occurs in mercuric chloride solutions during seed treatment, and that it is necessary to make periodic additions of the chemical to the solutions, there is no satisfactory recommendation regarding the length of time it is advisable to use a solution.

The Dominion Botanist[1] drew attention to the fact that the mercuric chloride removed by potatoes during seed treatment reduced the strength of the solution 10 per cent for one treatment. Orton (4) stated that solutions in which potatoes were treated were reduced in strength one-fourth during one treatment, and recommended the addition of 1 ounce of mercuric chloride to each barrel of solution when one lot of potatoes had been treated. After three or four treatments the solution was to be discarded. Weimer (5) found that washed sweet potatoes and Irish potatoes remove approximately the same amount of mercuric chloride from the solution and that this reduction was due in part to the potatoes themselves. The writers (2) observed that the addition of ¼ ounce of

[1] Read at the Potato Association Meeting in New York, 1928. The bibliographical reference will be found at the end of the paper.

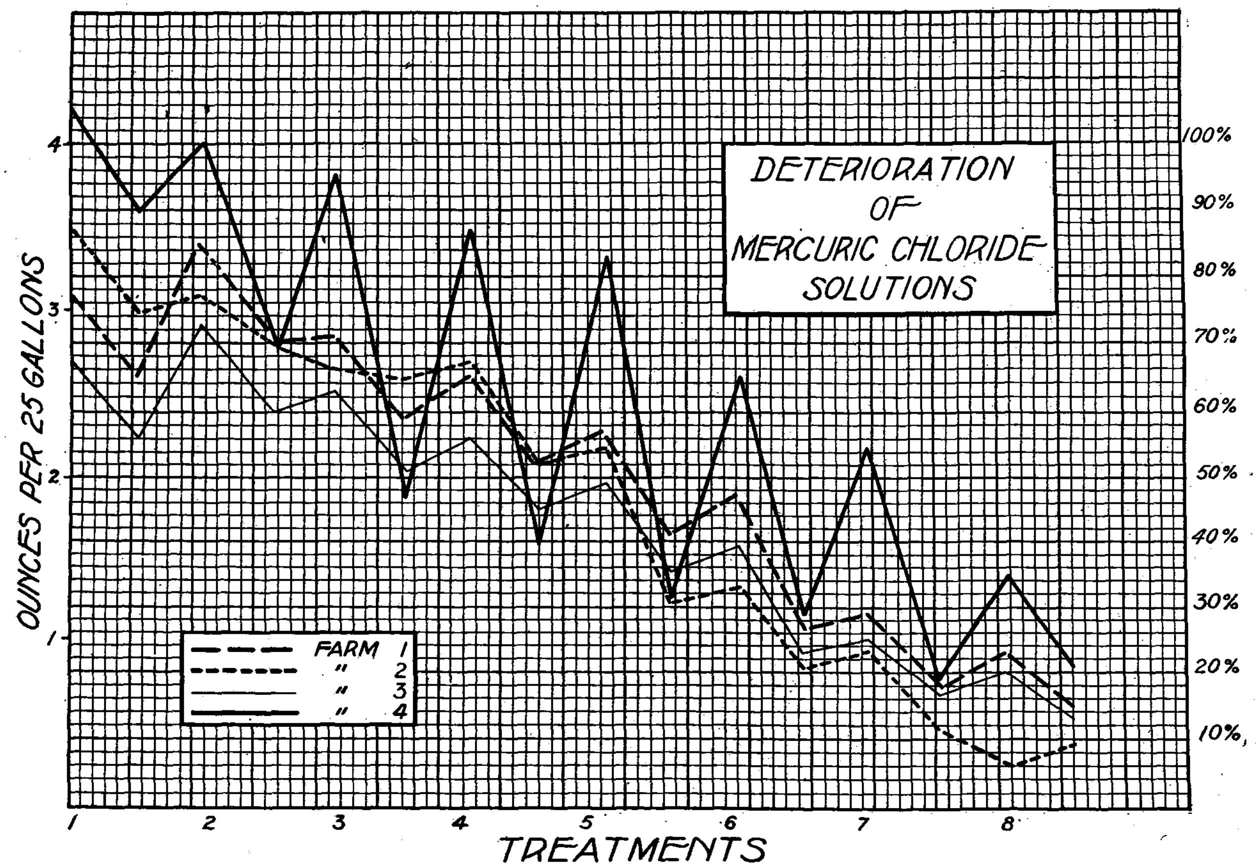


FIG. 30.—Illustrating the failure to overcome deterioration by adding ½ ounce of mercuric chloride after each treatment.

mercuric chloride after each treatment for 1½ hours not only failed to effect any benefit, but the solutions were of no fungicidal value after the first treatment (fig. 30).

The investigations reported in this paper deal with the reduction of mercuric chloride in solutions used for seed treatment of potatoes as practised in Prince Edward Island. The aim has been to detect any weakness in the method commonly followed and, if possible, to modify it to conform with the facts revealed. To this end the solutions examined were taken at farms where working conditions prevailed. In 1925 when these investigations were initiated, it was customary to soak the seed tubers for one and one-half hours in a solution of corrosive sublimate and water at the rate of 4 ounces of the chemical in 25 gallons, imperial measure. After each treatment ¼ ounce of corrosive sublimate was added to the original solution to compensate weakening sustained during the first soak, and the water was increased to its original volume. This was repeated usually until eight to ten lots were treated, when a new solution was prepared.

PROCEDURE AND METHODS

Samples of bichloride solutions were obtained at farms when seed treatment was in progress and were selected as follows: Original solution, after each treatment, and after the addition of each extra ½ ounce of bichloride (double the amount added in 1925). This was continued until eight lots were treated, making a total of sixteen samples from each farm. In 1928, the number of consecutive samples was reduced, representing fewer treatments, before a new solution was made up.

The analytical method employed in the years 1925 and 1927 was as follows:—

Mercuric mercury ($HgCl_2$) was precipitated by hydrogen sulphide (HgS) and filtered. The filtrate was caught on a tared filter paper, the whole dried, and the precipitate washed with carbon bi-sulphide, again dried, and finally weighed.

The mercuric sulphide (HgS) was then factored up to mercuric chloride ($HgS \times 1{\cdot}167 = HgCl_2$).

The method of determining mercuric chloride by titration against a standard potassium iodide solution was tested out but was too inaccurate to be of use in these investigations. The end point was too long, indefinite, and indistinct. The sodium arsenate iodine method offered the same drawbacks.

In 1928 the Jamieson (3) method was followed. This is based upon the precipitation of mercury from mercuric compounds in neutral or acid solutions with a reagent composed of 39 grams of ammonium thiocyanate and 29 grams of zinc sulphate per liter. The laboratory procedure was as follows:—

1. Take 100 ccs. of the mercuric chloride solution.
2. Add 25 cc. of the precipitating reagent.
3. Vibrate the beaker by striking the sides with a stirring rod to facilitate the separation of the crystals.
4. After 5 minutes stir briskly with a water moistened rod for 1 minute.
5. Let stand 1 hour.
6. Filter with gentle suction.
7. Wash 5 times with 5 cc. of the thiocyanate reagent in 450 cc. of water.
8. Place precipitate on filter paper in Erlenmeyer flask.
9. Add 45 cc. of hydrochloric acid composed of 35 cc. of HCl. and 10 cc. of water.
10. Add 6 to 7 cc. of chloroform.
11. Titrate partially with a solution composed of 19·2191 grammes of potassium iodide in 1000 cc. of water. (Shake well.)
12. Finish titration slowly with constant rotation of flask.

Disappearance of pink colour is the end point.

Duplicate tests were made from each sample, the average of these being given in the calculations.

RESULTS

The results of these investigations reveal some discrepancies in seed treatment in which corrosive sublimate is the disinfecting agent. It was shown that the periodic addition of ¼ ounce of corrosive sublimate was of no use, since the solution failed to increase in strength (fig. 30). In 1927 and 1928, ½ ounce was added after each treatment and a marked recovery resulted (figs. 31 and 32. This addition, however, did not maintain solutions at lethal strength, as will be seen later.

Figure 31 and table 80 illustrate the tendency in 1927 to prepare solutions below the required strength. In seeking explanation for this feature and the marked deterioration revealed by the analyses, it was recalled that, upon emptying the casks, a quantity of undissolved mercuric chloride had settled to the bottom and was, therefore, inactive. It is obvious that the water in which the chemical was dissolved was either not hot enough or the quantity was insufficient. It may have been that crystals were thrown down when the concentrated hot solution was added to the cold water in the cask. In 1928 the co-operating farmers were asked to treat only potatoes that were reasonably free from dirt and to exercise every possible care in preparing the solutions.

The analysis, represented in fig. 32, shows that the strength of the original solutions approximated to the requirements, and that the addition of ½ ounce of mercuric chloride prevented rapid deterioration.

TABLE 80.—DETERIORATION OF MERCURY BICHLORIDE SOLUTIONS

(A comparison of the results of analyses made in 1927 and 1928)

Treatment number and additional ½ oz. of $HgCl_2$	Farm number							
	1.		2.		3.		4	
	1927	1928	1927	1928	1927	1928	1927	1928
1	77·0	100·97	87·5	99·47	66·	101·51	104·6	103·90
½	64·45	73·08	74·6	95·81	56·	70·31	90·0	72·83
2	85·19	103·10	77·0	100·10	73·	93·64	100·0	87·29
½	69·35	73·11	70·0	92·07	62·	56·91	69·0	69·02
3	70·5	103·54	66·5	100·68	63·	94·10	94·7	82·45
½	59·5	72·92	64·1	59·87	51·	46·01	47·3	68·11
4	65·3	79·95	66·5	68·99	56·	76·49	87·3	72·18
½	52·5	44·10	52·5	61·35	45·	36·10	39·1	55·91
5	57·1	52·45	54·5	....	49·	....	81·8	....
½	40·8	....	31·2	....	35·	....	31·0	....
6	46·6	....	35·0	....	40·	....	65·0	....
½	26·8	....	20·5	....	23·	....	28·1	....
7	29·1	....	22·6	....	25·	....	56·3	....
½	18·6	....	12·0	....	16·	....	19·2	....
8	23·3	....	23·0	....	20·	....	35·0	....
½	15·1	....	8·2	....	13·	....	21·3	....

In seeking further explanations for the deterioration, tests were made in which impurities were added to mercuric chloride solutions. They were then analysed and the percentage decrease in strength calculated. Five grammes per liter of each of the following were added to as many solutions containing 1 gramme of mercuric chloride in 1000cc. of distilled water:—

Dry soil (air dried and screened).
Wet soil (from experimental plots).
Potato juice (from crushed potatoes).
Potato discs (cut with cork borer and sliced ⅛ inch thick).

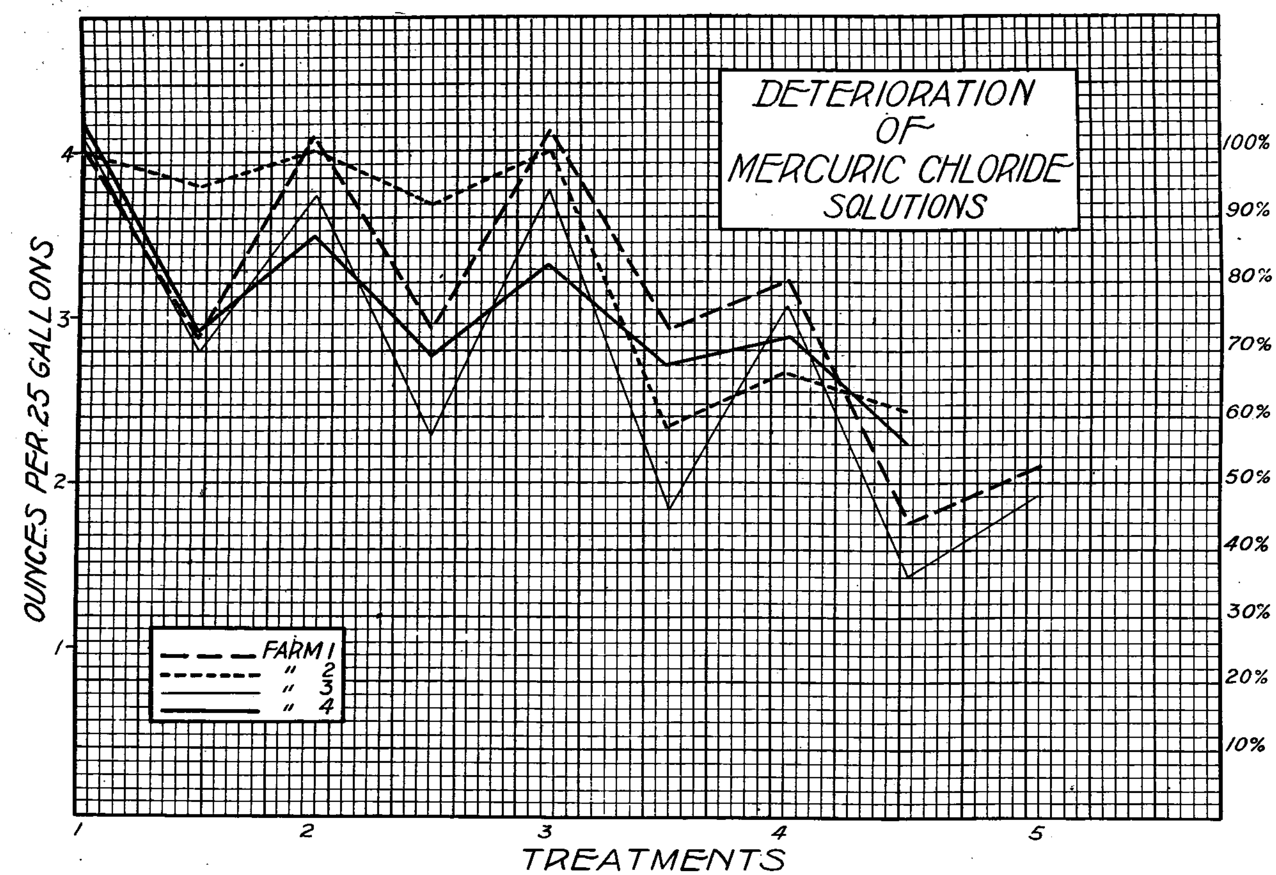


FIG. 31.—Illustrating the tendency for original solutions to be under strength when not carefully prepared.

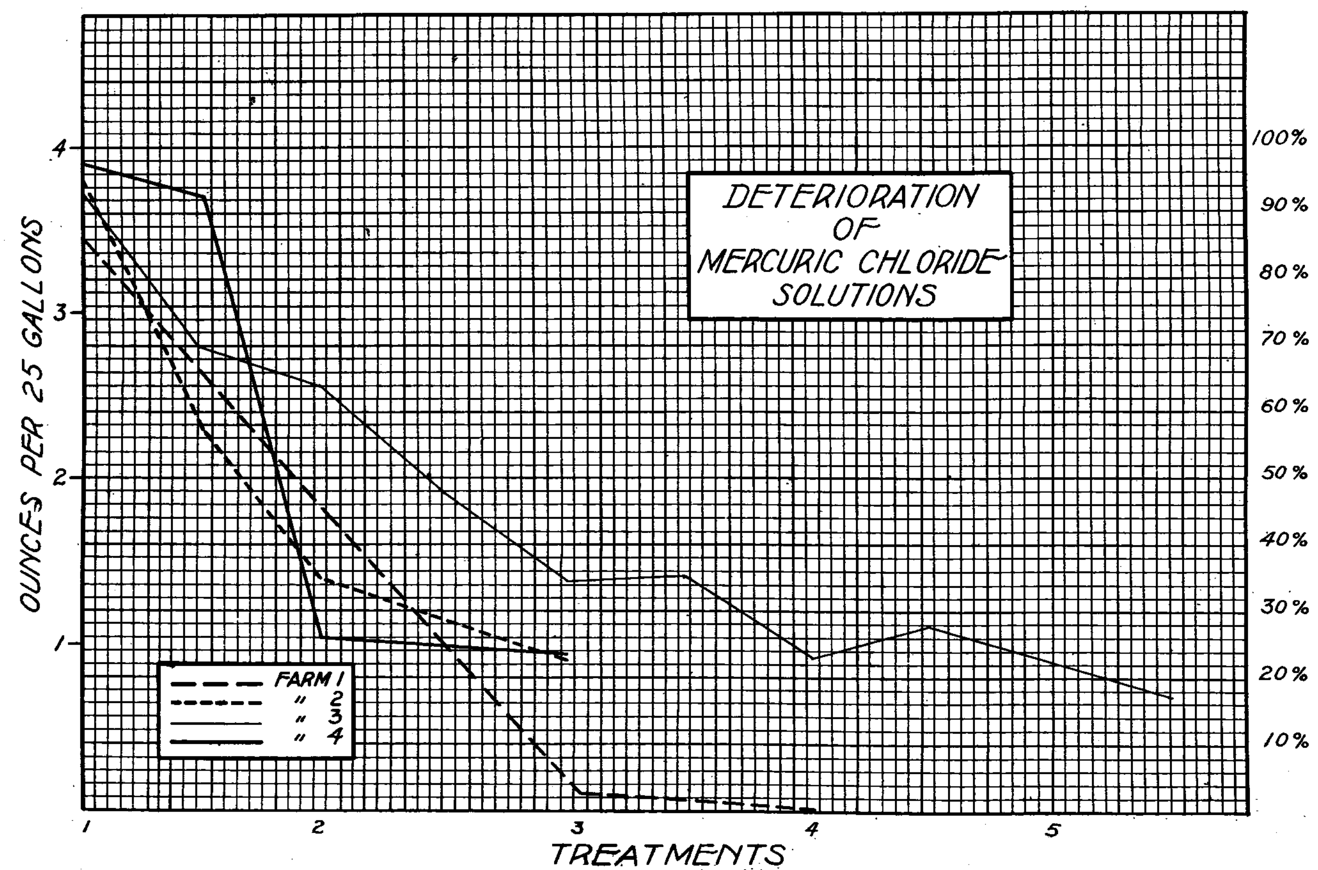


FIG. 32.—Illustrating the tendency to maintain the strength of the original solutions by the addition of ½ ounce of mercuric chloride and the exercising of care in preparing solutions.

The solutions containing these impurities were agitated for five minutes and allowed to stand 1½ hours, immediately after which the analyses were made.

Figure 33 illustrates the nature of the deterioration as it occurred in this instance.

Potato juice caused the greatest reduction by removing approximately 11 per cent of mercuric chloride. Potato discs caused a 10 per cent reduction, damp and dry soil approximately 7 and 6 per cent respectively. It is evident from the results that impurities such as these are important factors in the treatment of seed potatoes by mercuric chloride solutions.

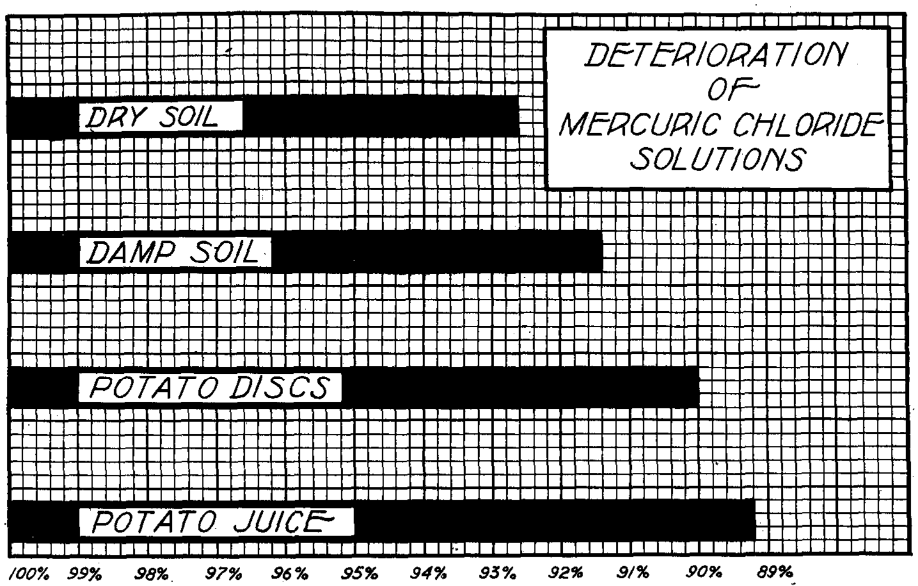


FIG. 33.—Illustrating the effect of impurities upon mercuric chloride in solution.

The Effect of Corrosive Sublimate in Solution upon the Viability of *Rhizoctonia* Sclerotia on Potatoes

The foregoing observations suggest the question of determining the number of times a solution should be used for seed treatment when adding ½ ounce of corrosive sublimate after each soak. In other words, how many bushels of potatoes is it possible to treat in this manner before this solution will be rendered ineffective? A point of contact was found in laboratory tests, whereby potato tubers infected with *Rhizoctonia* were treated in solutions containing corrosive sublimate giving the strengths representing the deterioraton observed in seed treatment, and illustrated in figures 31 and 32. Solutions containing corrosive sublimate were made up in double distilled water, at laboratory temperature of approximately 15° C. The strengths ranged from 1-1000 (4 ounces to 25 gallons) to 1-20000.

Potatoes bearing *Rhizoctonia* sclerotia were then immersed in these solutions as follows:—

1. Corrosive sublimate (cold), 1½ hours.
2. Corrosive sublimate (cold), 1½ hours, but presoaked 24 hours.

After treatment half of the tubers were placed in moist chambers. From the remainder, sclerotia were removed with a sterile scalpel and placed in culture plates containing potato dextrose agar. Realizing the probability that the effect of treatment is governed partially by the size of sclerotia, both small and large sclerotia were selected for culture plating, these being in diameter approximately ½ and 3 millimetres respectively. It will be seen from the results shown in table 81 that viability of large sclerotia occurred on tubers treated in dilutions lower than and including 1-1250. One per cent viability occurred in the treatment of 1-1000. All small sclerotia were generally killed at 1-1300 (3 ounces to 25 gallons).

TABLE 81.—VIABILITY OF *Rhizoctonia* Sclerotia SOAKED IN DIFFERENT SOLUTIONS OF COLD CORROSIVE SUBLIMATE OF DIFFERENT STRENGTHS FOR 1½ HOURS

Dilution strength of solution	Percentage strength of solution	Percentage Viable Sclerotia				Ounces per 25 gallons
		Pre-soaked 24 hours		Not pre-soaked		
		Large	Small	Large	Small	
1-1000	100	0	0	....	....	4
1-1052	95	0	0	1	0	
1-1100	90	0	0	0	0	
1-1177	85	1	0	1	0	3½
1-1250	80	1	0	2	0	
1-1330	75	1	0	7	0	3
1-1428	70	5	1	10	1	
1-1536	65	10	1	10	1	
1-1666	60	28	15	30	20	2½
1-1818	55	39	32	60	48	
1-2222	50	60	40	62	60	2

It is also shown that premoistening rendered sclerotia more susceptible, inasmuch as there was no viability at 1-1000, and fewer were viable after treatment in the various solutions.

In considering the significance of these observations it must be noted that the temperature of the solutions was at no time higher than 15° C., which is higher than the average temperature existing under practical conditions. Furthermore, the effect of treatment would be influenced by the size and texture of sclerotia and whether or not the tubers were moistened before treatment. In this case the tubers not presoaked were treated as they were removed from storage without being moistened.

PRACTICAL APPLICATIONS

(1) It can be seen from the foregoing that solutions should be discarded when reduced to 1-1250, or after the third or fourth soak. The additional ½ ounce of corrosive sublimate after that period is wasted and should be employed in making up original solutions.

(2) Moistening the potatoes before soaking is an aid in seed treatment. It permits of sclerotia being more easily killed, and the solution may be used four times before renewal.

(3) Corrosive sublimate in solution being affected by impurities, such as soil and the juice from broken potatoes, it is essential to observe every precaution to prevent the occurrence of such factors.

(4) Changing the solution into a clean cask and removing all dirt and sediment from the one used previously will prevent much deterioration.

(5) The corrosive sublimate must be dissolved thoroughly, otherwise a portion will settle to the bottom of the cask and remain undissolved.

(6) Instances of solutions being above strength were largely due to inaccuracies, either in weighing the chemical or measuring the water, or both. This might also partially account for so many original solutions being below strength.

(7) The question of adding more than ½ ounce involves further study. Possibly the greater efficiency obtained would be at the expense of tubers treated.

(8) One of the greatest difficulties confronting the farmer in applying the mercuric chloride method is lack of a suitable means for weighing the salt. At the best he can arrive only at approximations. Manufacturers would render valuable aid by providing the mercuric chloride in tablet form along with printed instructions for its use as applied to treatment of seed potatoes.

REFERENCES

1. Dominion Botanist's Report, 1912; 201-202.
2. Dominion Botanist's Report, 1925; p. 23.
3. Jamieson, George S. The Gravimetric and Volumetric Determination of Mercury Precipitated as Mercury Zinc thiocyanate. Jour. Indus. Engin. Chem. XI (4); pp. 296-297, 1919.
4. Orton, W. A. Selection and Treatment of Seed Potatoes to Avoid Diseases. U.S. Dept. Agric. Cotton, Truck, and Forage Crop Disease Investigations, Circ. 3, 1919.
5. Weimer, J. L. Jour. Agr. Research, XXI (8); pp. 575-587, 1921.

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

(D. J. MacLeod, Officer in Charge)

The year was one of continued progress, notwithstanding that certain important lines of endeavour were seriously interrupted by the unfortunate illness of the assistant pathologist, which prevented him from pursuing his duties after April 16. The problems thus temporarily discontinued will be resumed as soon as adequate assistance is again provided.

This laboratory was represented at a conference of plant pathologists, in charge of laboratories in the Maritime Provinces and Quebec, held at Charlottetown during the month of May. At this meeting, plans were arranged for a greater measure of co-operation, co-ordination, and concerted attack on broad problems than formerly, as well as a better dissemination of information as to the progress of current investigations. It was also agreed to allocate general supervision of problems relating to diseases of certain plants or groups of plants to each of the laboratories represented. This laboratory was assigned supervision of problems bearing on potato diseases.

Interest in the activities of the laboratory is becoming more apparent from year to year as evidenced by an increase in the number of visitors and requests for information. This interest is not purely of a domestic nature for there have been demands from a number of outside sources for miscellaneous information and pathological specimens.

During the year over a hundred specimens were received and examined in the laboratory. Many of these were sent by correspondents, and their identification and control measures, when desirable, were returned by mail. Cultural studies have been made for the determination of the cause of the disease in such instances as demanded the same. Specimens of fungi and pathological material collected were preserved in herbarium packets, and typical specimens of important diseases have been placed in glass museum jars for display purposes in the laboratory. This material will be increased as typical specimens are obtained.

Six articles on potato diseases and related subjects were prepared during the year. These appeared in various periodicals in Eastern Canada, in "Seasonable Hints," and in the "American Potato Journal." In addition, six addresses on timely subjects were broadcast through Radio Station C.F.N.B. during the summer months. Also, addresses on potato diseases were given at the meetings of the provincial Seed Board held at Moncton and Bathurst in March. Futhermore, a paper on "Bliss Triumph growing in New Brunswick," collaborated upon with Mr. C. H. Godwin, District Seed Potato Inspector, was read before the annual meeting of the Potato Association of America held at New York in December.

Four bulletins incorporating the results of investigations carried on for five seasons are now in course of preparation.

An effort was put forth to continue accurate and systematic observations on the important diseases occurring. The value of such observations is increasingly apparent; and there are clear indications that the steadily accumulated results of this plant disease survey are yielding information not only of scientific interest but of practical value to growers.

The prevalence of plant diseases was approximately normal. Late blight of the potato was less severe than during the previous season. Initial conditions in certain sections were conducive to the development of the disease in epidemic form, but, later in the season, changes in the weather suppressed it. Indications are, however, that there will be potential losses in storage as a result of this disease. Early blight of the potato was generally distributed throughout the Province, but created only slight damage. There was a slight increase in the amount of common scab and *Rhizoctonia* occurring. Blackleg showed a marked decrease and did not appear until late in the season. Such late manifestation is, however, to be feared, for there is greater possibility of infected tubers being admitted into storage under such conditions. The mosaic, leaf roll, and spindle tuber situations showed a decided improvement over the previous year, which seems to indicate that these diseases are yielding well to certification methods. Clubroot of turnips was generally severe. Apple scab manifested no increase over previous seasons, and appeared slightly earlier than usual. Bacterial wilt of cucumbers reached epidemic proportions during the latter part of the season in certain sections of the Saint John valley. *Verticillium* wilt of maples caused considerable damage to trees used for ornamental purposes, particularly in western New Brunswick. An undetermined disease of willows continued its ravages and destroyed many trees in the southern part of the province. Rusts and smuts of wheat and oats were not of serious consequence this season.

MILD AND RUGOSE MOSAIC

In 1924 a study was undertaken to obtain practical information concerning the distinct types of mosaic occurring in the province. This study was considered necessary in order to ascertain the local modes of transmission of these diseases, their respective effects upon plants, extent of their occurrence, and to become familiar with their varied manifestations as influenced by different environmental conditions. For the purpose of investigation, specimens of mosaic-infected potatoes of the three commercially grown varieties were collected in various sections of the province. These were grown under specially constructed cotton-covered cages to preclude any possibility of contamination with other virus diseases capable of transmission by insects. These different specimens were kept under careful observation during the growing season of each year, and necessary precautions were taken to protect them from early and late blight diseases. The different forms collected were compared from time to time with distinct types of the disease, described by other investigators, specimens of which were very courteously supplied by Doctors E. S. Schultz and D. Folsom, pathologists with the United States Bureau of Plant Industry and the State of Maine Experiment Station, respectively. These observations revealed that there are two types of mosaic of economic importance in this province, viz., mild and rugose. The former is characterized by a slight dwarfing of the entire plant, distinct mottling, accompanied by abnormal unevenness (ruffling) of the leaf surface and waviness of the leaf margin. No tuber symptoms are evident, except a gradual average reduction in size from year to year.

The characteristic symptoms of rugose mosaic on the other hand consist of distinct dwarfing, mottling of a more diffuse type, and extreme unevenness (rugosity) of the leaf surface, with a tendency to manifest brittleness, necrotic streaks or spots, dropping of the lower leaves, and premature death of the plant. There are also no tuber symptoms, excepting a more marked reduction in size from year to year.

FIG. 34.—Green Mountain plant infected with mild mosaic.

Efforts to transmit these diseases by insects showed that both types of mosaic can be carried from diseased to healthy plants by aphids. Observations covering a period of four seasons revealed that *Macrosiphum solanifolii, Myzus persicae,* and *Aphis abbreviata* are chiefly responsible for the dissemination of these diseases in this province. Negative results were found with Colorado beetle (*Leptinotarsa decemlineata* Say), flea beetle (*Epitrix cucumeris* Harris), margined blister beetle (*Epicauta marginata* Fabr.), potato stem borer (*Gortyna micacea* Est.), four-lined leaf bug (*Poecilocapsus lineatus* Fabr.), potato leaf hopper (*Emposca mali*), and seed corn maggot (*Phorbia fusiceps* Zett). Transmission of these types of mosaic was also effected by introducing infected juices by leaf mutilation, tuber graft, and hypodermic injection methods. Rugose mosaic was more readily transmitted than the mild type. Attempts to transmit these types by seed-piece, root, and vine contact, cutting knives, and mechanical planter were unsuccessful.

A study of the effect of environmental factors on symptom manifestation, revealed that the type of soil, soil moisture, and soil temperature are not closely associated with symptom variation in these types of mosaic under local conditions. On the other hand, observations under both greenhouse and field conditions indicated that the effect of air temperature, moisture, and sunlight was quite pronounced. Almost complete disappearance of mottling occurred in the case of mild mosaic at dry temperatures over 80° F. with bright sunlight. At lower temperatures, with more moisture and subdued sunlight, the characteristic symptoms of the mild form were more pronounced. In the case of rugose

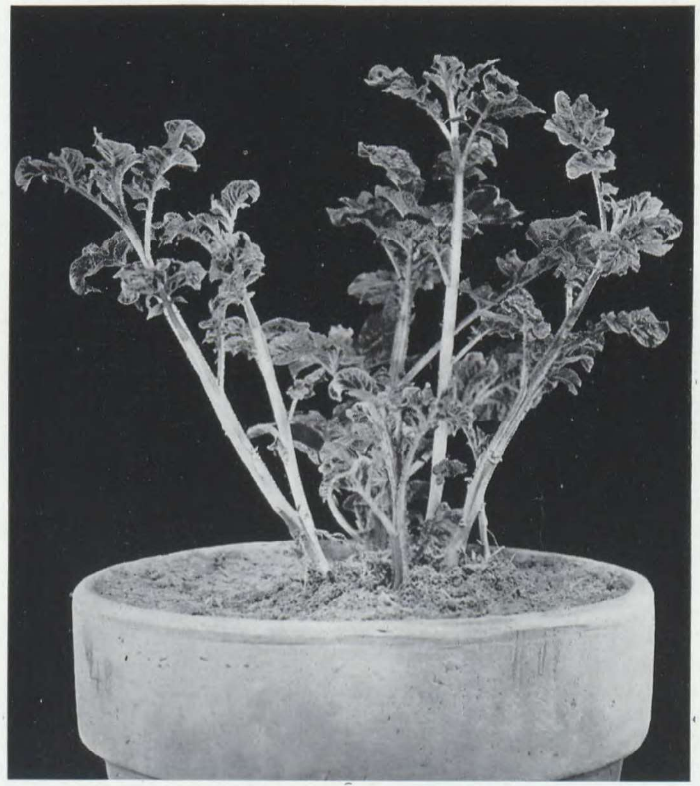


FIG. 35.—Green Mountain plant infected with rugose mosaic.

mosaic, the mottling was not changed to any appreciable extent by high and dry temperatures, but the unevenness (rugosity) of the leaf surface, brittleness, and leaf dropping appeared to be less in evidence under extremely cool conditions.

The results of intervarietal inoculations demonstrated that mild and rugose mosaic with certain varietal modifications of symptoms, occur in the three varieties tested, viz., Green Mountain, Irish Cobbler, and Bliss Triumph. In the case of Irish Cobblers there was observed an unusual masking of symptoms of mild mosaic, which renders detection of this form of the disease quite difficult in this variety. Such behaviour, it is believed, incidentally creates undesirable sources of infection from which this form of the disease can be readily disseminated. In the Bliss Triumph variety symptoms of both forms of mosaic were even more pronounced than in either of the other two varieties tested.

An investigation of the effects of both types of mosaic on different strains of Green Mountain, Irish Cobbler, and Bliss Triumph varieties, showed that mild mosaic, as its name implies, is not as destructive as the rugose type, and may cause only slight reduction in yield for the first two or three seasons. Our observations indicate that it reduces the yield rate from 10 to 30 per cent the first season. As a rule, however, this reduction does not increase to an appreciable extent in the second and third seasons. This type of mosaic requires from four to five seasons or more to render an average strain of potatoes unproductive. Rugose mosaic is much more destructive and reduces the yield rate from 35 to 60 per cent the first season. It is capable of rendering an average strain of potatoes unproductive in two or three seasons.

Mild mosaic appears to be a distinct type which does not ultimately change into another form. This is substantiated by the fact that specimens of this type of disease have maintained their identity, without appreciable symptom variation, for five seasons under caged conditions. Rugose mosaic is also believed to be a distinct type, but this disease behaved rather inconsistently at times, under low temperature conditions. It thrives best undoubtedly at high temperatures, while mild mosaic seems to develop more favourably at low or moderately low temperatures.

No strains of the varieties of potatoes tested were found to be immune to either of these two types of disease. Irish Cobblers seemed to manifest a higher degree of resistance than Green Mountains, and Bliss Triumphs appear to be the most susceptible of these three, commonly grown varieties.

With respect to the extent of occurrence of these diseases, a fairly extensive survey of the province shows that mild mosaic is much more prevalent than the rugose type; which seems to indicate that the latter is not to be feared as a serious limiting factor in potato production, under our conditions.

Both types of the disease yield quite favourably to control measures, such as roguing of diseased plants as soon as they appear, and exclusive use of Certified Seed. Our experiments also demonstrated that it is quite necessary to destroy all diseased plants, immediately upon their removal, in order to prevent aphids from transmitting the diseases from these to healthy plants. Such plants should be removed from the field in some conveniently carried insect-proof container. Our observations, moreover, showed that the presence of certain ordinary weeds, such as quack grass, curled dock, lamb's quarters, shepherd's purse, and buttercup, rose bushes, buckthorn, and even cultivated buckwheat, serve as breeding grounds for different species of aphids which are capable of disseminating these diseases.

Other forms of virus diseases, designated by investigators elsewhere, as leaf-rolling mosaic, curly dwarf, etc., occur to a minor extent, and were given some consideration. It is believed that these are disease complexes, in which one or the other types of mosaic may be involved. Inasmuch, however, as the information at hand concerning these forms is considered insufficient, they will not be reported upon until a later time.

EFFECT OF CERTAIN VIRUS DISEASES ON THE RATE OF GERMINATION IN POTATOES

While experimenting during the past four years with certain virus diseases of the potato, evidences were observed, from time to time, of variations in the rate of germination in tubers affected with certain types of these diseases. Consequently, it was considered of interest to devote some attention to this matter, in order to obtain any interesting and useful information which would form a humble accretion to the large body of knowledge already accumulated concerning these destructive diseases.

For the purpose of this experiment, germination tests were conducted in the laboratory on tubers affected with the following diseases: mild and rugose mosaic, leaf roll, and spindle tuber. The tubers chosen were uniform in size, about 6 ounces in weight, of the same variety and strain, and definitely known to be affected with only one of the virus diseases already mentioned. The Green Mountain variety was used throughout. These germination tests were performed on tubers taken from strains of potatoes which were affected with the disease, in each case, for one and two seasons respectively. A number of healthy tubers were used as checks. All tubers used for the experiment were taken from plants of the same age, all of which were grown under caged conditions to obviate any possibility of contamination with other virus diseases. All these tubers were harvested on the same day. Subsequent to digging time, all tubers under consideration were placed in a storage cellar and kept there during the dormant period of four months; at the expiration of which time they were brought to the laboratory for the germination tests. Observations on these were recorded at the end of five months. During the time these germination tests were carried out, the various tubers used in connection with the experiment were kept in the dark, at temperatures ranging from 15° to 25° C.

The following tables embody the results obtained in each case:—

TABLE 82.—GERMINATION TESTS.—MILD MOSAIC

Affected with disease, one season		Affected with disease, two seasons	
Tuber number	Length of sprouts in inches	Tuber number	Length of sprouts in inches
1	½	1	2
2	¾	2	1½
3	3	3	1
4	1	4	½
5	1½	5	3
6	½	6	2
7	2	7	1½
8	2	8	1½
9	1½	9	1¾
10	2½	10	2
11	3	11	½
12	2¼	12	¾
13	1½	13	1
14	2½	14	2
15	½	15	¾
16	1	16	¼
17	2½	17	2½
18	3	18	2
19	1	19	2¼
20	¾	20	1½

TABLE 83.—GERMINATION TESTS.—RUGOSE MOSAIC

1	1½	1	No sprout
2	½	2	No sprout
3	2	3	¼
4	¾	4	1
5	No sprout	5	¾
6	1	6	2
7	1½	7	1½
8	1¾	8	1
9	2	9	No sprout
10	1	10	1/8
11	1¼	11	½
12	1¼	12	1
13	2	13	¾
14	1¾	14	No sprout
15	1¾	15	1¼
16	¾	16	¼
17	2½	17	No sprout
18	No sprout	18	1½
19	1/8	19	No sprout
20	No sprout	20	¾

TABLE 84.—GERMINATION TESTS.—LEAF ROLL.

Affected with disease, one season		Affected with disease, two seasons	
Tuber number	Length of sprouts in inches	Tuber number	Length of sprouts in inches
1	2	1	1½
2	2	2	No sprout
3	1½	3	1¼
4	1¾	4	2
5	½	5	2
6	1	6	¾
7	2	7	2
8	3	8	1¾
9	2½	9	1¼
10	¾	10	½
11	2	11	1
12	1½	12	2½
13	1	13	1¾
14	1	14	1½
15	2½	15	1½
16	1½	16	1
17	1¼	17	1¼
18	1	18	2
19	½	19	1
20	2	20	¾

TABLE 85.—GERMINATION TESTS—SPINDLE TUBER

1	1¼	1	No sprout
2	1/8	2	1/8
3	½	3	1/16
4	No sprout	4	No sprout
5	No sprout	5	No sprout
6	¼	6	½
7	No sprout	7	1¼
8	No sprout	8	No sprout
9	¾	9	No sprout
10	No sprout	10	No sprout
11	1/16	11	No sprout
12	1/8	12	1/8
13	1½	13	1/8
14	1/8	14	¾
15	No sprout	15	No sprout
16	No sprout	16	No sprout
17	1¾	17	No sprout
18	No sprout	18	1/8
19	1/8	19	½
20	½	20	¼

TABLE 86.—GERMINATION TESTS.—HEALTHY (CHECKS)

1	2	21	3
2	2½	22	2½
3	2½	23	3¼
4	1¾	24	2
5	3	25	2¼
6	3½	26	1½
7	2	27	2½
8	1½	28	3
9	2	29	2
10	1¾	30	3½
11	2¼	31	1½
12	2½	32	1¾
13	2	33	2
14	2¾	34	2¼
15	3	35	2½
16	3½	36	2½
17	2½	37	2¾
18	2¾	38	3
19	2	39	2¼
20	1	40	2½

The foregoing results warrant the following deductions. Mild mosaic, whether of one or two seasons' duration, did not seem to have an appreciable effect on rate of germination. Rugose mosaic, however, appeared to affect rate of germination to a considerable extent even during the first season of attack and caused extreme retardation during the second season of infection. With respect to leaf roll, there was but slight evidence of retardation of germination in tubers affected with the disease for both one and two seasons. In the case of spindle tuber, moreover, there was evidence of an appreciable retarding effect on rate of germination in tubers thus affected for a single season, and extreme suppression of germination in tubers so infected for two seasons. This is confirmed by the large number of tubers affected with this disease which failed to germinate and the diminutive sprouts occurring on the vast majority of other tubers included in the spindle tuber test. Therefore, it appears that among the different virus diseases tested, and so affected for one and two seasons, with respect to their effect on rate of germination in tubers, rugose mosaic and spindle tuber, particularly the latter, cause the greatest degree of retardation.

The retarding effect on germination thus brought about by spindle tuber, in particular, as evinced by this experiment, is believed to be responsible in considerable measure for the occurrence of so-called "weak plants", which frequently appear in commercial fields of potatoes. This is substantiated by the fact, that of upwards of 200 such plants* kept under observation for two seasons, approximately 25 per cent were found to be affected with spindle tuber. Only thirteen per cent of these weak plants were affected with other virus diseases. In so far as the balance were concerned, the cause of their apparently retarded condition could not be determined.

Our observations also revealed that, while rugose mosaic is very destructive, it is not prevalent in this province, for which reason the disease is considered of no serious consequence as a limiting factor in potato production. On the other hand, however, our observations and results disclosed the fact that spindle tuber is not only one of the most destructive diseases of the potato now contended with in this province, but is sufficiently prevalent to bring about appreciable reduction in potato production.

BEST SPACING OF POTATO PLANTS FOR THE PRODUCTION OF CERTIFIED SEED

This experiment, as conducted over a period of three seasons, yielded useful information concerning the merits of close as opposed to wide planting in the production of the greatest amount of tubers commensurate with the weight required by the Dominion standards for certification.

While these results gave evidence of useful possibilities, they were not considered sufficiently conclusive to warrant definite recommendations. Therefore, in order to secure further practical information along these lines, the experiment was repeated in 1928 in exact accordance with the method carried out during previous seasons. The results obtained are included in the following table.

* Plants affected with *Rhizoctonia* were not considered.

TABLE 87—BEST SPACING FOR PRODUCTION OF CERTIFIED SEED*

Green Mountain

Spacing Interval	Yield per row in pounds			Yield per acre in barrels		
	Under 3 oz.	3–12 oz.	Total	Under 3 oz.	3–12 oz.	Total
	lb.	lb.	lb.	barrels	barrels	barrels
6 inches	39·5	103·0	142·5	59·2	154·5	213·7
8 "	32·0	81·0	113·0	48·0	121·5	169·5
9 "	29·2	103·0	132·2	43·8	154·5	198·3
10 "	32·7	94·4	127·1	49·0	141·6	190·6
12 "	30·7	95·4	126·1	46·0	143·1	189·1
14 "	28·7	87·0	115·7	43·0	130·5	173·5
Irish Cobbler						
6 inches	43·2	81·0	124·2	84·8	121·5	206·3
8 "	38·5	68·4	106·9	57·7	102·6	160·3
9 "	34·2	65·4	99·6	51·3	98·1	149·4
10 "	29·2	64·4	93·6	43·8	96·6	140·4
12 "	30·5	72·4	102·9	45·7	108·6	154·3
14 "	27·2	75·0	102·2	40·8	112·5	153·3

* The tabulated data represent the average results from duplicated plots.

While there are certain discrepancies in the foregoing results due to influencing factors incapable of being controlled under ordinary field conditions, they corroborate in considerable measure those obtained from previous experiments, further demonstrating that close as opposed to wide spacing produces a much cleaner crop, and a larger amount of tubers ranging from 3 to 12 ounces, thereby enhancing their eligibility for certification. In addition these results show that there is brought about an increase in the total yield in each case when the size of the spacing interval is decreased.

The marked consistency existing among the results of four seasons' efforts now definitely warrants a strong recommendation of the practice of planting potatoes, intended for certification, as close as is consistent with efficient roguing methods. Spacing intervals from 10 to 12 inches are recommended.

THE USE OF GYPSUM FROM LOCAL DEPOSITS IN THE CONTROL OF POTATO SCAB

Actinomyces scabies (Thaxt.) Güssow

Although the value of agricultural gypsum as a preventive of common scab of the potato has been known for over a decade, this mineral was not used to any great extent for this purpose in New Brunswick until two or three years ago, when deposits which gave promise of yielding considerable quantities of the mineral were found in certain parts of the province. In view of this, certain enterprising individuals, in the hope of developing these deposits and finding some beneficial use for their product, requested that the efficacy of this gypsum in the control of common scab of the potato be investigated.

Accordingly, in 1928, a quantity of gypsum from deposits in Victoria county was obtained for this object. Five one-hundredth-acre plots, in quadruplicate, on soil of average fertility and as uniform as possible, were arranged for the purpose of the experiment. These received varying applications of gypsum at the rate of 500, 1,000, 1,500, and 2,000 pounds per acre, respectively. Four plots which received no application of gypsum served as checks. The gypsum applied in each case was broadcast by hand, and then thoroughly mixed with the soil to a depth of ten inches, in order to insure uniform distribution of the mineral in each plot. Scabby, but otherwise healthy, potatoes of the Green Mountain variety were planted in each of these plots. These were given necessary attention during the growing season, for prevention of foliage diseases and control of insect pests.

At harvesting time samples of soil were taken from each of the plots at a depth of 8 inches, and the percentage of common scab occurring in each case was recorded. The hydrogen-ion concentration of the several soil samples collected was determined by the colorimetric method, using Clark and Lubs (Clark 1920) colour chart and standard buffers.

The following table embodies a list of the different rates of treatment, and results recorded at digging time.

TABLE 88.—GYPSUM AS A CONTROL FOR POTATO SCAB, *Actinomyces scabies* (THAXT.) GÜSSOW

Plot Number	Rate of application of gypsum	Hydrogen-ion concentration in terms of pH	Percentage of common scab*
			%
1	500 pounds per acre	6·34	3·78
2	1,000 " "	6·30	2·56
3	1,500 " "	6·32	2·94
4	2,000 " "	5·88	2·02
5	No treatment (check)	6·62	4·55

* These are the average results from plots in quadruplicate.

These results demonstrate in some measure that the gypsum used produced, when applied at maximum rates in particular, unfavourable conditions for the growth of the scab organism. This is indicated by the fact that slightly less scab developed in the plots receiving heaviest applications of the mineral. Correlated with this apparent suppression of activities of the scab organism, particularly in the plot receiving heaviest application, one finds the soil acidity of this plot, as expressed in terms of hydrogen-ion concentration, was increased to 5·88. This increase in soil acidity brought about by heavy application of gypsum approaches the point of inhibition of growth of the scab organism, which is considered to be approximately pH 5·0 to 5·2. This is responsible in some measure, undoubtedly, for the reduction in amount of common scab developing in this plot.

While the results of this preliminary investigation are not sufficiently conclusive to warrant definite recommendations, they are suggestive at least of possibilities in the direction of some value in the use of gypsum from certain local deposits, in the control of common scab of the potato. In view of this, the project will be continued another year.

THE EFFECT OF FUNGICIDES WITH HIGH LIME CONTENT ON SOIL REACTION

During the past five years certain enterprising growers in this province have been using copper-lime dusts and Bordeaux spray mixtures which contained exceedingly high proportions of hydrated lime. Such formulae, as 20-80, 15-85, and 10-90 for dusts, and 6-8-40 and 8-10-40 for Bordeaux mixture, were employed from time to time.

While no ill effects from the use of these mixtures with increased amounts of lime were brought to our attention, the question arose with regard to the probability of fungicides bearing such high lime content, increasing the alkalinity of the soil sufficiently to predispose to the occurrence of potato scab, *Actinomyces scabies* (Thaxt.) Güssow.

Therefore, in order to determine whether or not the application of these fungicides brought about such undesirable changes in the reaction of the soil, a number of one-fortieth acre plots, on soil of average fertility and uniform throughout, were treated with copper-lime dust and liquid Bordeaux, bearing different and extreme percentages of lime. Six applications of fungicide were given in each case. Scabby but otherwise healthy potatoes of the Green Mountain variety were used for seed.

At digging time soil samples were taken from all these plots and the percentage of common scab occurring was recorded in each case. The hydrogen-ion concentration of the several soil samples taken was determined by the colorimetric method, using Clark and Lub's (Clark 1920) colour chart and standard buffers.

The following includes in tabulated form the results obtained:—

TABLE 89.—EFFECT OF FUNGICIDES WITH HIGH LIME CONTENT ON SOIL REACTION

Fungicide and formula used	Hydrogen-ion concentration in terms of pH	Percentage of common scab
		%
Copper-lime dust 10–90	6·86	1·02
" " 15–85	6·68	0·80
" " 20–80	6·52	1·20
" " 25–75	6·48	0·92
Bordeaux mixture 5–5–40	6·56	0·61
" " 5–6–40	6·46	1·03
" " 6–8–40	6·70	2·76
" " 8–10–40	6·72	1·01
" " 10–12–40	6·56	1·06
Check No. 1 untreated	6·64	0·92
" 2 "	6·48	1·74
" 3 "	6·52	0·86
" 4 "	6·61	0·98

Perusal of these results reveals that there is but slight indication of an increase in the alkalinity of the soil, as determined by the colorimetric method, and in the amount of common scab occurring in the treated plots compared with the checks. In view of this it is doubtful whether the differences obtaining are sufficiently indicative of appreciable changes in soil reaction, as a result of the application of fungicides with high lime content, to predispose to increased development of common scab of the potato.

DUSTING VS. SPRAYING

This project has been carried on for four consecutive seasons with a view to comparing the relative efficiencies of certain copper-lime dust and spray mixtures in the control of foliage diseases of the potato.

While the results of these four seasons' efforts were fairly conclusive, it was considered advisable to continue the project another season in order to obtain, if possible, further practical information worthy of addition to the interesting and useful body of knowledge already accumulated concerning this important subject.

During 1928, the fungicidal values of copper-lime dust, Bordeaux spray mixture, and Burgundy spray mixture were compared. The copper-lime dust ingredients were obtained separately, and prepared for use according to the 20-80 formula in a mechanical mixer in the laboratory. The Bordeaux and Burgundy spray mixtures were prepared according to the standard 4-4-40 formula. The Burgundy mixture was prepared in a similar manner to Bordeaux mixture, with the exception that sal soda replaced the lime ordinarily used as an ingredient of the latter.

The weather throughout the growing season was cool and frequently cloudy. Rainfall was above the average. Protracted periods of wet weather, where the experiment was performed, rendered it difficult to carry out consistent spray and dust schedules. This, however, afforded an excellent opportunity for comparing the behaviour of the two different forms of fungicide under such extraordinary conditions. The humid conditions thus obtaining predisposed to the development of late blight, which reached epidemic proportions in the vicinity of the experimental plots late in August.

The following table includes a list of the fungicides compared, number of applications, total metallic copper, and estimated yield per acre in each case.

TABLE 90.—DUSTING VS. SPRAYING—APPLICATIONS AND YIELD

Fungicide	Number of applications	Total metallic copper per acre	Yield per acre
		lb.	bush.
Copper-lime dust (20-80)	6	13·63	294·1
Bordeaux spray (4-4-40)	6	14·71	304·8
Burgundy spray (4-4-40)	6	14·03	312·6
Check (poison dust)	3	....	131·0

The experiment proper consisted of four plots. Three of these, comprising one-half acre each, received applications of the different fungicides compared, while the fourth, serving as a check, included one-quarter acre, and received only insecticidal treatment. A mixture of lime and calcium arsenate, prepared according to the (20-80) formula was used for this purpose. All the other plots also received insecticidal treatment for the control of Colorado beetles in particular. The insecticide was incorporated with the first three applications of fungicide in each case.

Observations on the occurrence of diseases on the vines were recorded. Early and late blight appeared in mild form on August 8, in the check, copper-lime dust, and Bordeaux spray plots. No evidence of these diseases was observed in the Burgundy spray plot until August 15, when only slight infection of both appeared. On this date, there was moderate early and late blight infection in the check, copper-lime dust, and Bordeaux spray plots. On September 4, both diseases, particularly late blight, were quite severe in all the plots. The vines in the check plot were almost completely destroyed. The copper-lime dust plot was severely attacked; a large number of the vines had succumbed to the ravages of these foliage diseases. The Bordeaux spray plot showed less evidence of destruction by such diseases than the check and copper-lime dust plot. At the same time the Burgundy spray plot was still quite green, thus manifesting better control of the foliage diseases under consideration than any of the other plots. The following table includes the percentages of both diseases on the vines and tubers recorded on September 4 and at digging time. These results

TABLE 91.—DUSTING VS. SPRAYING—COMPARISON

Fungicide	Percentage early blight on vines			Percentage late blight on vines			Percentage late blight on tubers	
	Slight	Moderate	Severe	Slight	Moderate	Severe	Weight	Number
	%	%	%	%	%	%	%	%
Copper-lime dust (20-80)	4·8	14·4	27·4	2·6	9·6	68·4	2·9	3·4
Bordeaux spray (4-4-40)	4·7	23·8	26·5	5·2	13·7	46·6	1·3	1·4
Burgundy spray (4-4-40)	5·6	22·1	21·6	3·4	5·2	34·6	0·7	0·9
Check (poison only)	15·	21·0	54·0	0·0	3·8	96·2	3·6	3·4

show that the number and weight of late blight-infected tubers recorded, correlate in considerable measure with the amount of disease occurring on the vines.

Comparing the relative merits of copper-lime dust and Bordeaux spray mixture under the conditions obtaining in 1928, the latter was superior to the former in the control of both early and late blight. These results corroborate those of former seasons, further demonstrating that copper-lime dust is inferior to Bordeaux mixture, particularly during seasons when excessive rainfall prevails.

The excellent behaviour of Burgundy mixture in the control of early and late blight of the potato is further demonstrated by the foregoing results. The merits of this fungicide have long been known in other countries, particularly in Ireland, where it is used almost exclusively in the control of foliage diseases of the potato. Owing to the fact, however, that this spray mixture produced severe burning of the foliage from time to time, its use in this country was generally avoided. However, in 1927, a study of this particular fungicide was undertaken, with a view to testing its merits under New Brunswick conditions. The results of the experiments conducted revealed that this fungicide cannot be used safely with lead arsenate in a combination spray, because severe burning of the foliage results. This explains in part the reasons for the burning experienced in the past, for lead arsenate was commonly used as a potato insecticide in this province. It was found, however, from our experiments that Burgundy mixture can be used successfully and safely with calcium arsenate, which is now replacing lead arsenate to a considerate extent as a potato insecticide in this province. Thus it appears that any danger arising from the use of an insecticide in combination with this fungicide is now largely obviated by the use of calcium arsenate.

Another difficulty which presented itself in connection with the use of Burgundy mixture was such unusual precautions considered necessary in its preparation. This was alleged to be due to the fact that, unless the sal soda and copper sulphate were mixed in the proper proportion, there might exist an excess of copper sulphate or sodium carbonate in solution, either of which might prove injurious to the potato foliage. Our observations revealed, however, that, while it was quite essential to have a proper balance of sal soda and copper sulphate, the greatest danger rested in the nature of the sal soda used, for certain brands of this chemical contain impurities which result in severe burning of the foliage regardless of how well the mixture is neutralized. This difficulty is now largely surmounted, owing to the fact that brands of sal soda can be obtained from which these undesirable impurities are almost entirely eliminated. One of these brands of chemical was used for two seasons in connection with our experiments and in no instance was burning of the foliage observed with use of the same. Thus, it is believed, the possibility of foliage burning is reduced to a minimum by the use of Burgundy mixture prepared with such a highly purified brand of sal soda. With respect to the preparation of this mixture it was found that no greater precautions were necessary other than those ordinarily exercised in connection with that of Bordeaux mixture.

A few of the noteworthy features which commend the use of this fungicide are as follows: Its fungicidal value in the control of early and late blight of the potato is equal, if not superior, to Bordeaux spray mixture. It does not produce a precipitate in the sprayer, such as is commonly the case with Bordeaux mixture, which clogs the feed pipes and nozzles; thus it always permits unrestricted action of these parts. In addition, it does not stain the foliage to the same extent as Bordeaux mixture, thereby affording readier detection of mild forms of mosaic, which are easily obscured by the heavy precipitate formed by the lime in the case of the latter. The cost of preparing Burgundy is slightly more than that of Bordeaux mixture, but its commendable features more than compensate for the additional expenditure in materials.

These commendable features, we believe, warrant greater recognition of Burgundy mixture as a fungicide in the control of the foliage diseases of the potato commonly occurring in this province.

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, STE. ANNE DE LA POCATIERE, P.Q.

(H. N. Racicot, Officer in Charge)

LATE BLIGHT OF POTATOES

Spraying experiments, to determine (*a*) the number of applications necessary to control late blight in this district, (*b*) the best time to make these applications, and (*c*) especially whether spraying with Bordeaux mixture has a beneficial effect in blight-free years, were continued during 1928. The experiments included eight plots, each of which consisted of 24 replications of 25-foot rows, in order to equalize any variations of soil or other external conditions. Certified Green Mountain potatoes were used throughout. The sprayings were made with 4-4-40 Bordeaux mixture every ten days. Plot 8 was dusted with " Pota " dust. No late blight occurred either on vines or tubers this year. The treatment and the yield of the various plots are given in the following table.

TABLE 92.—RESULTS OF DIFFERENT TREATMENTS FOR LATE BLIGHT

Plot	Treatment	Total yield per acre	Marketable tubers, per acre
		bush.	bush.
1	Untreated	321	284
2	Sprayed, 4 applications beginning June 30	290	259
3	" 6 " " June 30	323	261
4	" 4 " " July 20	311	282
5	" 6 " " July 20	288	254
6	" 4 " " Aug. 10	312	291
7	" 6 " " Aug. 10	306	280
8	Dusted, 6 " " July 10	304	276
Average of all sprayed plots		305	271
Average of plots 2 and 3, sprayed early		306	260
Average of plots 4 and 5, sprayed during mid-season		300	268
Average of plots 6 and 7, sprayed late		309	286

The precipitation during the summer months was fairly evenly distributed, with no period of drought, and also not enough rain to favour the development of late blight. From the results of previous years (see Annual Report, 1927), it is believed that Bordeaux mixture is beneficial only during periods of drought or during outbreaks of late blight. Accordingly we would not expect any increase in yield from the use of Bordeaux mixture during this season and in this locality. The results for 1928, given in the table above, are in agreement with this. These results are very variable, and no conclusion can be drawn that one treatment was better than another, nor that spraying was beneficial. In fact, the unsprayed plot gave a slightly higher yield than the average of all the sprayed plots, namely, 4·8 per cent more of marketable tubers, but this figure is within the range of experimental error.

(a) Inoculation by Aphid Transfer

Aphids from healthy potato plants were transferred to plants infected with mosaic, and allowed to remain for a definite period of time. It could not be ascertained whether the aphids fed on these diseased plants or not. The aphids were then transferred to healthy Green Mountain plants. After these aphids had remained on the healthy plants for one day, they were transferred to another lot of healthy plants, etc. One hundred aphids were transferred the first time, but only about 50 per cent of them could be recovered on each successive transfer. Therefore five transfers was the largest number of transfers that could be made with one set of aphids. The table below gives the transfers made in 1927, and the results obtained, ascertained by planting tubers, harvested in 1927, during the summer of 1928, and observing if the plants were healthy or not.

TABLE 93.—RESULTS OF INOCULATION BY APHID TRANSFER

Number of days on mosaic plants	Kind of mosaic	Length of time between feeding on diseased plants and transfer to healthy plants	Condition of plants in 1928
1	Rugose	None	Healthy
1	"	1 day	"
1	"	2 days	"
1	"	3 days	"
1	"	4 days	"
1	Mild	None	Healthy
1	"	1 day	"
1	"	2 days	"
1	"	3 days	"
7	Rugose	None	Healthy
7	"	1 day	"

After these transfers were made, a period of cool, rainy weather killed the aphids (probably by attacks of *Entomophthoraceae*).

(b) Inoculation by Rubbing Plants Together

In the open, plants grown under cotton cages.—Tubers, produced by healthy Green Mountain plants which, during the summer of 1927, had been shaken vigorously against plants infected with mild mosaic or rugose mosaic, to simulate the rubbing together of plants against each other by strong winds, when planted in 1928, produced healthy plants.

In greenhouse.—1. From eight healthy Green Mountain hills planted adjacent to four mild mosaic hills, the plants on which had been shaken vigourously against each other, six hills became infected with mild mosaic.

2. From six healthy Green Mountain hills planted adjacent to two rugose mosaic hills, the plants on which had been shaken against each other, three hills became infected with rugose mosaic.

3. From six healthy hills planted adjacent to two crinkled mosaic hills, with the resulting plants shaken against each other as before, four hills became infected with crinkled mosaic.

In the above three cases, some of the leaves of the plants were crushed by tramping on the cement walk of the greenhouse, but careful examination failed to show that healthy leaves and diseased leaves had been crushed together in such a way as to transmit the disease by leaf mutilation. Nevertheless the observation casts doubt on the results obtained.

4. The plants from six healthy hills planted adjacent to those of three hills infected with leaf-rolling mosaic when shaken against the latter remained healthy.

The Green Mountain variety of potatoes was used throughout.

When tubers from the healthy plants produced in the above 4 experiments, carried out in the greenhouse, are planted, it is yet possible that they may produce diseased plants.

FIELD AND SEED TRANSMISSION OF BEAN MOSAIC

In order to observe the transmission, through the seed, of bean mosaic, from one season to the next, and, in the field, from diseased to healthy plants, healthy seeds and seeds from diseased plants were sown in adjacent 50-foot rows late in May. The final observations were made on August 22. The plan of the experiment, and the results for 1928 are given in the following table:—

TABLE 94.—RESULTS FROM FEED AND SEED TRANSMISSION OF BEAN MOSAIC

Row	Source or kind of seed	Percentage of mosaic	Yield per 50-ft. row	
		%	lb.	oz.
1	Healthy seed	0	2	12
2	"	0	2	12
3	"	1	2	14
4	Seed from mosaic plants	55	1	12
5	Healthy seed	6	2	13
6	Seed from mosaic plants	47	1	13

Rows 1 and 2 remained free from mosaic, or did not show current season symptoms. Row 3, with an adjacent row of mosaic plants on one side, had one per cent of mosaic. Row 5, with adjacent rows of mosaic plants on both sides, had six per cent of mosaic. Bean mosaic, therefore, was transmitted in the field from diseased to healthy plants. Rows 4 and 6 had 55 and 47 per cent of mosaic plants respectively, or an average of 51 per cent.

Seeds were harvested in 1927 from the healthy plants[1] growing in rows 1, 2, 3, and 5, and sown in 1928. The seeds from rows 1 and 2 produced all healthy plants. The seeds from row 3, adjacent to one row of mosaic plants, produced plants one per cent of which were mosaic. Seeds from row 5, between rows of mosaic plants, produced plants three per cent of which were mosaic. Some seeds from apparently healthy plants transmitted mosaic.

EXTENSION WORK

1. About 3,000 circulars on plant diseases were sent out.
2. A number of press articles were published.
3. Three plant disease exhibits were staged at Isle Verte, Rimouski, and Notre Dame du Lac.
4. Two field meetings were held on potato diseases and one on fruit diseases.
5. Three addresses on plant diseases were delivered at meetings of growers.

[1] See Annual Report, 1927, for the percentage of mosaic plants.

Sclerotial Diseases

(B. Baribeau and H. N. Racicot)

Sclerotia were collected from leaves of rose bushes and from leaves of lilac, during the late summer or fall, for the first time by this laboratory. The sclerotia collected from the leaves of the rose bush, were quite round, and larger than the sclerotia from potato stalks. Those collected from leaves of the lilac were medium sized, elongated, and slightly curved.

Potatoes, of the varieties Green Mountain, Sunrise, Early Rose, and King Edward, were inoculated with mycelium and with sclerotia from pure cultures, that had been obtained from potatoes. Three of the varieties were infected, while the fourth, the King Edward variety, remained free. Both mycelium and sclerotia were produced in the interior of the stalks of the first three varieties.

A number of varieties of sunflower were inoculated with sclerotia and mycelium of pure cultures of sclerotial disease of sunflowers, and only one variety showed any resistance, namely Mennonite Rosthern, apparently an early variety.

Sclerotia from sunflowers collected in 1921 and kept in the laboratory at room temperature and in the dry air of the room, germinated as well as freshly collected sclerotia. Unfortunately this exhausts our supply collected by Mr. Baribeau that year.

REPORT OF THE DOMINION FIELD LABORATORY OF PLANT PATHOLOGY, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, B.C.

(William Newton, Officer in Charge)

VIRUS DISEASE INVESTIGATIONS

During the past year we confined our virus disease investigations largely to potatoes. Some progress has been made in the development of new methods for the detection of virus diseases which may throw light upon their nature.

ENZYME REACTIONS.—The accumulation of starch in leaves of potato plants infected with rugose mosaic has been noted by numerous investigators. Our investigations showed that this symptom was constant for all potato varieties studied this year that were infected with rugose mosaic. The relative starch content was ascertained by the usual qualitative method. Leaves from normal and rugose mosaic infected plants were harvested in the evening and extracted immediately with hot 95 per cent alcohol until they were almost colourless. They were then immersed in a N/10 iodine solution for five minutes and the degree of darkening was assumed to be an index of their relative starch content. If the starch hydrolysing enzymes were assumed to be less active in rugose mosaic as compared with normal plants, the accumulation of starch in the leaves of the former could be explained. The starch hydrolysing enzymes were found to be less active in the juice expressed from the leaves of rugose mosaic infected plants as compared with the juice from the leaves of normal plants grown under the same conditions. The relative activity was determined by adding equivalent quantities of juice, 1 cc., to test tubes in series of six, containing from 0·01 to 0·06 grammes of soluble starch dissolved in 10 cc. of distilled water. To prevent fungal and bacterial growth 0·5 cc. of toluol was added to each test tube. At intervals of 24 hours all the solutions were tested for starch with iodine. Compared with the normal, the starch disappeared less rapidly in the tubes containing the juice from rugose mosaic infected leaves. The difference in the rate of starch hydrolysis between normal and rugose mosaic infected plants was small as indicated by the above method. It failed to reveal any differences in the enzyme activity of the juice between normal and mild mosaic, or primary infections of rugose mosaic.

The above starch hydrolysis method of studying the diastase activity was abandoned as a means of testing the possibility of an inverse relation between enzyme activity and the degree of virus infection. More promising results were obtained by studying the comparative invertase activity of the expressed juice from the leaves of normal and rugose mosaic infected plants. The investigation is too incomplete to predict whether there is an inverse relation between invertase activity and the degree of virus infection. The invertase activity of the juice was measured by adding 10 cc. of the expressed juice to 100 cc. of a 1 per cent sucrose solution to which 2 cc. of toluol were added. The flasks were tightly stoppered and incubated at 30° C. At intervals the invert sugar formed was determined by a standard method. The invertase activity of normal juice was much higher than that of the juice from the leaves of rugose mosaic infected plants. Our investigations suggest that the invertase activity is diminished by rugose mosaic virus to a greater degree than the diastase activity. This conclusion applies only to the juice expressed from the leaves. No significant differences were found in either the diastase or invertase activity of juice expressed from normal tubers and those from plants infected with rugose mosaic.

When equal quantities of the juice expressed from the leaves of normal and rugose mosaic plants were mixed, the invertase activity was intermediate between the values obtained when each juice was added separately to the sucrose solution.

The invertase activity of the juice expressed from the leaves of plants infected with mild mosaic was not significantly lower than normal. In all these experiments plants of the same variety and from the same habitat were used.

THE DETECTION OF VIRUS DISEASE IN POTATO TUBERS.—Attempts were made to detect virus infection in potato tubers. It has been already noted that no significant differences could be detected in either the diastase or invertase activity of potato tubers as the result of virus infection. However, a comparison of normal and rugose mosaic infected tubers showed characteristic differences which will be further investigated. Certain oxidizing enzymes appear to be more active in normal compared with rugose mosaic infected tubers, for cores of normal tissue crushed in a mortar change more rapidly to a red and finally to a black colour than do corresponding cores taken from tubers infected with rugose mosaic. There also appears to be present in normal tubers a compound that is readily oxidized by weak permanganate under neutral conditions, which is not present to the same degree in rugose mosaic infected tubers. This tentative conclusion is based upon the fact that a hot water extract of normal tissue will decolourize a weak potassium permanganate solution more rapidly than an extract from equivalent quantities of tissue infected with rugose mosaic. The substance oxidized by permanganate is not reducing sugar, for the quantities of reducing sugar were frequently greater in tissue infected with rugose mosaic as compared with normal tissue, as indicated by the reduction of Benedict's solution.

Extracts of normal tuber tissue and tissue infected with spindle tuber behaved similarly towards permanganate. There appeared to be less reducing sugar in spindle tuber tissue as compared with normal, as indicated by the reduction of Benedict's solution. The small quantity of reducing sugar in spindle tuber tissue may partially account for the delayed sprouting, which we have found to be a characteristic symptom of spindle tuber disease.

.Cores of rugose mosaic infected tubers placed in a desiccator dried out more rapidly than similar cores of normal tissue. There was considerable variability between the rate of drying of individual cores. Therefore, not less than a dozen cores from normal and diseased tubers were dried simultaneously to overcome the error due to variability. The dry matter content was likewise a variable factor. When at least a dozen cores were taken from tubers of corresponding size, the dry matter content was higher in normal as compared with tissue infected with rugose mosaic.

Two field experiments were conducted, one in the Metchosin and the other in the Saanichton district, to determine the influence of seed cutting upon the spread of virus disease. The percentage of virus was not significantly influenced by seed cutting. These field experiments upon " cut versus uncut seed " were undertaken primarily to study a tuber rot that was present in both districts. However, further field experiments will be undertaken before definite conclusions are presented.

The Effect of Seed Treatment on Black Leg

Seed treatment reduces, but does not control, black leg

(John Tucker, Chief Inspector)

Most of the present day literature dealing with the black leg disease of potatoes and its control advises seed treatment with corrosive sublimate or formalin. In recent years also, certain organic mercury preparations have appeared on the market, for which the claim is made, more or less emphatically, that good success in controlling the disease will result from their use.

Many field trials of the various treatments have been made, mainly under the direction of technical supervision. This paper is not concerned with trials of this nature but rather with the results which are actually being obtained by growers, in a commercial way, under ordinary farm practice. No reflection on seed treatment is intended, for apart from black leg, such treatment may have considerable value in controlling or reducing other diseases; but rather my aim is to point out that treatments as practised at present on a large number of farms reduce, but do not control black leg to the extent that appears to be generally expected.

During the past season over 9,000 fields were inspected, in nine very extensive districts, covering over 40,000 acres of potatoes in all. The inspectors were required to state on their reports, if the details were available, whether the seed had been treated, and, if so, to indicate the chemical used, and the method employed. The inspection report, of course, showed the percentage of plants affected with black leg.

Good reports, which gave full details, on 7,429 fields were used in compiling these data. These yielded most instructive details which are appended. The value of the figures lies in the fact that they were obtained under ordinary farm practice.

It should be borne in mind that local conditions may have considerable effect on the extent of the disease. In certain well favoured locations where the disease does not reach serious proportions, the growers do not generally treat their seed, and still secure crops showing little or no disease. In other locations, where conditions are more favourable to the development of black leg, growers more generally treat their seed. This procedure most probably results in a reduction of the percentage of infection which it is not possible to indicate in the report.

These conditions should receive consideration when comparing the non-treated with the treated classes.

TABLE 95—SEED TREATMENT AND BLACK LEG INFECTION

District	No Treatment			Bichloride			Formalin			Dipdust			Semesan		
	Total fields	Infected	Average infection	Total fields	Infected	Average infection	Total fields	Infected	Average infection	Total fields	Infected	Average infection	Total fields	Infected	Average infection
		%	%		%	%		%	%		%	%		%	%
No. 1	1,714	45·4	1·12	2,413	40·4	0·90	146	35·6	0·99	38	23·7	0·70	4	50·0	0·67
No. 2	401	51·6	1·14	....	....	....	318	37·4	0·83	....	....	....	....	....	....
No. 3	193	19·2	0·84	7	28·6	0·50	133	20·3	0·74	....	....	....	1	0	0
No. 4	727	60·7	0·61	21	23·8	0·43	67	61·2	0·53	....	....	....	12	83·3	0·22
No. 5	185	57·8	1·20	209	47·4	0·75	136	55·1	0·93	13	76·9	0·99	4	25·0	0·30
No. 6	72	70·8	1·41	4	50·0	1·00	2	0	0	2	100·0	0·65	....	....	....
No. 7	59	39·0	2·00	17	17·6	1·20	40	42·5	2·70	....	....	....	1	0	0
No. 8	25	52·0	1·44	11	9·1	0·30	39	36·0	1·07	3	33·3	0·30	....	....	....
No. 9	125	32·0	1·06	176	10·8	0·80	65	16·9	0·66	....	....	....	41	24·4	1·13
Total	3,506	47·6	1·20	2,858	28·5	0·73	946	33·9	0·94	56	58·5	0·66	63	30·5	0·39

The above table can be condensed as follows:—

3,506 growers did not treat	Average loss	·57% of crop
2,858 growers treated with bichloride	"	·21% "
946 growers treated with formalin	"	·32% "
56 growers treated with Dipdust	"	·38% "
63 growers treated with Semesan	"	·12% "

It is to be regretted that so few figures were available for the organic mercury treatments. A comparison between these, bichloride, and formalin is not justified.

Summary:

(1) Seed treatments, as at present applied on farms, reduce but do not altogether control black leg.

(2) Bichloride gives better results than formalin.

(3) Organic mercury preparations give promising results; the number of reports available are too few to justify a comparison with bichloride or formalin.

(4) It is possible that the solutions used are not fully up to strength in the first place, or that the solutions deteriorate faster than is generally allowed for.

Seed Potato Improvement

(W. K. McCulloch, District Inspector, Kentville, N.S.)

The experiments continued during the season of 1928 were as follows:—

THE EFFECT OF PERSISTENT SELECTION ON THE SHAPE OF THE TUBERS OF POTATOES

The work has been carried out with the Garnet Chili variety of potatoes. This variety is grown in certain districts of Nova Scotia and exported to Bermuda for seed purposes. Its shape is of the short oblong type but it varies considerably with the soil and season. On a sandy soil it approaches the round type while on heavier soils it becomes longer and flatter. If the season is dry, or the rainfall normal and regular, it keeps its shape fairly well, but when the rainfall is excessive or irregular, a large percentage of rough and poorly shaped tubers is produced.

At the time this experiment was begun the number of tubers running to a point at the seed end was very noticeable. After five years of selection such pointed tubers are of rare occurrence. Table 96 shows the result of five years' selection. The first column (1923) gives the percentage of tubers of ideal shape in the stock from which the first selection was made.

TABLE 96—EFFECT OF SELECTION ON THE SHAPE OF GARNET CHILI TUBERS

Grower	Per cent of tubers of ideal shape for the variety						Average per cent for period of selection 1924-1928
	Before selection 1923	After selection					
		1924	1925	1926	1927	1928	
1. E. Jennings	21·6	56·0	26·0	54·3	34·0	48·0	43·6
2. R. K. Loughead	40·0	40·2	55·0	59·5	47·5	60·3	52·5
3. A. Kent	38·6	50·9	35·0	55·0	47·5	58·8	49·4

As shown by table 96 there is an average gain of 22 per cent, 12·5 per cent, and 10·8 per cent respectively over the original stock.

The soil of No. 1 is a fairly heavy loam with a stiff sub-soil, consequently it suffers during a wet season. The soils of Nos. 2 and 3 are sandy loams and are more or less alike except that No. 2 is kept in a better state of tilth. No. 3 generally lacks humus.

This selection is being continued.

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

Pure line here means tuber line. The record of 25 lines or groups is presented in table 97. Each line is the progeny of a single tuber planted in 1924.

TABLE 97—RECORD OF TUBER UNIT LINES

Unit line	Virus diseases present X, absent, 0					Net average yield per hill, for 5 years
	1924	1925	1926	1927	1928	
						lb.
8 B.T.	0	X	X	0	X	2·10
9	0	0	0	0	X	1·93
45	0	X	X	0	0	2·21
46	0	0	0	0	0	1·97
47	0	0	X	X	X	
48	0	0	X	X	0	2·02
59	0	0	X	X	0	1·94
61	0	0	X	X	X	2·06
62	0	X	X	X	0	2·10
121 G.M.	0	X	0	X	0	2·19
122	0	0	0	X	X	1·93
126	0	0	X	0	0	2·01
129	0	0	0	0	0	1·94
146	0	0	X	0	0	1·87
147	0	0	X	X	X	1·95
153	0	0	0	0	0	1·96
168 I.C.	0	0	X	0	0	1·71
170	0	0	0	X	0	1·90
176	0	0	0	X	0	1·70
190	0	0	0	X	0	1·68
193	0	0	0	X	0	1·76
195	0	0	0	X	0	1·78
199	0	0	0	X	0	1·78
209	0	0	X	X	0	1·68
211	0	0	0	X	0	1·61

As will be seen from the above table, only three lines remained healthy during the five seasons. Line No. 9 (Bliss Triumph) showed no symptoms of disease until the second inspection this year. It was probably infected by the neighbouring plot No. 8, which carried a diseased unit on first inspection.

The majority of the tuber lines show a varied record in their reaction to virus diseases. No elaborate explanation is necessary to account for this. The two primary factors in the control measures, namely, isolation and roguing, have not yet been brought to such a stage, at this Station, as to preclude the possibility of infection by the ordinary means of transmission. Roguing, which is carried out by the Inspection Staff, is performed twice during the growing season; first, as soon as the plants are large enough to enable determination to be made, and, second, when the inspectors return preparatory to beginning the second field inspection. This amount of roguing may be regarded as the minimum, but the amount of control obtained should be of interest to the practical grower.

In a district that is not regarded as very favourable to the growth of the potato crop, the yielding power of the strains under test, has been maintained for five years in such a way as to give, as an average net yield, more than double that of the average yield of the province, which is about 200 bushels per acre.

Allowing for 5 per cent of missing plants which would more than cover the amount rogued out of the plots, and placing the rows 30 inches apart and the sets 12 inches apart in the rows, the following are the average net yields (less amount of seed used) of the highest and lowest strains of the three most important varieties, for five years (table 98).

TABLE 98—FIVE-YEAR AVERAGE NET YIELD OF UNITS

Unit		Yield per acre less weight of seed used
		bushels
B.T. Highest yielding unit	(2·21)	609·5
B.T. Lowest yielding unit	(1·93)	532·4
G.M. Highest yielding unit	(2·19)	604·2
G.M. Lowest yielding unit	(1·87)	515·9
I.C. Highest yielding unit	(1·90)	524·2
I.C. Lowest yielding unit	(1·61)	444·1

In addition, 78 new tuber lines consisting of Irish Cobbler, Green Mountain, Bliss Triumph, Early Rose, and Norton Beauty varieties, have been under development for two seasons, and 49 per cent of them have remained free from the virus diseases.

STUDY OF THE VARIETIES OF POTATOES GROWN IN THE PROVINCE OF NOVA SCOTIA

From time to time claims have been put forward by farmers regarding resistance to disease of varieties or strains of potatoes in their possession. In order to investigate these claims a preliminary study was begun last year of as many varieties as came under the notice of the Inspection Service. In all 38 different lots were obtained. Three of these were destroyed on account of 100 per cent of infection with virus diseases, and the remainder were planted again in 1928. Table 99 gives the complete results for 1928.

TABLE 99—TEST OF VARIETIES FOR DISEASE RESISTANCE

No.	Variety—local name	Percentage of Diseases							Average yield per hill, in pounds	Colour and shape of tuber
		Leaf roll	Mosaic	Early blight	Late blight	Scab	*Rhizoctonia*	Late blight rot		
		%	%			%	%	%	lb.	
1	White Blossom Cobbler		5·00	xxx		72·86	2·86		1·92	Resembles Irish Cobbler in shape; skin paler.
2	Manitoba Seedling			xxx		56·25	19·00		1·76	Same as No. 1.
3	Pride of Kildare			xxx		75·47	6·51	0·47	1·97	Identical with Irish Cobbler.
4	Early Queen			xxx		89·30		3·57	1·68	Apparently same as Irish Cobbler.
5	Early Queen			xxx		80·00		0·60	1·80	Apparently same as Irish Cobbler.
6	Eureka			xxx		89·00			1·67	Cobbler-like; white.
7	Russet	30·00		xxx		87·50	6·66		2·21	Cobbler-like; white.
8	Early Six Weeks			xxx		41·86			2·40	Roundish; white.
9	Russet			xxx		48·84			1·56	Rural type; russet skin.
10	Carmen			xxx		94·60	5·40		1·66	Mixed; some like Carman, some like Cobbler.
11	Sterling			xxx		22·38	41·80		1·20	Rural type; white; smooth.
14	Early Harvest			xxx		100·00			1·33	Narrow; oblong; white.
15	"Never Rot"			xx		59·87			1·77	Somewhat rseembles Green Mountain in shape; white.
16	"Never Rot"	15·00		xx		53·12			1·74	Same as No. 15.
17	Rural New Yorker			xx		44·56	36·29		1·45	Rural type; smooth; white.
18	Unnamed	20·00	10·00	xxx		81·00			1·50	Short oblong; blocky; white, with pink eyes.
19	Pink eyes	20·00		xxx		86·56	4·47		1·62	Narrow oblong; irregular; white, with pink eyes.
20	Early Ohio			xx		80·00	14·28	0·90	2·17	Short oblong; flesh colour.
21	Clark's No. 1		5·00	xxx		89·65	9·00		1·68	Medium oblong; flesh colour.
22	Early Six Weeks			xxx		95·43	1·71		2·17	Oblong; flesh colour.
23	Unnamed			xxx		57·00	1·33		2·00	Quite long; many eyes; flesh colour.
24	Blush			xx		70·70	7·00		1·85	Roundish oblong; flat; reddish.
25	Home Comfort	10·00		xxx		69·00	19·69		1·28	Oblong; very smooth; flat and tapering, often at both ends; light red.
26	Dakota Red	10·00		xxx		39·13			1·55	Oblong; reddish; eyes deep.
27	Northern Spy			xxx		62·86	10·00		1·45	Closely resembles No. 26.
28	Clark's No. 1	5·00		xxx		53·10	24·14		1·71	Closely resembles No. 26.
29	Dr. Wilson		10·00	xxx		37·65			1·58	Oblong cylindrical; very smooth; red.
31	Erin Victor			x		68·70			1·85	Oval to oblong; short; blue.
32	Unnamed			xxx		29·94	16·95		2·12	Oblong; tapering; dark blue.
33	Unnamed			xxx		28·12	25·00		1·82	" "
34	Unnamed			xxx		21·92	19·17		1·85	Irregular, oblong; rough; purple.
35	Irish Daisy	15·00		x		38·00	2·00		2·44	Rural type; smooth; white.
36	Blue Vay			x		48·85	9·71		1·80	Short oblong; purple with streaks of lighter colour.
37	Black Kidney			xxx		24·54	34·54		1·70	Narrow oblong; many eyes; dark purple.
38	Excelsior			xx		71·42	7·86		1·67	Short oblong; flesh colour.

x=slight. xx=moderate. xxx=severe.

Of the 35 varieties or lots planted, 11 have remained free from virus diseases to date. Early blight was present to a more or less severe degree on all plots this year. Last year it was absent. Late blight was apparently absent this season in striking contrast to last year, when it was moderate to severe in all plots, except Nos. 15, 16, and 31. Practically no resistance to scab was shown, while in 12 plots no *Rhizoctonia* has been found to date. This year tuber rot was very slight. Last year it was severe in all plots, except Nos. 9, 15, 16, 18, 23, 31, and 35, running from 10 to 76 per cent. The plots showing resistance in 1927, arranged in order of merit, were as follows: No. 16, 0·0 per cent; No. 15, 0·0 per cent; No. 31, 0·0 per cent; No. 35, 2·5 per cent; No. 18, 3·0 per cent; No. 23, 5·0 per cent; No. 9, 6·4 per cent.

PRELIMINARY TEST WITH MATERIALS FOR SEED TREATMENT OF POTATOES

Table 100 shows the results of a seed treatment test. A description of the materials follows:—

Sulphur.—Ordinary flowers of sulphur. About two pounds to the barrel of cut sets were used. The sets were placed in the barrel as they were cut, each fresh layer receiving a dusting with sulphur.

Mercuric chloride.—The ordinary cold solution composed of 4 ounces corrosive sublimate in 30 gallons of water. Time, 1½ hours.

Dip Dust.—The trade name of an organic mercury compound. It was used according to the instructions accompanying the material.

Formalin solution.—The ordinary cold solution of 1 pint formaldehyde in 30 gallons of water. This treatment was carried out too late in the afternoon to allow the seed to dry quickly, and, as the seed was in the solution for two hours, it is probable that much of the low yield was due to overtreatment.

Iodine dust.—A mixture of 2 per cent by weight of pulverized metallic iodine and hydrated lime placed in a closed container at a temperature of 70° to 125° F. to vaporize the iodine.

Formalin dust.—A mixture of 5 per cent by weight of formaldehyde in hydrated lime, placed in a closed container until the formaldehyde was absorbed.

The iodine and formalin dusts were applied to the respective lots of tubers in barrels which were kept covered until time to plant.

The variety used in the test was Irish Cobbler.

With the exception of sulphur which was applied to the cut sets, all the other treatments were applied to the whole tubers before they were cut for planting.

The season, which was exceptionally dry and warm, was probably favourable to the sulphur treatment.

TABLE 100.—PRELIMINARY SEED TREATMENT TESTS

Plot	Treatment	Rot.	Scab	*Rhizoctonia*	Yield per acre Small	Total yield per acre	Yield per acre clean, marketable
		%	%	%	bush.	bush.	bush.
5	Sulphur	....	0·94	4·71	69·3	210·6	133·03
4	Mercuric chloride	....	6·38	3·20	64·0	208·0	130·20
3	Dip Dust	....	1·81	16·36	53·3	200·0	119·47
6	Formalin cold solution	....	....	....	80·0	189·3	109·30
2	Iodine dust	....	20·73	....	85·3	200·0	90·60
1	Formalin dust	....	12·30	....	42·6	144·0	88·80
7	Check	....	20·78	9·00	74·6	197·3	86·04

SPINDLE TUBER DISEASE

For the past two seasons the spindle tuber disease of potatoes has been under observation at this laboratory. Tubers carrying the disease were obtained from the Fredericton Laboratory in 1927 and planted in the same plot with healthy tubers. The latter were planted between tubers carrying the disease, and an attempt was also made to inoculate some of the healthy plants by crushing diseased and healthy leaflets together.

The Irish Cobbler variety was used throughout. The results for 1928 are summarized in the following table:—

TABLE 101.—OBSERVATIONS ON SPINDLE TUBER DISEASE

Plot	Nature of seed	Plant symptoms, 1928	Tuber symptoms, 1928	Average yield per hill
				lb.
1	Spindle tuber 1926-27......	Much dwarfed, upright, leaflets small, slightly rolled and wrinkled.	Cylindrical, smooth, eyes very shallow.	0·22
2	do	do	do	0·20
5	do	do	do	0·30
6	do	do	do	0·37
11	do	do	do	0·25
3	Healthy. Inoculated from No. 1 in 1927.	Scarcely dwarfed, upright, no rolling.	20% more or less cylindrical and smooth.	0·52
4	Healthy. Inoculated from No. 2. 1927.	Nearly normal growth, partly upright, symptoms not marked.	Small and smooth, but shape normal.	0·95
7	Healthy. Inoculated from No. 5, 1927.	do	Shape normal...............	1·03
8	Healthy. Inoculated from No. 6, 1927.	do	3% cylindrical, remainder fairly typical of variety.	0·93
9	Healthy. Inoculated from No. 11, 1927.	Nearly normal growth, partly upright, symptoms not marked.	2% cylindrical, remainder typical of variety.	1·05
10	Healthy. Inoculated from No. 12, 1927.*	do	Very smooth for variety, but generally typical.	0·73
13	Healthy. between spindle tuber plants in 1927.	do	do	0·75
14	do	do	do	0·94

*Plot No. 12 was "spindle tuber" in 1926-1927, but the few small tubers produced rotted and left no seed for a plot in 1928.

The spindle tuber disease of potatoes has not been found in Nova Scotia, but it is elsewhere regarded as a serious virus disease and, therefore, demands careful study by the Inspection Service.

SEEDLINGS

Two seed balls were obtained from the so-called " Never Rot " variety which has shown such marked resistance to late blight in the variety test plots at this laboratory. Out of 40 seedlings which were raised in the greenhouse, 38 plants were successfully propagated in a field plot. During the season, disease symptoms, more or less definite, appeared, and 13 plants were rogued out on account of leaf roll, 3 because of mosaic, and 9 for severe *Rhizoctonia*.

The 13 apparently healthy plants remained green and vigorous until partly cut down by frost on October 20.

Early blight was observed on practically all the plants, consisting of small spots scattered over the leaflets. No late blight was noted. The tubers were clean and free from rot, and in many instances reached a weight of four ounces each.

The types of plant and tuber were uniform and strongly resembled those of the parent plant. Each seedling has been saved separately for further study.

Contact Frosts in Potato Shipments

(John Tucker)

It is extremely difficult to figure with any degree of accuracy the actual loss occurring in the potato crop from frost, but it is a well established fact that serious loss does occur every year from this cause. Growers, shippers, transportation companies, and the consuming public, all share the loss to a greater or less extent.

In the northern districts the loss from field frost is very great, which is to be expected to some extent, but field frost represents but a small percentage of the total losses due to frost, most of which are preventable. The greatest loss occurs in the harvested crop. Proper storage space on many farms is inadequate to house the crop and, therefore, it is in the temporary storages on the farm, in which the potatoes are held awaiting shipment, that a heavy direct loss from frost occurs, to which frequently must be added loss from chilling which may later appear in shipments from such storages. Some is unavoidable, but much damage of an avoidable nature results from the disregard on the part of those handling the potatoes, either unwittingly or from carelessness, of the fact that potatoes are at all times active physiologically, i.e., potatoes are living organisms and, as such, are susceptible to injury from bruising, overheating, freezing, chilling, etc.

The following data prepared from observations made under regular inspection conditions, in the field, at storages, and at car inspections on a commercial basis, are submitted solely for the purpose of pointing out to those interested in the handling of potatoes during the winter months the great care necessary to protect potatoes at every point from frost injury.

It is generally known that some protection in the form of covering, and heat, is necessary during transportation in the coldest weather, or potatoes will freeze, and will commence to rot as soon as the frost comes out; but it is too often taken for granted that sufficient protection has been provided, if the potatoes appear to remain sound at destination. Chilling and frost injury may appear later in such shipments, and it is with some of the causes of such injuries that we are here dealing.

Before proceeding further, to better illustrate the appearance of the particular type of blotch chilling to be referred to, it appears desirable to portray, at this time, the types of freezing injury usually found in potatoes.

Frost injured potatoes can be grouped under two general headings, chilled and frozen. First, potatoes slightly frozen or chilled, causing internal injury, which is not readily apparent on the surface of the tuber. Second, potatoes frozen solid which will break down to a wet, bad-smelling rot, when thawed out in warm, damp storage, or may dry white and mealy, or to a tough, chalky mass in a cold dry storage.

It is with the first type we are dealing more particularly, although, as will be shown later, the second type has been found directly responsible for the first, in some instances.

Vascular Ring Discoloration.—A mild type of field frost. Darkened, threadlike areas radiate from the stem end. These are limited to the vascular ring between the cortical and the external medullary layers. Occurs under certain conditions following a frost sufficiently severe to kill the tops. Rarely does any further injury develop, and the potatoes apparently are not injured for seed purposes. No external injury beyond an occasional slight shrinking of the tissue.

A more severe chilling may result in the darkened threadlike strands extending from the vascular ring into the cortical layer, and also to the inner medullary. Such potatoes should not be used for seed purposes.

Field Frosted.—Injury is caused by low temperature at the time potatoes are ready to dig. A rot develops fairly quickly when they are placed in storage, or are shipped in a heated car. When frosted potatoes are cut, a clear line of demarcation, usually slightly darkened, is apparent between the frosted and the sound parts of the tuber. Potatoes appear sound when first dug but soften later.

It is a fairly simple matter to determine, when frost injury is found in a car lot shipment, whether it is due to field frost or not. Field frosted potatoes, when present, will be scattered a few here and there throughout the car; whereas frost injury which occurred in transit will be found confined generally to the exposed areas in the car.

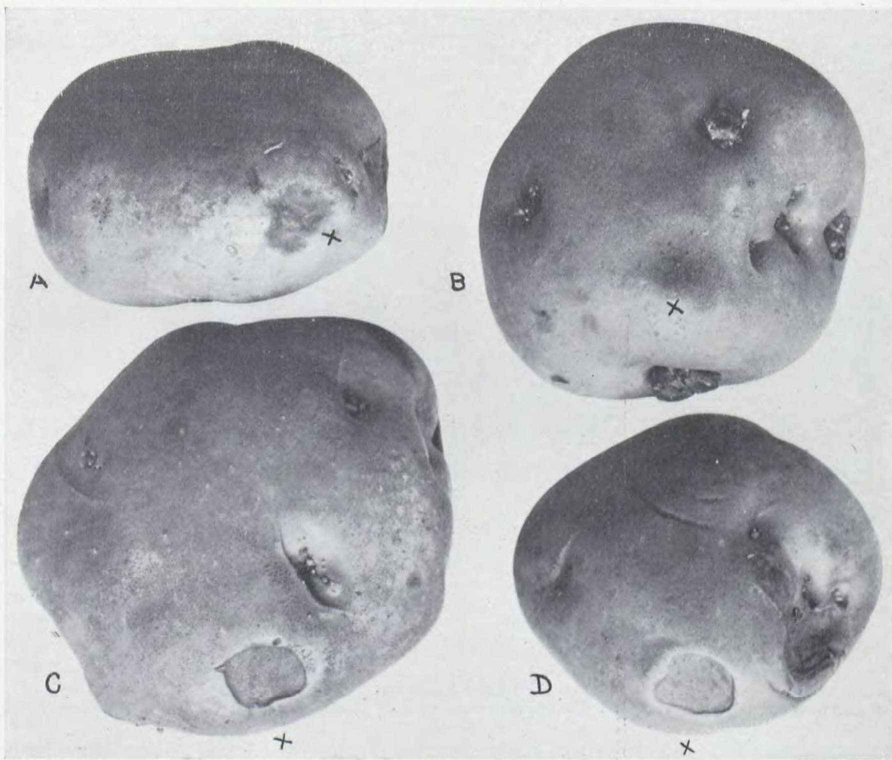


Fig. 36.—A. Frost injury. Note contact points X. The imprint of the sack can often be seen on the frosted area where it rested on ice. B. Contact frost, early stage. C and D. Note sunken areas X. The point of contact with frosted potatoes is clearly shown. (Photo by J. B. MacCurry)

Blotching.—This type of smoky discoloration may be found anywhere in the tuber and is caused by chilling. Light grey to blue black in colour, the discoloured area may be very small or may involve the whole inside of the potato. It is not apparent externally, except when the blotch happens to be situated in the cortical layer in clean, white-skinned potatoes.

A combination of all types of freezing is possible in the one tuber. Frequently a bag of potatoes which has been subjected to a low temperature exposure for a lengthy period may be found to contain all types of frost injury, no two potatoes showing exactly the same lesions, even though exposed to apparently similar conditions. Some varieties also appear to be able to stand more exposure than others, possibly due to the variable salts, sugars, and other soluble material content, which also permit of a lower degree of undercooling for potatoes than that of water, before actual freezing injury takes place. The late varieties can apparently stand more cold than the earlies.

Contact Frost.—It was found that potatoes may develop frost injury of the blotch type through coming in contact with frozen potatoes, with icy loading platforms, with frozen fuel in cars, with iron work gratings, iron work in cars, with ice on the floors of sleighs, and with car floors, and that undercooling may continue back into other layers of tubers under certain conditions.

Car lot inspection work at loading and unloading points offers opportunities for the study of frost injury in potatoes, on a commercial scale not possible in any other way. Of the many observations made under these conditions, only one or two need be referred to here to bring out the points intended.

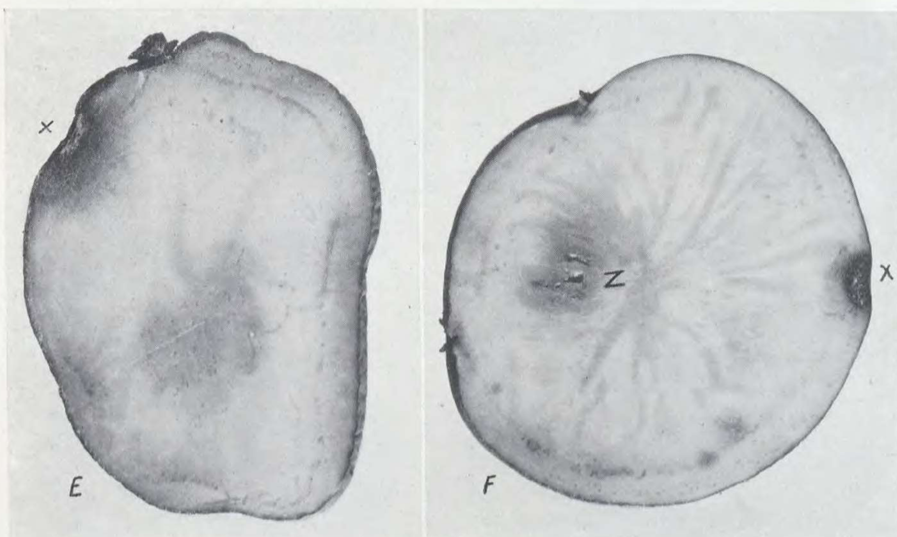


Fig. 37.—E. Contact frost injury. Blotched and ring type. Showing the point of contact with frozen potato X. F. Point of contact X. Blotched area drying out some days after inoculation Z. (Photo by J. B. MacCurry)

A refrigerator car of potatoes that had been in sub-zero weather for some days was opened up, and a sack, showing a wet spot from frost, was carefully removed from the pile. It had been in contact with iron on the door of the car. The sack was carefully slit open and the extent of the frost injury was traced as far back into the car as was apparent on the potatoes externally. On cutting other potatoes which were in contact with the frosted ones it was found that extensive blackened areas of the blotch type were evident even though they appeared sound externally. This condition extended back into the next layer of potatoes, but to a somewhat lesser degree. These potatoes did not show serious injury so far as their external appearance was concerned, and would be just as salable as uninjured ones, yet they were quite unfit for food in a few days, after being kept at ordinary room temperature. It is quite probable that the sudden change from a steady low winter storage temperature to that of a heated car caused an increased rate of respiration, and the potatoes consequently became more susceptible to undercooling through contact with frost during that period.

The unloading of potatoes from a heated car on to an icy platform also results in a chilling injury of the blotch type to the potatoes next to the ice, the extent of the injury being dependent to some degree upon the thickness of the ice. The heat in the potatoes melted the ice which in turn wetted the potatoes. The internal heat of a potato very quickly becomes exhausted through a wet spot, causing a degree of undercooling sufficient to injure the potato.

Potatoes which have just been harvested from a warm soil, and potatoes taken from a warm storage, when subjected to a sudden drop in temperature may develop slight internal discolouration of the blotch type before reaching that degree of undercooling which the variety will normally stand before actual freezing takes place.

The accompanying photographs illustrate clearly some of the contact injuries referred to. The spots indicated are points of contact through which the undercooling took place; these are frequently mistaken for diseases of various kinds.

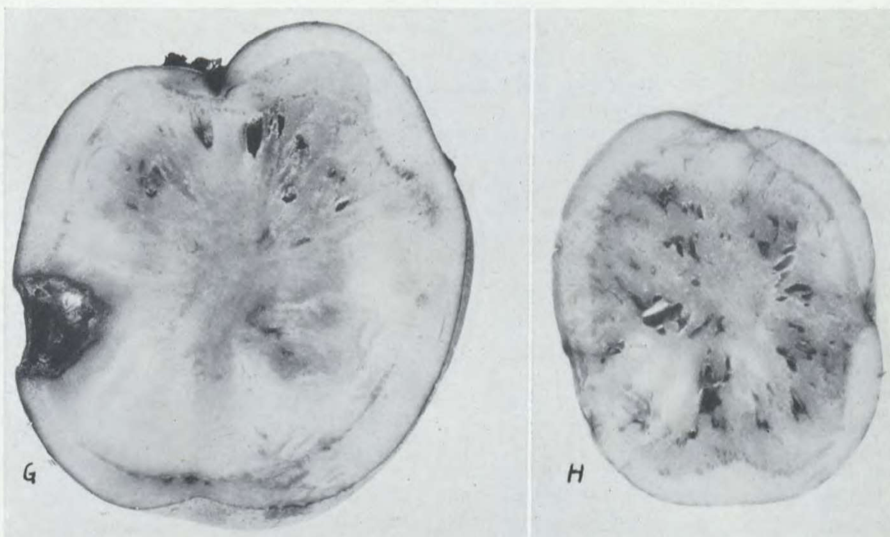


FIG. 38.—G and H. Contact frost injury. Blotched and ring type. Chilled areas drying out in storage. (Photo by J. B. MacCurry)

SUMMARY.—At least two, or three additional layers of potatoes, adjacent to those showing signs of external frost injury, should be removed when reconditioning frosted potato shipments.

Neglect in protecting potatoes from chilling before shipping has frequently resulted in a monetary loss to the grower in excess of the total value of the shipment.

Freezing is a serious factor to be considered when making cold weather shipments. Contact with metal, icy loading platforms, frozen fuel, the bottom and sides of cars, etc., may result in a serious chilling, not readily apparent unless potatoes are cut. A close examination of the surface of the tuber may reveal the point of contact where the undercooling commenced.

The temperature of potatoes in storage during the rest period may rise and fall from the normal freezing point for the variety, without injury to the potatoes if the change takes place very slowly. Potatoes subjected to rapid temperature changes, however, are much more susceptible to chilling injury.

Club Root of Turnips, *Plasmodiophora Brassicae*, Wor.

(D. J. MacLeod, Plant Pathologist, Fredericton, N.B.)

The disease known as club root of turnips is proving a serious limiting factor in the production of this vegetable in New Brunswick. This disease seems to be widespread in its occurrence and appears most serious commercially in the older and more intensive turnip-growing sections. While the disease does not occur in all turnip growing areas, there is reasonable ground for believing that it will be introduced into these parts sooner or later. If once introduced into these areas it will undoubtedly persist and spread, wherever conditions conducive to its development permit.

Efforts have been put forth, from time to time at this laboratory, to develop measures aiming at the control of the parasite causing the disease, when once it has been introduced into the soil. These attempts were, however, unsuccessful both from the standpoint of efficiency of control and commercial practicability. In consequence, the conclusion was reached that it is only through the medium of resistant strains, suited to local market requirements and environmental conditions, that the permanence of the industry can be safeguarded in most parts of the province. We believe this method of attacking the problem gives promise of a condition of permanent control which deserves attention.

During the past four years, advances have been made here, in the direction of finding varieties or strains of turnips or swedes, which possess sufficient club root resistance to be of commercial value under the conditions obtaining locally. The method followed to achieve this end is to select and cross varieties or strains manifesting appreciable degrees of resistance, until strains with desired resistance, which also possess the qualities required for local markets, are developed. The testing of all these strains or varieties was conducted on a plot of soil, specially prepared for the purpose, and heavily infested with the club root parasite. From 1924 to the present time, upwards of three hundred varieties have been tested, certain of which manifested favourable degrees of resistance to the disease. Stecklings of these were collected from time to time and kept for selection purposes. These were strictly isolated at flowering time to prevent contamination by foreign pollen. The vast majority of the varieties tested were swedes. It was found that the swede is easily self-fertilized by enclosing the inflorescences in a pollen bag before the buds open. Under these conditions abundant seed was obtained in most cases. Such selected varieties as manifested favourable degrees of resistance were continually tested on club root infested soil to determine whether their resistant qualities were maintained, increased, or reduced from generation to generation. Experience to date seems to indicate that this resistance is due to heritable differences, and that, through the selection of such resistant lines, strains may be developed which are highly resistant or even immune to club root. The results of these efforts also justify our confidence that, through careful and repeated selection, this resistance may be combined with many of the desired qualities of standard commercial varieties, because such resistance does not seem to be incompatible with any of the commonly recognized variables of the swede. The contention of others, that resistance is probably determined by multiple factors, holds true to a considerable extent with the swede. It might be conceded, then, that the degree of resistance is due to a combination of these factors and is for the most part only partial or relative, not absolute. This seems to be fairly consistent with the fact that, in the case of certain lines of swedes showing appreciable resistance, after proceeding to a certain stage of selection, little or no further progress towards disease resistance was made.

During 1928 upwards of 150 different varieties of swedes were tested on soil heavily infested with the club root organism, introduced from various sources in the Maritime Provinces. The seed for upwards of 100 of these, was courteously supplied by Dr. G. P. McRostie of the Forage Crops Division, while the balance were obtained from miscellaneous sources. Sixty-four of these varieties showed 100 per cent severe infection, and all these will be omitted here for the sake of brevity. The following table embodies a list of the other varieties tested and their behaviour towards club root in each case.

TABLE 102.—CLUB ROOT OF TURNIPS

Variety	Percentage club root					
	By number			By weight		
	Severe	Slight	Free	Severe	Slight	Free
	%	%	%	%	%	%
Bangholm Sludsgaard, D.L.F	96·2	3·8	0·0	87·2	12·8	0·0
Wilhelmsburger D.L.F	95·2	4·8	0·0	76·9	23·1	0·0
Yellow Williamsburger, Hartmann	97·8	2·2	0·0	92·0	8·0	0·0
Yellow Butter, Hartmann	97·9	2·1	0·0	98·7	1·3	0·0
Bangholm (8312) McDonald College	93·0	7·0	0·0	95·3	4·7	0·0
Ditmars, McNutt	84·0	11·2	4·8	81·3	13·6	5·1
Bangholm, Nappan, 1926	81·4	14·5	4·1	76·0	18·5	5·5
Bangbolm, Nappan, 1927	15·6	61·6	22·8	21·4	53·7	24·9
Bangholm, Kentville, 1926	78·1	21·9	0·0	78·2	21·8	0·0
Bangholm, Kentville, 1927	33·6	34·8	31·6	41·3	32·6	26·1
Purple Top, Ottawa	78·9	21·1	0·0	78·3	21·7	0·0
Hazard's Improved, Steele Briggs	80·9	19·1	0·0	66·6	33·4	0·0
Canadian Gem, Steele Briggs	75·6	16·3	8·1	69·5	16·8	13·7
Selected Purple Top, Steele Briggs	95·5	4·5	0·0	99·0	1·0	0·0
Good Luck, Steele Briggs	86·4	13·6	0·0	81·8	18·2	0·0
Jumbo, Steele Briggs	73·6	26·4	0·0	56·0	44·0	0·0
Durham, Steele Briggs	75·0	23·2	1·8	69·6	28·6	1·8
Selected Westbury, Steele Briggs	81·0	19·0	0·0	71·3	28·7	0·0
Halewood's Bronze Top, Steele Briggs	84·4	15·6	0·0	79·0	21·0	0·0
Bangholm Sludsgaard, Trifolium	77·2	21·0	1·8	66·0	28·0	6·0
Bangholm Pajberg V., Trifolium	86·7	13·3	0·0	83·2	16·8	0·0
Shepherd, Trifolium	67·6	32·4	0·0	63·6	36·4	0·0
Bangholm, Halifax Seed Co	81·3	18·7	0·0	82·5	17·5	0·0
Jumbo Crimson Top, Halifax Seed Co	69·6	30·4	0·0	74·8	25·2	0·0
Extra Improved, Drummond	79·0	21·0	0·0	79·3	20·7	0·0
Improved Lothian, Drummond	69·8	30·2	0·0	74·4	25·6	0·0
Sterling Castle, Drummond	78·0	22·0	0·0	71·5	28·5	0·0
Best of All, Rennie	66·2	33·8	0·0	58·0	42·0	0·0
Hartley's Bronze Top, Rennie	62·7	37·3	0·0	51·0	49·0	0·0
Hazards Improved, Rennie	57·3	42·7	0·0	50·6	49·4	0·0
Invicta Bronze Top, Rennie	46·7	53·3	0·0	44·2	55·8	0·0
Irish King, Rennie	66·8	33·2	0·0	66·5	33·5	0·0
Improved Jumbo or Elephant, Rennie	41·1	58·9	0·0	22·9	77·1	0·0
Kangaroo, Rennie	52·9	47·1	0·0	53·3	46·7	0·0
Sutton Champion, Rennie	61·2	28·7	10·1	63·0	24·1	12·9
Hall's Westbury, Rennie	34·8	53·7	11·5	46·4	45·4	8·2
Magnum Bonum, Rennie	51·0	36·4	12·6	52·0	38·4	9·6
Canadian Gem, Rennie	23·2	46·1	30·7	22·6	48·9	28·5
New Century, Rennie	34·5	34·5	31·0	31·0	32·7	36·3
Derby Bronze Top, Rennie	49·6	39·2	11·2	47·2	43·0	9·8
Prize Purple Top, Rennie	49·0	26·6	24·4	37·9	32·2	29·9
Bangholm, Rennie	55·8	25·3	18·9	54·5	29·6	15·9
Kangaroo, McDonald	42·0	44·0	14·0	50·5	40·7	8·8
Hall's Westbury, McDonald	41·2	36·1	22·7	41·8	30·6	27·6
Danish Queen, McDonald	34·2	34·2	31·6	31·0	35·6	33·4
Hartley's Bronze Top, McDonald	37·7	45·5	16·8	36·4	44·7	18·9
Magnum Bonum, McDonald	28·5	48·8	22·7	27·5	45·0	27·5
Improved Purple Top, McDonald	36·8	49·5	13·7	48·0	31·2	20·8
New Masterpiece, Webb	32·0	56·7	11·3	36·8	54·0	9·2
New Buffalo, Webb	44·4	40·9	14·7	51·2	36·9	11·9
New Balmoral, Webb	55·4	29·4	15·2	52·2	29·1	18·7
New Empire, Webb	44·6	36·2	19·2	38·4	39·2	22·4
Imperial, Webb	51·2	30·2	18·6	59·7	19·5	20·8
Giant King, Webb	35·9	51·4	12·7	34·5	51·7	13·8
Bangholm, General Swedish	46·4	29·6	24·0	39·6	32·3	28·1
Elephant, Sutton	93·9	6·1	0·0	92·1	7·9	0·0
Kangaroo, Ewing	93·8	6·2	0·0	91·3	8·7	0·0

TABLE 102—CLUB ROOT OF TURNIPS—*Continued*

Variety	Percentage club root					
	By number			By weight		
	Severe	Slight	Free	severe	Slight	Free
	%	%	%	%	%	%
Garton's Superlative, Ewing	98·3	1·7	0·0	95·9	4·1	0·0
Laing's Purple Top, Ewing	87·5	10·7	1·8	84·0	14·0	2·0
Invicta Bronze, Ewing	89·3	10·7	0·0	88·7	11·3	0·0
Hall's Westbury, Ewing	87·4	10·5	2·1	77·2	20·9	1·9
Magnum Bonum, Ewing	83·5	14·7	1·8	82·9	15·2	1·9
Sutton's Champion Purple Top, Ewing	95·1	4·9	0·0	93·7	6·3	0·0
Monarch, Ewing	79·4	17·2	3·4	77·8	18·5	3·7
Kangaroo, Dupuy & Ferguson	70·5	29·5	0·0	70·8	29·2	0·0
Monarch, Dupuy & Ferguson	81·1	18·9	0·0	72·0	28·0	0·0
Favorite, Dupuy & Ferguson	62·2	22·4	15·4	56·0	24·0	20·0
Perfection, Dupuy & Ferguson	66·0	28·0	6·0	65·5	27·6	6·9
Ne Plus Ultra, Dupuy & Ferguson	48·5	24·0	27·5	52·5	20·0	27·5
New Universal, Dupuy & Ferguson	55·2	21·6	23·2	60·0	20·0	20·0
Laing's Improved, Dupuy & Ferguson	55·0	30·0	15·0	53·5	33·6	12·9
Sutton's Champion, Dupuy & Ferguson	58·4	22·4	19·2	65·2	21·7	13·1
Bangholm, Dupuy & Ferguson	63·9	19·3	16·8	59·2	24·9	15·9
Perfect Model, Dupuy & Ferguson	69·7	14·2	16·1	71·2	15·2	13·6
Wilhelmsburger, Kentville	32·0	42·0	26·0	35·6	36·8	27·6
Bangholm Sludsgaard, Original	39·1	42·0	18·9	40·2	38·5	21·3
Bangholm, Charlottetown, 1927	50·6	26·0	23·4	47·2	23·1	29·7
Bangholm, Charlottetown, 1926	27·7	47·1	25·2	35·1	40·0	24·9
Shepherd's Golden Globe (No. 10)	35·3	38·7	26·0	54·3	22·2	23·5
Mammoth Clyde Purple Top, Ewing	37·4	37·4	25·2	33·5	25·5	41·0
Kangaroo Bronze Green Top, Rennie	26·6	43·4	30·0	30·8	28·6	40·6
Elephant, Halifax Seed Co	34·7	50·4	14·9	37·4	44·5	18·1
Derby Bronze Green Top, Fredericton	38·6	34·5	26·9	46·3	30·7	23·0
Westbury Selected, Rennie	36·7	42·1	21·2	34·2	42·7	23·1
Russian Swede, Fredericton	50·2	35·3	14·5	43·5	46·5	10·0

Perusal of the foregoing results shows that a number of these varieties manifest a fair degree of resistance and give promise of providing excellent selection material for the development of strains possessing higher degrees of resistance.

The following includes in tabulated form a list of selections made from 1924 to 1927 from certain resistant strains together with their behaviour towards club root in 1928.

TABLE 103.—CLUB ROOT OF TURNIPS

Variety	Percentage club root					
	By number			By weight		
	Severe	Slight	Free	Severe	Slight	Free
	%	%	%	%	%	%
White swede (X4)	0·0	35·0	65·0	0·0	12·5	87·5
Bangholm, Fredericton (X2)	15·6	35·5	48·9	15·2	26·6	58·2
Bangholm, Fredericton (X3)	24·3	32·4	43·3	28·8	28·0	43·2
Bangholm, Fredericton (X6)	8·1	61·3	30·6	12·9	59·6	27·5
Bangholm, Fredericton (X7)	8·5	14·8	76·7	4·8	17·2	78·0
Bangholm, Fredericton (X8)	7·8	31·9	60·3	10·5	16·6	72·9
Bangholm, Fredericton (X9)	16·3	37·0	46·7	10·7	29·8	59·5
Fynsk Bortfelder (X10)	25·7	34·7	39·6	24·1	34·6	41·3
Yellow Tankard (X5)	0·0	34·5	65·5	0·0	34·0	66·0
Yellow Swedish (X11)	19·0	39·3	41·7	18·0	34·0	48·0
Majturnip Marienlyst (X14)	0·0	11·2	88·8	0·0	5·5	94·5

The results enumerated in the foregoing table show that certain of the selections particularly White Swede (X4) and Majturnip Marienlyst (X14) continued to maintain a high degree of resistance to club root for four generations. Unfortunately, however, these selections do not possess all the desired qualities of the standard commercial varieties required for local markets. This applies particularly to the latter which does not possess the correct shape. With respect to the White Swede (X 4) selection which possesses certain desirable features, upwards of 60 per cent of these, however, have fanged roots and a tendency to split. These undesirable characteristics are apparently fixed, with the result that fears are entertained that no amount of crossing will eliminate such defects. Hopes are entertained, however, that, among the balance of this selection, will be found individuals which do not possess such undesirable features. Fynsk Bortfelder (X10) and Yellow Tankard (X5) are turnip selections which have maintained a fairly high degree of resistance for three generations. These, however, are also rather undesirable types on account of their shape and unfavourable keeping qualities, in particular. The several Bangholm selections in the list give greatest promise of the development of strains sufficiently resistant to be of commercial value. The Bangholm (X2) and (X3) selections have maintained a fair degree of resistance for three generations and Bangholm (X6) and (X7) for two generations. The latter behaved best in 1928 with 76·7 per cent of its number free from the disease. Bangholm (X7) and (X8) are selections of a single generation, which manifest a reasonable degree of resistance. All of these Bangholm selections possess the qualities ordinarily required for local markets and are adapted to our climatic conditions. Providing certain of these continue to maintain their disease-resistant potentialities they should ultimately prove of considerable commercial value. It should be borne in mind when considering these results that the soil upon which all of these swedes and turnips are tested is more intensely contaminated with the club root organism than soil from ordinary commercial areas. While certain of these selections manifest favourable degrees of resistance to club root it is not considered advisable until, by further selection, strains with higher resistance are developed, to release seed of such for commercial distribution.

Club-Root of Turnips

(J. Fred Hockey, Plant Pathologist, Kentville, N.S.)

Seeds from forty pure line selections and crosses of swedes were planted in the 1928 trial plots. These selections included five first generation crosses and four second generation pure line selections; the balance were first generation pure lines of resistant strains of swedes or desirable commercial varieties. The latter were included because of their high-yielding capacity and desirableness for crossing with resistant varieties.

The soil was fairly uniform and had been previously inoculated with manure obtained from stables in which club-root infected turnips had been fed to the stock. The soil reaction was close to neutral, varying from pH 6·4—7·0. In a few plots, where only a small amount of seed was available, the plants were started in a hot bed and transplanted to the field after the two first leaves had developed.

During the season the plants were described in accordance with the system suggested by McRostie *et al*[1] with some additional observations. At harvest, root type and colour of skin above ground were noted. The latter observation correlated very closely with those made earlier in the season.

One lot of selfed seed planted in 1928 broke up in a three to one ratio of purple to green roots, giving an indication that purple may be a simple dominant colour factor. The roots were uniformly of ovoid type. The purple top was

[1] McRostie, G. P. *et al.*—Field roots in Canada. Dom. of Can. Dept. of Agr. Bul. 84 n. s. 1927.

of the shade "Hay's Maroon," and the green top varied between a "Mignonette green" and "Lime green." These strains will be carried on through further generations in an attempt to establish a uniform colour and type.

In the progeny from crosses the F_1 generation only was studied. It was observed that in all crosses of club-root resistant swedes with susceptible commercial varieties the roots in 1928 varied from long to globe, whereas the first generation selfed lines of the parents maintained their ovoid to globe type. These roots will be carried further to determine resistance and type. Colour has been uniform in F_1 lines.

Photographic records of the roots have been made of all selections that are being followed through further generations.

Downy Mildew of Hop

(William Newton, Plant Pathologist, Vancouver, B.C.)

A survey was made of the hop plantations of the Lower Fraser Valley to ascertain the amount of injury caused by downy mildew (*Pseudoperonospora Humuli* M. et T.) and its distribution. We estimate that there was a twenty to thirty per cent reduction in yield this year as the result of injury by downy mildew. Our survey covered approximately eight hundred acres in the Sardis, Sumas, and Agassiz districts. No plantations were free from the mildew and it was found on hop vines used for ornamental purposes miles away from the commercial plantations. No evidence was obtained that it is parasitic upon nettles in the Fraser Valley. Of the three commercial hop varieties, Clusters, Kents, and Fuggles, the last two appear to be quite resistant. Unfortunately, these two resistant varieties are comparatively poor yielders. The survey was made during the latter part of August. At this time the dry weather appeared to have checked the progress of the disease. Owing to the general distribution of the mildew, the hop growers desire the aid of a pathologist to assist in the development of satisfactory control measures.

POTATO INSPECTION AND CERTIFICATION SERVICE

(John Tucker, Chief Inspector, Central Experimental Farm, Ottawa)

PROGRESS

We are pleased to report good progress in the work of inspection and certification of seed potatoes, during the year 1928. There was a large increase in the number of applications received, and in the fields and acres entered for inspection.

The number of applications accepted for inspection was 6,813, the fields listed numbering 9,610 for a total of 40,497 acres. The fields were all inspected twice, except for a few fields in the Prairie Provinces, where the plants had frozen down early in the season.

A total of 31,509 acres passed both field inspections, compared with 23,875 acres passed the previous year. The percentage of acress passed was 77·8, which is a remarkably good showing considering the increase in acreage planted, the best previous record being 75·6 per cent.

PRODUCTION

Official tags were issued for over 1,500,000 bushels of Certified Seed potatoes in 1928. Half a million bushels were from the 1927 crop, and one million bushels were fall shipments from the 1928 crop.

The quantity of seed produced in 1928 was ample to fill the requirements of the domestic trade at reasonable prices and, in addition, over three-quarters of a million bushels were exported. The demand for Certified Seed for spring shipment is surprisingly good considering the size of the crop harvested.

There was over-production of table stock potatoes in most provinces in 1928, and consequently the cash return received by the producers was disappointingly low, less than the actual cost of production in many cases. This condition had the effect of lowering the prices for Certified Seed, which is not in the best interest of the seed improvement work, as much careful work is necessary on the part of the grower to produce high quality seed.

The crop was short in the West and the higher prices there resulted in large shipments of table stock from the Maritime provinces where a surplus existed. The western demand for Certified Seed was good.

The advice to " plant the best seed " holds under all conditions. In years of over-production, the benefits are just as evident as in the years of low production. There are three grades for table potatoes. The market demand for the low grade is non-existent when potatoes are plentiful, and the middle grade is disposed of only at a considerable reduction in price compared with that obtained for the highest grade. The high yields of good quality potatoes obtained by planting Certified Seed keep the per bushel cost of production down to the minimum.

NO CHARGE FOR INSPECTION

All inspections for the certification of seed potatoes were provided free of charge to growers who sent in their applications before June 15, the closing date. As usual many were late and these were listed for inspection only on payment of a special fee. The final date for listing late applications was July 1.

During the year a letter was sent to all certified seed growers drawing attention to the ruling that a charge would go into effect for all inspections performed, in 1929. Owing to the condition of the potato industry it has since been decided to hold this ruling in abeyance for the time being; therefore, no charges will be made in 1929, with the possible exception of a special charge for applications accepted after the closing date for free inspection.

DEMAND FOR CERTIFIED SEED INCREASING

Whether potatoes are grown for seed purposes or table stock, it is essential that the very best seed be used, since good foundation stock is the basis of good crops and profitable markets. Certified seed has been adopted in all the principal potato-growing districts, for it is found to be the quickest way to reduce diseases, and the most efficient method of producing large quantities of desirable, marketable potatoes at a minimum cost.

In two or three provinces, the saturation point for domestic requirements of Certified Seed potatoes has been exceeded, while in all other provinces the potato area that is annually planted to Certified Seed for table stock production is still too small. There is a gradual improvement going on all the time, however, and conditions are much better than those existing a few years ago.

Fortunately, a good export market developed for the Certified Seed from the first province to produce a surplus, and the foreign demand has increased very materially every year since. The Canadian Certified Seed potato has an excellent reputation throughout Canada, the United States, Cuba, Bermuda, and the West Indies. Trial shipments have recently been sent to many other countries. The export trade in seed potatoes is well worth the best efforts of all concerned.

Fig. 41.—Field of potatoes planted with certified seed. (Photo by D. J. MacLeod)

Fig. 42.—Field of potatoes planted with uncertified seed.

Compare the above two fields. Both were planted on the same day, in the same district, under similar soil conditions, and were photographed on the same day. (Photo by D. J. MacLeod)

THE INSPECTION STAFF

The staff of inspectors employed on seed potato inspection work during 1928 consisted of two permanent Senior Inspectors, seven permanent District Inspectors, four seasonal, and fifty temporary inspectors. The seasonal and temporary men were employed for periods varying from three to twelve months, according to the requirements of the work in the districts in which they were placed. Most of the temporary positions are held by agricultural students who return to college at the close of the field inspection work.

The Ontario Department of Agriculture, as a co-operative measure, loaned the services of two temporary men to assist with the field inspection work in Ontario. This assistance will not be available in 1929. Therefore all inspectors engaged on seed potato inspection work in future will be Dominion Department of Agriculture employees.

The success of the work rests largely with the members of the staff. We are pleased to record their uniformly interested and satisfactory services rendered during the year.

OTHER ACTIVITIES OF THE INSPECTION SERVICE

In addition to the supervision of the inspections on the growing crop, and, after harvest, on the potatoes in storages, cellars, and freight cars, there are several other activities undertaken by the permanent inspectors. Demonstration plots of seed potatoes are planted annually in each province. These include potato diseases of all kinds, seed treatments, variety and strain tests. The plots are used as a training ground for the temporary inspectors, and afterwards afford an excellent opportunity to the farmers to become acquainted with the diseases represented there.

Potato " field days " are an annual event in most provinces. The inspector accompanies the farmers to the fields and points out the various diseases, mixtures, etc., which are present, and gives a short talk on the control measures recommended (see frontispiece).

The inspectors comply whenever possible with requests for lectures and addresses at potato meetings. The Senior Inspector at Ottawa attended over thirty meetings as principal speaker, during the winter months. The inspectors in most other provinces are in great demand for this type of work. Other activities include the judging of the standing field crop competitions, judging at the fall fairs, preparing and setting up potato exhibits at exhibitions and fairs.

INSPECTION STANDARD, 1928, FOR CERTIFIED SEED POTATOES

The following was the inspection standard for 1928 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

Providing that in no case shall a total of more than 6 per cent disease be allowed on first inspection nor 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.

The standard was found to be satisfactory in 1928. During the growing season we received a few reports from some districts of the suspected presence of spindle tuber, a type of virus disease not previously recorded in our fields. The percentage reported was quite small and was dealt with as for other virus diseases. Growers in whose fields the suspected plants were found were advised to dispose of their crops as table stock and to obtain new foundation seed.

In order to obtain more definite information covering the extent and distribution of spindle tuber, we plan to have the inspectors record on their field reports in 1929 the presence of all suspicious cases of this disease found in fields intended for seed purposes.

Our recommendation, to " rogue " all fields intended for seed purposes early and often, was followed to an encouraging extent in 1928, but there are still many who delay this important feature in disease eradication until just before the inspector arrives. Further efforts will be made to encourage earlier roguing. If more than a small percentage of disease appears in a field the grower is advised to withdraw it from certification altogether, and to sell the product for table stock, rather than to attempt to keep it rogued clean of disease all through the season. The danger of spread of disease in the field is more evident every year and should be carefully guarded against.

FIG. 43.—Certified and uncertified potatoes in one field. Certified to the right and uncertified to the left. The diseases present in the uncertified seed will spread to the adjacent healthy plants. Seed planted under such conditions will not be accepted for certification. (Photo by B. Baribeau)

OFFICIAL CERTIFIED SEED POTATO TAGS

Purchasers of Certified Seed should carefully note the tags on seed potatoes, before accepting delivery, to satisfy themselves that Certified Seed is being dealt with. Many misleading and unlawful tags have been found on potato shipments. Some resemble the official tag sufficiently to mislead an unsuspecting purchaser. The colour, the outline of the official stamp and the words " selected ", " inspected ", or " disease free seed potatoes " printed on a tag is misleading, to say the least. Any imitation tags of this description should be immediately reported.

The service of inspection and certification is free to all who can qualify with potatoes which conform to the standard considered necessary in good Canadian seed. Therefore, if a grower wishes to produce a crop intended for seed purposes, he should submit his fields for inspection, and the official tags will be issued for the crop, providing it qualifies.

The following is an extract from the regulation under the Destructive Insect and Pest Act covering Certified Seed potatoes:—

" V. An inspector shall have the power to inspect before export to any foreign country, or shipment within the Dominion, any plant, and to grant a certificate according to the requirements of any country demanding such, or for domestic purposes.

" All certificates so issued must bear a copy of the official seal of the plant disease or insect pest inspection service carried on under this Act.

" In the case of potatoes for which such certificates are required, no person shall be allowed to sell or offer, advertise, expose, or hold in possession for sale, for seed purposes, any potatoes in any manner or form described or designated as certified, inspected, registered, selected, or disease-free seed potatoes unless such potatoes are contained in sacks, barrels, or other containers, to each of which shall be durably attached a certificate stating that any such potatoes contained therein have been inspected in the field and after harvest by an inspector under the Destructive Insect and Pest Act and have been found sufficiently vigorous and free from serious diseases, other pests, foreign varieties, mechanical injury, or other blemishes, to warrant them being classed as Extra No. 1 Certified Seed Potatoes. All such certificates shall bear the grower's name or number as well as a copy of the official seal of the Plant Disease Inspection Service of the Department of Agriculture, Canada."

A Summary of the Field Inspection Work, 1928

A total of 40,497 acres of potatoes was entered for field inspection, with a view to certification, in 1928. This represents an increase of 8,896 acres, approximately 28 per cent more than was entered for inspection in 1927, the previous record year.

It is gratifying to find that, in spite of the large increase in acreage entered for inspection, the percentage which passed to our standard was also higher, 77·8 compared with 75·6 in 1927.

Included in the two following tables are summaries of the distribution and results of the work in the nine provinces of Canada during 1928, and the average percentage of the principal diseases found in the fields inspected, passed, and rejected.

TABLE 104.—SUMMARY OF THE FIELD INSPECTION WORK BY PROVINCES

Province	Number of applicants	Number of fields	Number fields of passed	Percentage	Total acres	Acres passed	Percentage
Prince Edward Island	4,629	6,254	4,875	77·9	32,079	25,883	80·6
Nova Scotia	214	382	251	65·7	645	425	65·8
New Brunswick	470	853	536	62·8	3,540	2,276	64·3
Quebec	746	807	548	68	1,107	724	65·4
Ontario	420	597	453	75·8	2,043	1,480	72·4
Manitoba	33	80	46	57·5	246	124	50·4
Saskatchewan	60	118	84	71·2	301	199	66·2
Alberta	44	82	67	81·7	100	80	80
British Columbia	197	437	296	67·7	436	318	72·9
Total (Canada)	6,813	9,610	7,156	74·5	40,497	31,509	77·8

TABLE 105.—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	0·25	0·08	0·2	0·36	0·37	0·73	0·68	0·27	0·11
Leaf roll	0·02	0·32	0·1	0·33	0·64	0·39	0·29	0·32	0·01
Mosaic	0·60	0·51	1·8	1·25	0·34	0·44	0·65	0·65	1·4
Wilts	0·015	0·32	0	0·006	0·002	0	0	0	·06
Average percentage of disease in fields passed—									
Blackleg	0·13	0·03	0·1	0·16	0·24	0·32	0·3	0·09	0·07
Leaf roll	0·01	0·22	0·06	0·07	0·3	0·14	0·14	0·05	0·003
Mosaic	0·06	0·11	0·4	0·31	0·13	0·1	0·21	0·14	0·19
Wilts	0·008	0·15	0	0·007	0·002	0	0	0	0·05
Average percentage of disease in fields rejected—									
Blackleg	0·65	0·11	0·3	0·78	0·79	1·23	1·6	1·08	0·23
Leaf roll	0·04	0·51	0·3	0·88	1·73	0·72	0·68	1·01	0·03
Mosaic	2·4	1·25	3·1	3·19	0·98	0·91	1·78	2·94	4·7
Wilts	0·037	0·64	0	0·003	0	0	0	0	0·1

COMMENTS ON REJECTIONS

Of the 9,610 fields planted with certified seed in 1928 and entered for inspection with a view to certification, 7,156 fields were finally accepted for certification, or 74·5 per cent. The remainder, 2,454 fields or 25·5 per cent, were rejected for various reasons, as specified in the table. It is evident from a study of the following table No. 106, that the need for continuing the seed certification work still exists, if for no other reason than to hold to the minimum the inroad that diseases are continually making in the potato crop, and against which the seed certification work appears the most logical control measure which can be adopted for large scale operations.

Mosaic was directly responsible for no less than 1,120 of the total fields rejected. The extent of the spread of mosaic in the field during the growing season is readily apparent, and should be rigidly guarded against by careful roguing throughout the growing season.

The black leg disease was responsible for the rejections of 369 fields. The various seed treatments before planting, as recommended in the literature published by this Division, if carried out, would reduce very materially the number of rejections due to this disease.

No fewer than 500 fields were rejected owing to lack of care on the part of growers in preventing their seed from becoming mixed with other varieties, and due to their planting the fields intended for seed purposes too close to uncertified stock. The fact, that certain diseases will spread readily in the field and to adjacent fields, has been well demonstrated. It is unreasonable for growers to expect their crops to be certified, if the regulations, which require 200 feet of space or more between certified and uncertified plots, are not carefully observed.

TABLE 106—NUMBER OF FIELDS REJECTED FOR CERTIFICATION—1928. REASONS FOR REJECTION

Province	Mosaic	Black leg	Leaf roll	Foreign	Adjacent to disease	Lack of vigour	Poor cultivation and insect injury	Miscellaneous *	Total rejections	
									Fields	Acres
Prince Edward Island	608	245	9	196	97	160	....	64	1,379	6,196
Nova Scotia	49	5	22	18	13	....	10	14	131	220
New Brunswick	226	35	12	14	18	3	3	6	317	1,264
Quebec	105	29	23	4	84	....	6	8	259	383
Ontario	16	32	45	1	20	....	16	14	144	563
Manitoba	13	8	1	4	6	....	....	2	34	122
Saskatchewan	15	10	4	1	4	....	....	....	34	102
Alberta	5	3	3	2	....	2	....	....	15	20
British Columbia	83	2	1	4	14	3	....	34	141	118
Totals	1,120	369	120	244	256	168	35	142	2,454	8,988
Percentage of total rejections	45·6	15·0	4·9	10	10·4	6·9	1·4	5·8	100	....

*Includes rejections for all other reasons than those specified, viz.—Wilts, streaks, frozen down, drowned out, etc.

Development of the Potato Certification Work

Following some preliminary work done on potato disease in New Brunswick and Prince Edward Island by the Dominion Botanist, a system of potato field inspection and certification was started in these two provinces, in a small way, in 1915. The service became popular and was extended to other provinces as its value was recognized. The inspection work now extends throughout the Dominion, with a strong and well balanced staff of permanent and seasonal inspectors, and is a most important phase in the activities of the Division of Botany.

By 1920 the plantings of Certified Seed had increased substantially and resulted in 3,956 acres passing inspection. This made available large quantities of Certified Seed for the domestic trade, and in addition 75 carlots were exported. By 1924 the area entered for inspection had increased to 19,238 acres, and the shipments of Certified Seed to 334,484 bushels. The potatoes exported made a favourable impression in the foreign markets, and the demand has continued to improve every year. In 1926 shipments totalled 1,081,825 bushels, in 1927, 1,509,200 bushels. In 1928, 40,497 acres were inspected and the shipments totalled 1,500,000 bushels. The total shipments from the 1928 crop will probably exceed any previous record.

The following table indicates the development of the field inspection work by provinces, and the popularity of the service with the public, and the potato growers and dealers generally.

TABLE 107.—DEVELOPMENT OF THE POTATO CERTIFICATION WORK. THREE-YEAR PERIOD ENDING 1928

Province		Fields entered	Fields passed	Percentage	Acreage entered	Acreage passed	Percentage	Increase or decrease in acreage passed
Prince Edward Island	1926	2,300	1,801	78·3	9,275	7,597	82·0	%
	1927	5,642	4,471	79·2	24,845	19,915	80·1	
	1928	6,254	4,875	77·9	32,079	25,883	80·6	+240·7
Nova Scotia	1926	137	106	77·4	219	172	78·5	
	1927	336	185	55·0	620	377	60·8	
	1928	382	251	65·7	645	425	65·8	+147·1
New Brunswick	1926	506	278	55·0	2,031	1,195	58·8	
	1927	654	418	63·9	2,777	1,732	62·4	
	1928	853	536	62·8	3,540	2,276	64·3	+ 90·5
Quebec	1926	184	107	58·2	340	182	53·6	
	1927	398	261	65·6	590	385	65·3	
	1928	807	548	68·0	1,107	724	65·4	+297·8
Ontario	1926	440	319	72·5	826	579	70·1	
	1927	467	359	76·9	1,205	950	78·8	
	1928	597	453	75·8	2,043	1,480	72·4	+155·6
Manitoba	1926	60	41	68·3	146	100	68·6	
	1927	53	32	60·4	145	57	39·3	
	1928	80	46	57·5	246	124	50·4	+ 24·0
Saskatchewan	1926	80	71	88·7	214	103	48·1	
	1927	113	50	44·2	407	131	32·2	
	1928	118	84	71·2	301	199	66·2	+ 93·2
Alberta	1926	75	53	70·7	152	56	36·8	
	1927	115	63	54·8	250	50	20·0	
	1928	82	67	81·7	100	80	80·0	+ 42·9
British Columbia	1926	430	318	74·0	512	408	79·7	
	1927	610	286	46·9	762	278	36·5	
	1928	437	296	67·7	436	318	72·9	− 22·1
Total for Canada	1926	4,212	3,094	73·5	13,715	10,392	75·8	
	1927	8,388	6,125	73·0	31,601	23,875	75·6	
	1928	9,610	7,156	74·5	40,497	31,509	77·8	+203·2

Standard 1926 — Total of 4 per cent diseased plants allowed.
1928 — Total of 3 per cent diseased plants allowed.

POTATO EXPORTS AND IMPORTS, 1928

The exports of potatoes from Canada in 1928 amounted to 6,308,917 bushels, valued at $4,638,378. The principal markets were the United States, Cuba, Bermuda, British Guiana, Jamaica, Trinidad, Newfoundland, and Panama.

The total imports of potatoes into Canada during 1928 amounted to 707,915 bushels valued at $501,729, of which 707,312 bushels, valued at $500,747, came from the United States.[1]

Included in the export figures are the Certified Seed shipments to foreign countries, amounting to over one and a quarter million bushels. An official tag was attached to every package of certified seed, describing the contents, variety, certificate number, etc.

The Bermuda shipments were practically all Certified Seed. The Cuban shipments were mostly table potatoes. Special health certificates are required by the Cuban Government covering all importations of potatoes into Cuba. A certificate is issued, in duplicate, for every individual shipment, by the seed potato inspection staff, at the seaboard shipping points. One copy accompanies the shipment, the other is filed at Ottawa. Health certificates were required for 2,139,067 bushels in 1928. As a result of the satisfactory crops obtained from the use of Canadian seed last year, the Cuban demand for seed increased appreciably in 1928. A much better demand is anticipated in 1929.

A test shipment, consisting of sample lots of seed, from one to fifty bushels each, of several varieties, went to South Africa to arrive in time for planting in December. Should the results prove satisfactory, it may lead to important business for Canadian seed potato growers.

Canadian Certified Seed continues to give remarkably good results in the many potato areas in the United States to which shipments have been sent.

SUMMARY OF FIELD INSPECTIONS. THREE YEAR PERIOD ENDING 1928

One outstanding feature of the field inspection work during the three year period ending 1928, is the lead that the Prince Edward Island growers have taken, in the production of Certified Seed, over other provinces. This applies not only to the number of fields inspected, but also to the quantity of Certified Seed shipped under the official tag. The percentage of acres "passed," 80·6 per cent in 1928, compares favourably with 82 per cent in 1926, and is considered a remarkable performance in view of the increased acreage and the large number of new growers taking up seed production.

A steady annual improvement is apparent in both Nova Scotia and New Brunswick. Good progress was also made in Quebec, as a study of the figures for the province reveals. The area entered for inspection in Quebec increased from 340 acres in 1926 to 1,107 acres in 1928, and the percentage of the acreage passed from 53·6 per cent to 65·4 per cent.

Good progress is recorded for Ontario, over the three year period. The prairie provinces likewise show some improvement, Saskatchewan in particular. In the case of British Columbia, the work was reorganized in 1927; mosaic was spreading rapidly in some seed stocks and several doubtful fields were rejected; the 1928 figures indicate a good improvement over 1927.

SUMMARY OF FIELD INSPECTIONS 1920-1928

The progress and expansion of the seed potato certification service over a period of nine years is demonstrated concisely in the following tabular and graphical summaries:—

[1] From "Trade of Canada 1928." Published by the Department of Trade and Commerce.

TABLE 108.—NUMBERS OF ACRES INSPECTED AND PASSED

—	Number of acres inspected	Number of acres passed	Percentage of acres passed
			%
1920	7,613	3,956	51·9
1921	7,900	4,290	54·3
1922	11,250	6,991	62·1
1923	9,681	7,099	73·3
1924	19,239	13,917	72·3
1925	14,452	10,857	75·1
1926	13,715	10,392	75·8
1927	31,601	23,875	75·6
1928	40,497	31,509	77·8

The standard for certification in 1920 was low, compared with the present standard. There were two grades for seed potatoes; No. 1, which permitted a tolerance of seven per cent of diseased plants, and five per cent of mixed varieties; No. 2, which permitted a tolerance of twelve per cent of diseased plants plus five per cent of mixed varieties; whereas the standard now permits of only three per cent of diseased plants, and no mixed varieties, on final inspection.

Of the 7,613 acres inspected in 1920 only 51·9 per cent passed, whereas, in 1928, a total of 77·8 per cent of the 40,497 acres submitted for inspection passed the present high standard.

TOTAL AREA OF POTATOES, CANADA, 1928

To demonstrate, in a complete and concise form, the distribution of the field inspection work, and the comparison between table stock and seed acreages, the following tabular and graphical summaries are presented:

TABLE 109.—COMPARISON OF TOTAL AREA GROWN WITH AREA INSPECTED FOR SEED PURPOSES, 1928

Province	Total area*	Total area inspected	Percentage
	acres	acres	%
Prince Edward Island	51,890	32,079	61·82
Nova Scotia	30,685	645	2·10
New Brunswick	52,239	3,540	6·78
Quebec	164,000	1,107	0·67
Ontario	181,241	2,043	1·13
Manitoba	31,054	246	0·79
Saskatchewan	42,800	301	0·70
Alberta	28,366	100	0·35
British Columbia	16,788	436	2·60
Total Canada	599,063	40,497	6·76

* From Dominion Bureau of Statistics, January, 1929.

TABLE 110.—PERCENTAGES OF THE TOTAL CROP WHICH WERE INSPECTED FOR SEED PURPOSES FROM 1920 TO 1928

—	1920	1921	1922	1923	1924	1925	1926	1927	1928
	%	%	%	%	%	%	%	%	%
Percentage of total potato crop which was inspected for seed purposes..................	1·00	1·12	1·65	1·72	3·43	2·79	2·62	5·52	6·76

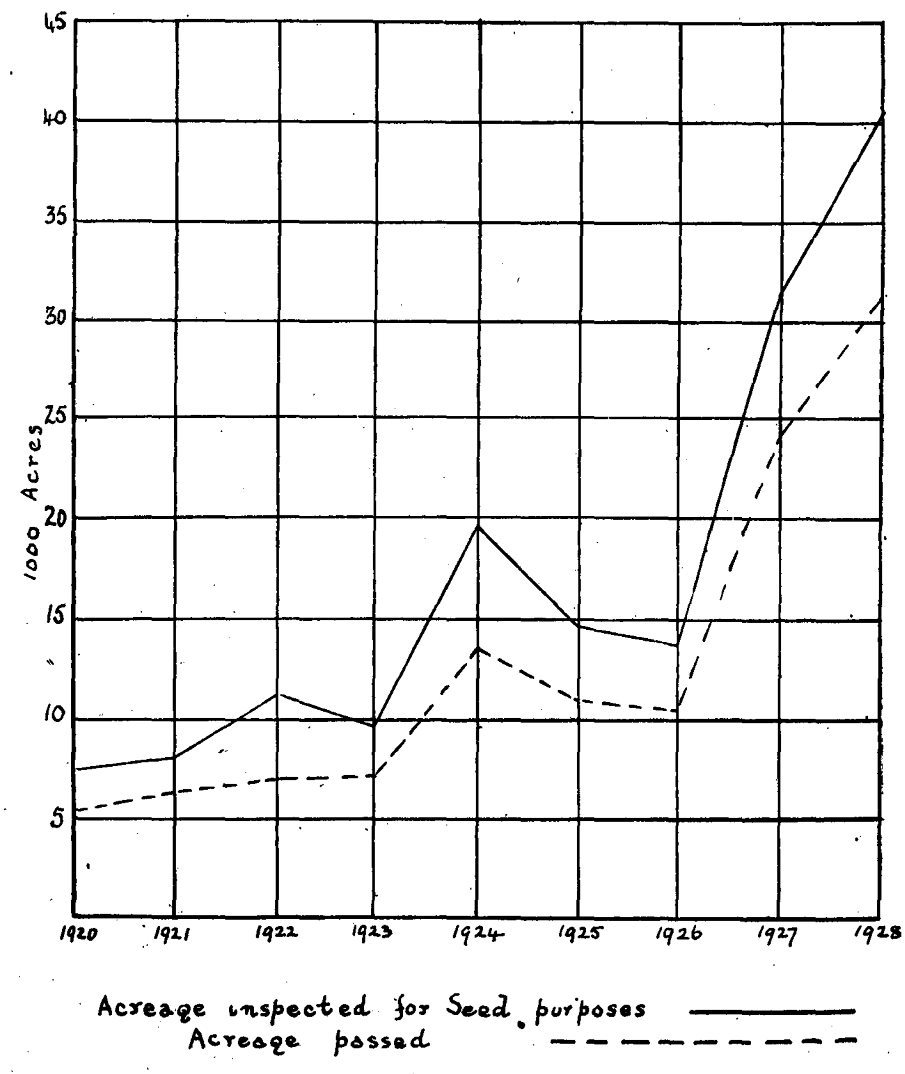


FIG. 39.—Showing progress in inspection work over a nine-year period, 1920-28.

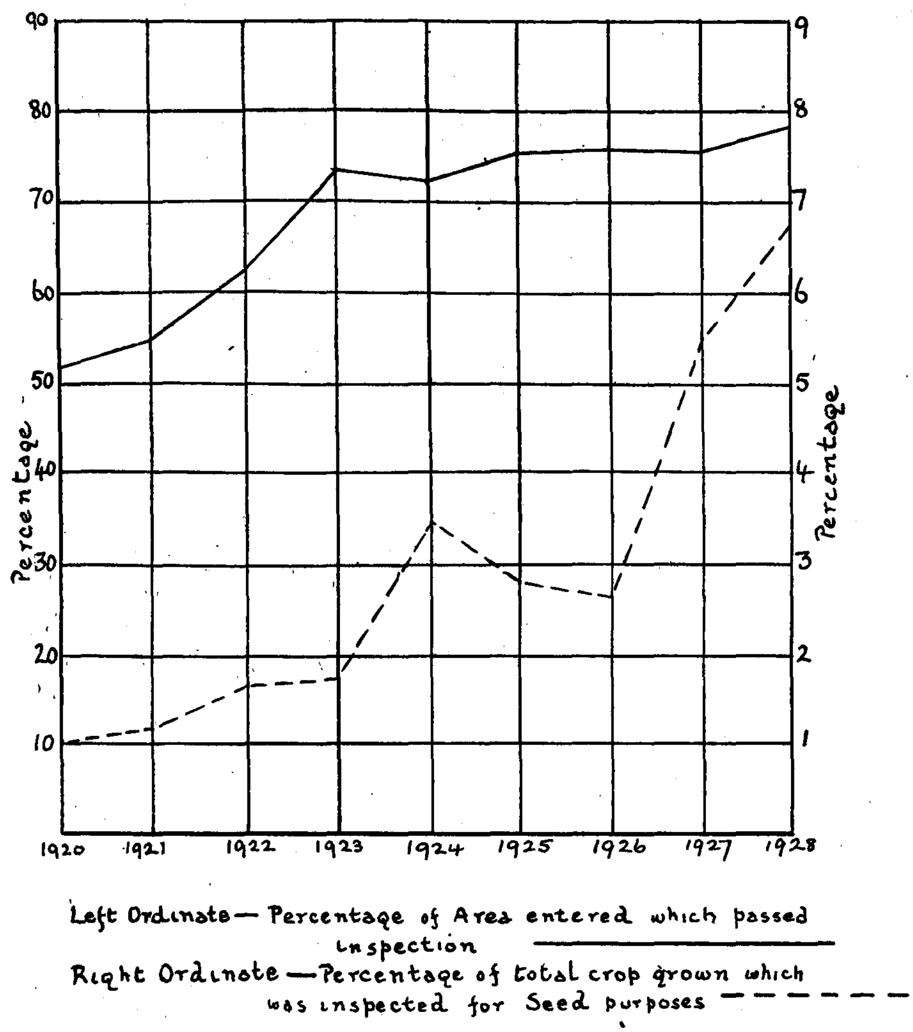


FIG. 40.—Percentage of areas passing inspection over a nine-year period, 1920-28

Possible Industrial Outlets for Surplus Potatoes

A good demand for potatoes, or good prices, will result in an increased acreage the following year. The law of supply and demand determines the prices of all products; and potato prices appear to fluctuate more than for any other crop. A short crop results in a lot of poor quality potatoes being marketed at high prices, but the producer as a rule benefits little. Likewise a large surplus may easily be ruinous to the producer, for the crop may not pay production costs when prices are low. Either condition is unsatisfactory.

It is extremely important to attain the highest efficiency in production; but it is equally important to keep the volume of supplies as nearly adjusted to the requirements of the market as possible. It is impossible to specify the exact area to plant that will nicely balance production with consumption for many reasons, chief of which is weather conditions. Due allowance is usually made for bad, growing conditions. Should these not occur, we may expect a surplus of crop over our normal consumption.

Having three grades for table stock helps to stabilize the market to some extent. In years of low production all grades may be marketed. Just what to do with the large surplus of low and medium grades left on the farms in some years is a problem. The potato crop is an expensive one to produce and, if not put to the most profitable use, its marketing results in a serious economic waste.

The world's potato crop exceeds that of any of the cereals. The value of low grade potatoes for stock feeding and industrial purposes has long been commercialized in Europe, especially in Germany, where approximately 30 per cent of the world's total potato crop is grown. Because of the importance of the industrial utilization of potatoes in Germany, varieties have been developed there which have a high starch content, and are grown specifically for the industrial purposes for which a maximum starch content is desired. Part of the crop annually goes into the manufacture of dried chips and flakes, the supply of potatoes for this purpose being reasonably uniform from year to year. From 200 to 300 factories are in operation, using annually some twenty million bushels of potatoes for drying.

In Canada, in years of normal production, the "culls" may be fed to the pigs, and in years of over-production cattle may consume quantities of otherwise marketable potatoes, but nowhere are potatoes grown primarily for feeding purposes for two main reasons. One is that it is usually possible to obtain a better price by marketing them for table stock, and the other, that food for live stock can be produced more cheaply from other sources than the potato.

In a year of over-production, as in 1928, all potato growers should critically consider the feeding value of potatoes for live stock generally, and the feasibility of using part of the crop for that purpose, so that, even with a surplus, they may be assured of a fair and reasonable return. The composition of the dry matter in the potato is the same as that of Dent corn, except for the somewhat higher ash and lower fat content in the potato, and they would have about the same feeding value. Both are low protein feeds, and should be used in rations properly supplemented with proteins. Raw potatoes can be successfully fed to cattle, sheep, and horses, in reasonable amounts in properly balanced rations. If fed carelessly they may cause colic or bloating, and prove too laxative for the best results. Potatoes should be steamed or boiled and mixed with grain for pigs; the water should be drawn off after cooking—it has a bitter taste.

There is much to be done before any recommendation can be made as to which method of industrial utilization will be the most promising under our conditions. The following are some of the products which may be obtained directly from starch material like the white potato: dried or dehydrated products, fermentation products, and potato flour and starch; dextrin, modified starches, nitro-starch, glucose, dextrose or starch sugar, and maltose syrup.

The fundamental basis of the profitable utilization of potatoes for low-price by-products, such as starch, is ample supplies of cheap potatoes every year sufficient to keep the plants running at a profit, and satisfactory markets for the finished product.

The imports of potato starch into Canada in 1928 totalled 4,954,241 pounds valued at $217,232 as follows: From the United Kingdom, 7,250 pounds, value $344; from the United States, 1,365,022 pounds, value $96,114; from the Netherlands, 3,549,908 pounds, value $118,903. Exports of potato starch from Canada were 3,500 pounds, value $261.

In presenting this material we are not attempting to encourage or discourage anyone in the production of by-products from potatoes as a means of disposing of cull or surplus crops. It will remain a risky financial venture as long as raw supplies and prices fluctuate as they have been doing in the past. The machinery required in the various processes is expensive and considerable overhead is required to carry a plant over a season of low supplies.

The following recommendations appear sound: stabilize the acreage in the recognized potato areas, planting only the land which is entirely suited for the purpose. Improve the quality and the yield per acre by the use of Certified Seed. Practise better grading, by which is meant " shipping for human consumption nothing but high quality potatoes."

The larger quantity of culls which will be left on the farms will have good value as feed for live stock. In the large potato areas where plentiful supplies of low grade potatoes will be available every year, the surplus potatoes can be dehydrated for use in the northern camps, or dried for cattle feed in chips and flakes, or manufactured into other by-products.

EXTRACTS FROM INSPECTORS' ANNUAL REPORTS, 1928

The following extracts were taken from the annual reports which were submitted to headquarters by the inspectors who have supervision over the work in the territories covered in their reports. They were submitted at the close of the fall shipping season, and are included here, as they describe the progress of the work by provinces.

PRINCE EDWARD ISLAND.—S. G. Peppin, Senior Inspector, Laboratory of Plant Pathology, Charlottetown, P.E.I.

The final shipment from the 1927 crop of Certified Seed Potatoes, in April, 1928, closed one of the most successful shipping seasons since the inception of the inspection work in this province.

TABLE 111.—SHIPMENTS OF CERTIFIED SEED POTATOES 1927 CROP, PROVINCE OF PRINCE EDWARD ISLAND

Variety	Fall shipments	Net Price (per bush. to growers)	Spring shipments	New Price (per bush. to growers)
	bushels	$	bushels	$
Green Mountain	127,400	0 80	88,790	1 00
Irish Cobbler	714,220	0 70	309,838	0 90
Spaulding Rose	2,948	0 80	....	....
	844,568	604,232 40	398,628	367,644 20

Total bushels shipped = 1,243,196.
Total value = $971,876.60.

The above figures represent an average of approximately 62½ bushels from each of the 19,915 acres which passed final field inspection. As a general rule the average crop will grade about 60 per cent of Certified Seed. The total yield harvested from the varieties entered for inspection and certification ranged between 250 and 300 bushels per acre, making approximately 150 to 180 bushels per acre actually available or eligible for certification as Extra No. 1, graded stock.

The area entered for inspection in 1928 increased to 32,079 acres from 24,845 acres in 1927, or by almost 29 per cent.

The season was, on the whole, favourable for good plant growth, with no serious outbreaks of any one disease. The spring opened up somewhat earlier than usual. Planting commenced in some districts on May 15. This practice, however, is not recommended except for early markets for table stock. Apparently the best average dates for planting and harvesting each variety are as follows:—

TABLE 112.—BEST AVERAGE DATES FOR PLANTING AND HARVESTING CERTIFIED SEED POTATOES IN PRINCE EDWARD ISLAND

Variety	Date of planting	Date of harvesting
Green Mountain	May 24 to 30	October 1 to 10
Irish Cobbler	June 1 to 10	September 24 to 30
Spaulding Rose	June 1 to 10	October 1 to 10
Bliss Triumph	June 1 to 10	September 24 to 30

The first inspection started on July 23, and was followed, in approximately three to four weeks, by the second inspection, the whole of the field work being completed by September 14.

The principal field diseases—black leg, leaf roll, and mosaic—were present in practically the same amounts as in 1927.

Since the inception of our campaign for the treatment of all seed potatoes the black leg disease has been considerably reduced. The treatment recommended is cold bichloride of mercury (1-1000, or 4 ounces to 25 gallons of water). Soak the whole tubers in this solution for 1½ hours. Nearly two tons of this mercury salt were sold by the Potato Growers Association to its members for this purpose last spring.

Leaf roll is of minor importance in this province and is found only occasionally.

Mosaic persists in the Green Mountains to a greater extent than it should. The time has come for drastic measures if we are to control this trouble. We still have one or two special strains which are almost entirely free of mosaic disease. These, unfortunately, are often shipped out of the province, leaving too little for local distribution. Our growers now realize, that the Green Mountain variety cannot be kept even relatively free of mosaic without resorting to isolated seed plots planned by the tuber unit method. We have encouraged a number of growers to carry on such work, and look for better results if sufficient time and care can be given to this very essential phase of Certified Seed potato growing.

Late blight infection on the vines was reported from several districts during the first week of inspection. The cases reported were not severe, and were more or less isolated. However, by the middle of August, many fields were seriously affected. Heavy and constant spraying with wet Bordeaux mixture assisted materially in holding the disease in check. A fatal mistake made by not a few growers is to refrain from spraying their fields after the middle of September. Therefore the foliage, having been kept in a green condition until this time, is liable to become affected by the spores of the disease which may remain viable either in isolated spots in these fields or neighbouring ones. If, consequently, the crop is harvested while the tops are still green, the infection thereby reaches the tubers with subsequent rot in storage. This happened in many instances, particularly in the Green Mountain variety. The Irish Cobbler is less liable to this late infection, since the vines are usually dead or dying by the middle of September. Spraying with arsenite of soda, 3 pints to 80 gallons of water, to kill the vines, about ten days before harvesting, has been recommended. This procedure has, we believe, proved quite successful in controlling much rot infection in the tubers.

Late blight rot, when present, made its appearance in the bins within two or three weeks after the average harvest date. Conditions prevailing in a pile of tubers immediately after harvest for a period of ten days to two weeks, when sweating is taking place, are ideal for the development of late blight rot. Where 3 per cent or more of tubers affected with rot are present at the time of bin inspection, grading for seed is not permitted until late fall or spring shipments.

Early blight was present this year in some fields. The plants most seriously affected were dead by the latter part of August. It is such cases as these, and those fields referred to as having late blight early in the season, which serve to demonstrate the necessity of early, late, and constant spraying with Bordeaux mixture to control these diseases on the foliage, and late blight rot in the tubers.

Tuber inspection commenced on October 1, and active shipping about October 17, with the assembling of a cargo for a steamer which sailed on November 1. Up to the end of 1928 the total fall shipments from this year's crop by direct rail and steamer aggregated 850,000 bushels. This is a remarkable figure when we consider the depressed condition of the market.

The field inspection work necessitated the employment of twenty-four plant disease investigators, with an additional six to carry on the tuber inspection work.

Nova Scotia.—W. K. McCulloch, District Inspector, Laboratory of Plant Pathology, Kentville, N.S.

The increased acreage entered for inspection for 1927 was maintained this year. A few growers who were unsuccessful last year did not request inspection, but their places were taken by new applicants, and the net result was an increase of 4 per cent in the total acreage inspected.

Tuber inspection cards to the number of 132 were sent out, and 122 were returned.

During February and March shipping inspection was required on 1,600 bushels of Irish Cobbler for export to Bermuda, and about 2,100 bushels of Green Mountain to the United States. The latter case was remarkable in that it was the first shipment of Certified Seed made directly from Nova Scotia to the United States.

The first shipment of Garnet Chili seed potatoes to Bermuda was made about the middle of October, and weekly shipments occurred thereafter until the end of November. In all about 24,000 bushels were exported, which is the normal annual requirement of Bermuda in this variety. In addition about 2,500 bushels were exported to Cuba, more or less as a test shipment, and the result is awaited with much interest by those concerned.

In addition to the regular inspection work we undertook the responsibility of judging and placing the potato crops of 58 contestants in a Potato Crop Competition instituted by the Provicial Seed Board.

At the request of farmers' societies, addresses on Certified Seed Potatoes were given at Antigonish and Middleton. Demonstrational work in tuber unit planting and roguing of seed plots was carried out in Kings, Colchester, Pictou, and Halifax counties, and investigational work at the Experimental Station, Kentville.

New Brunswick.—C. H. Godwin, District Inspector, Laboratory of Plant Pathology, Fredericton, N.B.

Proof of a greater willingness on the part of the seed growers to comply with the regulations governing Certified Seed Production was shown during the year by the large quantity of Certified Seed purchased for local planting, and from the increased number of inquiries regarding the same.

A total of 3,540 acres of potatoes was entered for certification, an increase of 763 acres or 27 per cent over the 1927 acreage. The season was ideal for potato growing, late blight causing little damage except in the northern section of the province, and the average yield of 273 bushels from fields which passed inspection exceeded that of 1927 by approximately 60 bushels per acre.

Of the acres entered, 64 per cent passed for certification, an improvement of 2 per cent over the 1927 results.

TABLE 113.—CERTIFIED SEED PRODUCTION

Variety	1927	1928
	bush.	bush.
Green Mountain	211,939	458,300
Irish Cobbler	141,309	78,025
Bliss Triumph	11,892	52,594
Other varieties	3,905	11,808
Total	369,045	600,727
	1927	1928
Average yield per acre of all varieties	213	273
Average yield per acre of Green Mountains	200	260
Average yield per acre of Irish Cobblers	230	262
Average yield per acre of Bliss Triumphs	264	297

It is satisfactory to note that nearly seventy-five growers followed our recommendations and maintained tuber unit seed plots in 1928. These growers welcomed our directions in planting and in the identification of the various diseases present. Other growers secure their seed each year from sections where good foundation stock is grown.

Table stock growers are realizing more than ever that Certified Seed produces larger crops of marketable tubers, of the highest grade. In some districts, where Certified Seed has not been used for the growing of table stock, small quantities were distributed so that the growers could compare the crops from Certified Seed with those from their own seed. Information was freely given on cultivation and disease control, where requested.

Seed Shipments.—The large 1928 crop and consequent low prices for table potatoes had a tendency to curtail seed shipments in the fall. For the year 1928 approximately 133,000 bushels of the inspected crop moved for seed purposes, of which 58,013 bushels were sold as Extra No. 1; of these 16,738 bushels were shipped in the fall, or some 2,000 bushels less than the shipments for the corresponding period of 1927.

Cuban Shipments.—Health certificates were issued for 575,000 bushels of potatoes shipped during the year 1928; of these 408,993 bushels were from the 1928 crop, shipped before December 31.

Other Activities.—Tuber unit seed plots of different varieties were established in various sections of the province.

Test plots of Bliss Triumph, some from our own 1927 plots and some from the western provinces, were planted to determine whether the different plant diseases were being controlled. No disease was seen in plots from our own seed. Some units from the western seed showed a small percentage of leaf roll. These results are decidedly encouraging. Selection of plants having desirable characteristics were staked off and kept for further observation.

Tests were made to determine the amount of damage caused by emptying potatoes into barrels, and by the digger. A quantity of Bliss Triumphs, free from cuts and bruises, was emptied into an upright barrel and a similar quantity was rolled gently down into a tilted barrel. The first lot showed 7·8 per cent bruised and 13 per cent cracked; the second showed no bruises or cracks. A test of tubers dug by machine showed 5·5 per cent bruised. Further tests will be made during the coming season with different varieties of tubers.

An experiment to determine the loss of potatoes in storage from disease and shrinkage was commenced during the fall.

Tests were made with both Dip dust and mercuric chloride for seed treatment, to obtain results for each as to yield and germination. No difference in germination was observed, but a slight increase in yield was shown in the seed treated with mercuric chloride.

An exhibit of photographs of potato fields, and specimens of potatoes affected with different diseases, was shown at four different places in the province. An inspector accompanied the exhibit. He gave information and distributed bulletins to those interested. Assistance was given to the Provincial Government in judging potato fields entered in the Field Crop Competition, and at the seed fairs at Moncton and Bathurst.

One paper and a number of short press articles were written for publication during the year.

QUEBEC.—B. Baribeau, District Inspector, Laboratory of Plant Pathology, Ste. Anne de la Pocatière, P.Q.

For the 1928 season, 1,107 acres were entered for inspection, an increase of 517 acres or almost 88 per cent over the 1927 entry. The percentage passing inspection, 65·4 per cent, was slightly higher than for 1927.

Another indication of the improvement in the potato growing industry is the discarding of varieties of little commercal value. Of the 590 acres entered in 1927, over 9 per cent were unprofitable varieties; while of the 1,107 acres in 1928, the percentage of such varieties fell to 3 per cent, the remainder being made up of Green Mountain 74 per cent, Irish Cobbler 14 per cent, and Carman 9 per cent.

This very distinct improvement is mainly due to the wider use of Certified Seed, which was distributed throughout the province by the provincial Department of Agriculture, and to better cultural practices.

The average yield for Certified Seed was approximately 214 bushels per acre; a few growers reported over 400 bushels. Unfavourable weather conditions and late blight seriously affected the yields in some districts, the average being 34 bushels less than that for 1927.

Field Inspection.—Of the 807 fields inspected, 259 failed to qualify for certification. Of this number, 84 fields planted with Certified Seed and submitted for inspection were rejected because of a too close proximity to fields containing a high percentage of mosaic. The remaining fields were rejected because of mosaic, black leg, leaf roll, etc.

Tuber Inspection.—Applications for tuber inspection numbered 483. About 85 per cent of the fields which passed qualified for certification at final tuber inspection. Approximately 51,000 bushels should grade Extra No. 1, as follows: 35,000 bushels Green Mountain, 5,600 bushels Irish Cobbler, 7,000 bushels Carman No. 1, and 3,400 bushels other varieties.

Late blight caused considerable loss, especially in Portneuf and Bellechasse counties. Approximately 16 per cent of the crop was affected. The amounts of black leg, *Rhizoctonia,* and common scab found were not of serious consequence.

The quantity inspected and tagged for shipping amounted to 8,226 bushels, all consigned to points within the province. The average price was $1.25 per 90 pound bag for Certified Seed as against 75 cents per 90 pound bag for table stock on the same shipping date.

Other Activities:—

The plots planted with seed selected from the 1927 tuber unit seed plots remained free from virus disease except for two lots which showed one-third of 1 per cent of disease. This selected seed gave increased yields, and 50 per cent of the tubers approached the ideal shape. Foundation stock growers are well advised to plant out a tuber unit seed plot every year to maintain the productive qualities of their seed stocks.

Our inspection staff is co-operating with officials of the Provincial Department of Agriculture in the field training of the judges of potatoes, judging the standing field crop competitions, putting on spraying demonstrations, attending meetings, etc. One outstanding meeting was held at New Carlisle, in April, when over 600 potato growers from Bonaventure and Gaspé counties met to listen to many expert speakers on the principles underlying successful potato production and marketing. This meeting has shown good results. Certified Seed, seed disinfectants, spraying and dusting machines were purchased by the growers in these districts, and the acreage of potatoes entered for certification increased 280 per cent.

During the year we conducted experiments to determine the value of Dipdust and other seed disinfectants. We also planned a series of demonstrations showing the proper method of tuber unit planting, and the roguing of seed plots. We planted our usual variety test plots and carried out investigational work on potato diseases.

Lectures were given, thirty-two in all, at many of the Agricultural meetings, short courses, field days, etc. We judged the potatoes at the Provincial seed and county fairs, and the collection of plant disease exhibits at the Agricultural school, Ste. Anne de la Pocatière.

Several press articles were prepared for publication, on certified seed production, selection, seed plot work, etc., and we had an exhibit of potato diseases at some of the larger fairs.

Potato Growing on Magdalen Islands.—Last spring, over 175 bushels of Certified Seed potatoes of the Green Mountain variety were entered for inspection on Magdalen Islands; the yields obtained were very good, some growers reporting up to 400 bushels per acre. There were no Colorado beetles found on these islands, but the aphids were particularly numerous. All the leaves of every plant in the thirty-seven fields visited bore traces of them. Mosaic, black leg, and late blight were the principal diseases found. Heavy losses occur every year from late blight.

ONTARIO. O. W. Lachaine, District Inspector, c/o Ontario Agricultural College, Guelph, Ont.

The acreage entered for inspection in 1928 totalled 2,043, or 838 more than in 1927. This is an increase of nearly 70 per cent, resulting, as might be expected, in a slight decrease in the percentage of acres passing inspection, 78·8 in 1927 and 72·4 in 1928. New growers of Certified Seed are not always well versed in the requirements of their more exacting work, and the weather conditions throughout the growing season were unfavourable.

Late blight was found to be present in the majority of the fields that were not sprayed. Bordeaux mixture, either in liquid or dust form, apparently gave excellent control over the disease where properly used.

Over-production kept the table stock prices down, and also adversely affected the seed market. Fall shipments of Certified Seed were not as heavy as in previous years, but an improvement is looked for in the spring. The need for better seed is very evident throughout the province.

Other Activities.—The inspection staff in co-operation with the provincial agricultural representatives gave a series of special lectures at many potato "Field Days" which were organized throughout the province, and at the Agricultural Short Courses and potato meetings held during the winter months. The inspectors also judged the potato entries at numerous county and winter fairs. Exhibits showing varieties, types, and diseases of the potato were set up at the Toronto, Ottawa, London, and Lindsay fall fairs.

The Provincial Department of Agriculture distributed several car lots of Certified Seed to school children, for seed plot and school fair work. We find that seed distributed in this way has been the nucleus of many fine fields of potatoes which have been entered for certification.

We are glad to acknowledge the hearty co-operation of the many provincial officials of the Department of Agriculture who have consistently supported this work in Ontario. As in former years, two Provincial inspectors were provided to assist us in the field inspection work, under the supervision of the Dominion District Inspector.

MANITOBA AND EASTERN SASKATCHEWAN.—J. W. Scannell, District Inspector, Experimental Farm, Indian Head, Sask.

Since the last report a furnished office has been allocated to the potato inspection staff by the Superintendent of the Experimental Farm, Indian Head. This generous co-operation is heartily appreciated.

During 1928 unfavourable weather caused low yields in eastern Saskatchewan and in the low lands of Manitoba. The crops on the higher lands of the latter province, however, were very good.

The 1928 Certified Seed was in great demand, the price in Manitoba ranging from 25 to 50 per cent higher than that for table stock. Even at these relatively high prices, the demand could not be met from local grown stock. Enquiries for several carloads of certified Cobblers for export were received but, unfortunately, none was available.

Late blight appeared in Manitoba again this year, and it is expected that spraying or dusting will soon become a necessity here, as it is in most other potato producing centres. Eastern Saskatchewan is still free.

Black leg was quite common, especially on the lower lands. *Rhizoctonia,* common scab, and early blight caused little damage.

Early Ohio and Irish Cobbler continue to be the popular varieties for this section of the Dominion. A large area of Cobblers, grown from Prince Edward Island seed, was inspected; the yield was very good, but the type is hardly as desirable for our trade as some of our western strains. There is a demand for Bovees and Wee McGregors, but few fields of these varieties are entered for certification. Netted Gem and Russet Burbank are grown more extensively in eastern Saskatchewan than in Manitoba. While the yield of these russet potatoes may be a little low under our dry land conditions, the resistance they show to common scab commends them where this disease is prevalent. They are in good demand for table stock.

Other Activities.—A variety test plot was planted of all strains of Certified Seed produced in 1927 on the prairies. Over 110 lots were tested, each lot being planted by the tuber-unit method and quadruplicated. A report of the disease found and yields of marketable and cull potatoes was sent to each grower, and to others interested.

A potato disease nursery was maintained in an isolated location, as a training ground for inspectors and for demonstration purposes.

A varietal study plot was grown, consisting of the more uncommon varieties found in the prairies.

A *Rhizoctonia* and seed treatment experiment was continued under the direction of Dr. G. B. Sanford.

Small samples of seed potatoes from our plots were mailed to anyone who applied. A large quantity was sent to the Experimental Station at Scott for distribution.

We had an exhibit of plant diseases and potatoes at the Regina Fair during the summer which drew considerable attention, and we shall extend this work if possible next year.

WESTERN SASKATCHEWAN AND ALBERTA.—J. W. Marritt, District Inspector, Experimental Farm, Indian Head, Sask.

Heavy rains in June and July, and early frosts, caused light yields in the late varieties. A dry fall, however, made excellent conditions for digging, and bin inspections showed the tubers to be exceptionally clean, smooth, and of good type, with a tendency to be rather small.

There were approximately 3,350 bushels of Certified Seed for sale in western Saskatchewan and 2,760 in Alberta. Most of our shipments are made in the spring when danger of freezing is over. A good market is indicated for practically all our western grown seed in the spring.

Some very good fields of the Sharples strain of Bliss Triumphs were grown in Alberta, with a view to developing an export trade in seed potatoes. Prices, however, were too low for profitable trade for the 1928 crop, but it is expected that growers will plant a good acreage of this variety in 1929, as next year will probably see an improvement in the demand and the prices..

Our western Certified Seed potatoes made a favourable impression at the Spokane, Washington, potato show. Three out of four exhibits were prize winners.

We co-operated with Mr. Scannell in making the seed plot tests at Indian Head as comprehensive as possible for the three prairie provinces.

Due to the wet cool weather in June, conditions were favourable for the development of *Rhizoctonia* injury to the plants, which could be detected very easily at that time.

Only one field inspection was possible on some fields, early frosts killing the tops before second inspection commenced.

BRITISH COLUMBIA.—H. S. MacLeod, District Inspector, Parliament Buildings, Victoria, B.C.

During the past season 437 acres were entered for certification of which 318 acres or 72·8 per cent passed; while in 1927, of the 762 acres inspected, only 278 acres or 36·5 per cent passed. This improvement was largely due to the better quality foundation stock planted. Continued improvement is indicated by the practice adopted by many growers of maintaining their own seed plots.

A car lot, over 500 bushels, of Certified Irisn Cobblers was secured from Prince Edward Island, and 65 bushels of Certified Bliss Triumphs of the Sharples strain were imported. The best of this material will be used as foundation stock in 1929. The demand for seed of these two varieties has been exceptionally good.

As an additional check on the value of the various strains of Certified Seed being produced in British Columbia, a test plot of approximately 1½ acres was planned. This was located at Sumas, about 60 miles from Vancouver. The climatic conditions there are favourable, and permit of easy identification of mosaic. All Certified Seed growers were invited to send us a sample of their seed. These samples were all planted by the tuber unit method, and much valuable information was gained from the plots, on the purity of the various stocks. A good check is also possible in this way on the previous year's field reports, and some guidance is also, to some extent, given the inspectors in the current year.

We found the yields from any one variety varied considerably; as, for instance, Netted Gems from one strain gave 290 bushels per acre and from another as high as 530 per acre. This should lead to useful results in weeding out the less vigorous strains.

The growers whose farms are located in low wet areas have experienced severe losses due to the planting of cut seed, a large percentage of which rotted. They claimed that whole seed did not rot to the same extent. We planned a trial plot in which we planted 3-ounce whole seed and 3-ounce cut seed under uniform conditions. Using the variety Early Rose, Certified Seed, we obtained a marketable crop from the whole seed of 380 bushels per acre and from the cut sets 130 bushels per acre. This experiment appears to indicate the advisability of planting whole seed under such conditions. We would, however, prefer to repeat the experiment another year before making definite recommendations in this regard.

Rhizoctonia is our most troublesome disease. Some soils are apparently infested with the organism which, under our conditions, destroys the tender shoots of the young plants, resulting in a considerable loss of crop.

Mosaic, which is our next most troublesome disease, was distinctly less this year in certified stock, and we hope to reduce it still further by encouraging the practice of hill selection, and the planting of tuber unit seed plots.

Spindle tuber has appeared in some fields. The growers in the States to the south of us regard this as one of their most serious diseases. We advised the growers of the necessity of taking all precautions, and to plant only seed stocks which are apparently free from this disease.

We are glad to report an increased demand for our Certified Seed stocks. Present indications are that the 1928 crop will be completely disposed of by spring.

OTTAWA: Printed by F. A. ACLAND, Printer to the King's Most Excellent Majesty, 1930.