DOMINION OF CANADA

DEPARTMENT OF AGRICULTURE

DOMINION EXPERIMENTAL FARMS

DIVISION OF BOTANY

REPORT OF THE DOMINION BOTANIST

H. T. GÜSSOW

FOR THE YEAR 1929

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SECTION I

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

GENERAL BOTANY REPORT FOR 1929

(J. Adams, Botanist)

The work during the year was mostly of the usual routine nature including inquiries regarding (1) the culture of various medicinal plants such as ginseng, golden seal, peppermint, seneca root, etc.; (2) plants providing feed for wild ducks and muskrats such as wild rice, cat-tail, etc.; (3) information relating to the culture of various plants such as water cress, coffee, *Pinus koraiensis*, gum succory as a rubber plant; (4) literature relating to the wild flowers of Canada, useful plants, flora of Newfoundland; (5) miscellaneous items such as sap-movements in plants, rain-trees, plants suitable for holding earthwork in position, etc.

The annual exchange list of seeds collected in the year 1928, comprising the names of 1,369 species and varieties, was distributed to 125 botanical gardens and similar institutions.

During the year 2,642 packets of seeds were received from foreign botanical gardens as well as twelve living cactus plants from Mexico. Included in the above number were 34 packets of species of *Aegilops* for plant-breeding work at the University of Saskatchewan and 141 packets of *Avena* for the use of the Dominion Cerealist.

In exchange 6,059 packets of seeds were sent out and 431 rooted plants and cuttings. To the Experimental Station at Morden, Man., 153 packets of seeds and 230 cuttings of willow, poplar, and Siberian pea were sent; and to the East Malling Research Station at Kent, England, 21 cuttings of several varieties of *Ribes nigrum*. A large number of seeds and cuttings of various plants were forwarded for planting on the banks of the new Welland canal.

At the special request of the Consul-General of the Netherlands at Montreal two packets of seeds of the Big Trees of California (*Sequoia gigantea* and *Sequoia sempervirens*) were obtained from the Eddy Tree Breeding Station, Placerville, California, for planting in the grounds of the Queen Dowager of the Netherlands.

A number of small trial samples of wild rice seed were sent to various persons in Canada, as well as seeds and roots of several medicinal plants.

At the special request of the authorities connected with the Pharmacy Department of the Merchant Venturers Technical College, Bristol, England, dried samples of the roots, barks, etc., of twelve Canadian plants used for medicinal purposes were forwarded to that institution.

The arranging and cataloguing of the large collection of foreign seeds has been almost completed.

Another section of the "Bibliography of Canadian Plant Geography" covering the period 1901-10 was published as Part I of the Transactions of the Royal Canadian Institute, Vol. XVII, 1929.

AGRICULTURAL BOTANY AND WEED STUDIES

(H. Groh, Botanist)

There are endless ways in which the science of botany touches the interests of the farmer. Plants, together with animals, and the soil itself, are of the very first importance among the things he works with; and plants, too, are among the most inveterate of his natural foes. Since crop plants in general receive appropriate attention elsewhere, weeds, which have been, too generally, nobody's clear responsibility, have come to claim a larger share of the time devoted to agricultural botany in this Division. Since 1922, when survey, life history, and control studies were planned, distinct progress has been made, particularly along the line of survey, which was considered to be the first thing essential to a broad and intelligent plan of offensive against weeds.

PASTURE INVESTIGATIONS.—Pasture renovation experiments have been laid down at several Experimental Stations in the east; and botanical surveys of the fields and plots as they enter the various treatments, and, at intervals, as necessary to record changes brought about in the composition of the vegetation, have been requested of us. Such surveys were commenced last year at Fredericton, and were carried out on similar lines this year at Charlottetown, Nappan, Ste. Anne de la Pocatière, and Ottawa, as well as at Fredericton again. Separate examinations to the number of 113 were required, and additional plots are still to be brought into the series at one Station. As yet only reconnaissance surveys of fields, and closer scrutiny of the entire area of plots, have been done; and it is an open question whether quadrat or transect analysis of these close eastern stands of vegetation is necessary, or indeed feasible, as it might be under conditions prevailing in other places.

The records obtained this year of the species occurring, and the rough ratings secured of the relative prominence of the species, both pasture, and weedy or useless plants, will serve as a basis of comparison for future surveys. These records should be supplemented immediately by similar examinations at one or two other dates, as the two now on hand for Fredericton, June, 1929, and August, 1928, have shown the seasonal character of many of the constituents of pastures. About equal numbers of species were detected at the two dates, an average of forty-three in the fields of several acres extent, and naturally fewer in the small plots; but their ratings in many cases are different. Early grasses are replaced in part by later developing ones; mosses, the low-growing white clover, and other plants of the under-strata, come into greater prominence with the pasturing down of the stand; and coarse weeds, like the buttercups, which are shunned by grazing animals, as the season advances come to occupy an increasing proportion of the space.

Some of the series at Fredericton and Ste. Anne de la Pocatière have been in progress for some time already, and, as compared with check plots on adjacent vegetation, have undergone some change. It is still too early to know the full significance and extent of the effects of these different fertilizers, seeding, rotation, and other treatments. The Stations concerned will no doubt publish any conclusions ultimately arrived at.

HAY ANALYSES.—From time to time samples of hay and other plants sent to the Division of Chemistry for analysis require to be examined botanically. Fifteen samples received from various provinces during the year were given botanical analysis, either for the detection of supposedly poisonous species, or for determination of the proportions of grasses, legumes, and weeds. Vegetation from reclamation experiment plots at Maple Creek, Sask., reveals a striking change from grass and weeds to strongly legume composition during the last two years of the six that these analyses have been made. These experiments with irrigation are still in progress.

RAGWEED SURVEY.—In September at the invitation of Canada Steamship Lines, a few days were spent at Murray Bay, Que., making an exhaustive search to establish the truth or otherwise of the assertion that ragweed does not occur at this well-known resort on the lower St. Lawrence. Ragweed is known to be among the most important of the plants whose pollen induces hay fever; and the claim is made that sufferers from late summer attacks of this distressing malady, find relief while there. Ragweed was found to occur sparingly at no great distances, and almost immediately across the St. Lawrence; but neither in the environs of the Manoir Richelieu, nor in the town or farming country for some miles inland, was any specimen found of either the common or giant ragweed. At that time of year many parts of Ontario and adjoining counties of Quebec were polluted with crops of ragweed, discharging their clouds of pollen dust in every breeze.

Chlorate Tests.—During past years various herbicides coming upon the market have been submitted to experimental trial. The prominence being given recently to the chlorates demanded that they be tested here, and sodium chlorate, as well as calcium chlorate in a prepared form known as Atlacide, were secured for this purpose. In all, some 40 applications of the former (not counting repetitions on the same plot), and 20 of the latter, were made. About 50 different weeds came under treatment with one or both substances. Plots of one square rod were used as a rule, although many applications were made to patches of small extent.

Among other facts more or less clearly ascertained the following are worthy of note. Both sodium chlorate and calcium chlorate are similarly efficient herbicides on the foliage of practically all weeds treated; but the rapidity and extent of injury sustained varies with the species. Both also extend their action to the root system, where the degree of efficiency is somewhat in proportion to the depth of rooting. Shallow-rooting perennials, like self heal, ground ivy, plantain, and chickweed, are, in many cases, like annuals, destroyed by one application. Deeper rooted weeds, like Canada thistle and perennial sow thistle, may require several applications, and even such deep and persistent pests as field bindweed, can to all appearances at present, be eradicated in a season. Couch grass, horsetail, and poison ivy, with root systems considerably varying in depth according to conditions, were sometimes killed with one application, but oftener required more. The uniform dose in most of these tests, of one pound sodium chlorate in one gallon of water to spray one square rod, could be varied to advantage with different weeds, thus securing a margin of safety for the grass in lawns containing certain weeds; and securing more drastic action where no vegetation is to be spared.

In water-logged ground where roots are forced to be shallow feeders, even trees six to eight inches in diameter have been so far weakened as to fall a prey to borers, and thus be killed. That the poison may work up from the roots as well as down from the foliage, was strikingly illustrated in the case of a Manitoba maple growing in wet soil. A clump of stems mostly not over two or three years old, growing from an older root, were treated by placing about a tablespoonful of sodium chlorate crystals on the ground around the base. By the time the crystals were all dissolved—in ten days—darkened patches were appearing in the soft current year's growth, several feet from the ground; as these extended the foliage wilted; and in three weeks all branches were defoliated and did not recover.

Single crystals of sodium chlorate placed in the rosettes of dandelions, and other weeds, are ample to kill the tops, and to follow down the tap-roots leaving a hole in which a pencil can be inserted, but the dandelion can usually renew itself from depths not reached by the poison, and only repeated destruction of its growth would suffice to destroy it entirely. A solution applied with an oil can is often more convenient and an equally effective way to treat scattered weeds of some size. In either case, a few inches radius of grass may be expected to turn brown, but will close in from the edges again in the course of a season.

The duration of injury to the soil is a point regarding which more information is needed. One plot sprayed on May 10 with a pound of sodium chlorate to a square rod, to kill ground ivy in a lawn, left the ground bare of the weed and of the sparse grass still left growing with it. Two months later crab grass seedlings were appearing and gradually covered the area. Plantain seedlings also re-occupied areas cleaned of it earlier. Other workers have considered that the use of the land is lost for the season; or, if application is made in the fall, that crops may be grown the next spring.

On the whole, it has been demonstrated that both sodium chlorate and calcium chlorate have a promising field of usefulness. Their present cost however, precludes their use on a field scale; sodium chlorate presents a certain amount of fire hazard; and much experimental work is needed before their general adoption as herbicides can be anticipated or recommended.

Weed Survey.—In addition to some elaboration of previous surveys in the east, made possible by the pasture and ragweed investigations already referred to, an opportunity was afforded rather late in the season to complete the general initial phase of the eastern survey west to the Manitoba boundary. For some purposes, at least, this eastern half of Canada can now be treated as a unit, separately from the Prairie Provinces, which will require a more ambitious program than means at present in sight can care for. In order to make available for use the voluminous notes on eastern Canada weeds already collected, card indexing and arranging is proceeding, and at present the two extremes of the territory, northern Ontario and the Maritime provinces, have been brought up-to-date; while the notes on the greater part of older Ontario and Quebec remain to be transcribed.

Attendance at a weed conference at Edmonton, Alta., on October 4, followed by a trip into the Peace River district, and south to Lethbridge, provided the means, along with stop-overs at a dozen points across the prairies, for gaining some first hand acquaintance with weeds and weed problems under western conditions. The Grande Prairie district, in particular, was given the closest inspection possible in the four days' visit, and a paper has been prepared for publication, recording the notes and impressions gathered. After a couple of decades of settlement, weeds are still a less distracting problem than in many other places, but most of the noxious species of the prairies have gained, or are gaining an entrance, and the situation should be regarded as crucial.

Northern Ontario Weeds.—Following up the practice in recent reports of presenting a list of the more important weeds of some part of the country which has received sufficient attention to make such a list possible, it is proposed to give here, in the order of their observed prevalence, fifty of the principal weeds of all northern Ontario, from Muskoka and Nipissing to the Manitoba boundary. The districts, though all visited this year or previously, have not received equal attention, nor, in any case, as exhaustive a survey as might be desirable. Well over 100 survey lists were secured, however, and, for so vast a tract, conditions are exceptionally homogeneous throughout. Inasmuch as our past knowledge of Ontario weeds has been based largely on southern Ontario data, it should be instructive to have a corresponding record of weeds for the newer area.

As explained in a previous report (1926), "it is felt that the method followed of repeating survey lists at frequent suitable intervals of travel, must give, not only a complete record of the species encountered, but also a fair approximation of their relative prevalence. The relative importance is another and more difficult study which must take into account, among other things, the weed's choice of habitat both as to soil and crop, numerical abundance, size and ability to crowd crop plants, resistance to control measures, facilities for dissemination, and for carrying over seasonally, and poisonous or other injurious properties."

Fifty Northern Ontario Weeds—in order of prevalence:—

Common yarrow—*Achillea Millefolium* L.
Pearly everlasting—*Anaphalis margaritacea* (L.) B. & H.
Tall buttercup—*Ranunculus acris L.*
Common dandelion—*Taraxacum officinale* Weber.
Common horsetail—*Equisetum arvense* L.
Canada thistle—*Cirsium arvense* (L.) Scop.
Ox-eye daisy—*Chrysanthemum Leucanthemum* L.
Sheep sorrel—*Rumex Acetosella* L.
Great willow-herb—*Epilobium angustifolium* L.
Bracken—*Pteris aquilina* L.
Couch grass—*Agropyron repens* (L.) Beauv.
Canadian blue grass—*Poa compressa* L.
Tufted vetch—*Vicia Cracca* L.
Common plantain—*Plantago major* L.
Lamb's quarters—*Chenopodium album* L.
Spreading dogbane—*Apocynum androsaemifolium* L.
Mullein—*Verbascum Thapsus* L.
Knotgrass—*Polygonum aviculare* L.
Curled lock—*Rumex crispus* L.
Evening primrose—*Oenothera* spp.
Peppergrass—*Lepidium apetalum* Willd.
Shepherd's purse—*Capsella Bursa—pastoris* (L.) Medic.
Common burdock—*Arctium minus* Bernh.
Upright cinquefoil—*Potentilla monspeliensis* L.
Perennial sow thistle—*Sonchus arvensis* L. (and smooth variety).
Everlasting—*Antennaria* spp.
Biennial wormwood—*Artemisia biennis* Willd.
Sensitive fern—*Onoclea sensibilis* L.
Wild buckwheat—*Polygonum Convolvulus* L.
Sweet fern—*Myrica asplenifolia* L.
Wild barley—*Hordeum jubatum* L.
Tumbling mustard—*Sisymbrium altissimum* L.
Canada fleabane—*Erigeron canadensis* L.
Orange hawkweed—*Hieracium aurantiacum* L.
Slender nettle—*Urtica gracilis* Ait.
Wormseed mustard—*Erysimum cheiranthoides* L.
Bull thistle—*Cirsium lanceolatum* (L.) Hill.
Goldenrod—*Solidago canadensis*, L. (and other spp.)
Wild mustard—*Brassica arvensis* (L.) Ktze.
Philadelphia fleabane—*Erigeron philadelphicus* L.
Common chickweed—*Stellaria media* (L.) Cyrill.
Willow-leaved dock—*Rumex mexicanus* Meisn.
Stinkweed—*Thlaspi arvense* L.
Mugwort—*Artemisia vulgaris* L.
Mouse-ear chickweed—*Cerastium vulgatum* L.
Sweet clover—*Melilotus alba* Desr.
Red-seeded dandelion—*Taraxacum erythrospermum* Andrz.
Toad flax—*Linaria vulgaris* Hill.
Russian pigweed—*Axyris amarantoides* L.
Bladder campion—*Silene latifolia* (Mill) Britten & Rendle.

Some of these fifty weeds, and many others of less prevalence, were observed in only a part of this wide range. Thus ox-eye daisy was rare, if occurring at all, west of Fort William; mullein, mugwort, and bladder campion seemed to reach their limits about Sault Ste. Marie; and orange hawkweed was practically confined to the eastern districts. Some weeds, like Russian pigweed, Russian thistle, gumweed, wild barley, and perennial ragweed, were more abundant in the western districts, adjacent to the prairies where they are general. It is of interest to know that perennial sow thistle, which is a serious pest in the Rainy River district, is represented there by the smooth form prevailing on the prairie; while, in the eastern districts of northern Ontario, the glandular form which predominates in old Ontario, occurs.

EXAMINATION OF PLANT IMPORTATIONS

(A. J. Hicks, Assistant Plant Pathologist)

During the year 1929 the Division of Botany, in co-operation with the Division of Foreign Pests Suppression of the Entomological Branch, has continued with the inspection of plant importations. The work entailed was sufficient to occupy the attention of one officer at the Central Laboratory for practically the whole year. As usual, the majority of shipments inspected were those of nursery stock, bulbs and corms of ornamentals being found to predominate.

Of 1,463 shipments intercepted because of the presence of disease or insect pests, 1,006 were dealt with by the Division of Botany.

Samples examined totalled 2,187, the number of individual specimens contained in these samples being approximately 27,700.

Comparison of the figures pertaining to the number of shipments and samples inspected in 1928 and 1929 is interesting. In 1929 a total of 1,006 shipments were dealt with by this Division as compared with 687 shipments in 1928, an increase of 319 shipments. However, the corresponding number of samples decreased from 2,819 to 2,187; that is to the extent of 632 samples. The amount of material rejected was approximately the same in 1929 as in the previous year. These data would appear to indicate that one result of the inspection service has been to cut down the large shipments of nursery stock to growers and nurserymen in this country, the tendency now being to import smaller lots of more valuable varieties.

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

(William Newton, Officer in Charge)

FACTORS ALTERING THE CHARACTER OF BORDEAUX MIXTURE

The character of Bordeaux mixture was studied as altered by different methods of preparation, and by the addition of spreaders or adhesives. Based upon the assumption that the solids of Bordeaux settle more slowly as the physical condition approaches the ideal, it appeared that the best method of preparation is to pour slowly a dilute solution of copper sulphate into a concentrated lime suspension.

The physical condition of alkaline Bordeaux appeared to be slightly superior to that of neutral Bordeaux, but no evidence was obtained that alkaline Bordeaux adhered to the foliage better than neutral. The former was prepared by using equal quantities of copper sulphate and burnt lime, and the latter by using five parts copper sulphate to 1·5 parts of burnt lime.

The addition of sodium silicate, fresh skim-milk, and several alcohols appeared to exert a harmful influence on the character of Bordeaux mixture as judged by the spread and permanence of the film formed when sprayed upon leaf and glass surfaces. No significant influence was detected as the result of the addition of 0·15 per cent wheat flour or agar. The addition of 0·15 per cent calcium caseinate improved the spread and permanence of the films formed when sprayed upon leaf and glass surfaces, but only to a slight degree. The addition of 0·15 per cent whale oil or ordinary washing soaps produced undesirable curds, but the quantity varied with the type of soap. In the case of a brand called "Crystal White" little curd appeared, and the spread and permance of the films on leaf surfaces was highly satisfactory. Certain patent spreaders sold in the form of Bordeaux soap emulsions gave much promise as spreaders. From our investigations it seems probable that soap emulsions may be found that will act as effective spreaders or adhesives for Bordeaux.

Of the spreaders tested, potassium-resin-soap was found to be the most satisfactory. It was prepared by boiling together two parts of resin, one part potassium hydroxide, and three parts water. This soap, at a concentration of 0·15 per cent, decidedly improved the spread and permanence of the films formed when sprayed upon leaf and glass surfaces.

In our laboratory investigation of spreaders, it was found that the comparative efficiency of spreaders could be roughly determined by rapidly immersing excised leaves into the Bordeau containing the spreader, followed by an examination of the Bordeaux film with a low-power microscope when the leaves were dry.

DOWNY MILDEW OF THE HOP

In 1928 the Downy Mildew of the Hop, *Pseudoperonospora Humuli* (Miy. & Tak.) Wils., was first reported in British Columbia, and occurred in epidemic proportions in the commercial hop yards of Sumas, Sardis, and Agassiz. In 1929 the hop interests appealed for the technical assistance of the Dominion Field Laboratory of Plant Pathology at Sidney, B.C. Our studies proved that the symptoms and life history of the disease were practically identical with those described by Professor E. S. Salmon and his associates in Great Britain. As a consequence, control measures were adopted similar to those practised in Great Britain and Germany. Under our direction the diseased "spikes" were removed by hand at regular intervals, and, after the vines were six feet high, they were sprayed or dusted at intervals of approximately ten days until the disease was checked by the dry weather. Our studies suggested that spraying in the early cone stage is a wise precaution, and such spraying was adopted by most of the growers.

The disease was found on wild hop plants (escapes from cultivation) both adjacent to and at considerable distances from the cultivated areas. With the assistance of the agricultural organizations of the hop districts great quantities of these infected wild hops were destroyed.

Our investigations indicated that the reappearance of the disease in the spring was not due to hibernating mycelia in the crowns of the hop plants. Also, we found that zoospore infection at the growing points will produce diseased "spikes," but the "spikes" thus produced are distinct in character compared with those that arise from the base of the plant. Young leaves were found more susceptible to zoospore infection than old leaves. The common nettle was found to be immune to the disease. All the commercial hop varieties grown in British Columbia were susceptible except Fuggles.

It was found that, without the addition of a spreader to Bordeaux, the coverage on the under surface of the hop leaves was not satisfactory. A number of spreaders were tested and of these potassium-resin-soap was the most satisfactory. It was prepared as indicated in the previous section, and one quart of this mixture was added to one hundred gallons of Bordeaux.

In one hop yard dusting was tried instead of using liquid Bordeaux mixture. The dust consisted of a mixture of anhydrous copper sulphate and hydrated lime in the proportions of 1 to 8. Satisfactory coverage was secured only by directing the dust with considerable force against the foliage when it was wet with dew. So little leaf infection occurred during the season of 1929 that it was impossible to secure satisfactory data upon the relative merit of dust compared with liquid Bordeaux.

In our general studies of immunity and control, we found that the sap bled from the cut tips of hop plants was quite toxic to the zoospores, but was practically non-toxic when bled from cut basal stems. The sap expressed from ground hop and other plant material was only slightly toxic. Commercial pine resin dissolved in methyl alcohol and potassium hydroxide was more toxic than copper sulphate, and preliminary evidence was obtained that commercial resin mixtures may be used as a barrier against zoospore infection.

ROSE NURSERY INSPECTION

With the assistance of the Provincial Pathologist, Mr. J. W. Eastham, the principal rose nurseries of British Columbia were systematically inspected throughout the summer. Late in the season diseased plants were found that agreed with the description of the virus disease known as "Infectious Chlorosis." All rose plants exhibiting suspicious symptoms were immediately destroyed. Among the precautions taken to prevent the spread of this disease, a careful inspection of the root and bud stocks was made before the budding operations of the nurserymen commenced.

Also, with the assistance of the Provincial Pathologist, the principal greenhouses were inspected where roses were grown. No suspicious symptoms of "Infectious Chlorosis" were found, although the stocks in a great many greenhouses were grown by local nurserymen.

THE TOXICITY OF CHEMICALS TOWARDS FUNGI

The toxicity of chemicals towards fungi in pure culture was studied to obtain information upon the relative tolerance of fungi to substances that may be utilized in the development of control measures. The organisms were grown by inoculating the centres of petri dishes containing the chemical dissolved in standard agar medium, and were incubated at 25° C. Beginning with a dilution of 1 part by weight of the chemical to 100 parts of medium, the dilution was increased 10 times until the growth on the petri dishes was not significantly affected by the concentration of the substance. At concentrations of 1-1000 the following substances were practically non-toxic: potassium chlorate, potassium perchlorate, potassium acid sulphate, potassium sulphocyanate (KCNS), sodium sulphite, potassium sulphite, sodium thiosulphate, methyl and ethyl alcohols.

The substances listed in table 1 prevented growth at a dilution of 1-100, and either prevented growth or markedly inhibited growth at 1-1000.

TABLE 1.—MAXIMUM DILUTION OF SALTS IN PETRI DISHES WHERE NO GROWTH OCCURRED

Disease organism	Mercuric chloride	Copper sulphate	Sodium acid sulphite	Potassium acid sulphite
Rhizoctonia Solani Kühn	1 : 10,000	1 : 1,000	1 : 1,000	1 : 100
Sclerotinia Sclerotiorum (Lib.), Mass	1 : 100,000	1 : 100	1 : 1,000	1 : 1,000
Fusaria spp. from Brussels sprouts	1 : 10,000	1 : 1,000	1 : 1,000	1 : 100
Botrytis Tulipae (Lib.) Lind	1 : 100,000	1 : 100	1 : 1,000	1 : 100
Botrytis sp. from narcissus	1 : 10,000	1 : 1,000	1 : 100	1 : 100
Botrytis, sp. from peony	1 : 10,000	1 : 1,000	1 : 100	1 : 100
Botrytis sp. from lily	1 : 10,000	1 : 1,000	1 : 100	1 : 100

The data of table 1 indicate that the concentration of the salts required to prevent growth varies with the different organisms. It also shows that the acid sulphites are quite toxic, for no growth occurred with three fungi at a dilution of 1:1,000. It has been noted above that sodium sulphite is non-toxic at this concentration; therefore the toxicity must be due to the acid sulphite ion rather than to the sulphite ion.

THE GROWTH RATE OF BACTERIA IN PURE CULTURE

In order to obtain relative values of the toxicity of substances towards bacteria in pure culture it was necessary to obtain normal growth curves to compare with the growth curves of the organisms in the presence of the toxic substance. An attempt was made to secure normal growth curves that could be duplicated within an error not greater than 2 per cent. The organisms were grown on a potato dextrose broth which contained 3 per cent dextrose. The disappearance of the dextrose was assumed to be a measure of the growth rate. Flasks which contained 500 cc. were inoculated with equivalent quantities of

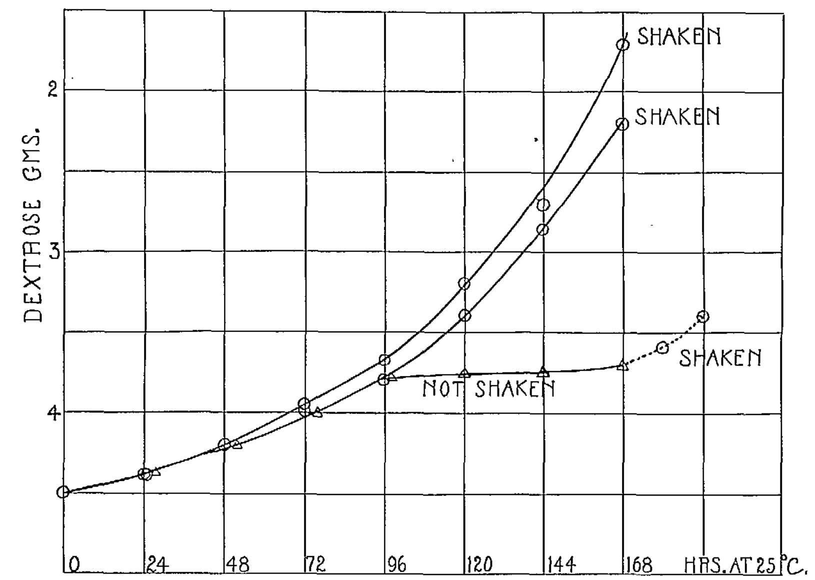

FIG. 1.—Curves showing the influence of shaking upon the growth rate as measured by the disappearance of dextrose.

inoculum from 72 hr. broth cultures and incubated in a constant temperature bath at 25° ± 0·1° C. Several types of bacteria were used which had been isolated from potato stem rot lesions. The sugar was determined by Benedict's titration method. We were not able to duplicate growth curves by this method within an accuracy greater than 10 per cent. Since the analytical error was less than 1 per cent it was apparent that one or more unknown factors were involved. In a search for the unknown factors, the effect of disturbing the culture was studied. Triplicate cultures were prepared. Each time the samples were drawn for analyses, two of the cultures were shaken, but the third was disturbed as little as possible. The curves are shown in fig. 1, and they illustrate that the disappearance of the sugar is much more rapid when the cultures are shaken. In order to prove that the flatness of the curve of the unshaken culture was due to its undisturbed condition, at the end of 168 hours it was vigorously shaken.

The rate of the disappearance of dextrose immediately increased. These results were a surprise in view of the fact that the organism was motile. Owing to the practical difficulties of drawing off samples for analysis without disturbing the cultures, this experiment suggests that superimposable curves can only be obtained when the cultures are automatically shaken in the constant temperature bath throughout the growth period.

THE FERMENTATION OF LOGANBERRY MUST

A study was made of the fermentation of loganberry must as influenced by selected yeasts and by the natural flora of loganberry juice. Yeasts were isolated from one-year-old loganberry wines of good quality and also from freshly expressed loganberry juice. Flasks of sterile loganberry must were inoculated with these organisms and incubated at 25° C. Samples from the flasks were analysed at intervals for alcohol and acid. Also, the effect of the yeasts was noted upon such characters as the bouquet and flavour of the resultant wine. As determined by these experiments, a strain was isolated that appeared to be superior to all others for the conversion of loganberry must into wine, and superior to the fermentation as affected by the natural flora en masse.

This strain, No. 95, was compared with the normal fermentation in a semi-commercial scale experiment. In this experiment twelve casks were used containing four gallons of must in each. Although this experiment has not been concluded, all the evidence suggests that it is desirable to introduce a "starter" of a yeast strain identical or similar to No. 95. When the strain was introduced, the fermentation was more regular, the final alcohol content was higher, and the content of volatile acid was lower, compared with the fermentation as effected by the natural flora.

Attention was directed to the problem of the nutrition of the yeasts in the fermentation of loganberry must through the discovery that fermentation frequently ceased, or became very slow before the optimum alcohol content in the wine was reached. In the nutritional experiments, the following results were secured: (1) The addition of ammonium salts accelerated the rate of fermentation, but these salts did not offset the tendency of fermentation to cease before the optimum alcohol content was reached. (2) With a number of the must samples the addition of phosphate salts accelerated the rate of fermentation, but the outstanding effect of these salts was to create conditions whereby the optimum alcohol content could be reached.

Bacterial Tuber Rot of the Dahlia

(J. K. Richardson, Assistant Plant Pathologist, Fredericton, N.B.)

During 1928 and 1929 a number of dahlia growers in the province requested this laboratory to investigate the cause of a serious rot occurring in dahlia roots while in storage, which resulted in loss of many valuable specimens from time to time.

In April 1929, an investigation of this trouble was undertaken. A number of dahlia roots, collected from various sources were examined; but only a few of these were fit for study purposes, due to the fact that the others were in advanced stages of decomposition when received.

A diagnosis of these specimens together with others secured at the Dominion Experimental Station revealed that a disease of bacterial origin was mainly involved. An outline of the symptoms of this disease is as follows:—

The first indications of the disease appear, 2 or 3 days after infection takes place, as slightly depressed, darkened areas on the root surface around the site of infection (fig. 2).

FIG. 2.—Bacterial tuber rot of dahlia. External appearance of healthy and diseased tubers. (Photo. J. K. Richardson)

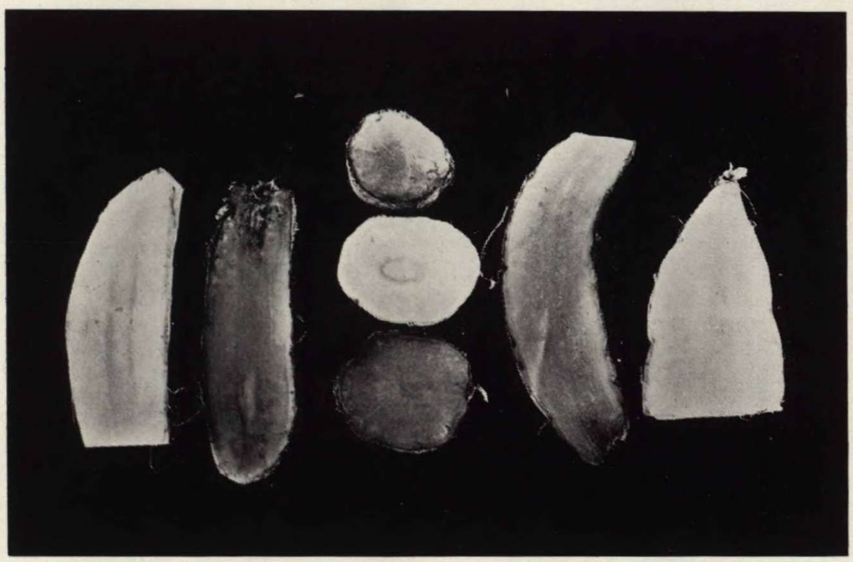

FIG. 3.—Bacterial tuber rot of dahlia. Internal appearance of healthy and diseased tubers. (Photo. J. K. Richardson)

Concurrently with the development of these discoloured areas on the surface, the underlying tissues assume a water soaked appearance, a condition which rapidly increases until the entire tuber is involved (fig. 3).

The affected tissues are soon reduced to a soft pulpy mass, and the final result is complete destruction of the root.

Isolations from diseased root-tissue disclosed the presence of the pathogen, the description and cultural characteristics of which are as follows:—

Rods: 0·5 to 1·75μ by 0·8 to 1·5μ, with rounded ends, occurring singly. Motile by means of peritrichous flagella. No endospores. Gram negative.

Gelatin stab: Growth best at top. Line of puncture slightly filiform. Liquefaction slow, saccate-stratiform.

Agar Colonies: Growth moderate. Circular, small, raised, smooth, undulate margin, yellowish-white.

Agar slant: Growth moderate. Indefinite, scalloped margins, effuse, glistening, opaque slightly rugose surface, yellowish white. Odour absent. Consistency butyrous.

Broth: Clouding slight. No ring or pellicle. Scanty, flocculent sediment. Odour absent.

Litmus milk: Slight coagulation after second day. Extrusion of whey after fourth day. Acid formed.

Potato: Growth rapid, abundant, spreading, glistening contoured. Decided odour of ammonia. Medium browned at edges of growth. Soft rot develops after five days. Consistency of culture butyrous.

Indol not formed.

Acid in dextrose, saccharose, galactose, mannite, lactose, levulose, and glycerine.

Slight gas in saccharose and mannite.

Hydrogen sulphide is formed.

Nitrates reduced to nitrites.

Starch unchanged.

Aerobic, facultative.

Optimum temperature, 20° C. to 30° C.

The organism just described failed to infect dahlia roots when placed in direct contact with their uninjured surfaces, but invariably produced a rot, similar to that formed in the original roots, when brought in contact with abrasions or punctures mechanically produced. Attempts to infect dahlia stems were all unsuccessful. This would seem to indicate that the organism, causing the trouble under investigation, can only infect the dahlia roots through wounds produced by mechanical or some other agency.

The organism causing the disease described above is also capable of producing a similar type of rot when artificially introduced into carrots, turnips, and potato tubers. Attempts to inoculate living potato stems with this organism were unsuccessful.

Hollyhock Rust Investigations

(Puccinia Malvacearum Mont.)

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

Rust is the most common disease of the hollyhock, a plant regarded very highly for ornamental purposes. This conspicuous disease attacks leaf blades, petioles, stems, and bracts. Severe infections stunt the plants and cause the leaves to die prematurely. The typical symptoms may be recognized by the appearance of brownish, wart-like spots or pustules which, on the leaves, are circular, while on the petioles and stems they are usually elongated. Commonly, the leaf tissue immediately surrounding these pustules bursts open, liberating the brownish mass of spores. These are blown from plant to plant and originate new infections.

The use of liquid Bordeaux and potassium permanganate in the year 1926 failed to control this disease.* In 1927 the same fungicides were used along with Bordeaux dust and sulphur dust. Weekly applications of each failed to give any evidence of control. It was apparent, however, that in 1927 primary infection was delayed by such methods, for rust was abundant on untreated check plants nine days before its appearance on treated plants. The reverse of this was true in 1926,* when rust was found on unsprayed checks thirty-seven days after appearing on sprayed plants.

In October, 1927, it was observed that fresh infections of rust were appearing upon leaves which had survived earlier attacks. This feature suggested a clue as to the overwintering habits of the fungus, and investigations were accordingly carried on to ascertain the ability of the parasite to survive the winter in the form of spores or mycelium.

On October 31, 1928, leaves showing late infections were enclosed in a screen-wire cage and the whole placed in an unprotected position out of doors where they remained until March 28, 1929. Also, on October 31, 1928, six hollyhock plants showing heavy fall infection were staked. Of these, the parts above ground were removed and destroyed by burning. At a distance of 100 feet eight hollyhocks showing late infection were staked. The tops in this instance were not removed.

Microscopic examinations of the sori, when collected the previous October, showed that approximately thirty per cent of the spores were empty, indicating that germination had taken place in situ before the date of collection. In view of this rapidity with which germination occurs, it would appear that the spores hibernate in an immature state.

Germination Tests.—On April first, 1929, germination tests were made of the overwintered spores taken from the caged material. Spores were suspended in tap water, using Van Tieghem cells. Four per cent germination took place in thirty hours. On June first, additional tests were made, but germination was not observed. This would indicate that the majority of immature spores do not survive winter and spring conditions in this climate and that primary infection is not to be expected from this source.

This is supported further by the facts, that spore germination ceased before June first, and that rust pustules appeared not earlier than late June on the plants from which the previous year's growth had not been cleaned away. On the other hand, in the six cases where the tops had been removed, infection was delayed until the first week in August, a reasonable length of time for transfer by air currents from the eight diseased plants 100 feet away.

Recommendations.—In view of the failure to control rust of hollyhock by applications of liquid Bordeaux, Bordeaux dust, or potassium permanganate, we must look to other practices for a successful means of control. All plants showing rust infection should be destroyed in the fall by burning. It also should be a beneficial practice in the spring to pick off and burn any leaves showing the disease, thereby lessening the source of infection.

Infectious Chlorosis of the Rose

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

This disease was observed for the first time in Canada in February of this year.

So far, in Ontario, the disease has been found only on stock imported from British Columbia, and has been largely confined to *Rosa Manetti*. The

* Report of the Dominion Botanist for the year 1926, p. 27.

disease has been found on eighteen varieties of outdoor roses, all budded on thornless *multiflora*. This disease has been reported from British Columbia, Ontario, and, in the U.S.A., from the following states, Oregon, New York, New Jersey, Massachusetts, Illinois, Indiana, Iowa, Michigan, Colorado, and Wisconsin.

SYMPTOMS

Affected plants become stunted and do not thrive. The leaves, especially, show the effect of the disease by becoming dwarfed and distorted, with a distinctive yellowish-green mottling, particularly along the main vein (fig. 4). The buds and resulting flowers are misshapen and imperfect. In some cases the buds do not unfold at all. All leaves of a plant do not necessarily show the symptoms. I have seen some plants with only two of the leaflets showing the disease. Again, the symptoms may be entirely masked at one time, and be very pro-

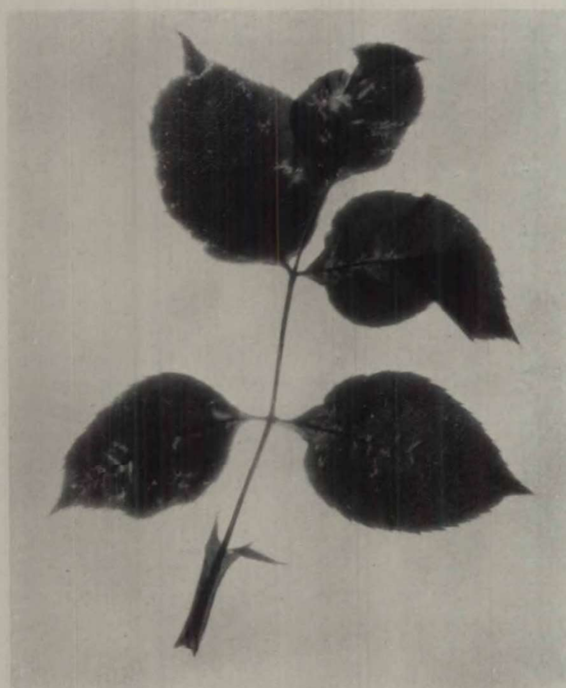

FIG. 4.—Infectious chlorosis of the rose.

nounced at another. For instance, one plant in our greenhouse at the present time (December) show no signs of the mottling characteristic of this disease, yet, in September, the mottling symptom was very pronounced. We have now in the greenhouse three plants of the Premier variety budded on British Columbia *Manetti;* two of these plants have produced a few short-stemmed, lop-sided, half-opened flowers. One plant has not produced any flower whatever. From these three plants only two perfect flowers have been obtained during the past year. On the other hand I have seen diseased plants in greenhouses at Toronto which produced a high percentage of average bloom.

Experimental work suggests that this trouble is apparently infectious and probably of a virus nature. So far, however, the disease has been produced in healthy plants only by budding and grafting. Dr. R. P. White of the Agricultural Experiment Station, New Brunswick, New Jersey, has done extensive work with this disease, and has proved it to be contagious and virus in type. We have been able to transfer, by budding, the disease from *Manetti* stock to the Premier variety. The manner of spread, other than by budding, grafting, or cuttings, is as yet unknown. All experimental work at the New Brunswick, N.J., station to date has failed to prove that spread takes place by means of insects, as is generally the case with virus diseases of this type. From all observations made so far the disease is apparently one of stock and scion. So far as our experience goes the only stock found affected has been *Rosa Manetti.* The disease has been found on hybrid teas, budded on thornless *multiflora,* but the disease has not been found on *multiflora itself.* Dr. White has experimentally proved that *multiflora* is susceptible to this disease. He has so far been unable to transmit this disease to *Rosa odorata.* It would appear, therefore, as though this stock is immune, or highly resistant.

From the standpoint of control, two points already established in connection with this disease are of some considerable importance: (1) that *odorata* is highly resistant, and, therefore, might replace one of the other stocks wherever possible; and (2) that spread in a greenhouse is very slow, and, therefore, roguing of diseased plants should be of great assistance. That such is actually the case was demonstrated in a range of greenhouses at Toronto where 50 per cent of the Premier variety were affected with this disease. All diseased plants were rogued, with the result that very few diseased plants were observed after three months' time.

Sunflower Wilt

(J. F. Hockey, Officer in Charge, Kentville, N.S.)

On account of a severe outbreak of wilt caused by *Sclerotinia Sclerotiorum* (Lib.) Massee in a field of sunflowers at the Experimental Station, Kentville (fig. 5), a project has been initiated to determine if economical soil treatments or cultural conditions could be found, which would decrease the loss caused by this fungus in a rotation where crops susceptible to this fungus are grown. Young and Morris* gave a list of fifty plants susceptible to the attacks of this fungus. To these may be added alfalfa and wild radish (*Raphanus Raphanistrum*). The latter plant, on account of its prevalence, is an important host of the disease in Nova Scotia.

The first serious outbreak of the disease on the field under observation occurred in 1926 in a crop of hemp, when a large number of fertilizer and varietal test plots were planted to this crop. Observations on the presence of wilt were made on approximately sixty of these plots at that time, and they were found to contain from 0 to 37 per cent of affected plants. During these observations wild radish was first observed affected by *S. Sclerotiorum.*

Oats were grown on the land in 1927.

In 1928 the field was planted to sunflowers. Over 50 per cent of the entire crop wilted, and many rows had less than 5 per cent of plants unaffected.

In 1929 it was decided to try soil treatments and thinning of plants as possible preventives to the spread of the disease. The soil treatments were made with two objectives in view. First, the application of sulphur as a fungicide, and second, the application of sulphur and hydrated lime to change the soil reaction. No attempt was made in 1929 to apply the materials on the plants as fungicidal protection.

* Young, P. A. and H. E. Morris, *Sclerotinia* wilt of sunflowers. Montana Agr. Exp. Sta. Bull. 208: 1-32. 1927.

SOIL TREATMENTS.—A portion of the infected field was divided off into thirty-two plots of approximately 1/32 acre each, comprising four ranges of eight plots each. The treatments were made as follows:—

Range A—immediately after seeding, June 1.
" B—seedlings at first leaf, June 18, 19.
" C— " " 2nd leaf, July 3.
" D— " " 6th leaf, July 15.

The following treatments were employed in each range:—

Plot 1— 3 lb. Toro Sulphur, or 246 pounds per acre
2— 6 lb. " " " 492 " " "
3— 9 lb. " " " 738 " " "
4— Check.
5— 6 lb. hydrated lime " 492 " " "
6— 9 lb. " " " 738 " " "
7—12 lb. " " " 984 " " "
8— Check.

FIG. 5.—Sunflowers severely affected with wilt in the field and showing white mycelium at base of stalk.

The first apothecia were found on June 18. Mature spores were present but apothecia were not found generally over the field for another two weeks. The first specimens of sunflowers showing wilt were found on July 3rd at the time of making the applications on Series C.

Observations on the number of wilted plants in each plot were made at weekly intervals commencing July 15. The results obtained from the above treatments indicate that the use of sulphur or hydrated lime, as current season applications, give negative results in control of the disease. The applications made on June 18 and July 3 appeared to cause a slight lessening in the intensity of the disease. From the data obtained, these two series—B and C—had, throughout the season after July 22, less total wilted plants than either of the other series. It is probable that the applications on Series A were made too early to affect the maturation of ascospores in the apothecia and the applications on Series D were made too late.

The acidity of the soil from these plots was determined by the colorimetric method. Soil samples were taken September 13 and the determinations made on air-dry soil. The soil throughout the series of plots ranged from 6·0 to 6·6 pH. Range A averaged 6·15 pH; Range B, 6·27 pH; Range C, 6·27 pH; and Range D, 6·5 pH. It is apparent that the soil on this area was well buffered, since plots receiving as much as one-half ton per acre of hydrated lime had an average acidity of 6·4 pH compared with an average pH of 6·2 on plots receiving sulphur at the rate of approximately 750 pounds per acre. The acidity of the soil in these plots may be considerably altered by the time the next season's crop is planted. There was no difference above the experimental error in the percentage of wilted plants from plots of different H-ion concentration within the range 6·0 to 6·6 pH. This would be expected, since the fungus has the ability to develop under wide ranges of acidity.

THINNING SUNFLOWERS TO PREVENT WILT.—Young and Morris, p. 23, state that "the rapidity of the spread of *Sclerotinia* in the rows was decreased by thinning the stalks until they were at least 20 cm. apart. In commercial fields the stalks in the rows are usually about 10 cm. apart." An area of infected land at Kentville was planted with Mammoth Russian sunflowers. The rows were 280 feet long and 42 inches apart, and each alternate row was divided into four equal parts in which the plants were thinned to different distances. Buffer rows between each thinned row were left unthinned.

No effort was made to have plants at the exact distance; but they were thinned so that plants were not closer than 3, 6, 9, or 12 inches from the adjacent plants in the row. It was felt that transplanting plants to have them all at exact distances would be inviting wilt, as there would be a number of broken roots, to allow infection, on each plant moved.

TABLE 2.—SUMMARY OF DATA AT HARVEST ON SUNFLOWER THINNING, 1929.

Distance apart in rows	Initial total	Percentage wilt	Number healthy	Yield healthy	Average weight per plant
		%		lb.	lb.
Unthinned	1,092	95·51	82	70·3	0·85
Approx. 3 inches	584	82·19	94	121·0	1·28
Approx. 6 inches	448	82·14	80	133·0	1·66
Approx. 9 inches	322	76·70	75	156·0	2·08
Approx. 12 inches	259	68·72	81	198·0	2·44

Table 2 gives a summary of the data obtained. Records on the number of wilted plants were made at weekly intervals from July 29 to September 17, when the final harvesting records were taken. The weight and number of healthy plants were taken at harvest. The yields from these uniform sized plots indicate a decided increase in yield in favour of the plots thinned to 12 inches. The yield decreased as the percentage of wilt increased.

In commercial planting of sunflowers thinning beyond a distance of 10 or 12 inches is not considered good practice, as the plants are likely to develop coarse stalks for ensilage. When grown for seed purposes, thinning to 10 or 12 inches should not be objectionable.

Testing Pure Lines of Sunflowers for Resistance.—Forty pure lines of sunflowers developed by the Dominion Agrostologist were planted on infected soil, together with three standard varieties, to determine their reaction to *Sclerotinia Sclerotiorum.* Of those tested, several gave indications of some resistance, and further trials will be carried on another year.

The three varieties, Ottawa No. 76, Mennonite, and Mammoth Russian, contained 80·31, 52·04, and 74·39 per cent wilt respectively by harvest. The plants were not thinned from their original seeding. The variety Mennonite is apparently the most resistant of these three standard varieties.

CONCLUSIONS

1. Applications, of sulphur at rates up to 750 pounds per acre, or of hydrated lime at rates up to 1,000 pounds per acre, have no commercial effect in reducing sunflower wilt in the current season's crop.

2. Sunflowers, thinned to 12 inches apart in rows 42 inches apart, gave a higher yield and lower percentage of wilt than rows unthinned, or thinned to 3, 6, or 9 inches apart.

3. Several pure lines gave indications of resistance to wilt. The variety Mennonite was the most resistant commercial variety tested. These observations suggest that it may be possible, by breeding and selection, to obtain a variety more resistant to wilt than any of the commercial varieties of sunflowers now grown locally.

SECTION II

FOREST PATHOLOGY AND RELATED SUBJECTS

Fume Injury to Forest Trees

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

In a country, such as Canada, in which mining, with the subsequent smelting of ores, is an important and growing industry, the effects of injurious gases, which result from the smelting of certain ores, becomes a question of great economic importance. Both gaseous and solid by-products resulting from the smelting process may be injurious, but in a modern smelter there is a high degree of recovery of metallic fume with little or no injury resulting from this source. Of the gases by far the most common and important is sulphur dioxide, which results from the smelting of ores containing sulphides.

In coniferous trees sulphur dioxide injury is usually characterized by the reddish-brown discoloration of the leaves from the tips downwards, generally involving only a part of the length, but in cases of severe injury reaching completely to the base. Later the leaves dry out, turn brown, and fall off prematurely. Usually the older leaves die off first. One of the most prominent symptoms of fume damage in coniferous trees, then, is thinness of foliage. As different species retain their leaves for varying periods of time, it is necessary, in studying fume injury, to have some knowledge of the variations in this regard which may be met. For instance, western yellow pine usually bears three years' leaves, Douglas fir eight, western white pine four, lodgepole pine six, and western hemlock five. These, of course, are average figures, from which there may be considerable variation, depending upon the conditions under which a particular tree is growing (see figs. 6 and 7).

Naturally, in different species of trees there is a variation in symptoms—in fact, in regard to plants generally, it seems desirable that a detailed description of the symptoms of sulphur dioxide injury for each species should be made, as these vary greatly. Typically, there is a killing and bleaching of the intercostal areas accompanied by a shrinkage of the killed parts; but there are several other types of injury. In certain plants the killed area is strictly marginal in character, in others it is confined to the tips, middle, or bases of the leaves, and in still others it may be localized, giving a spotted appearance. In lodgepole pine, for example, there is the typical reddish-brown discoloration with all or part of the leaf involved, while in western hemlock the discoloration is much lighter, being a whitish-gray shade, with the injury confined almost exclusively to the distal half of the leaf.

While, in coniferous trees generally, it is usually an easy matter to make a correct diagnosis where fume injury has been at all severe, it becomes much more difficult where the burning has been slight. This is so on account of the numerous other forms of leaf injury which may be encountered. Probably the type of injury which most nearly simulates fume damage is winter injury or "red belt" in its various forms. The symptoms of "red belt" may vary from the total or partial killing of a few leaves to the complete death of all that part of the tree which was exposed above the snow line. Usually, however, the whole leaf is injured, and not only part, as is so often true of fume injury. Then there is a difference in colour—fume damage producing a brighter reddish discolouration than winter injury. The condition of the foliage is often of great assistance in diagnosing fume injury since, if one is examining injured foliage from a tree which is bearing a normal set of leaves, the idea of fumes being responsible can generally be dismissed. While damage due to winter injury occurs quickly, that due to fumes is much slower and is progressive in

* Services of Mr. McCallum were loaned to National Research Council during season 1929.

character. Trees subjected to even heavy concentrations of sulphur dioxide may live for many years, death from this cause being in general a very slow and gradual process.

There are several other types of injury to foliage which may be confused with fume injury, and, indeed, are often distinguished only with difficulty. Among these are insect injuries due to sucking insects such as aphids, various forms of frost damage, and injuries due to drought. In addition to these there are the injuries due to fungi, but, generally, it is not very difficult to recognize these.

FIG. 6.—Yellow pine and Douglas fir (in background) severely damaged by sulphur fumes. Note that all old leaves have dropped off.

An invaluable aid to an accurate diagnosis is the use of indicator plants or species which are very susceptible to fume injury. When it has been determined that two or three such plants in a certain area are not injured, then it can safely be assumed that trees which are more resistant are also free from injury. Conversely, if such plants exhibit the symptoms of smoke damage, then similar injury upon trees should be carefully looked for.

In recent years the development of an automatic recording instrument, which gives a continuous record of the content of the air at a particular point in terms of sulphur dioxide, has been a marked improvement over the older methods, by which a sample of air was analyzed only occasionally.

Just as there is variation in the symptoms of smoke damage upon different plants, so there is also variation in susceptibility. In general the conifers are more susceptible to injury than the deciduous trees. Possibly one condition which makes them so is the fact that their leaves are retained throughout the year, and are thus subject to damage at all seasons, though it has never been

FIG. 7.—Sound yellow pine for comparison.

demonstrated that injury does occur during the winter. As regards trees this is a matter which merits investigation. Among deciduous trees maple seems to be one of the most resistant species, but, in general, the relative susceptibilities of the different tree species in this country are very imperfectly known.

Since the presence of sulphur dioxide in sufficiently high concentrations and under conditions favourable for injury results in a killing of a portion of the leaf surface, it follows that, as the amount of growth is directly related to the area of functioning leaf surface, a record of the damage done will be shown by a study of growth. While there may be differences of opinion as to whether or not certain forms of leaf injury are due to fumes, the plotted diameter growth of a large number of trees from a suspected smoke zone, when compared with a similar large number from an area known to be free from fume injury, enables one to decide very definitely whether injury is occurring in the group of trees under consideration. There can be no doubt but that the study of carefully collected and analyzed diameter growth data is the most satisfactory method of demonstrating fume injury in conifers. This, of course, only applies to living trees. When injury has been so severe as to kill trees, the degree of such damage can be ascertained by taking sample plots and classifying the dead trees as to the cause of death.

It is now generally recognized that, in addition to the presence of sulphur dioxide in sufficient concentration, there are several important factors which contribute to the occurrence of damage in plants. These are light, humidity, and temperature. O'Gara found that with alfalfa, a very sensitive plant, the first slight markings became apparent after a fumigation of 3 hours with a concentration of 1 part per million by volume under favourable conditions of light, humidity, and temperature. Generally speaking, bright light, high humidity, and high temperature are favourable to injury. It is readily apparent that there must be many occasions, when a sufficient concentration of sulphur dioxide is present to cause damage, when no damage will occur on account of unfavourable conditions of light, humidity, or temperature.

In regard to control of the sulphur dioxide nuisance, this can be accomplished either by the emission of smoke in such dilute form that damage will rarely occur, or by the elimination of sulphur dioxide from the smoke stream. For the former certain topographic conditions are necessary which are not always present. In regard to the latter it is quite feasible to convert sulphur dioxide into sulphuric acid, but it is usually not economical to do so. In addition, in a large smelter there would be the problem of disposal of the surplus acid, which might amount to several hundred tons a day. One way out of this difficulty is the manufacture of fertilizer, in which process sulphuric acid in large quantities is necessary.

Cultural Studies of Wood-destroying Fungi

(Irene Mounce, Assistant Plant Pathologist, Ottawa)

STOCK CULTURES OF WOOD-DESTROYING FUNGI

In the reports of the Dominion Botanist for 1926, 1927, and 1928, lists were given of the different species of wood-destroying and wood-inhabiting fungi included in the collection of stock cultures at Ottawa. Only two new species have been added during the year, namely, *Ganoderma oregonense* Murr. and *Pholiota albocrenulata* Peck.

We are indebted to Dr. J. Westerdijk of Baarn, Dr. J. Liese of Eberswalde, Mr. G. D. Darker of Harvard University, Dr. A. H. R. Buller of the University of Manitoba, Dr. W. H. Snell of Brown University, Dr. C. W. Fritz of the Forest Products Laboratory at Ottawa, the Dominion Botanist, and Mr. A. W. McCallum and Mr. R. R. Hurst of this Division for specimens and cultures from new localities and new hosts—a total of eight-four new cultures in all. During the past year one hundred and fourteen cultures, in duplicate, have been sent out to various workers in answer to requests.

HETEROTHALLISM IN *Fomes pinicola* (Sw.) Cooke

For the last four years notes on heterothallism in *Fomes pinicola* have been included in this report. The study has been continued during the year but the results obtained only amplify those reported previously, and since they have been published in the Proceedings of the Canadian Phytopathological Society,* they need not be mentioned here. During the summer a large number of sporophores, from various localities in British Columbia, the state of Washington, and Germany, were cultured, and it is proposed to continue experiments with this new material.

Miss Mildred Nobles, who was working in this laboratory during the summer, was able to demonstrate by means of stained preparations that in *Fomes pinicola* and *Polyporus Tuckahoe* there is a single nucleus in each cell of a mycelium of monosporous origin and a pair of nuclei which divide conjugately in each cell of a mycelium which bears clamp-connections. These results are similar to those obtained earlier by Kniep** and Bensaude† for other Basidiomycetes. This work is being continued by Miss Doris Head.

HETEROTHALLISM AND THE CLAMP-CONNECTION CRITERION FOR THE IDENTITY OF SPECIES AS APPLIED TO *Lenzites saepiaria* Fr. AND *Trametes protracta* Fr.

A note on this subject was included in the report of the Dominion Botanist for 1928. Monosporous mycelia of *Lenzites saepiaria* were obtained from two sources (No. 835, No. 854) and series of all possible pairings showed, in both instances, this fungus to be heterothallic and bisexual. Monosporous mycelia of *Trametes protracta* were also obtained from two sources (No. 903, No. 990) and this fungus similarly was shown to be heterothallic and bisexual. Further, any monosporous mycelium of *L. saepiaria* No. 835 produced clamp-connections when paired with any monosporous mycelium of *L. saepiaria* No. 854; and any monosporous mycelium of *T. protracta* No. 903 produced clamp-connections when paired with any monosporous mycelium of *T. protracta* No. 990; but no monosporous mycelium of *L. saepiaria* from either source could be induced to form clamp-connections when paired with a monosporous mycelium of *T. protracta*.

During this year monosporous mycelia of *Lenzites saepiaria* were isolated from two new sources, No. 835B, a sporophore collected on *Abies balsamea* in 1927 at Timagami, Ont., and No. 996, a sporophore collected at Cranberry Lake, N.Y., by Mr. E. J. Eliason. All possible pairings of ten monosporous mycelia of No. 996 and of four monosporous mycelia of No. 835B showed *Lenzites saepiaria* from these two additional sources to be heterothallic and bisexual. Clamp-connections were produced when a monosporous mycelium of *L. saepiaria* from either of these sources was paired with one from any other source; but no clamp-connections were ever found in any pairing of one of these monosporous mycelia with one of *Trametes protracta*. These results confirm and amplify those published previously.

* Vide: Irene Mounce, Notes on sexuality in *Fomes pinicola* (SW.) Cooke, *Fomes roseus* (Fr.) Cooke, etc., etc. Proceedings Inaugural Meeting, Canadian Phytopathological Society, p. 27-28. 1930.

** Kniep, Hans. Beiträge zur Kenntniss der Hymenomyceten III. Zeitschr. f. Bot. 7: 369-398, 1915.

† Bensaude, Mathilde. Recherches sur le cycle évolutif et la sexualité chez les Basidiomycètes. Nemours. 1918.

NOTES ON SEXUALITY IN *Fomes pinicola* (Sw.) Cooke, *Fomes roseus* (Fr.) Cooke, *Polyporus Tuckahoe* (Güssow) Sacc. et Trott., *P. resinosus* (Schrad.) Fr., *P. anceps*. Peck, *Lenzites saepiaria* Fr., *Tametes protracta* Fr., and *T. suaveolens* (L.) Fr.

A paper with this title was read at the annual meeting of the Canadian Branch of the American Phytopathological Society held at Ottawa in December, and will appear in the Proceedings of the Canadian Phytopathological Society. It contains a brief account of the more recent results obtained with monosporous mycelia of *Fomes pinicola*, *Lenzites saepiaria* and *Trametes protracta* from different sources; with *Fomes roseus, Polyporus Tuckahoe*, and *P. anceps* which are considered to be heterothallic species, and with *P. resinosus* and *T. suaveolens* which are probably homothallic.

SECTION III

INVESTIGATIONS OF THE DISEASES OF CEREALS AND GRASSES

20437—3½

REPORT OF THE DOMINION RUST RESEARCH LABORATORY, WINNIPEG, MANITOBA

(J. H. Craigie, Officer in Charge)

Rust Epidemiology

(Wm. Popp and J. H. Craigie)

FIELD STUDIES

One of the most interesting, if disconcerting, features of stem rust epidemiology is that every season furnishes a new combination of environmental conditions, which, in turn, influences materially the expression of the disease in the maturing crop. The summer of 1929 afforded a rather extreme example, being one of the driest in the history of the Prairie Provinces. The rain-fall for the month of June, in most districts, was little more than half the average amount for that month; for July, the proportion was still less; and in August, practically no rain fell at all. Moreover, what rain fell in June and July generally came as light showers, and did little more than dampen the surface of the ground. The month of June was moderately cool, particularly the latter part, but July and August were excessively hot. As a consequence of these conditions, the stand of grain in most of the fields was thin and short; the best fields were not above the general average for other years, and the poorer fields were scarcely worth cutting.

The first traces of rust in the field were found at Brandon and Portage la Prairie, Manitoba, on July 3. A survey of the districts lying between Winnipeg and Morden was made on June 28 and 29, but no trace of rust could be found in this area. However, on July 5 and 6, scattered primary infections were found in this area, and, doubtless, traces of rust could have been found on July 3, if a survey of this area had been made on that date. The particular significance of the simultaneous appearance of stem rust over this large area, from the southern part of the province northward to Winnipeg and westward to Brandon, will be pointed out in the discussion of the spore-trapping results.

Throughout the month of July the amount of rust in Manitoba gradually increased. As already pointed out, the weather was extremely hot and dry, but heavy dews occurred during the nights, and thus permitted fresh infections to take place. The condition of the wheat plants, however, seemed to prohibit the luxuriant growth of the fungus in their tissue. The individual pustules were, in general, much smaller than those usually found in other years.

By the end of July, the early varieties of wheat were quite evidently beyond the stage where rust could do them any appreciable damage, but on most of the Marquis wheat the amount of infection had increased very appreciably, and, before most of it had ripened, its margin of safety became very narrow indeed. However, from certain data gathered by Mr. Greaney in his sulphur-dusting experiments, it would appear that the actual loss due to stem rust was not very great. The high average grade of the wheat this year supports this conclusion.

Barley ripened generally earlier than wheat, and was less affected by rust. Oats in general, and particularly the later-sown fields, bore a fairly heavy infection, but possibly, like wheat, were not very appreciably damaged.

In Saskatchewan, no trace of rust in the fields was observed until July 22. A survey of the eastern part of the province, through the Qu'Appelle Valley and northward, indicated that infection had possibly occurred in this part somewhat earlier than either further south or west. At any rate, no rust occurred at

Indian Head until July 31. Rust was, therefore, at least two weeks later in appearing in Saskatchewan than in Manitoba. From that time onward, a very light general infection spread over most of the province. In some cases, 60 per cent of the plants bore a trace of rust, but, owing to the lateness of its appearance and to the fact that the crop ripened almost simultaneously with that of Manitoba, rust made little headway at all; and, certainly, no loss in yield or grade can justly be attributed to it.

In Alberta no trace of rust appeared until the middle of August. By that time much of the grain had ripened. The infection was, therefore, confined to a few widely scattered primary infections.

Acknowledgment is made to the Dominion Laboratory of Plant Pathology, Saskatoon, for making a systematic survey of Saskatchewan, and to the Dominion Laboratory of Plant Pathology, Edmonton, for reports from Alberta. Also to Dr. J. B. Harrington, of the University of Saskatchewan, and Dr. A. W. Henry, of the University of Alberta, for several individual reports.

(*b*) STATIONARY SLIDE EXPOSURES

(Co-operative project with the Dominion Laboratory of Plant Pathology, Saskatoon, Sask.)

The spore-trapping work was continued this year, but the number of stations at which slides were exposed was considerably reduced. It was thought that the data gathered during the last three or four years were sufficient to warrant this reduction. Slide exposures were carried out in Alberta at only one station, Edmonton, and at two in Saskatchewan, Saskatoon, and Indian Head. In Manitoba, however, slide exposures were made at five stations, in order that a fairly accurate indication of the first arrival of spores could be obtained.

In table 3 are given the results of these exposures between June 10 and July 31. Although slides were exposed at all the stations, except Edmonton, from the first of June to the middle of August, very few spores were detected during the earlier period and the spores of the later period can be considered to have been produced in the district where the slides were exposed, except in the case of Edmonton where no rust was found in the fields up to the middle of August, although spores were found on the slides exposed there much earlier.

TABLE 3.—STATIONS AT WHICH SLIDES WERE EXPOSED, WITH DATES AND NUMBER OF SPORES FOR EACH EXPOSURE, BETWEEN JUNE 10 AND JULY 31, 1929

Date	Emerson	Morden	Treherne	Winnipeg	Brandon	Indian Head*	Saskatoon*	Edmonton*
June 10	0	0	0	....	0	0	0	....
" 11	0	0	0	0	0	....	....	....
" 12	0	0	0	0	0	2	0	....
" 13	0	0	0	0	0	....	....	....
" 14	0	0	1	0	0	1	1	....
" 15	10	0	0	0	0	....	....	....
" 16	....	31	9	182	0	1	0	....
" 17	84	238	252	266	84	....	....	....
" 18	14	0	....	0	9	0	0	....
" 19	0	0	0	0	0	....	....	....
" 20	0	0	0	0	0	0	0	....
" 21	0	0	0	0	0	....	....	....
" 22	0	0	0	0	0	0	0	....
" 23	....	0	0	....	0	....	....	....
" 24	0	0	0	0	0	2	0	....
" 25	0	0	0	0	0	....	....	....
" 26	1	0	0	0	0	1	31	....
" 27	1	0	0	0	0	....	....	....
" 28	0	20	0	1	0	2	0	....
" 29	0	0	0	0	0	....	....	....
" 30	....	0	0	....	0	1	....	....

TABLE 3.—STATIONS AT WHICH SLIDES WERE EXPOSED, WITH DATES AND NUMBER OF SPORES FOR EACH EXPOSURE, BETWEEN JUNE 10 AND JULY 31, 1929—*Concluded*

Date	Emerson	Morden	Treherne	Winnipeg	Brandon	Indian Head*	Saskatoon*	Edmonton*
July 1	0	1	0	....	0	....	....	....
" 2	0	0	0	0	0	1	1	....
" 3	0	1	2	2	2	....	....	....
" 4	0	0	0	0	0	0	0	....
" 5	0	0	0	0	0	....	....	....
" 6	1	0	0	4	0	1	4	....
" 7	....	0	8	....	1	....	....	....
" 8	0	0	0	3	0	21	1	....
" 9	0	0	0	2	0	....	....	....
" 10	0	3	0	658	0	5	2	....
" 11	6	0	4	392	0	....	....	....
" 12	23	1	4	0	0	1	3	....
" 13	....	0	0	43	0	....	....	....
" 14	....	2	0	....	0	2	0	....
" 15	0	3	13	56	0	....	....	....
" 16	0	0	7	4	0	4	2	....
" 17	3	3	14	3	5	....	....	0
" 18	0	0	0	{	0	6	1	....
" 19	0	168	126	1,204 }	31	....	....	....
" 20	0	104	112	3,066	4	30	?	0
" 21	0	14	49	....	36	....	....	....
" 22	50	0	9	12	0	16	1	....
" 23	23	161	182	273	154	....	....	2
" 24	420	42	196	0	19	27	4	....
" 25	182	420	308	5	316	....	....	....
" 26	27	344	3	few	31	24	0	3
" 27	10	84	112	14	55	....	....	....
" 28	....	210	70	....	6	?	2	....
" 29	356	0	0	350	3	....	....	1
" 30	476	2,408	3,108	2,058	308	42	3	....
" 31	2,100	980	98	36	81	....	....	....

* At Indian Head and Saskatoon each slide was exposed for a period of two days, and at Edmonton, for a period of three days.

The first definite spore showers occurred over Manitoba on June 17. It will be seen from table 3 that the spore count for all the Manitoba stations was quite high. This fact indicates that the shower was relatively heavy and general. Two weeks later, primary infections appeared almost simultaneously in the southern and central parts of the province. The evidence seems fairly convincing that this spore shower was responsible for the early infections.

A few circumstances in connection with this spore shower are worth noting. At this time, according to information received from the United States Department of Agriculture, the northern limit of rust in the Central States might be indicated roughly by a curve passing through central Colorado, through Nebraska northeasterly into southeastern South Dakota, and from there dropping southeast into central Illinois. It should, however, be pointed out that there was but a trace of rust along this northern limit, and that, even in the more southerly States, not more than a light infection was anywhere present. However, the maps of the Meteorological Service of Canada (Fig. 8) show that there was a continuous LOW over some part of the Prairie Provinces from June 13 to June 19, and that there was a general movement of air from Texas northward through the Central States into Western Canada. On June 17, the wind velocity over Manitoba and the adjoining States to the south was approximately 20 miles per hour. It seems, therefore, that, although stem rust was nowhere very abundant in the area just indicated, urediniospores in sufficient numbers were accumulated by these northward-blowing winds to provide a very definite spore shower for Manitoba. Confirmatory of this hypothesis is the fact that at St. Paul, Minn., a definite spore shower occurred at that time. This evidence points to the west-central States as the probable source of the inoculum.

Just why the slides exposed at Indian Head and Saskatoon, Saskatchewan, did not detect any spores on June 17 may be difficult for novices in Meteorology to explain, but it might be pointed out that the LOW of that date centered in central Saskatchewan and northwestern North Dakota, and the isobar lines for June 16 and 17 indicate that the wind from the rust-infected area passed over Manitoba and the adjoining portion of western Ontario, and that the wind which passed over southern Saskatchewan came from the west or northwest and thus passed over non-rusted areas.

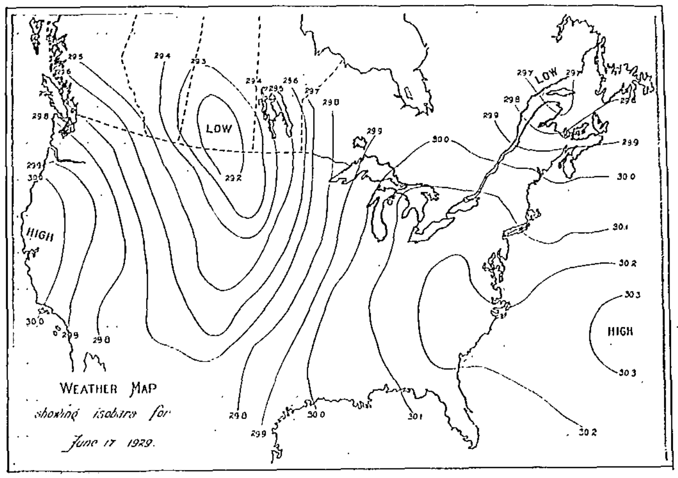

FIG. 8.—Isobars for June 17, 1929, redrawn from weather map of that date. Air currents move counter clock-wise around a Low, and clock-wise around a High. Winds from States west of the Mississippi river would pass over Manitoba. The closeness of the isobars east of the Low indicates a relatively strong wind. (By permission of the Director, Dominion Meteorological Service.)

From this time onward until July 10, very few spores were intercepted by the slides, but on that date, as well as on July 11, the number on the slides exposed at Winnipeg was quite high. An exposure by aeroplane (see table 4, page . . .) for 30 minutes at Portage la Prairie, west of Winnipeg, on July 10 furnished 32 spores. On July 11, another exposure of 30 minutes, over the same district, furnished 17 spores and one at Lac du Bonnet, for 15 minutes, had 48 spores. These aeroplane exposures substantiate the findings of the stationary slide exposures, that, in the vicinity of Winnipeg during these two days, there was present in the atmosphere a fairly high concentration of stem rust spores. The isobar lines for these two dates show that wind from the States where rust was present at this time would pass over Manitoba, but not over Saskatchewan. An explanation of how slides exposed at other stations in Manitoba detected very few spores on these dates is not attempted. It might be suggested, however, that the air over the west central States would be fairly highly heated and would move northward as a rising current. The temperature in Manitoba on both days was comparatively low, maximum 74° and 70°, minimum 52° and 58° F., for Winnipeg, July 10 and 11, respectively. It can be imagined that relatively warm air from the south, bearing spores, would move northward as an upper current, but on reaching the cooler latitude of Manitoba would begin to descend. It might, therefore, pass over the stations in the southern part of this province.

but come to ground level by the time it reached Winnipeg. Certainly there were no local infections around Winnipeg at this time that could account for this spore shower.

After the lapse of a week, during which only a relatively small number of spores were intercepted, a sudden increase is registered by the slides at three of the stations on July 19 and 20. None were found at Emerson, and only 35 at Brandon, Man., and 30 at Indian Head, Sask., for the two days. Why none were detected at Emerson is difficult to see. It is one of those anomalies that have been so frequently encountered in this work. The slides at Winnipeg had by far the largest number of spores. Possibly this spore shower might be explained again by descending air. At Winnipeg, for July 16 and 17, the maximum was 90° and the minimum, 60° F.; for July 18, the maximum was 80° F., but the minimum fell to 42° F.; and for July 19, the maximum was relatively low, 72° F., the minimum 46° F. On July 20 the temperature rose to a maximum of 80° and a minimum of 60°. The spore shower occurred on the date of low temperature. It might also be pointed out that the isobar lines occupy approximately the same position for Manitoba and the States to the south, that they did in the two previously discussed instances. At this time a light primary infection was present over most of the wheat-growing part of Manitoba, but nowhere in the province was there heavy infection. Some of the spores found on the slides may, therefore, have been of local origin, but local infections can scarcely account for the large number found at Winnipeg, especially as a comparable number of spores were not shown again by the slides at this station until July 30.

The spore count, however, was relatively high again for the Manitoba stations between July 23 and 26, but dropped sharply during the next two or three days. Here again the isobar lines indicate a northward movement of air, but, as the amount of infection was gradually increasing in this province, locally produced spores were becoming more and more plentiful, and might account for a large percentage of the spores. From August 1 onward to the middle of the month the spore count became relatively constant, although quite evidently showing local intensities of spore concentration in the air, due to harvesting operations.

In Saskatchewan, not more than a trace of spores was detected by the slides exposed at Indian Head until July 20, with one exception on July 8, or at Saskatoon until about the first of August, with one exception, June 26. In comparison with Manitoba the number of spores present in Saskatchewan was small, and the earliest arrival of spores comparatively late. As already noted, rust was somewhat later than usual in appearing in the fields in this province—the first trace being discovered on July 22. Rust development was early terminated by the rapid ripening of the grain. The small number of spores and their late arrival seem to account for the fact that Saskatchewan had considerably less rust than Manitoba.

In Alberta, slides were exposed at Edmonton from July 15 to August 31, each for a three-day period. A few spores were caught during the last ten days of July and throughout August. The highest number on any slide was eight. This indicates that the spore content of the air over Alberta was very low indeed. No trace of rust was found in the province until after the middle of August, and nowhere in the province did more than a trace of rust occur. The exceedingly light infection in Alberta seems to be correlated directly with the small amount of inoculum: in Saskatchewan there was more inoculum present and more rust in the field, and still more of each in Manitoba.

(c) SLIDE EXPOSURES BY AEROPLANE

(Co-operative project with the Royal Canadian Air Force)

Reference has already been made to slides exposed during aeroplane flights. The results of these exposures are given in table 4. Arrangements were made for a series of flights between Portage la Prairie and Winnipeg, and Portage la Prairie and Brandon, by the machine which was to do the sulphur dusting, but unfortunately an accident put this plane out of commission early, and only four flights were made. However, two of these, on July 10 and 11, gave very important evidence bearing on the spore shower that occurred at Winnipeg on those two dates, as did also the exposure at Lac du Bonnet, Man., on July 11.

TABLE 4.—STATIONS AT WHICH SLIDE EXPOSURES BY AEROPLANE WERE MADE IN 1929, WITH DATES OF EXPOSURES AND NUMBER OF SPORES INTERCEPTED

Date	Number of spores		
	Lac du Bonnet	Cormorant Lake	Portage la Prairie
July 10	...	...	32
" 11	48	...	17
" 12	...	...	0
" 13	...	0	...
" 16	...	...	2
" 18	...	0	...
" 19	...	1	...
" 20	...	2	...
" 22	0	0	...
" 23	0	...	...
" 24	34	0	...
" 25	...	0	...
" 26	7	...	...
" 28	...	0	...
" 29	...	2	...
" 30	2	0	...
Aug. 1	5	8	...
" 3	...	0	...
" 4	...	1	...
" 5	...	0	...
" 6	...	4	...
" 11	...	0	...
" 12	...	0	...
" 14	...	0	...

From the middle of July to the middle of August, seventeen exposures were made at Cormorant Lake in northern Manitoba. This station is more than 350 miles north of Winnipeg and widely separated by forests and lakes from wheat-growing areas. Although the highest number of spores for any one of these exposures (15 minutes) was eight, not many spores were to be expected this season at a point so far remote. But the evidence does show again that, when even but a moderately light infection of rust is present in the wheat belt, some spores are carried away from it to a considerable distance.

Physiologic Forms of Wheat Stem Rust, *Puccinia graminis* Pers. var. *Tritici Erikss.* & Henn.

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

The present report summarizes the results of the tenth year of research in Canada on physiologic specialization in wheat stem rust, *Puccinia graminis Tritici* (see table 5).

TABLE 5.—PHYSIOLOGIC FORMS OF *Puccinia graminis Tritici* FROM CEREALS AND GRASSES IN CANADA BETWEEN 1919 AND 1928 WITH A RECORD OF THE NUMBER OF TIMES EACH FORM WAS COLLECTED ANNUALLY

Form	Number of times form was collected									
	Year									
	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
1	2	1	...	...	...	...	...	...	...	2
2	...	...	...	...	1	...	...	...	...	...
3	...	4	3	10	10	16	...	...	...	...
9	4	6	2	3	...	...	...	1	5	...
11	2	5	2	3	5	9	...	...	...	4
12	...	2	...	...	...	5	...	...	...	...
14	...	...	...	...	...	...	...	2	16	2
15	1	...	...	...	...	...	...	2	8	21
16	...	...	...	...	...	...	...	...	2	...
17	9	31	27	16	10	1	...	1	14	6
18	4	7	3	2	...	...	...	...	...	...
19	1	...	...	...	...	...	...	1	1	6
21	4	...	4	24	...	1	44	84	133	103
23	...	...	...	...	...	...	...	...	...	4
24	1	...	1	...	...	...	...	...	...	...
29	...	17	1	...	...	...	13	28	4	11
30	...	1	...	...	...	...	1	7	5	...
32	...	4	1	...	...	...	3	12	4	...
34	...	...	...	1	3	7	1	4	9	15
35	...	...	...	...	...	...	...	1	...	...
36	...	...	...	2	...	...	113	211	201	154
38	...	...	...	...	...	...	...	18	25	32
40	...	...	...	...	...	...	...	...	...	1
48	...	...	...	...	...	...	...	2	...	...
49	...	...	...	...	...	...	...	3	8	14
50	...	...	...	...	...	...	...	...	4	...
52	...	...	...	...	...	...	...	1	3	5
A	...	...	...	...	...	...	...	...	...	1
B	...	...	...	...	...	...	...	...	...	1
C	...	...	...	...	...	...	...	...	...	1
D	...	...	...	...	...	...	...	...	...	1
E	...	...	...	...	...	...	...	...	...	1
F	...	...	...	...	...	...	...	...	...	1
G	...	...	...	...	...	...	...	...	...	4
Total number of forms	9	10	9	8	5	6	6	16	16	22
Total number of collections made in year	28	78	44	61	29	39	175	378	442	390

During the entire period thirty-nine physiologic forms have been isolated in Canada. As was stated in the 1927 annual report, all forms of stem rust collected in Canada, until 1926, were identified as one or other of the forms found in the United States. Since that time sixteen physiologic forms, different from those described by Stakman and Levine, have been isolated in Canada. The first eight of these were described in full in *Scientific Agriculture*, Vol. IX, No. 4, 1928. The remaining eight, designated by the letters A, B, C, D, E, F, G, and L, were all collected in 1928. The distribution of these new forms is shown in tables 6 and 7. The figures represent the total number of times each form was isolated in the different provinces. It will be seen that form G occurred in four collections from British Columbia, but that each of the others was collected but once. Forms B, C, D, E, and F were all isolated from the rust nursery rows at Charlottetown, Prince Edward Island, while Form L was obtained from barberry, artificially inoculated with telial material collected at Winnipeg, Manitoba.

TABLE 6.—DISTRIBUTION BY PROVINCES OF THE PHYSIOLOGIC FORMS OF *P. graminis Tritici* FROM CEREALS AND GRASSES IN CANADA IN 1928

Province	Physiologic forms																						
	1	11	14	15	17	19	21	23	29	34	36	38	40	49	52	A	B	C	D	E	F	G	Total
Alberta	1	1	..	..	1	..	13	2	....	....	19	....	....	....	1	....	....	....	....	....	....	....	38
British Columbia	..	..	..	..	..	..	1	2	....	....	1	....	....	....	....	....	....	....	....	....	....	4	8
Manitoba	1	..	..	11	..	5	42	....	5	9	59	7	....	8	2	....	....	....	....	....	....	....	149
New Brunswick	..	..	..	..	..	..	2	....	....	1	3	2	....	....	....	....	....	....	....	....	....	....	8
Nova Scotia	..	..	1	2	..	1	2	....	....	....	1	10	....	....	....	....	....	....	....	....	....	....	17
Ontario	..	1	..	1	..	..	3	....	....	2	5	8	....	2	....	1	....	....	....	....	....	....	23
Prince Edward Island	..	..	..	..	..	..	2	....	....	1	1	1	....	....	....	....	1	1	1	1	1	....	10
Quebec	..	..	..	2	..	..	....	....	2	....	4	2	....	1	....	....	....	....	....	....	....	....	11
Saskatchewan	..	2	1	5	5	..	38	....	4	2	61	2	1	3	2	....	....	....	....	....	....	....	126
	2	4	2	21	6	6	103	4	11	15	154	32	1	14	5	1	1	1	1	1	1	4	390

It is not definitely know how these sixteen new forms originated. They may have been present for some time and merely escaped detection; or they may have arisen through hybridization and segregation on the barberry, or through the mutation of already-existing forms. As all the forms arose either from uredinial material collected in the field, or from barberries artificially inoculated with naturally-occurring telia, there was no way of determining the

TABLE 7.—DISTRIBUTION BY PROVINCES OF THE PHYSIOLOGIC FORMS OF *P. graminis Tritici* FROM BARBERRIES IN CANADA IN 1928

Province	Physiologic form													Total
	1	9	11	15	17	21	29	33	34	36	49	52	L	
Manitoba	1	1	2	5	1	23	....	....	1	34	....	24	2	94
Ontario	....	....	....	1	....	....	....	1	....	....	....	....	....	2
Prince Edward Island	....	....	....	....	....	....	....	....	....	....	1	....	....	1
Quebec	....	....	....	....	....	....	1	....	1	....	....	....	....	2
Saskatchewan	....	....	1	....	....	....	....	....	....	....	....	....	....	1
Total number of collections made in year	1	1	3	6	1	23	1	1	2	34	1	24	2	100

facts of their earlier history. Certain evidence, however, pointed to hybridization and segregation on the barberry: (1) three of the forms, each of which has been collected but once, were found at Ottawa in rust-nursery rows which were planted in close proximity to a barberry hedge; (2) three of the forms were collected only on barberries; (3) most of the remaining collections of these new forms came from provinces in which the barberry is quite common.

During the present year experimental evidence has been secured, under controlled conditions in the greenhouse, that hybridization and segregation of forms occur on the barberry. It is, therefore, very probable that the new forms mentioned in the preceding paragraph arose in this way. The experimental work is yet in progress, and an account of it will appear in the next report.

TABLE 8.—A COMPARISON OF THE FREQUENCY OF OCCURRENCE OF PHYSIOLOGIC FORMS 21 AND 36 IN CANADA DURING THE YEARS 1925, 1926, 1927 AND 1928

Year	Total number of collections	Number of times form 21 was collected each year	Percentage o total collections	Number of times form 36 was collected each year	Percentage of total collections
			%		%
1925	175	44	25·14	113	64·57
1926	378	84	22·22	211	55·82
1927	442	133	30·09	201	45·47
1928	390	103	26·41	154	39·49

Since 1925, the two physiologic forms, 36 and 21, have been the prevailing forms in western Canada. From table 8 (percentage of total collections) it will be seen that form 36 has been growing less prevalent from year to year during this time, while form 21 has remained more or less constant.

As forms 21 and 36 have been the prevailing forms in western Canada, it might be supposed that they have been the first to arrive each season. Such is not the case. Sometimes one form appears first, sometimes another. Table 9, which is a summary of the frequency of occurrence of physiologic forms of *P. graminis Tritici* in Manitoba and Saskatchewan in the very early and late seasons of 1926, 1927, and 1928, indicates that no appreciable difference in kind or number of forms can be detected in the very early or in the late group.

TABLE 9.—FREQUENCY OF OCCURRENCE OF PHYSIOLOGIC FORMS OF *P. graminis Tritici* IN MANITOBA AND SASKATCHEWAN IN THE VERY EARLY AND LATE SEASONS OF 1926, 1927 AND 1928

Physiologic form	Percentage of collections from June 30–July 31				Percentage of collections from August 1–October 31			
	Year				Year			
	1926	1927	1928	Average for 3 years	1926	1927	1928	Average for 3 years
	%	%	%	%	%	%	%	%
1	0	0	1·76	0·59	0	0	0·64	0·21
9	0·72	1·88	0	0·87	0	1·06	0	0·35
11	0	0	0·88	0·29	0	0	0·64	0·21
14	0	4·24	0	1·41	1·19	3·19	0·64	1·67
15	0·72	1·88	11·50	4·70	1·19	4·25	1·28	2·24
16	0	0	0	0	0	1·06	0	0·35
17	0·72	3·30	1·76	1·93	1·19	5·32	1·92	2·81
19	0	0	0·88	0·29	0	0	2·56	0·85
21	22·30	29·71	21·23	24·41	23·81	34·04	35·25	31·03
29	10·07	0·47	1·76	4·10	2·38	3·19	3·84	3·14
30	2·87	0·94	0	1·27	4·76	3·19	0	2·65
32	2·16	0·47	0	0·88	2·38	0	0	0·79
34	1·43	2·35	1·76	1·85	1·19	3·19	5·76	3·38
36	58·27	49·05	46·90	51·41	60·71	36·70	41·02	46·14
38	0	2·35	4·42	2·26	0	2·12	2·56	1·56
40	0	0	0	0	0	0	0·64	0·21
49	0	1·88	5·30	2·39	1·19	0	2·56	1·25
50	0	0·94	0	0·31	0	0	0	0
52	0·72	0·47	1·76	0·98	0	2·12	1·28	1·13

Form 38, a form to which Marquis is resistant, was discovered in 1926. At that time it was present in seventeen of the one hundred and eight isolations originating in eastern Canada, but it was found in only one of the two hundred and eighty-six isolations from western Canada. The reason for this is not entirely clear, but it is known that, while Marquis was grown almost exclusively in the west, a greater variety of wheats was grown in the east, and, as Marquis is resistant to form 38, it seemed possible that this form had been prevented from appearing in Western Canada by the scarcity of congenial hosts. In 1927 and 1928, through fear of rust, farmers, in both Western Canada and in the north central States, sowed a considerable proportion of durum wheat and varieties other than Marquis. Greenhouse experiments had previously shown that form 38 could attack many of these wheats. The question naturally arose, would an extensive introduction of these wheats bring about an appreciable change in the prevalence of such forms as 38 in the west. The results seem to indicate a slight change. Form 38 appeared in thirteen of the collections made in the west in 1927, and in nine of the collections made in 1928. It has remained the most prevalent form in Eastern Canada since 1926.

The Constancy of Physiologic Forms of *Puccinia graminis Tritici*

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

In a previous report the occurrence of abnormally coloured uredinia in certain physiologic forms of *Puccinia graminis Tritici* was mentioned. Three physiologic forms have shown the presence of such uredinia. In one of these, form 9, uredinia of an orange colour appeared among the normal red uredinia. The other two abnormally couloured physiologic forms, 36 and 52, have each appeared, on several occasions, in the first generation of uredinia arising from infections by aeciospores. These two forms do not differ pathogenically from the normally coloured forms 36 and 52, but possess uredinia of a greyish-brown or chocolate colour, which contrasts rather sharply with the red colour of normal uredinia.

During the winter of 1928-29 an attempt was made to determine to what extent abnormally coloured forms of rust appeared from barberry infected by teliospores formed in the field. *Hordeum jubatum,* collected in the spring of 1928 in the neighborhood of the Agricultural College at Winnipeg, and bearing abundant telia, served as source for the inoculum. Barberries were infected on several occasions by this material, and the aecia resulting from these infections were used to establish cultures on wheat plants. Abnormally coloured uredinia were observed in a number of these cultures. These, as well as the uredinia of normal colour, were isolated, and studied to determine what physiologic forms they represented. In all, forty-eight cultures were studied and identified. Of these thirty-two were cultures of the normal, red-coloured rust, while the remaining sixteen cultures were abnormal in the colour of their uredinia, which were of a greyish-brown or chocolate colour. The following physiologic forms were identified from the normal and grey uredinia respectively.

From Normal Uredinia

23 cultures of form 21
2 " " 36
5 " " 52
2 " " L (a new form)

From Greyish-brown Uredinia

5 cultures of form 36, greyish-brown
11 " " 52, greyish-brown

Another colour variation has been found in form 36 in addition to the ones described above as greyish-brown. This new one is likewise of a greyish colour, but of a shade so different as to warrant a separate description. It has been named, temporarily, form 36 light-grey, to distinguish it from the cultures of the greyish-brown form. While it appears to be the same pathogenically as the cultures of the greyish-brown 36, its uredinia are considerably paler in colour. This variant may, perhaps, be considered as a mutation of the greyish-brown form 36, since it appeared in the first generation of uredinia from aeciospores of that form. These aeciospores, in turn, arose from an infection of barberry by teliospores of the original culture of the greyish-brown form 36, which appeared in 1926, and has been mentioned in previous reports.

This light-grey-coloured culture of form 36 was found to differ from the greyish-brown or chocolate-coloured form 36 in other respects than colour. Some difficulty was experienced in maintaining this culture in the greenhouse, for, although the infection type was characteristic of form 36, yet the infections were fewer and the pustule development poor. For this reason a comparison was made of the urediniospore germination of this form with those of the greyish-brown forms 36 and 52. The following percentages of germination are the averages of several tests:—

Form	*Percentage germination*
36 light-grey	18.5
36 greyish-brown	49.5
52 greyish-brown	85.1

From these figures it would appear that the explanation of the poor infections by the light-grey culture of form 36 lies in the low germinability of its urediniospores.

It would seem from these experiments that these abnormally coloured rust strains are of not uncommon occurrence in rust originating from the barberry. They are, however, extremely rare in uredinial collections made on cereals and grasses in the field. In the rust survey work for the four years 1925-28, only two collections of rust were of this type, and one of these was directly traceable to barberry.

Co-operative Uniform Rust Nurseries

(Margaret Newton)

The co-operative uniform rust nurseries were continued as in previous years. From tables 10 and 11 it will be seen, that twenty-five varieties of wheat and eleven varieties of oats were tested for their relative resistance to stem rust at twenty-two different stations. There is included in these tables the total number of physiologic forms isolated at each station.

TABLE 10.—PERCENTAGE OF STEM RUST ON 25 VARIETIES OF WHEAT GROWN IN UNIFORM RUST NURSERIES AT 22 STATIONS IN CANADA IN 1928

Wheat Varieties	Percentage infection of stem rust*																					
	Charlottetown, P.E.I.	Kentville, N.S.	Nappan, N.S.	Fredericton, N.B.	Ste. Anne de la Pocatière, Que.	Ottawa, Ont.	Guelph, Ont.	Kapuskasing, Ont.	Winnipeg, Man.	Brandon, Man.	Morden, Man.	Saskatoon, Sask.	Indian Head, Sask.	Swift Current, Sask.	Rosthern, Sask.	Scott, Sask.	Lethbridge, Alta.	Lacombe, Alta.	Edmonton, Alta.	Beaver Lodge, Alta.	Summerland, B.C.	Sidney, B.C.
Kubanka......218	tr	tr	tr	0	0	0	tr	tr	50	tr	40	tr	tr	0	0	tr	tr	tr	0	0	0	0
Kubanka......219	tr	tr	tr	0	0	0	5	tr	40	tr	30	tr	tr	0	0	tr	0	tr	0	0	0	0
Arnautka......225	tr	tr	tr	0	0	0	tr	tr	70	5	30	5	tr	0	tr	tr	0	tr	0	0	0	0
*Iumillo.........7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mindum.......217	tr	tr	tr	0	0	0	tr	tr	70	tr	25	tr	tr	0	tr	tr	tr	tr	0	0	0	0
†Acme........220	0	0	tr	0	0	0	0	tr	5	0	0	tr	0	0	0	tr	0	tr	0	0	0	0
Axminster......75	5	tr	tr	0	0	0	0	tr	65	25	60	40	10	tr	tr	tr	0	tr	0	0	0	0
D.C. 8252.....379	0	0	tr	0	0	0	0	0	45	30	20	40	30	tr	tr	tr	0	0	0	0	0	0
†Ceres........127	tr	0	tr	0	0	0	0	tr	55	20	55	60	40	0	tr	tr	0	tr	0	0	0	0
Garnet.........15	10	tr	40	tr	tr	tr	5	5	75	65	70	60	70	tr	5	5	tr	tr	tr	0	0	0
Huron..........20	5	tr	5	0	tr	0	tr	....	....	60	60	65	40	tr	5	tr	tr	....	....	....	0	0
Kota..........221	tr	tr	tr	0	0	0	0	tr	40	25	20	45	5	0	tr	tr	0	tr	0	0	0	0
Marquillo.....132	tr	0	0	0	0	0	0	tr	5	5	10	5	0	tr	tr	tr	0	0	0	0	0	0
Marquis........84	tr	tr	tr	tr	0	0	tr	20	75	50	80	40	25	tr	5	tr	tr	tr	0	0	0	0
Reliance......198	tr	5	tr	0	tr	0	0	10	70	50	75	50	35	tr	5	tr	0	tr	0	0	0	0
†Ma. x Ko.....126	tr	0	tr	0	0	0	0	0	45	10	15	25	tr	tr	0	tr	0	tr	0	0	0	0
White Russian.49	5	tr	tr	0	0	0	0	tr	75	45	60	40	25	0	tr	tr	0	tr	0	0	0	0
Reward........79	tr	0	tr	0	0	0	0	tr	70	50	70	50	30	tr	5	5	tr	tr	0	0	0	0
Parker's.......71	tr	tr	tr	0	0	0	tr	tr	65	45	65	40	10	tr	tr	tr	0	0	0	0	0	0
Webster.......365	0	0	0	0	0	0	0	0	40	0	tr	5	0	0	0	tr	0	0	0	0	0	0
†H-44-24......229	0	0	0	0	0	0	0	tr	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Little Club....223	5	5	tr	0	0	0	0	tr	80	65	65	60	35	tr	5	5	tr	tr	0	0	0	0
†Khapli.......215	tr	tr	tr	0	0	0	0	0	15	5	10	0	0	0	0	0	0	0	0	0	0	0
†Vernal.......216	tr	tr	tr	0	0	0	0	0	0	tr	0	0	0	0	0	0	0	0	0	0	0	0
Einkorn.......227	0	0	0	0	0	0	0	0	tr	0	tr	0	0	0	0	0	0	0	0	0	0	0
	Physiologic forms isolated																					
	21	15	14	21	15	11	21	36	15	21	1	11	14	21	21	21	21	21	1			
	34	21	15	34	19	34	34	....	19	36	15	15	15	36	....	36	23	36	36			
	36	38	19	36	36	36	36	....	21	38	21	17	21	....	....	....	36	....	52			
	38	....	21	38	38	38	38	....	34	49	36	21	34									
	....	....	36	....	49	....	49	....	36	....	38	29	36									
	....	....	38	....	29	....	....	....	....	....	....	34										
	....	....	....	....	....	....	....	....	....	....	....	36										
	....	....	....	....	....	....	....	....	....	....	....	40										
	....	....	....	....	....	....	....	....	....	....	....	52										

* The rust percentages were estimated by the scale devised by the Office of Cereal Crops and Diseases, U.S.D.A.
† The pustules on these varieties were consistently small.

Table 11.—Percentage of Stem Rust on 11 Varieties of Oats Grown in Uniform Rust Nurseries at 22 Stations in Canada in 1928

Oat Varieties	Percentage infection of oat rust																					
	Charlottetown, P.E.I.	Kentville, N.S.	Nappan, N.S.	Fredericton, N.B.	Ste. Anne de la Pocatiere, Que.	Ottawa, Ont.	Guelph, Ont.	Kapuskasing, Ont.	Winnipeg, Man.	Brandon, Man.	Morden, Man.	Saskatoon, Sask.	Indian Head, Sask.	Swift Current, Sask.	Rosthern, Sask.	Scott, Sask.	Lethbridge, Alta.	Lacombe, Alta.	Edmonton, Alta.	Beaver Lodge, Alta.	Summerland, B.C.	Sidney, B.C.
Victory	tr	tr	tr	0	0	0	0	0	40	60	30	60	45	tr	30	10	0	0	tr	0	0	0
Minn. x White Russ	0	0	0	0	0	0	....	0	20	tr	0	5	tr	0	tr	tr	0	0	0	0	0	0
†Richland	0	0	0	0	0	0	0	tr	tr	0	0	tr	tr	0	tr	tr	0	0	0	0	0	0
Banner	tr	tr	tr	0	0	0	0	tr	40	40	10	40	40	tr	5	10	0	0	0	0	0	0
†Heigira Strain	0	0	0	0	0	0	0	0	0	0	0	tr	tr	0	0	tr	0	0	0	0	0	0
O.A.C. 72	tr	tr	tr	0	0	tr	....	tr	20	35	10	45	30	tr	5	10	0	0	tr	0	0	0
†Monarch Strain	0	0	0	0	0	0	0	tr	0	0	tr	tr	0	0	tr	tr	0	0	0	0	0	0
White Russian	tr	0	0	0	0	0	0	tr	tr	0	tr	tr	tr	tr	0	tr	0	0	tr	0	0	0
Alaska	0	tr	tr	0	0	0	0	tr	60	0	15	....	....	....	....	....	0	0	....	....	....	....
Joanette Strain	0	tr	tr	0	0	0	0	tr	5	tr	tr	tr	5	tr	tr	5	0	0	0	0	0	0
Gold Rain	tr	tr	tr	tr	tr	tr	0	5	40	25	25	35	10	tr	25	15	0	tr	tr	0	0	0
	Physiologic forms isolated																					
	1 2 5	1 2 5	1 5	2 5	1 2 5	2 5	2 5 7	2 5	1 2 3 5 7	1 2	2 5	1 2 5	2 5	1 2 5	2	2 5	....	2	2 5	....	....	....

Reactions of Wheat Varieties in the Seedling Stage to Physiologic Forms of *Puccinia graminis Tritici*.

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

In 1926 the writers undertook to test the rust resistance of a number of wheat varieties and crosses to some of the physiologic forms of wheat stem rust prevalent in Canada. In a previous publication they reported the reactions of twenty-three common wheat varieties and crosses, and six durum wheat varieties, to seven physiologic forms of *Puccinia graminis Tritici* Erikss. and Henn. This work has been extended to include a number of other varieties and crosses. The rust reactions of these to twenty-two physiologic forms, including the seven forms above mentioned, are discussed in this report. On the other hand, several of the less promising varieties tested in the earlier work have been dropped. Consequently, the present report includes all the information presented in the earlier publication, excepting the reactions of these few varieties.

It should be pointed out that these reactions are the reactions of seedlings only, and they may or may not be identical with the reactions of the mature plants. The question of the relationship between seedling and mature plant reactions has been discussed by several authors. They have concluded that some wheat varieties may develop rust resistance, or increase their resistance progressively, as they mature. On the other hand, experimental evidence obtained at the Rust Research Laboratory points to the fact that varieties resistant in the seedling stage will normally remain resistant when mature.

A full report of these investigations was published in *Scientific Agriculture*, Vol. IX, No. 10, June, 1929.

Nuclear Association in the Accium of *Puccinia graminis* Pers.

(W. F. Hanna)

It is well known that when the teliospores of the rusts germinate they give rise to small hyaline spores, called sporidia, which are uninucleate. The germ tubes put out by the sporidia are able to penetrate the leaves of their particular host plants, and there develop mycelia which, under certain conditions, produce chains of binucleate spores. This change from the uninucleate to the binucleate condition is brought about in certain rusts by fusions of uninucleate cells in pairs at the base of the young aecium, and in others by a method known as "nuclear migration." In the latter process a nucleus passes through its cell wall into a neighbouring cell and there becomes associated with another nucleus. In view of the fact that *Puccinia graminis*, the fungus causing black stem rust of cereals, had been shown to be heterothallic, it was a matter of considerable interest and importance to discover the manner in which the binucleate condition arises in this species.

Sporidia of *P. graminis* were collected on clean glass slides by suspending above the slides pieces of straw of *Hordeum jubatum* bearing germinating teliospores. When collected in this way the sporidia adhere to the surfaces of the slides and may be taken through the fixing and staining process without any further treatment. Preparations, fixed with Flemming's weaker solution, and stained in Heidenhain's iron-alum haematoxylin, were examined microscopically. Usually but one nucleus was present in each sporidium, but quite frequently sporidia were found having a pair of nuclei, even before they had begun to germinate. Presumably these sporidia were not originally binucleate, but became so as a result of division by the single nucleus of the sporidium in preparation for germination. Sometimes when moisture had condensed on the slides a few of the sporidia germinated and produced secondary sporidia. Although similar in shape to the primary sporidia, these secondary sporidia were never seen to be discharged from their sterigmata.

Young barberry leaves were inoculated in the usual manner by suspending germinating telial material above the plants. The pycnia which make their appearance about 8 days after inoculation generally occur on the upper surface of the leaf, but sometimes they are found on the lower surface as well (fig. 9).

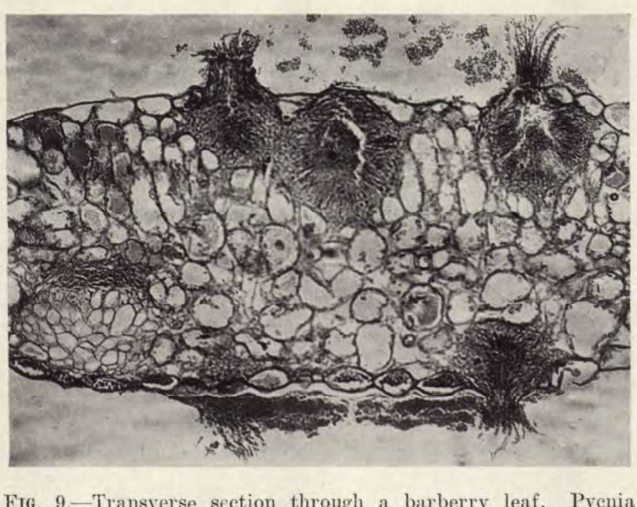

FIG. 9.—Transverse section through a barberry leaf. Pycnia have developed on both surfaces of the leaf. x 130. (Photomicrograph by W. F. Hanna)

More rarely they have been found entirely embedded in the tissues of the leaf. The stimulus of gravity seems to play little if any part in determining the particular region of the leaf in which pycnia and aecia develop, since plants inoculated on the lower surfaces of their leaves and kept inverted bore pycnia on the upper epidermis and aecia on the lower epidermis in the usual manner. It is probable, therefore, that these organs develop in response to stimuli from particular regions of the leaf.

About 10 days after pycnia had appeared on the leaves of the inoculated plants, a quantity of pycnial nectar was collected and applied to all of those pustules which seemed to have arisen from infections by single sporidia. Some of the leaves having monosporidial pustules which had been treated in this way were removed at once, and the portion of the leaf bearing the pustule was cut out and fixed in Fleming's solution. Other pustules were allowed to continue their development for various lengths of time, ranging from 24 to 97 hours, after the addition of the nectar, and were then cut out and fixed in the usual way. All of the material was embedded in paraffin, sectioned, and stained in safranin and aniline blue.

Sections through pustules fixed immediately after the pycniospore containing nectar had been added showed the presence of numerous haploid hyphae ramifying through the intercellular spaces of the leaf. The pycnia, which occur in considerable numbers on the upper surface of the leaf, produce quantities of haploid pycniospores. Towards the lower surface of the leaf, usually between the palisade and the spongy parenchyma, were found crescent shaped wefts of mycelium made up of haploid hyphae. The concave side of each weft faces towards the lower epidermis and is filled with large thin-walled sterile cells. The wefts of mycelium may be regarded as haploid rudiments of aecial cups which require some further stimulus in order to complete their development.

About 48 hours after the addition of pycniospore-containing nectar to the pustules, the nuclei at the base of each hyphal weft become enlarged and stain more deeply. Shortly afterwards binucleate cells make their appearance here and there throughout the weft (fig. 10). These binucleate cells have been found to arise in a number of instances from fusions of pairs of uninucleate cells (fig. 11). They elongate and form stalk cells, which cut off at their tips binucleate aeciospore-mother-cells. Sections through pustules, fixed 65 hours after the application of pycniospores, have been found to have young aecial cups with as many as four aeciospores in some of the chains. In one preparation a nucleus was found which appeared to be migrating through the cell wall into a neighbouring cell. This process, however, is not considered to be the usual method by which the binucleate condition is brought about in *P. graminis*.

In the early stages of aecial development, large multinucleate cells are frequently found near the centre of the hyphal weft. As many as sixteen nuclei have been counted in a single cell. Some of these cells arise from fusions of pairs of cells, and it is probable that their multinucleate condition is the result of a number of divisions in preparation for aeciospore production (fig. 12). Others appear to have been formed by the fusion of several cells. In the later stages of aecial formation, the multinucleate cells disappear, and are replaced by binucleate stalk cells which bear the aeciospore-mother-cells. Occasionally two stalk cells have been found to arise from a single cell at the base of an aecium. If the multinucleate cells were to develop in a similar manner, each one producing two or more stalk cells, their many nuclei would soon be used up in the process of aeciospore production.

The rôle which the pycniospores play in bringing about aecial development is not yet fully understood. Attempts were made to germinate them on a number of liquid and solid media, but without success. Germinated pycniospores were never observed in any of the microtome sections which were exam-

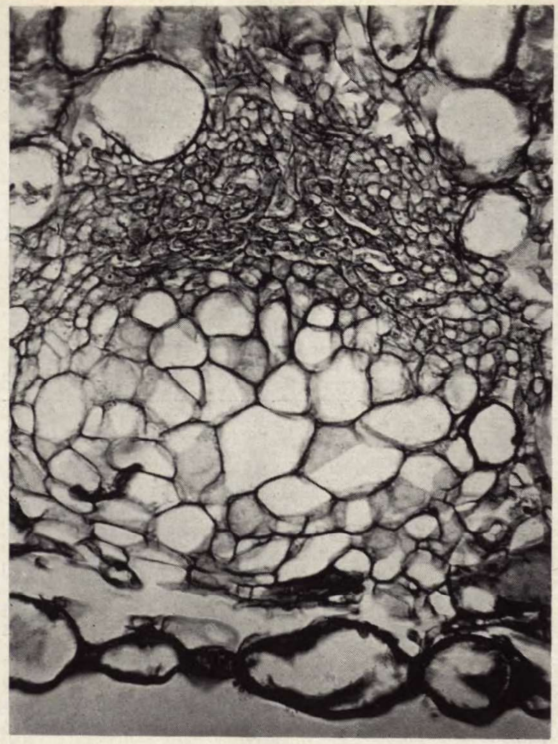

FIG. 10.—Transverse section through a young aecial cup 17 days after the inoculation of the barberry leaf and 57 hours after the addition of nectar from other pustules. Binucleate cells are appearing near the centre of the mycelial weft. x 450. (Photomicrograph by Dr. A. Savage)

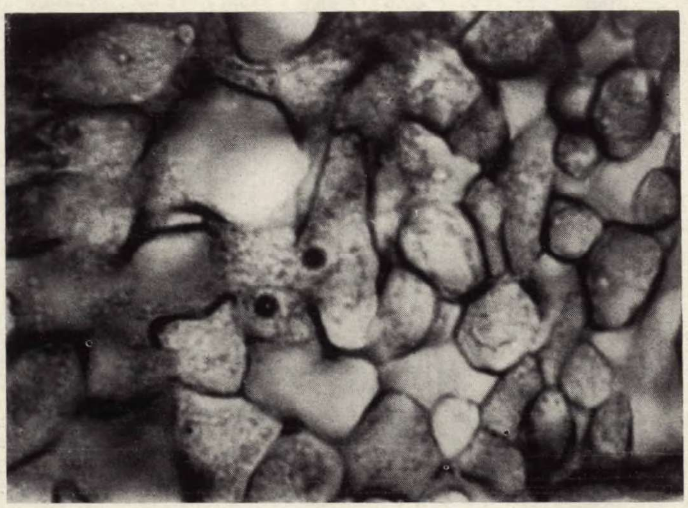

FIG. 11.—Fusion of two uninucleate cells near the base of a young aecium. x 2000. (Photomicrograph by W. F. Hanna)

ined, although in one preparation it was found that the spores of some other fungus had germinated in the pycnial nectar. However, when a mixture of (+) and (—) pycniospores, which had been added to a pustule, were withdrawn after a period of about 24 hours, and examined under the microscope, it was found that a few of them had elongated to two or three times their normal length. One pycniospore treated in this way was found to have a germ tube 15μ in length.

FIG. 12.—Transverse section through the base of a young aecial cup 57 hours after the addition of nectar from other pustules. The large cell with six nuclei appears to have developed from two fused cells. x 1300. (Photomicrograph by W. F. Hanna)

In view of the foregoing observations, it was suggested that the diploid phase in the life cycle of *P. graminis* is initiated in the following manner: The pycniospores are haploid and, when applied to pycnia of opposite sex, they germinate and give rise to haploid hyphae which grow down through the pycnia to the aecial rudiments below and there fuse with hyphae of opposite sex. Although binucleate cells make their appearance in the young aecium a relatively short time after the pycniospores of opposite sex have been applied, it must not necessarily be assumed that the hyphae from the pycniospores have a rapid rate of growth. If a pycniospore hypha were to elongate at the rate of about 60μ per day, the distance from a pycnium to the aecial rudiment immediately below it could be traversed in 48 hours. This is a ·delatively slow growth-rate when compared with a growth of 4 mm. per day for the hyphae of *Coprinus lagopus*, or 30 mm. per day for those of *Rhizopus nigricans*.

The results of this investigation were summarized briefly in a letter to *Nature*, Vol. 124, p. 267, 1929.

The Reactions of Wheat Varieties in Two Stages of Maturity to Sixteen Physiologic Forms of *Puccinia graminis Tritici**

(C. H. Goulden, Margaret Newton, A. M. Brown)

Certain varieties of wheat possess a type of resistance to stem rust which is not exhibited in the seedling stage. This type is referred to as mature-plant resistance, and has been shown in previous studies with two crosses to be inherited independently of seedling resistance.

Fourteen varieties of wheat were tested, in the seedling stage and in the mature stage in the greenhouse, to sixteen physiologic forms of stem rust. It was possible to divide the varieties into three groups on the basis of these tests. (1) Varieties showing no evidence of mature plant resistance,—Garnet, Marquis, Quality, and Khapli. (2) Varieties showing varying degrees of mature plant resistance, from an indication to a very pronounced evidence,—Reward, Kota, Marquillo, Black Persian, Hope, H-44-24, Pentad, and Acme. (3) Varieties showing no appreciable difference between the seedling and mature plant reactions, but suspected of possessing the mature plant type of resistance in a fairly high degree,—Vernal Emmer, and Iumillo. These varieties are highly resistant in the seedling stage to most physiologic forms, and differentiation of the reactions in the two stages is consequently very difficult or impossible.

The reactions obtained in the mature plant stage with respect to size of pustules and percentage of infection agree with any theory accounting for mature plant resistance on the basis of the plants possessing a mechanism, which prevents the entrance of the rust organism.

Relation between Stem Rust Infection and the Yield of Wheat*

(C. H. Goulden and F. J. Greaney)

Two experiments were conducted in which varying amounts of stem rust were obtained on plots of Marquis wheat by different treatments of sulphur dust. Rust percentages and yields of individual plots were then correlated.

The first experiment consisted of 196 one four-hundredth-acre plots arranged in a 14 x 14 Latin Square. The average percentage of rust was not very high, but a correlation coefficient of —·4143 was obtained between rust percentages and yield. The odds of significance of this correlation are considerably greater than 100 to 1. By means of the regression equation, it was shown that each 10 per cent increase of rust brought about a reduction in yield of 1·97 bushels per acre, or 6·8 per cent of the yield of the best yielding series.

In the second experiment there were 113 one two-hundredth-acre plots in which the average percentage of rust was somewhat higher than in the first experiment. A correlation of —·6085 was obtained for yield and percentage of rust. Each 10 per cent increase of rust reduced the yield by 3·83 bushels which is 9·7 per cent of the yield of the highest yielding series.

In both cases regression was linear showing that the decrease in yield for a given increase in the rust percentage is the same throughout the entire range of infection.

Physiologic Forms of Oat Stem Rust

(W. L. Gordon)

The work dealing with the identification of the physiologic forms, in the collections made during the summer of 1928, was carried on in the usual manner. Oat stem rust appeared later in the season than in 1927, and did very little damage to the crop.

* Co-operative study between the Cereal and Botany Divisions.

Two hundred and six collections of oat stem rust were cultured in the greenhouse during 1928. The majority of the collections were made in Manitoba and Saskatchewan. The number of collections obtained from each province is shown in table 13, and the distribution by provinces of the physiologic forms in table 14.

TABLE 13.—NUMBER OF COLLECTIONS OF *P. graminis Pers. var Avenae* ERIKSS. & HENN. MADE IN EACH PROVINCE IN 1928

Province	Number of cultures
British Columbia	2
Alberta	15
Saskatchewan	70
Manitoba	86
Ontario	16
Quebec	5
New Brunswick	3
Nova Scotia	7
Prince Edward Island	2

TABLE 14.—DISTRIBUTION BY PROVINCES OF PHYSIOLOGIC FORMS OF *P. graminis Avenae* IN 1928

Form	Provinces									Total isolations
	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	
1	......	2	12	18	1	3	1	3	1	41
2	2	10	34	56	11	3	1	2	1	120
3	......	......	......	1	......	......	......	......	......	1
4	......	......	......	1	......	......	......	......	......	1
5	1	9	39	37	9	2	2	5	1	105
6	......	......	......	2	......	......	......	......	......	2
7	......	......	......	2	3	......	......	......	......	5

As usual, forms 2 and 5 were far the most frequently isolated, but form 2 predominated. Form 1 was much more common than usual (table 15).

TABLE 15.—COMPARISON OF 1928 ISOLATIONS WITH THOSE OF 1925–1927

Form	1928 isolations	1925–27 isolations
	%	%
1	14·90	2·18
2	43·63	38·22
3	0·36	0·14
4	0·36	1·45
5	38·18	57·55
6	0·72	0·43
7	1·81	....

Form 3 appeared again this year, but was not found in 1926 and 1927. Forms 4 and 6 were rarely isolated (table 16).

Crown Rust of Oats in Canada

(B. Peturson)

Two phases of this problem were investigated in a preliminary way during the past year, namely, (*a*) prevalence and distribution of physiologic forms, and (*b*) testing of oat varieties for resistance under field conditions.

Collections of crown rust of oats (*Puccinia coronata* Corda) were secured in 1928 from widely separated localities in Canada. The forms represented by these collections were identified, as well as those in a few collections made late in 1927. There were, in all, thirty-seven collections, and from them were isolated eight distinct physiologic forms, five of which had not previously been identified. The number of times each form was isolated is given in table 19.

TABLE 19.—NUMBER OF ISOLATIONS OF EACH PHYSIOLOGIC FORM OF *Puccinia coronata* in 1928

Form	Number of isolations	Form	Number of isolations
1	10	7	....
2	0	8	1
3	0	9	1
4	8	10	1
5	0	11	6
6	1	12	9

Determination of many more collections of crown rust must be made before anything very definite can be said regarding the prevalence of the various physiologic forms. The collections determined to date, however, indicate that some of the forms are of common occurrence, while others are apparently quite rare. Table 19 indicates that forms 1, 4, 11, and 12 are fairly common. Of all the forms identified to date forms 1 and 4 are the most virulent. No variety tested thus far in the seedling stage was resistant to form 1, and only one variety, Ruakura, to form 4. The other forms have a more limited range of hosts. The more virulent forms appear to be most prevalent, forms 1 and 4 comprising 50 per cent of all the collections.

As regards distribution, it is clear that at least some of the forms are by no means localized. Each of the four most prevalent forms has been collected in three provinces. The distribution of the forms identified is given in table 20.

TABLE 20.—DISTRIBUTION BY PROVINCES OF COLLECTIONS OF PHYSIOLOGIC FORMS OF *Puccinia coronata* in 1928

Province	Physiologic forms											
	1	2	3	4	5	6	7	8	9	10	11	12
Prince Edward Island	1	....	....	....	....	....	....	....	....	....	....	....
Nova Scotia	....	....	....	....	....	....	....	....	....	....	....	....
New Brunswick	....	....	....	....	....	....	....	....	....	....	....	....
Quebec	....	....	....	....	....	....	....	....	....	....	....	....
Ontario	....	....	....	1	....	1	....	....	....	1	....	3
Manitoba	6	....	....	6	....	....	....	1	1	....	3	5
Saskatchewan	3	....	....	....	....	....	....	....	....	....	2	1
Alberta	....	....	....	1	....	....	....	....	....	....	1	....
British Columbia	....	....	....	....	....	....	....	....	....	....	....	....
Total number of isolations	10	....	....	8	....	1	....	1	1	1	6	9

Testing for varietal resistance to crown rust was begun in 1927, and continued in 1928. An artificially induced epidemic was initiated in the plots by the introduction of cultures of crown rust, when the plants were from 6 to 8 inches high. Forms 1 and 8 were employed as inoculum the first year and forms 1, 4, and 8 the second year. The same varieties, 220 in all, were used each year. Of these, 214 proved very susceptible in both years, the average severity of infection for 1927 and 1928 being 45 per cent and 60 per cent respectively. The percentages of infection of one representative, susceptible variety and of all the varieties which showed resistance in either year are given in table 21.

TABLE 21.—PERCENTAGE SEVERITY OF INFECTION OF ONE SUSCEPTIBLE VARIETY AND OF ALL RESISTANT VARIETIES TESTED IN 1927 AND 1928

Variety	Severity of infection	
	1927	1928
	%	%
Sparrow Bill	45	60
Avena brevis	40	15
Avena sterilis nigra	10	70
Green Mountain C.I. 1892	30	5
Green Russian (Iowa 96)	40	5
Ruakura Rust Proof C.I. 2025	10	40
Noir de Picardie	15	5

Among the resistant varieties, only one, Noir de Picardie, was resistant both years. The other resistant varieties were resistant the first year and susceptible the next, or *vice versa.* Although more forms were used to initiate the epidemic in 1928, a greater number of varieties proved resistant that year. This, however, is what one would expect when all the factors are considered. In 1927 a heavy natural epidemic of crown rust developed in Manitoba, while in 1928 crown rust was relatively scarce. It seems, therefore, very probable that in 1928 only those forms which were transferred from the greenhouse were present in the plots; whereas, in 1927, several additional forms were very probably present. This circumstance would account for the more general susceptibility of the varieties in this year.

So far, under greenhouse conditions, no variety of oats in the seedling stage has proved resistant to form 1. As this is the most common and widely distributed of all the known forms, the outlook for the production of varieties resistant to crown rust is not very promising. Until some variety possessing resistance to this form is discovered, breeding for resistance to crown rust offers little assurance of success. In order to explore further possibilities, varieties are being tested in the greenhouse and in the field in an endeavour to discover varieties, that are resistant to this and the other more virulent forms.

It should be pointed out, however, that as the inoculum was introduced into the plots when the plants were little beyond the seedling stage, a considerable amount of infection occurred while the plants were still quite immature, and, consequently, the mature plant type of resistance, which is so marked in certain wheat varieties, had small opportunity of being recognized. A comprehensive series of tests is now in progress to discover to what extent, if any, oat varieties possess this type of resistance.

Physiologic Specialization in the Dwarf Leaf Rust of Barley, *Puccinia anomala* Rostr.

(A. M. BROWN)

In 1927, by the use of the varieties Gold and Odessa as differential hosts, two physiologic forms of *Puccinia anomala* were isolated. The variety Gold is resistant to form 1, but it is susceptible to form 2, Odessa being susceptible to both forms.

TABLE 16.—THE PLACE AND DATE OF COLLECTION, WITH HOSTS UPON WHICH FOUND, OF NEW AND RARE PHYSIOLOGIC FORMS ISOLATED DURING 1928

Rust survey number	Place of collection	Date collected	Physiologic form	Host
69	Ste. Agathe, Man.	10-8-28	4	Avena sativa
108	Guelph, Ont.	17-8-28	7	Banner 44
109	Guelph, Ont.	17-8-28	7	Iowar
111	Guelph, Ont.	17-8-28	7	O.A.C. 144
158	St. Laurent, Man.	29-8-28	6	A. sativa
160	Inwood, Man.	29-8-28	6	A. sativa
162	Poplarfield, Man.	31-8-28	7	A. sativa
185	Winnipeg, Man.	7-9-28	3	Richland
205	Winnipeg, Man.	5-9-28	7	Heigira x Monarch strain

Form 7 was isolated for the first time in Canada in 1928. This form was reported first from Australia. The reaction of the differential hosts to it is shown in table 14. It was present in collections from Ontario and Manitoba (table 16). The presence of this physiologic form should not interfere with the present work of breeding for rust resistance, as Heigira strain is resistant also to this form.

TABLE 17.—REACTION OF DIFFERENTIAL HOSTS TO PHYSIOLOGIC FORMS OF *Puccinia graminis Avenae*

Form	White Russian	Richland, Heigira strain, Monarch strain	Joanette strain, Strain 703	Victory
1	3	2	1	4
2	3	2	4	4
3	4	2	1	4
4	4	4	1	4
5	3	2	x	4
6	4	4	4	4
7	4	2	4	4

Since 1925, four physiologic forms of oat stem rust have been found in Canada, which were not known previously to occur here. All are more virulent than forms 1, 2, and 5, but are apparently quite rare. It cannot, of course, be foretold, whether or not any of these forms will become common and widespread in the future.

Yellow Stripe Rust

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

The work on stripe rust, *Puccinia glumarum* (Schm.) Erikss. & Henn. for the past year, has been limited to laboratory and greenhouse experiments on certain phases of the stripe rust problem. Effort was concentrated mainly on determining the reactions of a large number of wheat varieties to this rust. The question of the relation of spore germination to temperature was also given some attention.

As stated in previous reports, the distribution of stripe rust has been restricted almost exclusively to the provinces of Alberta and British Columbia. It is but rarely found extending as far east as the western boundary of Saskatchewan. The spread of this parasite to the east is evidently not limited by a lack of available hosts, for these are abundant in Manitoba and Saskatchewan as well as in Alberta. It seems likely, therefore, that climatic conditions, in some way or other, determine its eastward distribution.

It was thought desirable, in this connection, to investigate the conditions that favoured or inhibited spore germination, especially with respect to temperature. Hence a study was made of the germination of urediniospores at different temperatures, with the object of determining the minimum, maximum, and optimum temperatures for germination. The following percentages of germination were the means for a large number of trials—

Temperature. . . .	2-3° C	5° C	7-10° C	15-17° C	20-22° C
Per cent germination.	11·70	45·75	59·25	38·69	trace

From these results it appears that the optimum temperature for germination is about 10° C., the minimum being just above the freezing point of water, and the maximum about 20° C. These temperatures are considerably lower than the corresponding temperatures for the germination of the other cereal rusts.

Since this work was done, the epidemiology of stripe rust has been taken over by the Dominion Laboratory at Edmonton, and hence the work on this phase of the problem has been discontinued.

Another phase of the stripe rust problem, which has been investigated during the past year, is the resistance of a considerable number of wheat varieties to this rust. Forty-three varieties were tested, in the seedling stage, to a culture of the rust obtained from Dr. Sanford in the fall of 1928. These were classified according to their reactions as susceptible, semi-resistant, and resistant. It seems fortunate that the majority of these varieties, including many of those commonly grown by farmers, are either entirely resistant or semi-resistant, as is shown in table 18.

TABLE 18.—REACTIONS OF WHEAT VARIETIES IN THE SEEDLING STAGE TO YELLOW STRIPE RUST

Susceptible	Semi-resistant	Resistant
Chul	Little Club	Kota
Kanred	Marquis	Haynes Bluestem
		Huron
Mindum	Parkers	Power
Acme	Quality	Garnet
Reward	Supreme	Marquillo
Prelude	Ruby	Axminster
	Renfrew	Arnautka
	Ceres	Speltz Marz
	M.D. 1656	Iumillo
	Webster	Pelissier
	Alberta 222	D.C. 825–2
	Ottawa 682 B	Black Persian
	Hope	Vernal
	H-44-24	Khapli
	H 99 (H-44-24 x Marquis)	
	H 148 (H-44-24 x Marquis)	
	H 208 („ x „)	
	Sevier x Dicklow	
	Kubanka	
	Monad	
	Pentad	
	Einkorn	

In addition to testing these seedlings, a few varieties were tested for their rust reaction in a more advanced stage of growth. The trials were made when the plants were heading out, or subsequently. This work was undertaken mainly in order to ascertain whether the reactions of the seedlings were a reliable index to the rust reactions of the mature plants. Two varieties, Reward and H-44-24, have given fairly conclusive results. Reward, which is susceptible in the seeding stage, is also susceptible in the more advanced stage. H-44-24, which is classed as semi-resistant in the seedling stage, shows a high resistance in the mature stage.

This rust was not so plentiful in 1928 as it was the previous year, only three collections being made. One of these came from Victoria, B.C. This collection, when cultured on the differential hosts used the previous year, was different from the two forms already isolated. The variety Moroccan, as shown in table 23, was resistant to this form, but susceptible to forms 1 and 2, thus indicating the presence of a third form. Two collections were made in Manitoba, one at Lundar, and the other at Holland, which proved to be forms 1 and 2 (Table 24). No collections were made in Saskatchewan in 1928.

An analytical key to the physiologic forms of *Puccinia anomala,* which serves to identify the individual forms by the reaction of two differential hosts, is given in table 22. Form 3 produces a very weak infection on the variety Moroccan, while forms 1 and 2 infect it heavily. These latter forms, 1 and 2, are differentiated from one another by their reactions on the variety Gold. Form 1 infects Gold very weakly, while to form 2 it is moderately susceptible.

Types of Infection

0 Plants are immune, no uredinia are developed, but hypersensitive flecks occur.

1 Plants are very resistant. Uredinia are very small, and surrounded by sharp, hypersensitive, necrotic areas.

2 Plants are moderately susceptible. The uredinia are small to medium in size; hypersensitive areas are present in the form of necrotic halos, surrounding green island, in the centre of which the uredinia are usually located.

3 Plants are susceptible. The uredinia are of medium size, sometimes coalescing. Necrosis and hypersensitiveness are absent, but chloritic areas may surround the uredinia.

Degrees of Infection

(—) Uredinia are few and rust development poor,
(+) Infection above the normal of its type.

Studies in Spore Germination

Studies in spore germination were reported last year, and indicated the optimum temperature for spore germination as being from 11° C to 17° C. Studies were continued this year, each physiologic form being studied separately. The germination tests were made in hanging drops of distilled water. The optimum temperature for all three forms was identical. It will be seen from table 25 that the optimum temperature lies between 11° C and 17° C, which is somewhat lower than that of *Puccinia graminis.*

Table 22.—Analytical Key for Identification of Physiologic Forms of *Puccinia anomala*

Infection homogeneous on all differential hosts.
Moroccan susceptible
Gold resistant...Form 1
Gold moderately resistant...Form 2
Moroccan resistant...Form 3

Table 23.—Reaction of Differential Hosts of *Hordeum* spp. to Physiologic Forms of *Puccinia anomala*

Physiologic forms	Gold		Moroccan		Odessa	
	Range	Mean	Range	Mean	Range	Mean
1..............................	1— to 2+	1+	3 to 3+	3	3 to 3+	3
2..............................	3— to 3	3—	3 to 3+	3	3 to 3+	3
3..............................	3 to 3+	3	1— to 2+	1+	3 to 3+	3

TABLE 24.—DISTRIBUTION OF PHYSIOLOGIC FORMS OF *Puccinia anomala* IN WESTERN CANADA, WITH A RECORD OF THEIR INFECTION CAPABILITIES

Form	Place of collection of rust	Date	Host on which collected	Character of infection on differential hosts		
				Gold	Moroccan	Odessa
1	Winnipeg, Man.	7-10-27	Hordeum spp.	1+	3	3
	Lundar, Man.	20- 8-28	"	....	....	....
2	Birds Hill, Man.	24- 7-27	Hordeum spp.	3−	3	3
	Morden, Man.	18- 8-27	"	....	....	....
	Brandon, Man.	20- 8-27	"	....	....	....
	Indian Head, Sask.	1- 9-27	"	....	....	....
	Indian Head, Sask.	1- 9-27	"	....	....	....
	Holland, Man.	18- 8-28	"	....	....	....
3	Victoria, B.C.	26- 5-28	Hordeum spp.	3	1+	3

TABLE 25.—PERCENTAGE GERMINATION OF UREDINIOSPORES OF *Puccinia anomala* AT SEVEN DIFFERENT TEMPERATURES

Temperature	5° C.	11°C.	14° C.	15° C.	17° C.	20° C.	23° C.
Number of spores counted	910	482	835	655	807	518	309
Number of spores germinated	66	201	650	527	685	334	85
Percentage of germination	7·2	41·7	77·8	80·4	84·9	64·5	27·5

The Influence on Yield and Grade of Harvesting Rusted Marquis Wheat at Different Stages of Maturity

(F. J. Greaney)

In recent years considerable work has been done, in the United States and in Canada, to determine what influence the cutting of rusted wheat at different stages of maturity has on the yield and quality of the grain. In Western Canada, the studies of Fraser, Bracken, Ellis, and Harrington have indicated that, when rusted wheat is harvested before the normal time, there is a decided reduction in yield and grade. However, the belief is still more or less prevalent among growers that a badly rusted wheat crop may be harvested with the most satisfactory results, before it has reached full maturity. The importance of the question in its bearing on wheat production in western Canada seemed to justify a more thorough investigation.

Thus, in an effort to obtain more definite information concerning the problem, experiments were undertaken at the Dominion Rust Research Laboratory, Winnipeg, Manitoba. In 1927, a study was made of the results of harvesting Marquis wheat, heavily infected with stem and leaf rust, at different stages of maturity. With the same object in view, experiments were undertaken in 1928 and 1929. A summary of the results obtained in 1927, 1928, and 1929 is presented in this report.

The primary object of the investigation was to determine whether yields and grades were significantly influenced by cutting a badly rusted wheat crop before it was fully mature, and to discover if there were any indications, as popularly claimed, that food materials in the stem were translocated to the kernels when such wheat was cured under normal harvest conditions.

In 1927, 1928, and 1929, very satisfactory conditions were obtained in Manitoba for the purpose of the studies. A very severe natural epidemic of leaf and stem rust occurred in 1927. In 1928 and again in 1929, late-sown Marquis wheat was subjected to a severe infestation of stem rust, with the result that yields and grades of normally matured Marquis wheat were seriously reduced by rust.

In 1927, under conditions of a severe natural epidemic of leaf and of stem rust, Marquis wheat was harvested 18, 12, and 6 days before, and also at, maturity, in the districts of Morden, Thornhill, Graysville, and Winnipeg. At Winnipeg in 1928, a diseased crop was cut at the following stages: 12, 9, 6, and 3 days before, and again at, maturity. In 1929, under an artificially induced epidemic of stem rust, representative samples of wheat were cut at intervals of two days, beginning on August 7, and ending at maturity, August 21. In each year, the yield data were studied statistically. The yields obtained from the various cuttings were compared, and the significance of the yield differences were determined. Weight per bushel, 1,000-kernel weight, percentage of green and shrunken kernels, and grade, were determined for each date of cutting.

EXPERIMENTAL RESULTS

In 1927, 1928, and 1929, cutting rusted wheat before it was fully mature significantly reduced the yield. Grain quality, as indicated by weight per bushel and 1,000-kernal weight, was markedly improved when the plants were permitted to mature before harvesting; while the percentages of green and shrunken kernels were reduced. In 1927 and 1929 particularly, stem rust developed rapidly, and its destructiveness increased as the wheat approached maturity. Under these conditions, yield and quality of wheat harvested prematurely were significantly less than the yield and quality of the more heavily rusted wheat harvested at the normal time.

The results of harvesting Marquis wheat, at different stages of maturity at Winnipeg in 1927, 1928, and 1929, are summarized in table 26. From a study of the data of this table, it is apparent that, under severe rust epidemic conditions, the yield and quality of the grain improves as the crop becomes progressively more mature. The failure of rusted wheat, cut at very early stages of maturity, to approach that cut at later stages in respect to yield per acre, weight per bushel, and grade, indicates that little or no filling of the grain occurred after cutting.

Harvesting wheat early, to avoid hail, frost, and insect injury, is a justifiable practice, but, from the results of this investigation, it would seem that there is nothing to recommend the practice of cutting wheat early to avoid damage from rust. In 1929, a difference of two days between times of cutting caused a significant difference in yield.

The opinion, that rusted wheat should be cut on the "green-side" to avoid maximum injury from rust, has not been supported by the results of these investigations. The results obtained in 1927, 1928, and 1929 distinctly show that, in order to secure the largest yield and best quality of grain, rusted wheat should be harvested when the majority of the kernels are in the hard dough condition.

TABLE 26.—SUMMARY OF THREE YEARS' RESULTS. THE EFFECT OF HARVESTING MARQUIS WHEAT, GROWN UNDER RUST EPIDEMIC CONDITIONS, AT DIFFERENT STAGES OF MATURITY, ON THE YIELD AND QUALITY, IN 1927, 1928 AND 1929, AT WINNIPEG, MANITOBA

	1927				1928				1929			
Days to maturity when harvested	Per cent stem rust severity	Weight per bushel	Yield per acre	Grade	Per cent stem rust severity	Weight per bushel	Yield per acre	Grade	Per cent stem rust severity	Weight per bushel	Yield per acre	Grade
	%	lb.	bush.		%	lb.	bush.		%	lb.	bush.	
12	75	43·1	12·6	Feed	20	57·0	22·3	4	50	56·0	23·4	4
10	....	....	....	....	....	....	....	....	50	56·2	21·0	4
9	....	....	....	....	25	59·7	23·7	3	....	....	....	....
8	....	....	....	....	....	....	....	....	55	56·5	21·3	4
6	75	49·3	12·6	Feed	40	59·9	23·8	3	60	57·0	24·3	3
4	....	....	....	....	....	....	....	....	65	57·7	25·1	3
3	....	....	....	....	55	60·2	27·0	2	....	....	....	....
2	....	....	....	....	....	....	....	....	70	58·0	24·1	2
Mature	85	54·1	13·2	6	55	60·4	28·5	2	70	59·0	26·2	2

Salt Applications for the Prevention of Stem Rust of Wheat

(F. J. Greaney)

In order to test the value of applying common salt (NaCl) in various quantities and at different times to the soil for the control of rust, use was made of small blocks of Marquis and Garnet wheat. In each block, 15 one four-hundredth acre plots were used, in which three treatments were arranged in the same order in five replicated series. Applications of salt were made by hand. The Marquis plots were treated on June 13 when the plants were about 4 inches tall, and the first applications to Garnet plots were made on July 1. The various treatments were as given in table 27.

TABLE 27.—METHODS OF TREATING PLOTS OF WHEAT WITH SALT IN ORDER TO DETERMINE ITS EFFECTIVENESS IN CONTROLLING RUST

Variety	Marquis			Garnet		
Treatment No.	1	2	3	1	2	3
Amount of salt per acre in pounds	500	1,000	0 Check	100	100	0 Check
Date applications were made	June 13	June 13	....	July 1	July 1 July 20	....

From a study of the data in table 28, it is evident that salt did not reduce the amount of stem rust, and that yield was not influenced by any of the treatments. It is questionable whether the early ripening effect is sufficiently important in reducing infection to recommend the use of salt applications for the control of rust.

TABLE 28.—RESULTS OF TREATING PLOTS OF MARQUIS AND GARNET WHEAT WITH SALT IN EXPERIMENTS TO DETERMINE ITS EFFECTIVENESS IN CONTROLLING STEM RUST AT WINNIPEG IN 1929

Variety	Treatment No.	Amount of salt per acre	Date of application	Mean results of 5 plots			
				Per cent of stem rust severity at harvest		Yield bushels per acre	Grade
				Range	Average		
		lb.		%	%	bush.	
Garnet	1	100	July 1	10-35	20	26·4	No. 2 Northern.
	2	100	July 1, 20	15-30	20	25·6	No. 2 Northern.
	3	Check		15-35	20	24·9	No. 2 Northern.
Marquis	1	500	June 13	25-65	50	22·8	No. 2 Northern.
	2	1,000	June 13	30-65	50	21·9	No. 2 Northern.
	3	Check		30-60	50	22·2	No. 2 Northern.

Sulphur Dusting for the Prevention of Cereal Rusts

(F. J. Greaney)

Experiments in the control of cereal rusts by sulphur dust have been carried on by the Dominion Rust Research Laboratory since 1925. In 1929 they were carried out on a more adequate scale than in previous years. In an effort to study some of the factors influencing the effectiveness of treatments, approximately 600 small plots of Marquis wheat were used at Winnipeg, Manitoba.

Extensive field dusting trials were made on farms at Graysville and Homewood; and, to devise an efficient dusting schedule for the control of wheat stem rust, co-operative experiments were carried on between the Dominion Experimental Farms at Brandon and Morden, and the Dominion Rust Research Laboratory. Thus, in Manitoba, five ground-dusting machines were used in large field tests.

Co-operative aeroplane experiments between the Department of Civil Air Operations and the Department of Agriculture were designed also, to study the practicability of using the aeroplane for dusting large acreages of wheat. At Macdonald, Man., an area comprising approximately 600 acres of summer-fallow Marquis wheat was selected for the aeroplane trials. Unfortunately, the aeroplane duster was seriously damaged after completing the first dusting flights, and the proposed 1929 experiments had to be abandoned.

A

WINNIPEG SMALL PLOT EXPERIMENTS

These experiments were designed to determine the effect of various rates and frequencies of dusting, the time to begin dusting, the most efficient brands of sulphur dust, the effectiveness of different methods of applications, intervals between dustings, and the fungicidal efficiency of oxidized sulphur dusts.

In previous studies, considerable difficulty had been experienced in determining the significance of small yield differences which were obtained when the various dust treatments were compared. In field plot experiments it is extremely important to reduce the error due to soil heterogeneity, and to study the yield data statistically. Small plot dusting experiments, conducted in 1925, 1926, 1927, and 1928, have emphasized the importance of using better experimental technique.

Thus, in 1929, the experiments were so arranged that the yield data from various dust treatments could be analyzed, and the significance of the yield results determined. In each experiment the plots of Marquis wheat were arranged at random in the form of a Latin Square, and the yield data were studied statistically. This plan of plot arrangement is ideal for dusting tests, and, where five to ten treatments are to be compared, there is no other plan to compare with it in precision. The methods and advantages of arranging plots in a Latin Square have been fully discussed by Fisher (Statistical Methods for Research Workers, 1925).

At Winnipeg, the experiments were carried out on a block of land sown to Marquis wheat on May 19, and later divided into one two-hundredth and one four-hundredth acre plots. The plots were rectangular in shape, four feet wide, and were particularly adapted for hand-dusting and harvesting operations. To prevent dust-drifting, buffer strips were left between the plots.

In order to insure a sufficient amount of stem rust in the experimental plots, an artificially induced epidemic of stem rust was secured by transplanting, at ten foot intervals, halfgrown wheat plants from the greenhouse which had been previously heavily infected with rust. Although the spread and development of the disease from the various infection centres was slow during the early part of July, pustules of stem rust could be found on every undusted plant in the field by July 20, and from that time the disease spread rapidly.

The wheat was sown on May 19; the plants headed on July 6, and blossomed on July 17. Dusting operations were commenced on July 9, when a light trace of stem rust was found. At this time, leaf rust was fairly common, most of the plants showing from 5 to 20 per cent. Owing to the excessive drought, however, the lower leaves of the plants shrivelled early and died, and the amount of leaf rust was difficult to estimate. It was not, however, a serious factor in 1929. Final rust data were obtained on August 17. The percentage of stem rust infection was determined by Mr. T. Johnson and Mr. B. Petourson. The range of rust infection on stem and leaves of Marquis wheat at Winnipeg, in 1929, are shown in figures 13 and 14. The effect of rust control on the size and plumpness of heads of Marquis wheat is shown in figure 15.

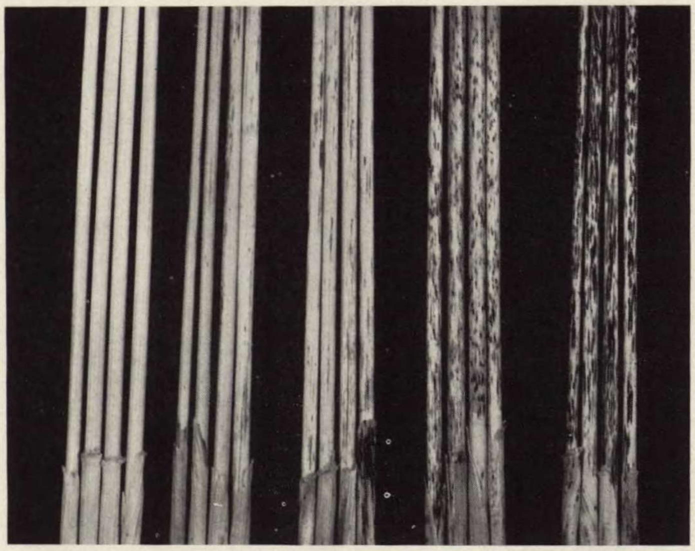

FIG. 13.—Stems of Marquis wheat grown at Winnipeg, 1929, showing the range of stem rust infection in the sulphur dusting plots. Left to right, clean trace, 20 per cent, 40 per cent, 80 per cent.

FIG. 14.—Leaves of Marquis wheat grown at Winnipeg, 1929, showing different amounts of leaf rust in the sulphur dusting plots. Left to right, trace, 20 per cent, 45 per cent.

FIG. 15.—Heads of Marquis wheat grown at Winnipeg, 1929. Right, heads of plants dusted bi-weekly at the rate of 30 pounds per acre. Left, heads of which were not dusted.

The wheat was harvested on August 21. Yield data were obtained by harvesting and threshing each plot separately. The weight per bushel and grade of each replicated series in each experiment were obtained by submitting random samples of the threshed grain to the Dominion Grain Inspection Laboratory at Winnipeg, Manitoba.

TABLE 29.—DIFFERENT METHODS OF TREATING PLOTS OF MARQUIS WHEAT WITH SULPHUR AT THE WEEKLY RATE OF 30-POUNDS PER APPLICATION PER ACRE FOR THE CONTROL OF RUST IN A 5 x 5 LATIN SQUARE, TO DETERMINE THE INFLUENCE OF THE TIME AT WHICH DUSTING IS COMMENCED ON THE CONTROL ACHIEVED

Treatment symbol	Date dusting commenced	Severity of stem rust when dusting commenced	Total number of dustings
		%	
A	July 10	trace	6
B	July 17	tr.- 5	5
C	July 23	10 - 20	4
D	July 31	25 - 40	3
E	non-dusted	....	0

TABLE 30.—ANALYSIS OF THE YIELD OF PLOTS IN A LATIN SQUARE SHOWING THE METHOD BY WHICH THE STANDARD DEVIATION WAS CALCULATED IN AN EXPERIMENT TO DETERMINE THE INFLUENCE OF THE TIME AT WHICH DUSTING IS COMMENCED ON STEM RUST CONTROL AT WINNIPEG, IN 1929

—	—					Sums of rows
	A 27·5	B 29·7	C 20·9	D 21·5	E 23·1	122·7
	D 20·6	E 20·2	B 27·5	C 29·2	A 28·9	126·4
	A 24·3	C 17·3	E 22·5	A 20·9	D 17·6	102·6
	C 27·5	D 19·8	A 35·8	E 17·3	B 30·5	130·9
	E 17·7	A 27·2	D 23·9	B 30·4	C 28·5	127·7
Sums of columns............	117·6	114·2	130·6	119·3	128·6	610·3

General Mean 610·3 ÷ 25 = 24·4

Variance due to	Degrees of freedom	Sums of squares	Variance	Standard deviation
Rows..	4	102·085	....	....
Columns..	4	41·326	....	....
Treatments..	4	329·259	....	....
Remainder..	12	159·284	13·2766	3·6437
Total....................................	24	631·954	....	....

Standard deviation of experiment.. = 3·6437
Probable error of experiment 3·6436 x 0·6745.................................. = 2·4576
Probable error in per cent of general mean

$$\frac{2{\cdot}4576 \times 100}{24{\cdot}4} = 10{\cdot}0721$$

Probable error in per cent of each treatment

$$\frac{10{\cdot}0721}{\sqrt{5}} = 4{\cdot}5045$$

TABLE 31.—RESULTS OF DUSTING MARQUIS WHEAT WITH SULPHUR. EFFECT OF THE TIME AT WHICH DUSTING IS COMMENCED ON THE AMOUNT OF STEM RUST INFECTION, ON THE YIELD, WEIGHT PER BUSHEL, AND GRADE

Treatment symbol	Date of dust application		Total number of dustings	Mean results of 5 plots in a Latin Square				
	July	August		Percentage of severity		Yield per acre	Weight per bushel	Grade
				Range	Average			
				%	%	bush.	lb.	
A...........	10, 17, 24, 31	6, 13	6	15–25	21	28·1±1·3	64·5	No. 2 Northern.
B...........	17, 24, 31	6, 13	5	20–40	29	28·5±1·3	60·0	No. 2 Northern.
C...........	24, 31	6, 13	4	25–45	37	24·7±1·1	63·0	No. 3 Northern.
D...........	31	6, 13	3	35–65	51	20·7±0·9	61·5	No. 3 Northern.
E...........	Check	Check	0	50–70	60	20·1±0·9	60·0	No. 3 Northern.

Experimental Results

In order to study the effectiveness of various rates and frequencies of dusting, 196 one four-hundredth acre plots of Marquis wheat were arranged in the form of a 14 x 14 Latin Square, in which thirteen different treatments were used, the fourteenth being the check which was left undusted.

The rates of application were 45, 30, and 15 pounds per acre, and the intervals between dustings, 14, 7, 4, and 2 days. Applications of 15 pounds at any one of these intervals were as effective as were those of 30 or 45 pounds at the same interval. The most satisfactory interval was seven days. A comparison of the yield results shows that dustings at this interval were just as effective as were those of 30 or 45 pounds at the same interval. The most satisfactory interval was seven days. A comparison of the yield results shows that dustings at this interval were just as effective as were those at the shorter intervals of 4 and 2 days. It would seem that, in a very dry season like 1929, weekly applications of sulphur dust at the rate of 15 pounds per acre are sufficient to control rust.

To determine how late dusting could be begun and yet be effective in controlling rust, an experiment was planned in which dusting was commenced at four different stages in the development of the stem rust epidemic. The date at which initial applications were made, the amount of stem rust present when dusting was commenced, and the total number of dustings given to plots of Marquis wheat arranged in a 5 by 5 Latin square are presented in table 29. The arrangement of plots, individual plot yield in bushels per acre, and the analysis of the yield data showing the method by which the standard deviation of the experiment was calculated are given in table 30. The effect of dusting on the percentage of rust at harvest, and on yield and grade, is given in table 31. A summary of comparisons between the mean yields of the various treatments is presented in table 32. The difference in yield between the treatments compared, divided by the probable error of that difference, was used to determine the mathematical significance of the results on a probable error basis. In this study three times the probable error of the differences is arbitrarily chosen as a significant yield result.

TABLE 32.—SUMMARY OF COMPARISONS BETWEEN THE MEAN YIELDS OF PLOTS OF MARQUIS WHEAT IN AN EXPERIMENT TO DETERMINE THE INFLUENCE OF TIME AT WHICH DUSTING IS COMMENCED ON THE CONTROL OF STEM RUST

Treatments compared	Yields in bushels per acre and probable errors compared	Difference in yield in bushels per acre	Diff. ÷ probable error
A – B	28·1 ± 1·3 – 28·5 ± 1·3	0·4	....
A – C	28·1 ± 1·3 – 24·7 ± 1·1	3·4	2·1
A – D	28·1 ± 1·3 – 20·7 ± 0·9	7·4	4·8
A – E	28·1 ± 1·3 – 20·1 ± 0·9	8·0	5·2
B – C	28·5 ± 1·3 – 24·7 ± 1·1	3·8	2·4
B – D	28·5 ± 1·3 – 20·7 ± 0·9	7·8	4·4
B – E	28·5 ± 1·3 – 20·1 ± 0·9	8·4	5·0
C – D	24·7 ± 1·1 – 20·7 ± 0·9	4·0	3·0
C – E	24·7 ± 1·1 – 20·1 ± 0·9	4·6	3·4
D – E	20·7 ± 0·9 – 20·1 ± 0·9	0·6	0·4

Under the conditions of the experiment, dusting as early as July 10 did not give better results than when dusting was started on July 17, but, when the dusting was delayed until July 24, considerable rust damage resulted, although the data in table 32 show that there was a significant yield difference above that of the check. When the wheat was not dusted until July 31, subsequent applications of sulphur failed to reduce effectively the amount of stem rust infection, and the resulting yield was not significantly better than the yield of the untreated check plots.

In experiments to determine the relative influence on rust control of applying Kolodust just before and immediately after rain, some very striking results were obtained. Although the standard treatment (six 30-pound per acre dustings) reduced the amount of stem rust infection from 72 to 41 per cent, and increased the yield 16·7 bushels per acre, equally favourable results were obtained by one of the treatments in which three dustings were made in relation to weather conditions. In this case, three 30-pound dust applications made, immediately following light rain showers on July 10, 20, and 31, gave effective stem rust control, and increased the yield 16·4 bushels per acre. When the mean yield of plots dusted just before and those dusted after rain were compared, it was found that the difference of 9 bushels per acre was a significant one. The odds in favour of the after-rain treatments were 415:1.

Weekly applications of Kolodust were made, in which the series of plots were dusted in the ordinary way, the dust being forcibly applied to the growing plants. Another series of plots were treated in such a way that the dust was allowed to drift and settle over the plants. From a study of the yield data it was apparent that both treatments gave effective rust control. The dusting method gave an increased yield over the check of 16·7 bushels per acre, as compared with 12·4 bushels for the drifting method. When the two methods were themselves compared, it was found that stem rust was more satisfactorily controlled by forcibly applying the dust to the wheat plants. In this instance the mean yield of the dusted plots was 39·3—1·59 bushels as compared with 35·2—1·43 for the drifting treatment. It is apparent from the results that the efficiency of the fungicide is reduced when the finely divided dust is allowed to drift across the standing crop.

In another experiment, Marquis wheat crops were used to study the comparative effectiveness of different brands of sulphur dusts. Six different dusts were tested on a block of wheat in which 49 one two-hundredth acre plots were arranged in a Latin square. The seventh treatment was the undusted check. Dusting was commenced on July 10, and continued at seven-day intervals until August 14. The dusts were applied at the rate of 30 pounds per application per acre.

The effects of dusting on the amount of stem rust at harvest time and on the yield are given in table 33. From a study of the data, it is evident that Kolodust, Koppers lime dust, Electric sulphur, Sulfodust, and Koppers dust gave exceptionally good rust control. The results show that yields were increased to a significant degree, and the grade improved from No. 4 to No. 1 Northern by treating with these dusts. In the field test, Gas Dust was not effective. Comparisons between the mean yields of the variously treated plots are arranged in table 34. Kolodust gave the most effective rust control. Five 30-pound weekly dustings with Kolodust reduced the amount of stem rust infection at harvest time from 71 to 39 per cent, and increased the yield 9·7 bushels per acre.

The purpose of another test was to test the effect upon rust of oxidized sulphur dusts. In this test one series of plots was dusted with Kolodust, another with Kolodust to which 2 per cent of finely ground potassium permanganate had been added, and a third series with 5 per cent permanganate in Kolodust. Another series of plots was treated with a preparatory oxidized sulphur dust. All of the dusts gave efficient rust control. However, when the effects of the various dusts were compared, it was found that none of the oxidized sulphur dusts were as effective as the Kolodust. The 1929 field results do not favour the use of oxidized sulphur dust for the control of rust.

TABLE 33.—RESULTS OF DUSTING MARQUIS WHEAT WITH SIX DIFFERENT BRANDS OF SULPHUR DUST, AT THE RATE OF 30 POUNDS PER ACRE, AT 7-DAY INTERVALS FROM JULY 10 TO AUGUST 14, IN LATE-SOWN PLOTS ARRANGED IN A 7 x 7 LATIN SQUARE, AT WINNIPEG, IN 1929

Treatment symbol	Kind of dust	Total number of dustings	Per cent stem rust severity		Weight per bushel	Grade	Yield per acre
			Range	Average			
			%	%	lb.		bush.
A	Kolodust	5	15–55	39·2	63·5	No. 1 Northern	34·4 ± 1·1
B	Koppers dust	5	45–65	55·7	62	No. 1 Northern	29·3 ± 0·9
C	Electric sulphur	5	30–65	51·7	62	No. 1 Northern	31·7 ± 1·0
D	Koppers 30% lime	5	35–65	55·7	62	No. 1 Northern	32·6 ± 1·0
E	Gas dust	5	40–75	65·0	60·5	No. 2 Northern	26·3 ± 0·8
F	Sulfodust	5	30–65	50·7	63	No. 1 Northern	31·8 ± 1·0
G	Check	non-dusted	50–80	70·7	56·5	No. 4 Northern	24·7 ± 0·8

TABLE 34.—SUMMARY OF COMPARISONS BETWEEN THE MEAN YIELDS OF MARQUIS WHEAT PLOTS, TREATED WITH DIFFERENT BRANDS OF SULPHUR DUST FOR THE CONTROL OF RUST AT WINNIPEG, IN 1929

Treatments compared	Yields in bushels per acre and probable errors compared	Yield difference in bushels	Diff. ÷ probable error
Kolodust—Check	34·4 ± 1·1 — 24·7 ± 0·8	9·7	7·5
Koppers Lime—Check	32·6 ± 1·0 — 24·7 ± 0·8	7·9	6·2
Sulfodust—Check	31·8 ± 1·0 — 24·7 ± 0·8	7·1	5·7
Electric—Check	31·7 ± 1·0 — 24·7 ± 0·8	7·0	5·6
Koppers—Check	29·3 ± 0·9 — 24·7 ± 0·8	4·6	3·9
Gas Dust—Check	26·3 ± 0·8 — 24·7 ± 0·8	1·6	1·4
Kolodust—Koppers	34·4 ± 1·1 — 29·3 ± 0·9	5·1	3·7
Kolodust—Electric	34·4 ± 1·1 — 31·7 ± 1·0	2·7	1·9
Kolodust—Koppers Lime	34·4 ± 1·1 — 32·6 ± 1·0	1·8	1·2
Kolodust—Gas Dust	34·4 ± 1·1 — 26·3 ± 0·8	8·1	6·1
Kolodust—Sulfodust	34·4 ± 1·1 — 31·8 ± 1·0	2·6	1·8
Koppers Lime—Koppers	32·6 ± 1·0 — 29·3 ± 0·9	3·3	2·4
Koppers Lime—Electric	32·6 ± 1·0 — 31·7 ± 1·0	0·9	0·6
Koppers Lime—Sulfodust	32·6 ± 1·0 — 31·8 ± 1·0	0·8	0·5
Koppers Lime—Gas Dust	32·6 ± 1·0 — 26·3 ± 0·8	6·3	4·9
Sulfodust—Electric	31·8 ± 1·0 — 31·7 ± 1·0	0·1	0·1
Sulfodust—Koppers	31·8 ± 1·0 — 29·3 ± 0·9	2·5	1·1
Sulfodust—Gas Dust	31·8 ± 1·0 — 26·3 ± 0·8	5·5	4·4
Electric—Koppers	31·7 ± 1·0 — 29·3 ± 0·9	2·4	1·8
Electric—Gas Dust	31·7 ± 1·0 — 26·3 ± 0·8	5·4	4·3
Koppers—Gas Dust	29·3 ± 0·9 — 26·3 ± 0·8	3·0	2·5

Dusting with Sulphur for the Control of Leaf and Stem Rust of Oats

To test the value of sulphur dusting for the control of oat stem rust, *Puccinia graminis Avenae*, and the crown rust of oats, *Puccinia coronata*, an experiment was planned in which 100 one four-hundredth acre plots of Victory oats were arranged in a 10 by 10 Latin Square. Nine treatments were used to determine the least number of dustings and the most satisfactory rate of application for the most effective rust control, the tenth treatment being the undusted check.

Dusting was begun on July 15 and continued until August 10. Kolodust was applied by means of a hand-duster. The rates of application were 15, 30, and 45 pounds per acre, and the intervals between dustings, 2, 4, and 7 days.

Owing to the light rust infection conclusive results regarding the best rate and interval of application were not obtained. The data from two of the treated replicated series and from the untreated check plot are given in table 35. Rust was controlled perfectly by semi-weekly applications of Kolodust at the rate of 45 pounds per acre. The yield increase was 6·1 bushels per acre. The 30-pound applications at 7-day intervals gave just as effective control. Sulphur dust will apparently control rusts of oats just as well as of wheat.

B

FIELD DUSTING EXPERIMENTS

Experiments to determine the practical value of dusting large fields of wheat with sulphur for the control of rust were continued in 1929. In two extensive field-dusting trials, ground-dusting machines were used by Mr. A. Murray, Graysville, Man., and by Mr. F. Froebe, Homewood, Man. In addition, to devise an effective and practical field dusting schedule for the control of wheat stem rust, co-operative experiments were undertaken between the Dominion Experimental Farms at Morden and Brandon and the Dominion Rust Research Laboratory.

TABLE 35.—RESULTS OF DUSTING VICTORY OATS WITH SULPHUR AT WINNIPEG, MANITOBA, IN 1929

Amount of dust per application per acre	Date dusted		Percentage infection of stem rust		Average results of 10 plots	
	July	August	Leaf	Stem	Weight per bushel	Yield per acre
			%	%	lb.	bush.
30 pounds	15, 22, 29	5	trace	tr-5	37·5	64·6
45 pounds	15, 19, 22, 26, 29	2, 5, 9	"	trace	37·5	65·1
Check	non-dusted	....	5	15	37·0	59·0

Grateful acknowledgment is made to Mr. Murray and Mr. Froebe and to the Experimental Farm Superintendents at Morden and Brandon for their valuable and generous co-operation in carrying on the field experiments. Appreciation is also expressed to the Niagara Sprayer and Chemical Company of Middleport, N.Y., for the loan of four dusting machines, and to the Cockshutt Plow Co., of Winnipeg, Man., for the loan of the power-dusting machine of the Shunk Manufacturing Co., Bucyrus, Ohio.

Graysville and Homewood Field Trials

At Graysville the trial was carried out on the farm of Mr. Alex. Murray. Six acres of late-sown Marquis wheat were used, in which five acres were dusted five times at the rate of 30 pounds of Kolodust per application per acre, and one acre remained untreated as a check. The first dusting was made on July 12, at which time only about 65 per cent of the plants were headed out, and stem rust could only be found after a thorough search. On July 12, about 90 per cent of the plants were infected with a degree of leaf rust infection ranging from 10 to 20 per cent. After July 12, 30-pound applications of dust were made at weekly intervals until August 5.

By August 5, a moderately heavy infection of stem rust was present in the untreated portion of the field, and leaf rust was very abundant. Owing to the unusual drought experienced in the 1929 season the crop ripened early. The drought also served to check the development of a heavy stem rust epidemic. The wheat appeared sufficiently mature by August 5, so that further dust applications seemed unnecessary. Following this date, however, stem rust developed with remarkable rapidity on the undusted areas, so that at harvest time a heavy infection was found. Considerable rust developed also on the dusted portion. An additional application of dust would have afforded more protection to this area, and would undoubtedly have given better rust control.

The dust was applied by means of the Niagara tractor power-duster with an attached boom dust distributor (fig. 16). The machine proved extremely satisfactory in eliminating serious mechanical injury to the standing crop, and it effectively dusted a swath 25 feet wide.

At Homewood, a 45-acre field of summer-fallow Marquis wheat was used for the dusting trial. Early plant growth was uniform, and a very fine stand of wheat resulted. The field was one-half mile long and was divided into a 15-acre and a 30-acre section. On July 12 the 30-acre section was dusted with Sulfodust at the rate of 30 pounds per application per acre. Thereafter, dustings were made at 7-day intervals until August 10. Fifteen acres were left untreated as a check.

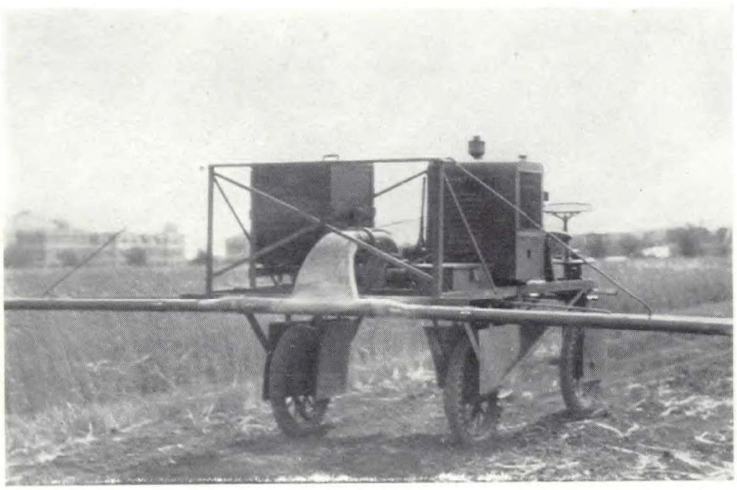

FIG. 16.—Niagara tractor power-duster with an attached boom dust distributor. This machine can effectively dust a swath 25 feet wide.

On July 12, only a trace of stem rust was present in the field, but leaf rust was fairly abundant. Stem rust did not become prevalent until about July 30; but, by August 5, a heavy infection of both stem and leaf rusts were found in the undusted crop. At harvest an average of 65 per cent of stem rust was present in the undusted portion of the field.

In the Homewood trial, the "Shunk" power duster was used (fig. 17). Dusting was done either in the early morning or late evening, when air conditions were most favourable for effective dust distribution. Under such conditions the machine seemed quite capable of dusting a swath 100 feet wide. With conditions favourable for dusting, at least 50 acres an hour could be treated with this machine.

Final rust data were taken on August 15 at Graysville, and at Homewood on August 18. Yield results were obtained by harvesting twenty rod-rows from the dusted and undusted portions of the Graysville field, and forty rod-rows were chosen at random from each section of the field at Homewood. The rod-rows were cut and threshed separately, and the average of the rod-row samples was used to calculate the yield of the treated and untreated sections of each field in bushels per acre. The threshed samples were graded by the Dominion Grain Inspector at Winnipeg, Man.

Results

The results of the Graysville and Homewood tests are summarized in table 36. An analysis of the cost of the treatment, in relation to the resulting increase in yield and grade, is presented in table 37.

At Graysville, four 30-pound dustings gave satisfactory rust control. In this field the average amount of stem rust infection was reduced from 75 per cent in the check to 25 per cent in the treated plot. Owing to the late development of the rust epidemic and to the early ripening of the grain, the yield difference is not very striking. Nevertheless, under the condition of the trial at Graysville, dusting increased the yield 3·5 bushels per care and improved the grade from 3 to 2 Northern. After deducting the cost of the treatment the net gain per acre due to dusting was $1.34.

FIG. 17.—Horse-drawn power dusting machine (Shunk duster) in operation. The dust is forcibly discharged through a wide delivery tube.

In the Homewood test, similar results were obtained. Rust was effectively controlled by six 30-pound applications of Sulfodust. At harvest time, the dusted grain was practically free of rust, while the average amount of stem rust infection in the undusted portion of the field was 65 per cent. Both the dusted and undusted portions ripened somewhat early, and thus rust was less severe than on late-maturing grain. In the dusted portion, there was a net gain of $1.72 per acre over the undusted portion.

The results of the Graysville and Homewood experiments indicate quite clearly that, even in a year when the damage from rust is not very appreciable, dusting with sulphur does enhance the value of the crop sufficiently to return a profit after all deductions for material and labour have been made. The experiments show also that large acreages can be successfully treated.

TABLE 36.—RESULTS OF SULPHUR DUSTING MARQUIS WHEAT FIELDS WITH POWER DUSTING MACHINES AT HOMEWOOD AND GRAYSVILLE, MANITOBA, IN 1929. KOLODUST WAS APPLIED AT THE RATE OF 30 LB. PER ACRE AT 7 DAY INTERVALS FROM JULY 12 TO AUGUST 9

Field	Treatment	Size of field	Dusting schedule: Dates dusted: July	Dusting schedule: Dates dusted: August	Severity of stem rust: Range	Severity of stem rust: Average	Yield results: Weight per measured bushel	Yield results: Canadian grade	Yield results: Yield per acre	Yield results: Gain per acre
		acres			%	%	lb.		bush.	bush.
Graysville...........	Dusted............	5	12, 19, 26	2	20–30	25	62·5	No. 2 Northern	15·7	3·5
	Non dusted........	1	....	....	65–85	75	60	No. 3 Northern	12·2	0
Homewood...........	Dusted............	30	12, 19, 26	2, 9	tr–10	5	62	No. 2 Northern	32·5	4·5
	Non dusted........	20	....	....	50–80	65	61	No. 2 Northern	28·0	0

TABLE 37.—COST OF DUSTING MARQUIS WHEAT FIELDS WITH SULPHUR FOR THE CONTROL OF RUST AT HOMEWOOD AND GRAYSVILLE, MAN., IN 1929. AN ANALYSIS OF THE COST OF TREATMENTS IN RELATION TO THE RESULTING INCREASE IN YIELD AND GRADE

Field	Treatment	Rate of dust per acre	Total number of dustings	Yield, per acre	Canadian grade	Value per bushel*	Cost and profit per acre: Total value of crop per acre	Cost of sulphur	Cost of application	Total cost of treatment*	Net value of crop	Increase in value of dusted field
		lb.		bush.		$ cts.	$ cts.	$ cts.	cts.	$ cts.	$ cts.	$ cts.
Graysville........	Dusted............	30	4	15·7	No. 2 Northern	1 43	22 46	3 66	40	4 04	18 42	1 34
	Non dusted........	0	0	12·2	No. 3 Northern	1 40	17 08	....	....	....	17 08	0 00
Homewood.......	Dusted............	30	5	32·5	No. 2 Northern	1 43	46 47	4 59	12	4 71	41 76	1 72
	Non dusted........	0	0	28·0	No. 2 Northern	1 43	40 04	....	....	....	40 04	0 00

* Winnipeg cash prices, Oct. 1, 1929.
† Depreciation of dusting machine is not included.

Co-operative Field Dusting Experiments

In co-operative experiments to devise a practical dusting schedule for the control of wheat stem rust, horse-drawn dusters were used at the Dominion Experimental Farms at Morden and Brandon, and on the College Farm, Winnipeg. At each station Marquis wheat was sown late in half-acre plots. To determine the effectiveness of different rates and frequencies of dusting, and to test the comparative value of two brands of sulphur dust, an experiment was planned in which four treated plots and one untreated one were used.

The experiment was arranged so that the yield data from the various treatments could be studied statistically, and the actual significance of the yield differences determined. The following treatments were run at Morden, Brandon, and Winnipeg. One plot was dusted with Kolodust at the rate of 20 pounds per application per acre, at intervals of 7 days, commencing July 12 and continuing until August 12. Another plot was dusted at the rate of 20 pounds per acre, but dustings were made twice each week. The third plot was treated with Kolodust at 7 day intervals at the rate of 40-pounds per application per acre. Another plot was dusted weekly with Electric sulphur at the rate of 40 pounds per acre. The fifth plot was left untreated as a check. In order to prevent the dust from drifting, buffer strips, six feet wide, were left between the plots. At Morden and Winnipeg, the experiment was run in duplicate, so that each treatment in the test was replicated five times.

Niagara "Aero" horse-drawn dusters were used at Morden and Brandon (fig. 18), and the Niagara modified orchard duster was operated at Winnipeg.

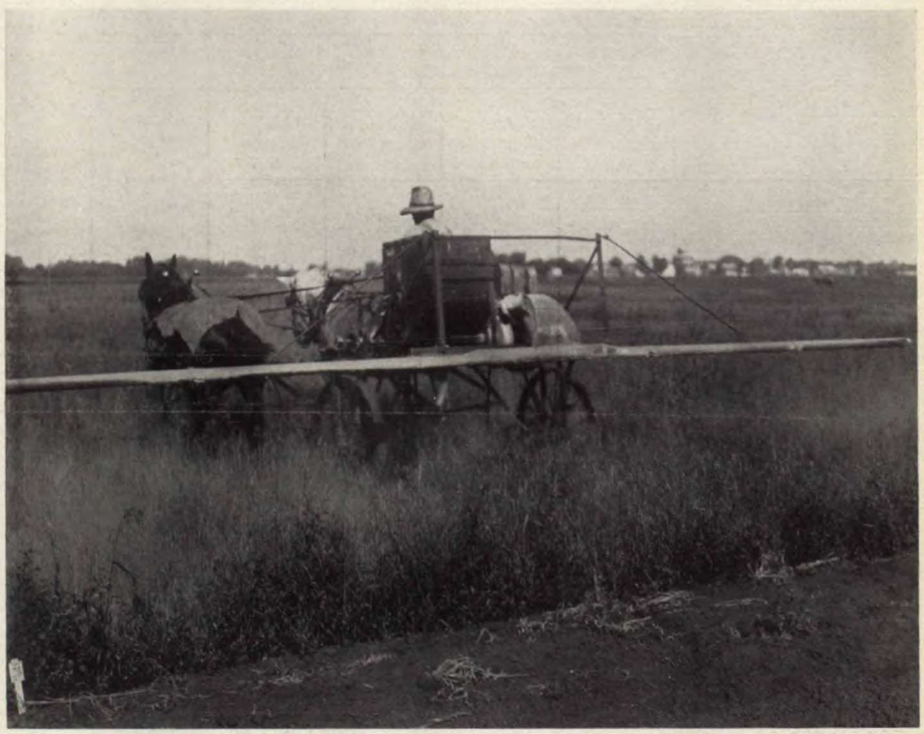

Fig. 18.—Horse-drawn power duster (Niagara Aero duster) with an attached boom distributor. This machine is capable of dusting a strip 30 feet wide.

The "Aero" dusters were equiped with booms which could effectively dust a swath 30 feet wide. Although some grain was tramped down, a surprisingly small amount of actual damage was caused to the standing crop.

Dusting operations were commenced at each farm on July 12, when only a light trace of stem rust could be found. At this time, however, leaf rust was very general, about 60 per cent of the plants being infected with a degree of rust ranging from a trace to 10 per cent. In Manitoba, stem rust development was slow during the critical period of plant growth, so that, before the epidemic reached serious proportions, the wheat was too far advanced to be seriously affected by the disease. At Brandon, however, conditions were more favourable for the development of stem rust, and a moderately severe epidemic occurred. The crop at Morden was very light, and rust did not develop to any extent. At Winnipeg, only a very light stem rust epidemic occurred, and under the unusually dry conditions the crop ripened early. The fields at Morden, Brandon, and Winnipeg were practically mature by August 18.

Final rust data were taken on August 19 and August 20. Yield data were obtained by harvesting and threshing separately rod-rows from each half-acre plot at each station. The average of ten rod-row samples was used to calculate the yield of each plot in bushels per acre. Weight per bushel and grade were determined from uniform lots of threshed grain from each treated and untreated plot.

TABLE 38.—ANALYSIS OF THE YIELDS OF MARQUIS WHEAT FROM ONE-HALF ACRE PLOTS AT MORDEN, BRANDON AND WINNIPEG, SHOWING THE METHOD BY WHICH THE PROBABLE ERROR OF THE EXPERIMENT WAS CALCULATED.

Replicate	Yields of plots in bushels per acre — Treatments—Kind and amount of dust per application per acre and frequency of dust applications					Means of replicates
	Kolodust 20 pounds weekly	Kolodust 20 pounds bi-weekly	Kolodust 40 pounds weekly	Electric sulphur 40 pounds weekly	Check undusted	
Morden A	11·0	11·2	10·5	11·7	10·4	10·96
Morden B	10·0	10·8	11·0	10·3	9·6	10·34
Brandon	36·0	40·0	41·0	38·0	33·4	37·78
Winnipeg A	28·0	32·6	27·8	26·9	25·5	28·16
Winnipeg B	32·8	36·8	38·2	38·7	28·9	35·08
Means of treatments	23·55	26·28	25·70	25·12	21·56	122·22

General mean = 122·22 ÷ 5 = 24·445

$$\frac{2}{T} = \frac{18604\cdot47}{25} - 597\cdot558 = 146\cdot6208$$

$$\frac{2}{R} = \frac{3002\cdot05}{5} - 697\cdot558 = 2\cdot052$$

$$\frac{2}{G} = \frac{3670\cdot4116}{5} - 597\cdot558 = 136\cdot5243$$

General probable error of experiment =

$$\cdot6745 \frac{5x5\ (146\cdot6208-2\cdot052-136\cdot5243)}{(4x4)} = 2\cdot3913$$

Probable error in per cent of general mean =

$$\frac{2\cdot3913 \times 100}{24\cdot445} = 9\cdot7823$$

Probable error in per cent of mean of 5 plots $= \frac{9\cdot7823}{\sqrt{5}} = 4\cdot3749$

As shown in table 38, the Variance Method of analysis was applied to the yield data in these tests. The method involves the calculation of a generalized probable error or standard deviation of all the treatments of the test. For experiments of this kind the Variance Method gives a high degree of accuracy. The formula given by Student (Biometrika, Vol. 15, pp. 271-293), for the generalized probable error is as follows:—

$$\text{P.E.} = \pm .6745 + MN \frac{(\overset{2}{T} - \overset{2}{R} - \overset{2}{G})}{(M-1)(M-1)}$$

$\frac{2}{T}$ = squared standard deviation or variance for the yields of all plots in the test.

$\frac{2}{R}$ = variance of the means of the treatments.

$\frac{2}{G}$ = variance of the means of the replicates.

M = number of treatments.

N = number of plots of each treatment.

These constants are obtained by calculating as follows:—

$\frac{2}{T} = \frac{S\,(T)^2}{MN} - X^2$ where T = yields of individual plots.
X = general mean of all plots.

$\frac{2}{R} = \frac{S\,(R)^2}{M} - X^2$ where R = mean yields of treatments.

$\frac{2}{G} = \frac{S\,(G)^2}{N} - X^2$ where G = mean yields of replicates.

It is important to realize that the object of the application of statistical methods to dusting experiments is essentially the determination of the significance of the difference between various treatments. In this test the various treatments were compared. The difference in yield between the treatments compared divided by the probable errorr of that difference was used to determine the significance of the results on a probable error basis.

Experimental Results

The effect of dusting on the amount of stem rust at harvest time, and on the yield at Morden, Brandon, and Winnipeg is given in table 39. A comparison of the amount of rust at harvest time in dusted and undusted plots indicates that rust was very light at Morden, moderately heavy at Winnipeg, and heavy at Brandon. There was not enough rust at Morden to determine clearly the effect of different dustings. The Winnipeg and Brandon results show that rust was satisfactorily controlled when frequent applications of Kolodust and Electric dust were made. The 40-pound weekly dustings of Electric Sulphur seemed to control rust as well as the same number of 40-pound dustings when Kolodust was used. Weekly applications of Kolodust at the 20-pound rate also controlled rust to a considerable degree. From a study of the data in table 32, it is apparent that the yield was not influenced to a significant degree. Bi-weekly applications of 20 pounds per acre gave a significant increase in yield over the check plots of 4·7 bushels per acre.

Bi-weekly 20-pound applications of Kolodust, therefore, gave the most effective control of stem rust. In this case, the odds that the yield difference of 4·7 bushels per acre is a significant one are 31·2 : 1. The differences in yields of 3·6 and 4·2 bushels per acre obtained by 40-pound weekly applications of Electric and Kolodust respectively, when considered in the light of their probable errors, were barely significant. Nevertheless, when dustings were made at seven-day intervals at the rate of 40 pounds per acre, the percentage of stem rust was markedly reduced. The results indicate the effectiveness of weekly applications.

In general, the 1929 season was not a satisfactory one for conclusive demonstrations of the control of rust by dusting. Nevertheless, much valuable information was obtained. Although it has been shown that stem and leaf rusts of wheat can be controlled by applying precipitated sulphur to the growing plants, is it still necessary to continue the search for cheaper and more effective dusts. The general technique of dusting grain crops to combat disease does not seem to be more difficult than that required for dusting fruit and vegetable crops. However, much has to be learned regarding the most economic and effective method of treating large grain fields.

Root-Rots and Foot-Rots of Cereals in Manitoba

(W. L. Gordon)

The root-rot and foot-rot survey, carried on in Manitoba during 1928, showed that these types of disease were more prevalent than was previously thought.* During the summer of 1929, an extensive survey was again carried on in order to gain as much information as possible concerning the prevalence and distribution of the several organisms, and the damage attributable to them. The survey was carried out in conjunction with the survey for stem rust by members of the Dominion Rust Research Laboratory.

Two hundred and thirty collections of plants, all apparently infected with root- and foot-rotting organisms, were made in 108 localities within the province. The distribution of these localities is shown in figure 19. The majority of the collections were obtained from fields of wheat and barley, but a few from fields of oats and rye.

Root-rots and foot-rots were not confined to any definite localities, but were widely distributed throughout the grain growing area of the province (fig. 19). Infected plants could be found, to a greater or less extent, in almost every field of wheat and barley examined. Very few of the fields of oats and rye showed any infection by root-rotting organisms.

The amount of infection in different fields varied from a mere trace to almost 100 per cent of the plants. Approximately 25 per cent of the fields of wheat and barley showed infection of 50 per cent of the plants, or more. Infected plants generally appeared to be more prevalent in the lighter soils, although they were by no means confined to them.

The foot-rot type of diseased condition was more evident than definite injury to the roots. The basal part of infected plants, between the crown and first node, showed distinct browning. These plants were not always limited to definite patches in the fields, but isolated plants also showed this discolouration. In a few fields, however, the roots of the plants were poorly developed and discoloured, but the basal part of the stems was normal. Occasionally, both the roots and the basal part of the stem were discoloured.

Isolations made on potato dextrose agar plates from the discoloured basal part of the stem and from the roots of apparently diseased plants yielded *Helminthosporium sativum* P.K. et B., and *Fusarium* spp. *Helminthosporium* was more frequently isolated this year from individual collections than *Fusarium,* although the latter was also commonly present.

"Take-all" (*Ophiobolus graminis* Sacc.) was not detected this year by a macroscopic examination of the plants in the field, although it was frequently found during 1928*. The severe drought during the summer may have seriously retarded its development. It does not seem possible that it could be entirely absent.

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* Gordon, W. L. Root rots and foot rots of cereals in Manitoba. Annual Report of the Dominion Botanist for the year 1928.

* Gordon, W. L. Ut Supra. Annual Report for the year 1928.

There is no doubt that, where there is heavy infection, root-rotting organisms are causing a decided reduction in the yield, particularly of wheat and barley. However, if the infection is only slight, the plants appear to be capable of maturing seed, with little, if any, reduction in the yield, especially if growth conditions are good.

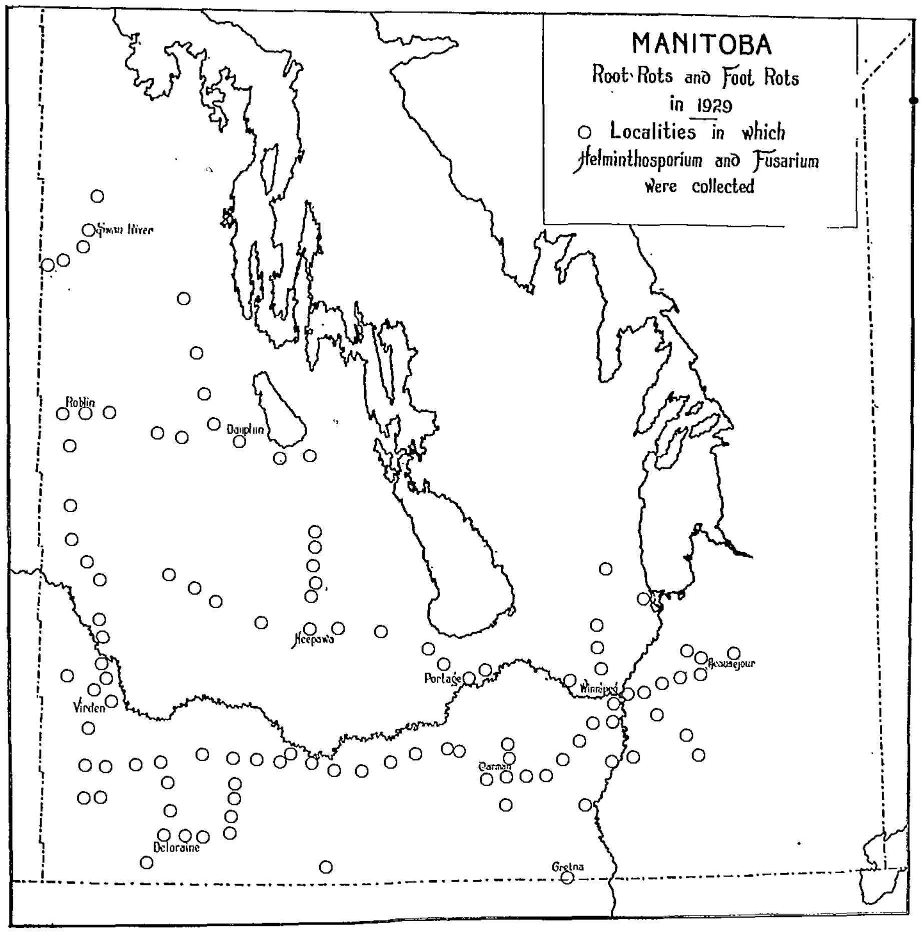


FIG. 19.—The small circles represent localities in which collections of root- and foot-rotting organisms were made in Manitoba.

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

(G. B. Sanford, Pathologist in Charge)

A STUDY OF THE PATHOGENICITY OF FUNGI ISOLATED FROM MATURE WHEAT PLANTS DAMAGED BY ROOT-ROT

(G. B. Sanford and W. C. Broadfoot)

The object of this experiment is to provide knowledge on which a plant breeding program may be based for obtaining resistance to the foot- and root-rotting fungi attacking wheat. The immediate aim is to determine the degree of pathogenicity of the root-rotting fungi on wheat found in a field-to-field study within a given area. The tests are first made in the greenhouse under controlled temperature, after which, tests are made in the field. The isolations made from the damaged wheat plants are taken to be fairly representative of the fungi associated with a diseased condition of the basal parts. At the same time it is recognized that certain fungi, such as *Ophiobolus graminis* Sacc. do not appear in ordinary culture.

The first field to be studied was located near Camrose, in the black soil area. In this field of Marquis there was an estimated foot-rot injury of about 25 per cent reduction in yield. This field was chosen because of the uniform distribution of affected plants. Many plants, obviously affected with take-all, as evidenced by the black foot and the plate mycelium, were scattered here and there throughout the field. The basal parts of the remaining plants were more or less brown with root-rot injury, and the grains of these plants showed various degrees of shrinkage. The plant material for study consisted of 80 representative samples taken from as many points equally distributed in the field.. For plating, the plants showing typical take-all were rejected.

The technique for culture consisted of disinfecting the surface of about one inch of the main haulm in a 1-1000 mercuric chloride solution. This portion, which always included the point of attachment to the secondary root system, was plated on three per cent potato dextrose media. The fungi thus obtained consisted mainly of *Helminthosporium sativum* Pamm. King. & Bakke and *Fusaria* (*culmorrum* type predominating). Seventy-five monosporous cultures, (11 of *H. sativum*, and 64 *Fusaria*) were chosen for pathogenicity tests. Each culture was increased on ground oat hull media to supply inoculum for pot culture.

The experiment is divided into two parts (*a*) pathogenicity test for the seedling stage (*b*) a pathogenicity test for the maturity stage. The temperature of the greenhouse is held at approximately 20° C. Elite Marquis seed, given the standard hot water treatment for loose smut, is used for the experiment. For the " seedling " test, 20 grains per pot are planted. For the " maturity " test only seven grains are planted. The soil, which is steam sterilized in six-inch pots, consists of three parts of black loam to one of sand. Ten grams of inoculum are placed in each pot at the seed level. Each culture is replicated five times for each experiment. Every tenth pot throughout the experiment is a check, to which is added a ten-gram portion of sterilized ground oat hulls. The plants in the seedling test are harvested after six weeks. Precise notes on the intensity of infection of crown, sub-crown and secondary roots are taken. From this examination an arbitrary infection rating, ranging from 0-10, is given. Zero indicates a clean undamaged plant and 10 a dead plant. The " maturity " test is harvested when the plants are mature, and the infection rating given.

Both " seedling " and " maturity " tests on the Camrose isolations have been carried out twice. Another, and final test will be made before proceeding to study the fungi from another field. Each test of the Camrose field has involved 800 pots—a total of 2,400 pots. Under greenhouse conditions it is not possible to carry out more than two tests in one year as the temperature conditions cannot be regulated during the late spring, summer and early fall months.

Space does not permit of a tabulated result of all the data so far obtained. Consequently, only the average infection of the five replicates of each culture for one test will be given. This will indicate the nature of the data. In table 40 are arranged the results for both " seedling " and " maturity " test.

TABLE 39.—RESULTS OF SULPHUR DUSTING LARGE PLOTS OF MARQUIS WHEAT BY MEANS OF HORSE-DRAWN DUSTING MACHINES AT MORDEN, WINNIPEG AND BRANDON, IN 1929

Treatment			Date dusted		Effect of treatments on stem rust infection, yield and grade								
					Morden†			Winnipeg†			Brandon†		
Kind of dust	Amount of dust per acre	Number of dustings	July	August	Stem rust at harvest	Yield per acre	Grade	Stem rust at harvest	Yield per acre	Grade	Stem rust at harvest	Yield per acre	Grade
	lb.				%	bush.		%	bush.		%	bush.	
Kolodust............	20	10	12, 15, 19, 22, 26, 29	2, 5, 8, 12	trace	11·0	No. 2 Northern	5	34·7	No. 1 Northern	5	40·0	No. 1 Northern
"	20	5	12, 19, 26	2, 8	10	10·5	No. 2 Northern	20	30·4	No. 1 Northern	30	36·0	No. 1 Northern
"	40	5	12, 19, 26	2, 8	trace	10·7	No. 2 Northern	18	33·0	No. 1 Northern	15	41·0	No. 1 Northern
Electric..............	40	5	12, 19, 26	2, 8	5	11·0	No. 2 Northern	10	32·8	No. 1 Northern	10	38·0	No. 1 Northern
Check................	0	0	Non-dusted	....	15	10·0	No. 2 Northern	55	27·2	No. 2 Northern	70	33·4	No. 2 Northern

† Average of 2 plots.

TABLE 40.—THE RELATIVE VIRULENCE OF SINGLE SPORE CULTURES OF *Fusarium (culmorum* type), AND OF *Helminthosporium sativum*, ISOLATED FROM A FIELD OF MARQUIS WHEAT NEAR CAMROSE, ALBERTA, IN 1928

Culture number[1]	Infection rating		Culture number	Infection rating		Culture number	Infection rating	
	Seedling stage	Mature stage		Seedling stage	Mature stage		Seedling stage	Mature stage
A-1	0·63	3·19	B-16	0·52	2·41	D-10	0·56	1·72
A-2	0·15	1·77	B-17	0·51	4·05	D-check	0·04	0·49
A-3	0·45	2·88	B-18	0·18	2·18	D-11	0·79	2·91
A-7	1·54	3·31	B-19	0·55	1·73	D-13	1·33	2·68
A-8	0·40	2·31	B-20	0·37	2·68	D-14	0·63	0·51
A-9	0·48	3·38	C-2	0·24	1·37	D-15	0·70	1·22
A-check	0·31	1·52	C-4	0·50	2·09	D-16	0·60	0·98
A-13	0·37	2·35	C-5	0·41	2·91	D-17	0·78	1·31
A-15	0·37	2·13	D-6	0·85	2·34	D-18	0·61	0·52
A-17	0·90	2·80	C-7	0·67	3·34	D-19	0·71	2·38
A-18	0·33	2·51	C-8	0·31	1·02	D-20	0·66	1·37
A-19	0·28	2·37	C-9	0·50	2·48	D-21	0·67	2·31
B-1	0·52	2·65	C-10	0·43	2·23	D-22	0·18	1·16
B-2	0·46	2·82	C-check	0·05	0·28	D-23	0·26	1·48
B-3	0·17	2·86	C-12	0·47	2·14	1-1	0·48	1·81
B-4	0·21	1·87	C-13	0·55	1·91	1-2	0·62	1·34
B-5	0·08	0·66	C-15	0·55	1·46	1-14	0·74	0·58
B-6	0·15	2·69	C-16	0·66	2·70	1-20	0·62	0·12
B-7	0·24	2·72	C-17	0·61	1·94	2-4	0·78	0·78
B-9	0·17	0·85	D-1	0·34	1·53	2-6	0·48	1·79
B-10	0·20	0·46	D-2	0·82	2·55	E-check	0·00	0·62
B-check	0·05	0·47	D-3	0·68	1·06	2-10	0·68	0·89
B-11	0·09	2·32	D-5	0·96	1·88	3-7	0·13	0·99
B-12	0·85	3·09	D-6	0·83	0·74	3-10	1·30	2·96
B-13	0·67	3·40	D-7	0·74	1·76	3-11	0·78	0·27
B-14	0·59	1·80	D-8	0·94	1·42	4-23	0·99	1·38
B-15	0·20	1·48	D-9	1·16	3·26	....	....	....

[1] The cultures with letters A, B, C and D, are *Fusaria*. Those with numbers 1, 2, 3 and 4, are *H. sativum*.

THE EFFECT OF CHEMICALS ON THE DEVELOPMENT OF THE FOOT- AND ROOT-ROTS OF WHEAT

(W. C. Broadfoot)

In view of the variability of the evidence in the literature concerning the effects of certain fertilizers on the development of the foot- and root-rots of wheat, a study of the subject under Alberta conditions was thought advisable. Accordingly, a uniform field experiment has been laid down at the Dominion Experimental Station at Lacombe, the Dominion Irrigation Station at Brooks, and the University of Alberta, Edmonton. The two latter points are in the black soil area, while Brooks is in the brown or plains soil area. After consulting Dr. F. A. Wyatt, Professor of Soils, University of Alberta, it was decided to use the following fertilizers at the rates indicated below.

1. P 250 pounds per acre of superphosphate.
2. K 200 pounds per acre of potassium sulphate.
3. N 200 pounds per acre of ammonium sulphate.
4. PK 250 pounds per acre of superphosphate + 200 pounds per acre of potassium sulphate.
5. PN 250 pounds per acre of superphosphate + 200 pounds per acre of ammonium sulphate.
6. KN 200 pounds per acre of potassium sulphate + 200 pounds per acre of ammonium sulphate.
7. PKN 250 pounds per acre of superphosphate + 200 pounds per acre of potassium sulphate + 200 pounds per acre of ammonium sulphate.
8. Ca 2,000 pounds per acre of lime (CaO).
9. Cu 250 pounds per acre of copper sulphate.

Each treatment was replicated four times. The chemicals were sown on prepared soil, and raked in. Finally, the seed, mixed with the inoculum, was sown in rows. *Ophiobolus graminis* was used to inoculate the plots this year.

At harvest, random samples of wheat plants were taken from each plot and examined. The degree of injury was estimated by examining the split "foot." The basal parts of plants from each sample were disinfected and cultured for the purpose of comparing the number, and kind, of fungi isolated from the various plot-treatments. The infection rating and the fungi so obtained from the plants from the Edmonton, Lacombe and Brooks plots are contained in table 41.

In examining the data there does not appear to be any marked differences in the degree of injury. Probably the lack of definite results can be attributed to the very dry conditions of the soil throughout the experiment. The severity of infection, however, appears to have been greatest on the Edmonton plots, where the rainfall was lightest. In the Edmonton plots the plants from the complete fertilizer plots (PK) had the lowest infection rating, and the tendency seems to have been in this direction at Lacombe and Brooks, although less marked.

A matter of interest, from the plating record in table 42, is the fact that the prevalence of *H. sativum* and *Fusaria* varied in their relative amount at the three stations. At Edmonton the former represented over 46 per cent of the total isolations, while the *Fusaria* made up the balance. In contrast to this *H. sativum* comprised only 8·2 per cent of the total isolations at Lacombe, while at Brooks it included about 41 per cent. Further study of this project over a term of years should yield interesting and practical information.

TABLE 41.—THE EFFECT OF VARIOUS CHEMICALS ON THE RELATIVE AMOUNT OF FOOT- AND ROOT-ROT INJURY TO WHEAT UNDER FIELD CONDITIONS. The PLOTS WERE INOCULATED WITH *Ophiobolus graminis*.

Station	Chemical treatment[1]	Infection rating on roots — Replicate A	B	C	D	Average
Edmonton	P	3·45	4·35	2·90	1·80	3·12
	K	4·90	5·30	3·35	3·00	4·13
	N	6·50	3·45	2·40	3·50	3·96
	PK	1·90	1·75	2·85	3·40	2·47
	PN	3·55	4·50	3·50	1·55	3·27
	KN	4·15	4·35	1·80	3·75	3·51
	PKN	3·70	2·75	2·65	2·00	2·77
	Ca	3·70	3·60	5·25	1·95	3·62
	Cu	3·40	3·55	3·30	4·55	3·70
	O	4·70	3·60	2·00	2·45	3·18
	Check	4·15	3·35	2·15	4·00	3·41
Lacombe	P	1·30	1·70	1·60	1·55	1·53
	K	2·85	1·95	2·55	3·55	2·72
	N	1·10	1·10	3·35	3·50	2·27
	PK	2·20	2·45	2·85	3·45	2·73
	PN	0·80	1·95	1·45	2·25	1·61
	KN	1·35	1·50	3·00	1·40	1·81
	PKN	1·35	1·25	2·65	1·75	1·75
	Ca	0·60	2·45	1·80	0·95	1·45
	Cu	1·10	1·90	3·10	2·50	2·15
	O	1·55	1·10	3·40	1·50	1·88
	Check	1·90	2·40	1·65	3·15	2·27
Brooks	P	2·80	2·10	1·60	0·40	1·72
	K	2·75	1·70	2·80	1·80	2·26
	N	0·75	1·83	1·85	Lost	1·48
	PK	1·65	1·50	1·10	3·60	1·96
	PN	3·20	2·40	2·65	1·40	2·41
	KN	2·20	1·70	1·75	1·20	1·71
	PKN	1·30	1·00	1·35	1·90	1·38
	Ca	1·25	1·80	1·75	0·85	1·46
	Cu	0·90	1·70	2·00	1·20	1·45
	O	1·35	1·30	1·45	1·90	1·50
	Check	2·15	1·85	1·65	2·20	1·96

[1] P, K, N, Ca, Cu, are symbols for Phosphorus, Potassium, Nitrogen, Calcium, and Copper, and O indicates no treatment.

TABLE 42.—THE RELATIVE NUMBER OF ISOLATIONS OF *Helminthosporium sativum* and *Fusaria* OBTAINED FROM THE FOOT OF WHEAT PLANTS WHEN GROWN ON PLOTS TREATED WITH VARIOUS CHEMICALS

Chemical[1] Treatment	Number of isolations of *Helminthosporium sativum* and *Fusaria*[2]														
	A[3]			B			C			D			Total		
	H	Fc	F	H	Fc	F	H	Fc	F	H	Fc	F	H	Fc	F
(Edmonton)—															
P	6	0	4	6	3	2	5	0	5	4	5	3	21	8	14
K	6	1	3	2	5	3	4	4	3	4	0	2	16	10	11
N	2	2	6	1	2	7	4	1	5	3	0	7	10	5	25
PK	6	1	1	6	1	3	3	4	3	2	6	3	17	12	10
PN	6	3	3	8	3	1	3	2	5	4	0	1	21	8	10
KN	7	1	2	4	2	2	1	2	7	7	3	2	19	8	13
PKN	6	0	4	7	1	2	2	3	5	4	3	5	19	7	16
Ca	5	2	3	7	3	1	1	2	7	7	0	0	20	7	11
Cu	6	1	2	1	3	4	3	4	3	6	5	1	16	13	10
O	2	2	6	5	3	2	5	1	4	6	1	5	19	7	17
Check	3	2	4	7	2	1	7	1	2	3	3	4	20	8	10
(Lacombe)—															
P	1	4	5	0	9	1	0	10	0	0	10	0	1	33	6
K	0	7	3	0	6	4	0	10	0	0	8	2	0	31	9
N	2	8	0	1	5	4	1	9	1	2	10	0	6	32	5
PK	0	7	3	1	10	0	1	10	0	0	10	0	2	37	3
PN	1	9	1	2	6	3	1	9	0	1	10	0	5	34	4
KN	0	6	4	1	10	0	0	9	1	0	10	0	1	35	5

TABLE 42.—THE RELATIVE NUMBER OF ISOLATIONS OF *Helminthosporium sativum* and *Fusaria* OBTAINED FROM THE FOOT OF WHEAT PLANTS WHEN GROWN ON PLOTS TREATED WITH VARIOUS CHEMICALS—*Concluded*

Chemical Treatment	Number of isolations of *Helminthosporium sativum* and *Fusaria*														
	A′			B			C			D			Total		
	H	Fc	F	H	Fc	F	H	Fc	F	H	Fc	F	H	Fc	F
(Lacombe)—*Concluded*															
PKN	4	8	1	1	9	1	0	10	0	0	7	3	5	34	5
Ca	1	9	1	0	10	0	0	6	4	2	8	0	3	33	5
Cu	1	7	2	0	6	4	2	9	0	1	9	0	4	31	6
O	1	5	5	2	8	2	3	7	3	0	10	0	6	30	10
Check	1	9	0	2	8	1	0	7	3	2	10	0	5	35	4
(Brooks)—															
P	1	10	0	4	5	2	6	3	2	6	4	1	17	22	5
K	0	8	0	3	3	3	6	1	0	3	3	0	12	15	3
N	3	5	1	4	4	2	1	6	1	Lost	Lost	Lost	8	15	4
PK	2	4	2	0	5	3	1	0	3	1	8	0	4	17	8
PN	3	7	0	4	5	0	7	2	3	2	6	1	16	20	4
KN	1	5	3	9	2	1	7	1	5	7	3	3	23	11	12
PKN	1	5	2	4	5	1	1	4	2	9	2	1	15	16	6
Ca	2	8	0	6	2	2	8	1	2	10	2	2	26	13	6
Cu	3	4	2	2	6	1	5	0	3	7	3	1	17	13	7
O	5	4	1	2	4	3	5	3	4	6	2	1	18	13	9
Check	1	4	1	4	6	0	2	2	2	4	3	3	11	16	6

[1] P. K, N, Ca, Cu, are symbols for Phosphorus, Potassium, Nitrogen, Calcium, and Copper, and O indicates no treatment.

[2] H, indicates *H. sativum*; Fc, *Fusaria* (*culmorum* type) and F, *Fusaria*, undetermined.

[3] A, B, C and D are replicates.

A STUDY TO DETERMINE WHETHER THE WHEAT PLANT BECOMES MORE SUSCEPTIBLE WITH ADVANCING AGE TO FOOT- AND ROOT-ROTTING FUNGI

(H. T. Robertson)

It is considered important to know whether the foot of the wheat plant becomes more susceptible to root-rot during the post seedling stage.

For this study pathogenic cultures of *Fusarium culmorum*, *Helminthosporium sativum*, *Ophiobolus graminis*, and of *Leptosphaeria herpotrichoides* de Not. are used singly and in combination. The degree of injury is obtained by inspection and by histological examination of the plant. Approximately 400 pot-cultures were involved in the first experiment. These experiments must be repeated one or more times before conclusions can be made.

HISTOLOGICAL STUDIES ON THE FOOT- AND ROOT-ROTS OF CEREALS

During the summer of 1929 a histological study of the basal portions of wheat plants attacked by various root-rotting fungi was begun at this laboratory. Since practically all of the work of this nature, reported to date, has been carried out on plants in the seedling stage, it was proposed in the present study to use more mature plants. This study includes pathogenic species of *Ophioblus, Leptosphaeria, Wojnowicia, Helminthosporium, and Fusarium.* It is hoped from this study to discover something of the nature of the injury done to the mature wheat plant by these organisms, and how, and to what extent, they penetrate the tissues of the plant.

Frequently in the survey work, fields have been found where the yield is materially cut and perhaps the plants stunted, but where the roots appear healthy outwardly. One object of this study is to find out whether it is practical to determine microscopically what organism, if any, is present in these cases, and to establish a definite relationship between discoloration and the presence of mycelium.

For various reasons it was thought advisable to begin this work with a study of the effects of *Ophiobolus graminis* on the mature plant. With this in view, roots from a number of fields visited during the 1929 survey, were fixed in the field and later embedded. Additional material has been obtained from plants grown in the greenhouse and inoculated with a pure culture of *O. graminis*.

This work has not been carried far enough, as yet, to permit of any detailed report; but will be continued throughout the coming year. Several months have been spent in trying out various fixing, slicing, and staining methods, in order to find a satisfactory technique. The accompanying photographs (figure 20, 1-4) shows tissues of plants infected with *O. graminis*.

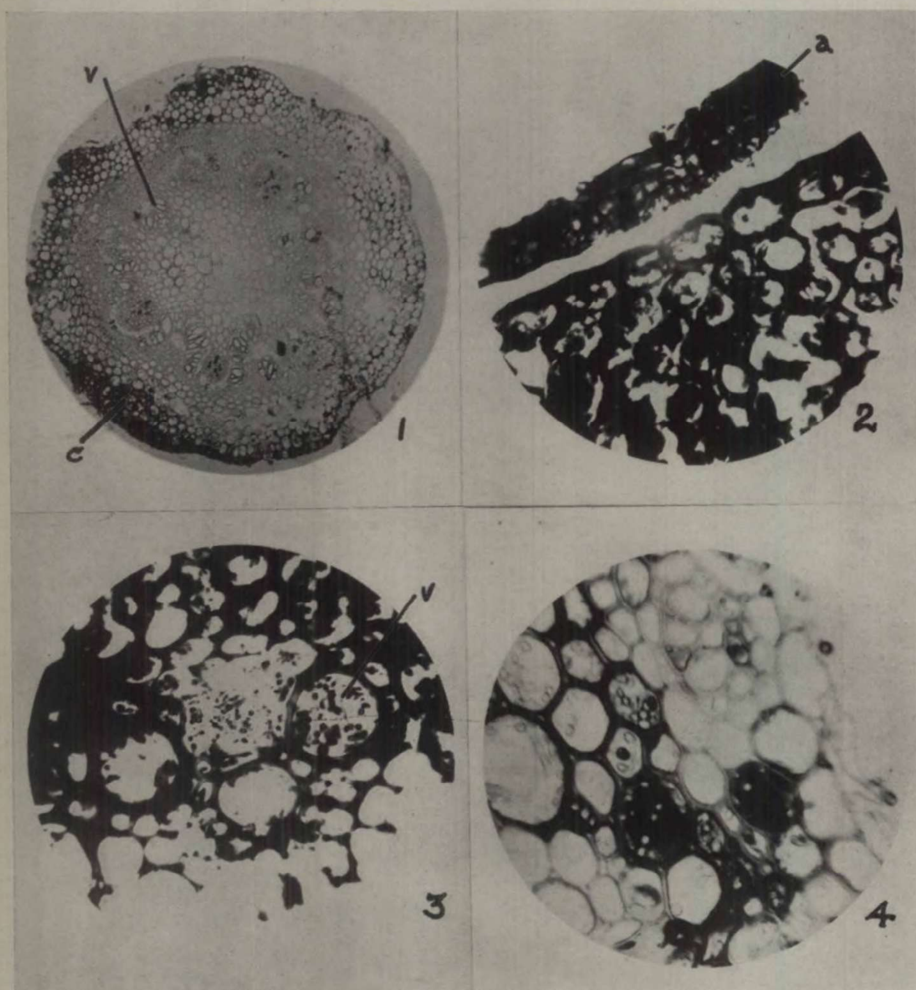


FIG. 20.—Mycelia of ***Ophiobolus graminis*** in the stem and subcoronal internode of wheat plants.

1. Cross section of subcoronal internode of plant inoculated when 40 days old, fixed 60 days after inoculation. Cortex (c) is filled with fungous mycelium and discolored, but very little has penetrated to the vascular ring (v). x 60.

2. Cross section through stem of plant inoculated when 50 days old, fixed 44 days after inoculation, showing plate mycelium (a). x 500.

3. Cross section through stem of plant inoculated when 50 days old, fixed 44 days after inoculation, showing mycelium in xylem vessels (v). x 500.

4. Cross section of stem of plant inoculated when 50 days old, fixed 30 days after inoculation, showing mycelium in cells, some of which are filled with a dark substance. x 500.

STUDIES ON THE EPIDEMIOLOGY OF STRIPE RUST IN ALBERTA

(G. B. Sanford and W. C. Broadfoot)

This laboratory has undertaken to study the distribution and development in Alberta of stripe rust, *Puccinia glumarum* Erikss. and Henn. A note on this subject appeared in *Scientific Agriculture*, Vol. 9, p. 337, 1929. In this study data are collected by ordinary survey methods, and from uniform nurseries in which varieties susceptible to stripe rust are planted, and located at strategic points, and from observations on overwintering of rusted plants. In order to discover if stripe rust survived the winter of 1928 and 1929, fields of winter wheat were examined early in May this year. Although these fields had carried a moderate infection the previous fall, not a single case of stripe rust was discovered this spring. Contrary to the appearance of the wheat in the spring of 1928, when much of the old foliage had remained green, the fall foliage was completely killed, and with it went all traces of the rust. The new growth was apparently free from stripe rust, and apparently remained so until harvest. About June 25 fields of spring and winter wheat were again examined for stripe rust. The area inspected was from Edmonton in the north, to Cardston near the Montana boundary in the south. Fields of wheat and patches of *Hordeum jubatum*, favourably situated for the development of this rust, were carefully inspected. No stripe rust was found.

This year stripe rust was first observed on wheat and *H. jubatum* at Claresholm in southern Alberta, August 15. Indications were that the rust was then from ten to fifteen days old. This rust was general on *H. jubatum* in the area roughly bounded by Claresholm, Nobleford, Lethbridge, Raymond and Cardston. Occasionally a field of spring wheat in this area was rusted. Near Claresholm a field of wheat, identified as Kitchener, was practically defoliated by stripe rust. *H. jubatum, Agropyron Smithii*, and *A. dasystachyum*, growing on the edge of the field, were also heavily rusted. Directly across the road was a field of Marquis wheat in which no stripe rust was found—a fact which indicates a distinct difference in susceptibility of the two varieties.

The results of the survey data have been summarized and indicate the development of stripe rust throughout the season. During September a trace of stripe rust was found at several points, after a careful search, as far north as the Edmonton district. With the exception of a case which occurred on Chagot wheat in the nursery at Edmonton, all infections were found on *H. jubatum*, growing in very favourable places. In the south, near Claresholm, stripe rust continued to develop on *H. jubatum* and fall-sown wheat, until late in the autumn. A particularly heavy infection occurred in one field of Kharkov fall-sown wheat near Claresholm. The infection on the leaves was so heavy that the ground underneath was yellowed by the uredospores.

The uniform rust nurseries which are being used to study the spread of stripe rust include varieties of wheat and barley already found susceptible to *Puccinia glumarum*. Marquis, Reward, and Garnet are included in these nurseries for comparison. The varieties used in the uniform rust nurseries in 1929 are shown in table 43. As stripe rust was not observed in 1929 in any of the nurseries except at Claresholm and Edmonton only these are mentioned in this table. The location of the other seven nurseries are found in table 44. It was interesting to note that in the nursery located at Claresholm, the district where stripe rust was most pronounced, only a trace of rust appeared on White Federation, Bunyip, Marquis 7, Early Baart, Vermilion, and Chagot, the last variety being most susceptible. The other varieties of wheat and barley escaped infection. Unfortunately the nursery at Claresholm ripened too early for the best results. At Edmonton, all the varieties except Chagot escaped infection, notwithstanding that the foliage remained green until October 11.

At Olds, where stripe rust had developed in 1926, 1927 and 1929, all the varieties in the special stripe rust nursery escaped infection. In this nursery there were 21 varieties of wheat, 16 of which have been listed as being susceptible by Hungerford and Owens, Journ. Agri. Res., Vol. 25: 363-401, 1923. The first evidence of stripe rust at Olds this year was on *H. jubatum*, September 26, at which time the varieties in the nurseries were mature.

TABLE 43.—THE REACTION OF 16 VARIETIES OF WHEAT AND 2 VARIETIES OF BARLEY TO *Puccinia glumarum* AT THE PROVINCIAL SCHOOL OF AGRICULTURE, CLARESHOLM, ALBERTA, AUGUST 15, 1929, AND AT EDMONTON, ALBERTA, SEPTEMBER 16, 1929

Variety[1]	Group	Claresholm		Edmonton	
		Early seeding	Late seeding	Early seeding	Late seeding
White Federation Cal. 3213	White	0	Trace	0	0
Bunyip Cal. 3203	"	0	"	0	0
Chagot	Hard Red Spring	0	"	0	Trace
Marquis 7	" "	0	"	0	0
Early Baart Cal. 3929	White	0	"	0	0
White Barbless Barley	Six Row	0	0	0	0
Bishop	Hard Red Spring	0	0	0	0
Chagot	" "	0	Trace	0	Trace
Vermilion	" "	0	"	0	0
Early Red Fife Ottawa 16	" "	0	0	0	0
Chagot	" "	0	Trace	0	Trace
Early Java	" "	0	0	0	0
Hybrid 143	Club	0	0	0	0
Prelude	Hard Red Spring	0	0	0	0
Marquis	" "	0	0	0	0
Garnet	" "	0	0	0	0
Reward	" "	0	0	0	0
Barley O.A.C. 21 U. of A	Six Row	0	0	0	0

[1] Varieties kindly supplied by Mr. A. T. Kemp, Agronomist, School of Agriculture, Olds, Alberta.

TABLE 44.—LOCATION OF STRIPE RUST NURSERIES IN ALBERTA IN 1929, AND NAMES OF CO-OPERATORS AT EACH LOCALITY

Locality	Co-operators
Beaverlodge	Mr. W. D. Albright, Superintendent, Dominion Experiment Station.
Edmonton	Dominion Laboratory of Plant Pathology.
Lacombe	Mr. G. E. Delong, Agronomist, Dominion Experiment Station.
Claresholm	Mr. W. Robinson, Agronomist, Provincial School of Agriculture.
Olds	Mr. A. T. Kemp, Agronomist, Provincial School of Agriculture.
Vermilion	Mr. B. J. Whitbread, Agronomist, Provincial School of Agriculture.
Cowley	Mr. C. Elton, Farmer.
Provost	Mr. E. C. Muir, Farmer.
Moyerton	Mr. H. Thibodeau, Farmer.

No attempt is made at this time to offer an explanation for the uneven development of stripe rust in 1929. The meteorological data from 70 points show that a very scant amount of rain fell over the entire area during June, July, August, and September. Records show that the air temperatures were high. However, in the absence of more complete data on the exact moisture and temperature conditions, we are inclined to the belief, which is based on our observations, that dew played a very important part in the development and spread of stripe rust in 1929.

A NEW DISEASE OF CORN IN ALBERTA

(G. B. Sanford)

What appears to be a disease, new to Alberta, on corn, was first observed in 1927, at Brooks. A number of full-grown plants in a field of Golden Bantam corn, in the ear stage, were severely blighted, and several were dead. In 1928 this disease was again observed at Brooks. Samples were taken and photographs made each year.

The disease affects all the above ground parts of the plant and severe lesions may enter the cob or stalk from the outside, producing necrosis. The leaves appear to be the most severely attacked. The first indications of the disease on the green leaf is an exudate which later dries, leaving a small, raised, light-coloured spot, which is about one millimeter, or less, in diameter. The exudate is soon surrounded by a water-soaked area of varying width and shape. There is perhaps a slight tendency for the lesions to be restricted by the leaf veins. After a time each spot is usually bounded by a brownish, rusty margin. Lesions may coalesce, producing long or irregular water-soaked or rusty areas. The lesions may appear on either surface of the leaf, but they are more numerous and pronounced on the upper surface. The nodes of affected plants become purplish. In figure 21, (*a*) represents a magnified view of the disease lesions on the surface of a leaf of Golden Bantam corn, in (*b*) is shown a view of the upper surface of the leaf less magnified, while (*c*) shows a portion of the diseased stalk with the coloured node.

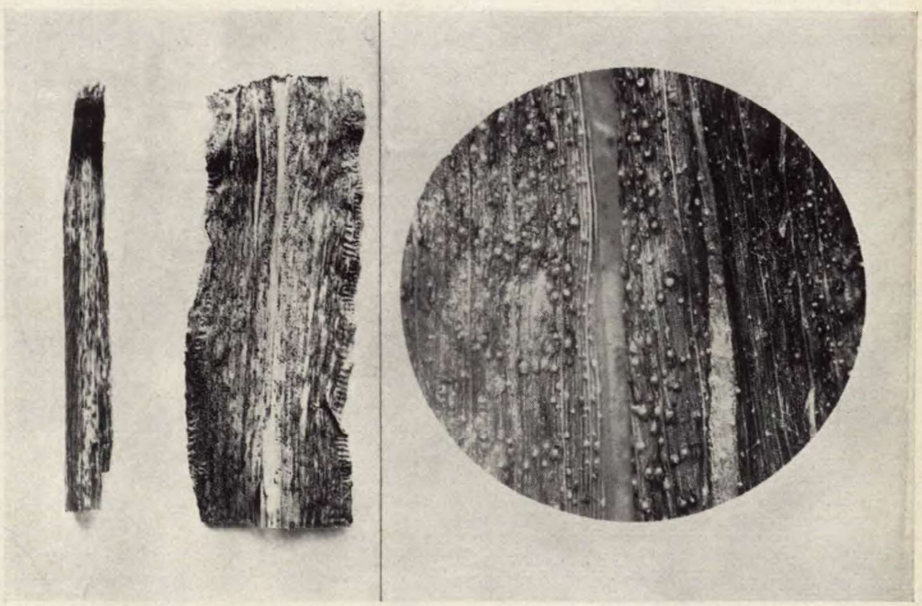


FIG. 21.—Leaf and stalk portions of Golden Bantam corn showing the disease lesions. Note the darkened node on the stalk portion at the left. On the right is an area of the leaf showing the lesions magnified. (Photo. by H. T. Robertson)

A number of bacteria, some of which are very difficult to culture, have been isolated, but the casual organism has not yet been determined. At present the disease gives every indication of being caused by bacteria.

OBSERVATIONS ON MISCELLANEOUS FUNGI IN ALBERTA

(W. C. Broadfoot)

Following are brief notes on some fungi isolated from wheat plants during the past season. *Leptosphaeria herpotrichoides* was obtained from the basal parts of winter and spring wheat plants of the 1928 crop. In figure 22 are photographs of a broken perithecium with liberated asci and ascospores, and also highly magnified asci containing mature ascospores. Obviously there is a fairly close similarity between ascospores of *L. herpotrichoides* and pycnidiospores of *Wojnowicia graminis* (McAlp.) Sacc. & D. Sacc.

W. graminis is widely distributed and prevalent on wheat in Alberta. In figure 23 are photographs showing a pycnidium, the spore discharge, and pycnidiospores of *W. graminis*.

An unknown disease attacking the glumes of Reward wheat is being studied, a photograph of which is found at the left in figure 24. In the centre of the same figure is a photograph of Septoria glume spot, on wheat, caused by *Septoria nodorum* Berk. The photograph at the right in figure 24 illustrates the characteristic arrangement in rows of pycnidia of *Septoria Tritici* Desm. Such specimens are relatively common in the grain fields of Alberta. Among other fungi collected on wheat are *Ascochyta graminicota* Sacc, from Cowley, Pincher Creek, MacLeod, and other points; *Septoria nodorum* was obtained at Beaverlodge. *Septoria Tritici*, *Septoria nodorum*, and *Mycosphaerella Tulasni* were isolated from wheat, and *Hormodendrum Hordei* Bruhne from *Hordeum vulgare*.

In figure 25 is a photograph of mature asci and ascospores of *Mycosphaerella Tulasnei* (Jancz.) Lindau. The left part shows a crushed perithecium with spore discharge.

Nematodes were isolated from the roots of winter and spring wheat at Cowley and Edmonton. These appear to be *Heterodera punctata*. However, the exact identity of these collections is receiving further attention.

FIG. 22.—*Leptosphaeria herpotrichoides*. On the left is a crushed perithecium showing asci and ascospores, x 125. Center and right show these asci and ascospores highly magnified, x 250. (Photographs by H. T. Robertson)

FIG. 23.—*Wojnowicia graminis*. On the left is an individual pycnidium with elongated beak, x 60. Such pycnidia might be easily mistaken for perithecia of ***Ophiobolus graminis***. Center, spore discharge of pycnidium, x 60. Right, shows pycnidiospores, x 350. (Photographs by H. T. Robertson)

Fig. 24.—On the left is an unknown disease of Reward wheat showing black discoloration on glumes and rachis, x 2. Center shows blotch on spike of wheat caused by ***Septoria glumarum***, x 2. On the right is a culm of wheat showing the typical arrangement of pycnidia of ***Septoria tritici*** in rows, x 5. (Photographs by H. T. Robertson)

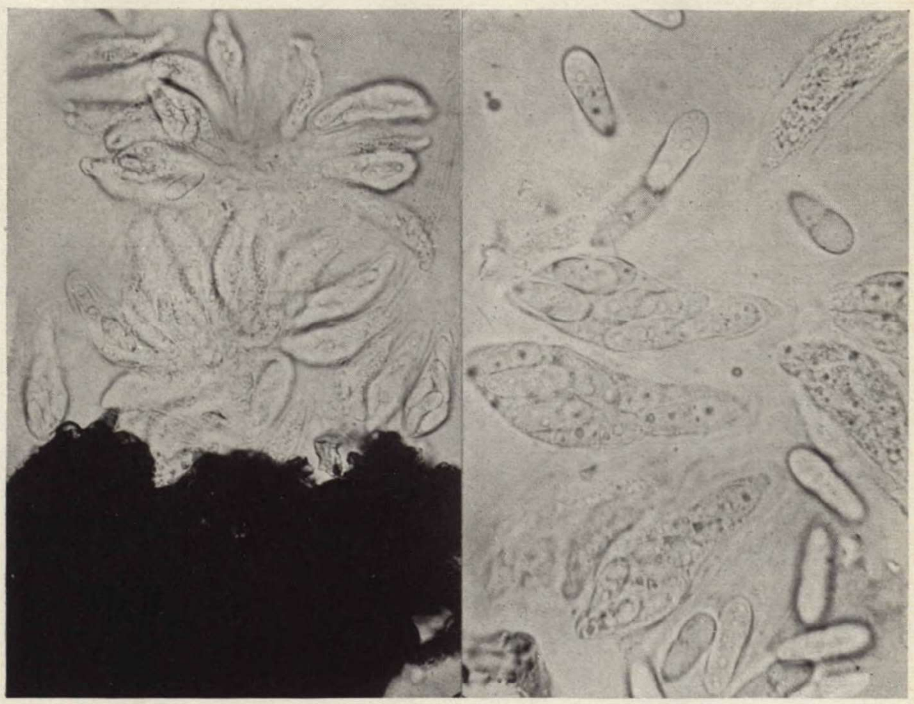


Fig. 25.—***Mycosphaerella Tulasnei***. On the left is a crushed perithecium with discharged asci. x 250. On the right is a magnified view of same showing asci and ascospores, x 500. (Photographs by H. T. Robertson)

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, SASKATOON, SASKATCHEWAN

(P. M. Simmonds, Senior Pathologist in Charge)

FUSARIUM STUDIES

The taxonomic work on Fusarium cultures has been continued. Forty-nine isolations which represent a part of the large number made during the summer were carefully studied. These isolations were made from the roots, crowns, and heads of wheat and from roots and crowns of the other cereals. The plants from which the isolations were made, were collected in various parts of the western provinces. The forty-nine cultures were finally worked down into eleven groups and representatives of these groups are being studied at present. In a like manner a large number of isolations obtained during the past summer are being grouped for further study. Along with the above work, fifteen cultures of known identity were studied in order to become familiar with the various characters of this difficult group.

Four Fusarium isolations suspected of causing " pre-maturity blight " were tested in the greenhouse but with negative results.

TAKE-ALL STUDIES

(R. C. Russell)

As the investigator was away taking post graduate work during the winter 1928-29, the chief phases of the take-all studies to be reported this year are the field experiments and field survey. At the close of summer, however, cultural studies and greenhouse experiments were resumed.

FIG. 26.—Moisture relations of *Ophiobolus graminis*; on the left, check and inoculated groups grown in soil 30 per cent saturated; on the right check and inoculated groups grown in soil 45 per cent saturated.

Laboratory and Grenhouse Studies.—One additional isolation of *Ophiobolus graminis* Sacc. has been made and it is planned to continue the study of the comparative morphological and physiological characteristics of the different isolations in our collections. Experiments dealing with moisture relations and the relative pathogenicity of our different isolations are being carried out in the greenhouse, as well as several minor investigations. In the case of the moisture relations experiment, the moisture holding capacity of the soil is computed and enough water is added daily to the various groups of crocks to bring the soil in them to a specified degree of saturation if the water were evenly distributed through the soil, but as a matter of fact, the distribution is not uniform. Nevertheless, we get a fairly satisfactory gradation of moisture conditions in the different groups of crocks as is shown by the results obtained (figs. 26 & 27). We now have isolations of *O. graminis* from six different points in Saskatchewan. Five of these were made in our Laboratory and one was secured from Mr. T. C. Vanterpool of the University of Saskatchewan. There appears to be a distinct difference in the virulence of some of these cultures (figs. 28 & 29). During the past winter a short paper concerning the phenomena connected with the penetration of wheat plants by *O. graminis* was given at the annual meeting of the Can. Br. of the Amer. Phytopathological Soc. (see abstract in Phytopathology 19:4:414, 1929).

FIG. 27.—Moisture relations on *Ophiobolus graminis*; on the left, check and inoculated groups grown in soil 60 per cent saturated; on the right, check and inoculated groups grown in soil 75 per cent saturated.

Field Experiments.—Rotation experiments were started this year on our experimental fields at St. Gregor and Melfort. The greater part of each field was laid out into plots of wheat, barley, oats and summerfallow. Each plot was replicated twice. No artificial inoculum was used on these plots this year as the land was fairly uniformly infested with *O. graminis* from artificial inoculations made on wheat in 1927 and 1928. While it was not easy to appraise the amount of infection, on account of the relatively dry condition prevailing at both places this year, still it was evident that the wheat was heavily infected at St. Gregor and that the barley was diseased to a lesser extent. The plots of oats did not appear to be affected. At Melfort very little disease was evident.

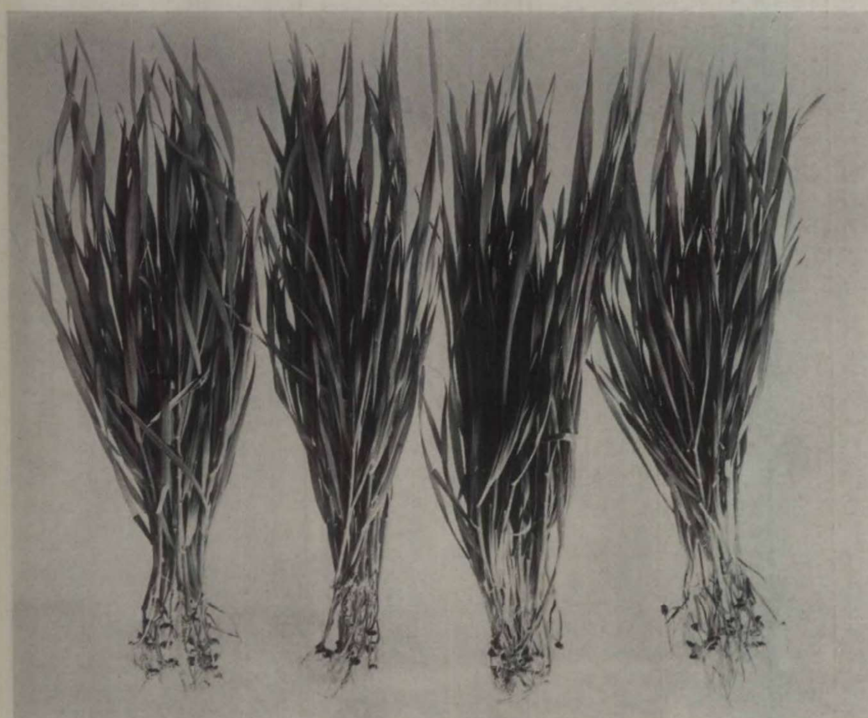


FIG. 28.—Relative virulence of different isolations of *Ophiobolus graminis*; two groups, on the left, are from uninoculated check crocks; two groups, on the right, are inoculated with a weakly pathogenic culture.

Several minor experiments were run in one corner of the main plot at St. Gregor and Melfort and for the first time a preliminary test was carried out in the field at Saskatoon. Since several year's tests, regarding varietal susceptibility, had failed to demonstrate any marked resistance on the part of any of the one hundred wheat varieties tried, this test was discontinued. The ranges formerly occupied by the variety tests were cut up into small plots which were sown alternately to Marquis and Garnet and a study was made of the relative effect which the previous treatments of these plots had on the yield. The following table (45) gives the average results:—

TABLE 45.—AVERAGE YIELDS IN GRAMS FROM SMALL PLOTS OF TAKE-ALL FIELDS, 1929

St. Gregor

—	Marquis	Garnet	Both
Average yield of 6 inoculated plots (fall dug)	95	25·5	60
" " 3 inoculated plots (spring dug)	133	59	96
" " 6 check plots (fall dug)	363	388	376
" " 3 naturally inoculated plots (spring dug)	484	534	509
" " 3 naturally inoculated plots (fall dug)	427	468	448
Melfort			
Average yield of 2 inoculated plots (fall dug)	314	279	296
" " 3 inoculated plots (spring dug)	383	359	371
" " 6 check plots (fall dug)	383	427	405
" " 3 naturally inoculated plots (spring dug)	527	547	537
" " 3 naturally inoculated plots (fall dug)	None harvested.		

While the infection was much more severe at St. Gregor, the results were fairly consistent and the following points stood out clearly:—

(1) Garnet was more susceptible to the disease than Marquis. While Garnet out-yielded Marquis in the check plots, it yielded less on the plots which were inoculated last spring.

(2) Very little take-all appeared in the plots which were inoculated in previous years but left uninoculated last spring. This result was quite unexpected. Possibly the high mortality in the seedling stage in 1928 and the subsequent thinness of the weeded stand which remained, led to conditions which were not conducive to the development of the fungus to a stage in which it over-winters readily. In the main plot where the early infection was less severe in 1928 and the resultant stand was thicker, the fungus over-wintered and injured the 1929 stand quite noticeably.

(3) The average yields of both the artificially inoculated and the naturally inoculated plots which were dug in the spring, were higher than the average yields of the corresponding plots which were dug in the fall.

(4) The average yield of the artificially inoculated plots at Melfort was 302 gm. while that of the corresponding checks was 473 gm. At St. Gregor the average yields of inoculated and check plots respectively was 83 gm. and 434 gm. The average reduction in yield at St. Gregor amounted to 81 per cent while at Melfort it amounted to only 36 per cent. Although the Melfort plots were sown nine days later than the St. Gregor plots, the difference in extent of injury is thought to be due mainly to drier conditions at Melfort, because the second date of seeding plot at St. Gregor, sown the day after the bulk of the plots at Melfort, was more severely injured than the first date of seeding plot which was sown at the same time as the bulk of the St. Gregor plots.

At each of the above places an experiment was run to test the effect of the date of seeding upon the amount of take-all in artificially inoculated plots. The following table (46) gives the results in brief form:—

TABLE 46.—DATES OF SEEDING TEST: YIELDS IN GRAMS FROM PLOTS SOWN AT DIFFERENT DATES TO WHEAT INOCULATED WITH *O. graminis*

Date sown		Yields of check plots		Yields of inoculated plots	
St. Gregor	Melfort	St. Gregor	Melfort	St. Gregor	Melfort
1st date.........May 6	May 15	405	390	90	282
2nd date........May 16	" 25	434	397	70	98
3rd date........May 29	June 4	344	236	282	243

In comparison with the checks the second date of seeding was most severely damaged in each case and the third date was least injured.

Wheat was sown again on a plot which had four circular patches artificially infected with take-all in 1928. This year no evidence of take-all appeared in these patches. The plot was not dug, but merely surface-worked.

Several plots which were infected in 1928 were sown this year to wheat dusted with Ceresan, a commercial seed treatment. Very little take-all appeared in the checks and the yields were contradictory, although the average yield of the Ceresan plots was higher than that of the checks, being 482 gm. and 468 gm. respectively.

Wheat and barley inoculated and grown on the Saskatoon plots were severely injured, particularly the wheat. This shows that field inoculations for experimental purposes are quite feasible in this locality.

FIG. 29.—Relative virulence of different isolations of ***Ophiobolus graminis***; two groups, on the left, are inoculated with a moderately virulent culture; two groups, on the right, are inoculated with a very virulent culture.

Field Survey.—In most districts of Saskatchewan, conditions during the growing season were much drier in 1929 than usual.

As was to be expected, take-all was not nearly so prevalent as it was in 1927 and 1928. Where it did occur the signs of the disease were not so well developed as they are in wet years. In many cases the discoloration of the stem bases was not pronounced above the crown and in very few cases were the lower sheaths well blackened. In some cases the discoloration and mycelium were confined mainly to the roots and were not noticeable even on the subcrown internode.

Nevertheless a number of clear cut cases were found and in one instance the injury appeared to reach about 40 per cent of the entire crop. This was the second crop of wheat stubbled in on new land. Three cases of a scattered infection affecting about 2-3 per cent of the plants were found in comparatively old fields on the open plains. These fields had been raising practically nothing but wheat since they were first broken and had been summerfallowed about every third year.

The systematic survey of the twenty-six fields chosen for this purpose in 1925 was continued as usual. All observations made on these fields, as well as on other fields which we have found infested with take-all, confirm our opinion that the trouble can be satisfactorily controlled by the judicious use of simple crop rotations (see last paragraph of the section on take-all studies in the 1928 report). It should also be pointed out that it is not a safe practice to sow wheat after barley on infested land. This year we found definite traces of take-all in barley under ordinary field conditions, and one wheat crop immediately following two crops of barley showed about 10 per cent of take-all.

Helminthosporium Studies

(G. A. Scott and B. T. Sallons)

Studies were continued during the current year on *Helminthosporium sativum* P. K. & B. the causal organism of a foot rot of cereals. These include field tests on dates of seeding and greenhouse experiments on head inoculations, effect of soil moisture on the parasitism of *H. sativum* and the effect of temperature on the growth of the fungus.

Dates of Seeding.—An experiment was designed to determine the effect of different dates of seeding of Marquis wheat inoculated with *H. sativum.* Two plots were sown on each date, each consisting of six rod-rows one foot apart with two hundred seeds to the row. The plots were separated by a three foot space. One plot was uninoculated to serve as a check while the other was inoculated with a strain of *H. sativum* grown on oat hull medium and sprinkled in the open drill on top of the seed at planting time. April 26 was the first date of seeding, two other seedings being made at three week intervals. The results are given in table 47.

Table 47.—Results of Field Experiments on Dates of Seeding of Marquis Wheat Inoculated with *H. sativum*

Plot No.	Date of seeding	Treatment	Date of emergence	Number of seed	Per cent emergence	Disease rate
1	April 26	Check	May 15	1,200	82·8	10·1
2	" 26	Inoc.	" 15	1,200	57·8	26·9
3	May 18	Check	" 28	1,200	50·7	11·8
4	" 18	Inoc.	" 28	1,200	48·3	21·5
5	June 7	Check	June 16	1,200	71·6	....
6	" 7	Inoc.	" 16	1,200	31·8	33·9

The results of this test were seriously interfered with due to severe wireworm injury which made the emergence very irregular and made it impossible to take accurate counts on seedling blight due to the fungus. On June 5, one row of plot No. 2 was dug up and 28 per cent of the 105 seedlings which emerged were affected by wireworms, and there is little doubt that much of the non-emergence was due to the seed having been destroyed by the worms. The disease rate was taken on fifty plants from each plot when nearly mature. The number of blighted and lesioned tillers and the severity of lesions of the primary and crown roots, and of the subcrown internode were taken into consideration in estimating the disease rates.

There appears to be some evidence in this test that the later dates of seeding with the consequent higher soil temperatures favoured the fungus in its parasitism of wheat. However, no definite conclusions can be drawn from it on one year's work especially in view of the wireworm injury, and it is proposed to carry on further tests of a similar nature during the coming season.

Head inoculations of Marquis with H. sativum.—In the report for 1928, experiments on the inoculation of foliage and heads of wheat at four stages of development, namely, seedling, shot-blade, heading and flowering stages, are outlined. It was shown that spraying a heavy spore suspension of *H. sativum* on the heads at flowering time and placing them in moist chambers for two days resulted in very marked discolorations of the glumes and the germ ends of 90 per cent of the kernels. Further work along this line was carried on during the past year. Inoculations were made on a large number of heads at stages beginning with the shot-blade and extending to over twenty days after flowering. This work was carried on in the greenhouse in March, April, and May on plants grown from the fall of 1928. During January and February about five hours of artificial light was supplied to the plants daily. The heads were tagged at the time of flowering, which was taken as the day on which the first anther was extruded from any spikelet of the head. Inoculations were made with spore suspensions of *Helminthosporium* conidia in sterile, distilled water. A medicine dropper, drawn out to a fine point was used to force small quantities of the suspension directly inside the flowering glume. After inoculations, the plants were incubated for 48 hours by placing them in a large moist chamber with a fine spray of water playing on a cloth hung on one side. Usually at the end of this time the glumes showed distinct discoloration. The plants were then removed to the greenhouse bench to mature. Check plants were treated alike in every respect except that sterile distilled water was injected inside the flowering glumes in place of the spore suspension. At maturity the heads were harvested and each one threshed separately. Records were kept of the number of kernels in each head and the number which showed distinct blackening. The results are summarized in table 48.

TABLE 48.—RESULTS OF HEAD INOCULATIONS OF MARQUIS IN THE GREENHOUSE USING *H. sativum*

Stage when inoculated	Inoculated series			Check series		
	Number of heads	Number of kernels	Number discoloured	Number of heads	Number of kernels	Number discoloured
In sheath	6	29	10	1	27	0
Heading	27	133	41	7	172	7
Flowering	17	199	120	3	49	0
1 day after flowering	13	147	69	4	112	0
2 " "	4	54	29	7	155	0
3 " "	9	74	33	2	51	0
4 " "	17	283	121	4	79	0
5 " "	17	374	138	1	8	1
6 " "	17	353	166	4	102	0
7 " "	41	1,145	742	4	95	0
8 " "	23	635	387	12	383	0
9 " "	37	917	546	9	244	10
10 " "	25	706	336	8	188	1
11 " "	19	499	398	3	79	0
12 " "	24	671	501	6	162	2
13 " "	13	356	225	8	203	0
14 " "	26	771	549	7	207	1
15 " "	3	71	64	8	227	2
16 " "	22	509	384	10	256	0
17 " "	1	30	27	3	93	0
18 " "	3	68	65	4	119	1
19 " "	3	100	82	2	51	0
20 " "	1	18	18	4	109	0
Over 20 days	16	367	358	18	536	7
Totals	384	7,509	5,409	139	3,707	32

A number of the discoloured kernels were grown in sterile sand to the seedling stage. Notes were taken on emergence, weak germination, seedling blight, and severe and slight lesioning of the coleoptiles. Infection rates were calculated using the following values: non-germination 5; weak germination 4; seedling blight 3; severe coleoptile lesions 2; and slight coleoptile lesions 1.

Isolations were made from one hundred of the coleoptile lesions from inoculated seed, and twenty-five lesions from check seed. Table 49 is a summary of the sterile sand test and table 50 of the results of the isolations.

TABLE 49.—GREENHOUSE TEST OF DISCOLOURED KERNELS OF MARQUIS FROM HEADS INOCULATED WITH *H. sativum* IN STERILE SAND

Stage when inoculated	Number of kernels	Emergence	Weak germination	Seedling blight	Coleoptile Les.		Infect. rate
					severe	slight	
Check	200	155	24	0	19	28	26·7
In sheath	10	8	1	0	8	0	50·0
Headed	40	18	6	6	16	2	78·0
Flowering	100	20	38	2	4	12	77·6
1 day after flowering	50	13	19	1	5	6	74·0
2 " "	25	5	10	1	2	3	80·0
3 " "	30	5	17	0	4	1	78·0
4 " "	100	14	49	4	10	4	83·4
5 " "	100	13	35	3	7	6	85·8
6 " "	100	16	45	2	8	7	80·8
7 " "	100	13	37	2	6	7	84·6
8 " "	100	14	46	5	13	1	85·2
9 " "	100	20	42	4	11	9	80·2
10 " "	100	18	36	3	12	6	82·6
11 " "	100	20	39	4	13	7	81·2
12 " "	100	23	43	4	12	11	77·8
13 " "	100	31	44	3	23	8	72·8
14 " "	100	17	36	5	9	7	83·8
15 " "	50	15	16	6	11	4	81·2
16 " "	100	29	45	5	21	8	75·0
17 " "	25	2	18	0	1	1	80·0
18 " "	50	17	21	4	8	9	72·4
19 " "	50	8	21	3	6	2	84·8
20 " "	10	1	9	0	1	0	76·0
Over 20 days	100	23	55	4	17	6	76·4

TABLE 50.—RESULTS OF ISOLATIONS FROM LESIONS PRODUCED IN THE SAND TEST ON KERNELS FROM HEADS INOCULATED WITH *H. sativum*

Source of lesions	Number of pieces	Helminthosporium	Alternaria	Fusarium	Undetermined
From inoculated seed	100	99	0	0	1
From uninoculated seed	25	12	5	2	4

It is evident from table 48 that the fungus produced marked discoloration in a high percentage (73 per cent) of the kernels as compared with less than one per cent occurring in the checks. Table 49 shows an average infection rate of about 80 per cent in seedlings grown in sterile sand from discoloured seed and table 6 demonstrates almost one hundred per cent re-isolation of the fungus from these diseased seedlings. Counts were made of all shrivelled or shrunken grain from the inoculated and check heads. The checks yielded about 8 per cent and the inoculated 12.5 per cent shrivelled kernels. It is seen that in this test little if any shrivelling occurred as a direct result of infection by *H. sativum*, other factors probably accounting for much of the lack of filling of these seeds.

An analysis of table 48 indicates that the inoculations produced a marked reduction in the average number of seeds per head as compared with the checks, in the case of those inoculated up to the third day after flowering. This cannot be ascribed to mechanical injury in inoculation or to the presence of water as the checks were treated in the same manner. After the third day there is little or no such reduction as probably most of the seed had been set at this time.

Rate of Growth of H. sativum at Different Temperatures and on Different Media.—In these tests the fungus was grown on potato dextrose, corn meal, and oat agars, in petri dishes at seven temperatures. Inoculations of the plates were made using discs, three millimeters in diameter, cut from nine day old cultures, which were placed in the center of the plates. The tests were made in duplicate, the average diameters of the two colonies for each temperature on each medium at the end of the seventh day being presented in table 51.

TABLE 51.—THE RATE OF GROWTH OF *H. sativum* ON THREE DIFFERENT MEDIA AT SEVEN TEMPERATURES. MEASUREMENTS ARE DIAMETERS IN MILLIMETERS AT THE END OF THE SEVENTH DAY

Medium	4°C.	12°C.	16°C.	20°C.	24°C.	28°C.	32°C.
Potato dextrose agar	11·0	28·0	35·0	75·0	90·0	73·0	71·0
Corn meal agar	9·5	25·0	29·0	45·0	55·0	65·0	55·5
Oat agar	11·0	36·0	57·5	85·0	90·0	88·5	75·5

The optimum temperature for radial growth of the fungus is between 25° and 28°C. Oat agar supported the most rapid and corn meal the least rapid growth.

Soil Moisture Tests with H. sativum.—Several experiments were run in the greenhouse to determine the effect of soil moisture on the parasitism of the fungus on wheat. Marquis was grown in one-gallon crocks in the greenhouse at the following percentages of the moisture holding capacity of the soil: 35, 45, 55, 65, 75 and 85 per cent. One series of two crocks for each moisture content was inoculated and a similar series served as checks. Infection rates were calculated on non-germination, seedling blight, severe and slight coleoptile lesions. The results proved to be somewhat conflicting, though in general the highest infection rates were at the lower moistures, namely at 45 and 55 per cent of the moisture holding capacity of the soil. Further work is at present being carried on and it is hoped that more definite results will be available by next year.

ALTERNARIA STUDIES

(B. J. Sallans)

In isolations made from seed wheat at this Laboratory for some years past, *Alternaria* have appeared very commonly, often from large percentages of the kernels. Some species of this genus have been proved to be parasitic on their respective hosts, and the possibility of some form of damage to wheat was considered to be important enough to warrant investigation. The studies here reported were undertaken in an attempt to establish the significance of this very common association.

A review of literature indicated that *Alternaria* have been found to be present in seed wheat by several investigators and some ascribe a seed discoloration somewhat similar to that caused by *H. sativum* to this fungus.

Thirty isolations of *Alternaria* from wheat were used in these studies. Of these twenty-two were from grains, five from roots, two from crowns and one from a glume. They were obtained from widely separated points in the prairie provinces.

Spore Trap Counts of Air-borne Alternaria.—Spore trap slides exposed at Indian Head primarily for making counts of the uredospores of *Puccinia graminis* were observed to have caught numbers of *Alternaria* conidia. Records were made of these at Indian Head for the summers of 1928 and 1929, and at Saskatoon for 1929. The slides were exposed for 2 day periods but for convenience the records were combined for 10 day periods. Table 52 gives the results of these counts.

TABLE 52.—SPORE TRAP COUNTS OF *Alternaria* CONIDIA DURING JUNE, JULY AND AUGUST AT INDIAN HEAD FOR 1928 AND 1929, AND AT SASKATOON FOR 1929

Period	Indian Head, 1928	Indian Head, 1929	Saskatoon, 1929
June 1 to June 10	30	23	13
June 11 to June 20	177	51	20
June 21 to June 30	38	93	23
July 1 to July 10	146	115	27
July 11 to July 20	194	179	31
July 21 to July 30	750	126	50
July 31 to Aug. 9	1,071	27	72
Aug. 10 to Aug. 19	843	127	49
Aug. 20 to Aug. 29	638	65	33

It will be seen that there was a sharp increase in the numbers of conidia caught on the slides from the 21st of July on through August in 1928 at Indian Head. The number of conidia caught in 1929 were comparable with those of 1928 up to July 20, but after that they were very much fewer. This is reflected in the isolation of *Alternaria* from wheat grains matured during the two periods. In 1928 an average of 70 per cent of all wheat grains gave *Alternaria* while in 1929 the average was less than 20 per cent. There is also an evident correlation between the amount of rainfall and the number of conidia in the air. In 1928 the precipitation, during the period, June to August, was fairly abundant while the same period in 1929 was unusually dry.

The Stage of Development at which Alternaria Became Associated with the Wheat Grains.—Collections were made of Marquis and Kubanka heads at intervals from the time seed was set to maturity. These were dried and stored in clean envelopes until isolations could be made. One hundred seeds of each variety for each of the dates of collection were thoroughly washed in sterile water and planted on potato dextrose agar in petri dishes. The results are summarized in table 53.

TABLE 53.—ISOLATIONS FROM MARQUIS AND KUBANKA COLLECTED AT DIFFERENT STAGES OF DEVELOPMENT TO DETERMINE THE STAGE AT WHICH WHEAT SEED BECAME INFECTED WITH *Alternaria*

Date of collection	Stage of development	Marquis		Kubanka	
		Alternaria	Total fungi	Alternaria	Total fungi
Aug. 24	Grain half normal size	6	69	0	30
Aug. 31	Early milk	8	51	10	28
Sept. 9	Milk	19	107	14	94
Sept. 18	Soft dough	51	176	11	138
Oct. 8	Mature	71	197	21	120

The results for Marquis indicate the large increase of *Alternaria* in wheat seed occurs in the late milk and dough stages. The results for Kubanka are irregular, the numbers of *Alternaria* being much smaller at the latter stages of development than were expected from other isolation tests of seed collected from an adjacent plot.

Overwintering of Alternaria at Saskatoon.—Isolations were made on March 15 and April 17, 1929, from materials taken from field plots on those days. Table 54 is a summary of these isolations.

TABLE 54.—ISOLATIONS FROM DIFFERENT PARTS OF MATURE WHEAT PLANTS LEFT IN THE FIELD THROUGH THE WINTER

Material	Number of pieces	March 15		April 17	
		Alternaria	Other fungi	Alternaria	Other fungi
Seed	65	37	91	46	59
Glumes	60	40	88	51	73
Rachises	10	5	15	9	8
Leaves	20	19	18	20	28
Internodes	20	0	20	4	30
Nodes	20	6	23	9	34
Crowns	20	0	42	0	25
Roots	40	0	45	0	41

This table indicates that *Alternaria* can over-winter in or on dead plant parts left in the field.

Pathogenicity Tests on Wheat with Alternaria Cultures.—Pathogenicity tests of all the *Alternaria* strains obtained from wheat were made in pots. They were grown on ground oat hull medium and placed in the pots at seed level. The seed, Marquis 70, was surface sterilized in mercuric chloride (1-1,000) for 25 minutes and washed in four changes of sterile water. Tables 55 and 56 give the results of these tests.

TABLE 55.—POT TESTS OF *Alternaria* CULTURES ON WHEAT. FIRST SERIES

Culture No.	Number of seeds	Emergence	Per cent lesioned coleoptiles		Per cent plants with lesioned roots	
			severe	slight	severe	slight
Check	150	88	0	0	0	0
6	150	102	3	11	0	6
15	150	99	0	6	61	20
17a	150	99	0	6	0	9
19	150	107	0	0	14	42
Check	150	116	0	2	0	0
20	150	98	0	0	0	0
21	150	99	0	5	4	9
24	150	115	3	0	0	0
25	150	106	0	3	4	2
Check	150	109	3	3	0	1
26	150	109	2	5	25	5
27a	150	100	3	5	0	16
28	150	111	3	3	0	0
Check	150	107	2	0	0	0

TABLE 56.—POT TESTS OF ALTERNARIA CULTURES ON WHEAT. SECOND SERIES

Culture No.	Number of seeds	Emergence	Per cent lesioned coleoptiles		Per cent plants with lesioned roots	
			severe	slight	severe	slight
Check	150	131	0	0	0	0
1b	150	135	0	0	0	0
2	150	134	0	0	0	0
3e	150	131	0	0	50	0
4a	150	122	0	7	26	0
Check	150	132	0	0	0	0
5	150	140	0	4	2	0
7	150	133	4	4	0	2
8	150	125	2	0	0	7
10	150	121	0	0	0	14
Check	150	119	0	0	0	0
11	150	129	2	0	0	5
12	150	122	0	0	29	40
13	150	134	4	0	46	30
14	150	131	0	0	0	11
Check	150	135	0	0	0	0
16	150	136	0	0	5	9
23	150	139	0	0	9	4
Check	150	123	0	0	0	0
29	150	133	0	0	0	0
30	150	126	0	0	0	0
31	150	131	0	0	0	0
Check	150	128	0	0	0	0

The poor emergence is probably due to excessive treatment with mercuric chloride, possibly aggravated by considerable frost injury to the seed when maturing. Lesioning of the coleoptiles is rare and in no case does it appear to be significant. Certain strains apparently did produce distinct black or grey lesions of the primary roots. When these lesions were washed in sterile water and plated on potato dextrose agar a few *Alternaria* colonies were produced, but a sterile, dark form of fungus appeared very consistently. This form resembles *Alternaria* in culture quite closely, but efforts to cause sporulation failed to establish any connection. The fact that this fungus did not appear in the check or in about half of the *Alternaria* strains excludes the seed, water and unsterilized soil as possible sources. All cultures from which the form arose had been single-spored and appeared to be pure when grown on oat hull medium. Considering all possibilities the most probable explanation seems to be that the sterile form arose from the *Alternaria* cultures as "mutants" or "variants" either in the oat hull medium or in the soil.

All the cultures were used in leaf inoculations on plants grown in the greenhouse for three to six weeks. The inoculations were made by spraying with conidial suspensions using an atomizer, the plants being placed in moist chambers for two days. Suitable checks were sprayed with sterile water. None of the strains produced any macroscopic evidence of infection, but they all grew readily on dead spots of leaves without any evidence of enlarging the dead areas.

Spore suspensions of one of the *Alternaria* cultures were used in inoculating wheat heads in the field at Indian Head and Saskatoon in 1928. These were made when the grain was forming, when in the dough stage and after maturity. On harvesting, counts were made of discoloured grains in the inoculated and check samples for the various dates of inoculation. No evidence was obtained of any discoloration due to *Alternaria* inoculation. All blackened seeds were quite evidently of the Basal Glume Rot (*Bacterium atrofaciens*) type.

Head inoculations were also made in the greenhouse during April and May of 1929, under conditions similar to and at the same time as those made by Mr. G. A. Scott with *Helminthosporium sativum* mentioned elsewhere in this report. The following (table 57) is a summary of this work:—

TABLE 57.—RESULTS FROM HEAD INOCULATIONS

—	Inoculated series	Check series
Number of heads	57·0	46·0
Number of kernels developed	1,542·0	1,115·0
Average number of grains per head	27·0	24·2
Number of discoloured grains	142·0	10·0
Average number of discoloured grains per head	2·49	0·22

Fifty of the discoloured grains were planted on agar in petri dishes, every one yielding a colony of *Alternaria*. There seems to be some evidence here that this fungus may produce some discoloration of wheat seed under very favourable conditions in the greenhouse.

Morphology and Cultural Studies.—The thirty isolations of *Alternaria* were compared as to cultural characters on oat and potato dextrose agars under the same conditions of temperature, medium and light. No two of the cultures appeared to be identical in every respect, variations occurring in rate of radial growth, amount of aerial mycelium, colour of submerged mycelium, colony colour, and abundance of sporulation. Colony colour appeared to be closely correlated with sporulation and varied from a deep olive green, where spores were very numerous and aerial mycelium scant, to a light grey, where spores were few and mycelium abundant. Comparison of the conidia of the strains failed to indicate more than minor differences in spore size, septation, form or colour. In this work sectors differing from the parent colony in one or more cultural characters were of quite frequent occurrence, appearing in sixteen of the thirty isolations.

Temperature studies were made on the rate of growth of four *Alternaria* cultures in petri dishes on potato dextrose, corn meal and oat agars. Slight growth occurred at 4° C., and increased regularly to 24° C. The rate of growth dropped off rapidly from 28° to 32° C. Sporulation occurred at all temperatures except 4° C., being most abundant at the highest temperatures. Of the three media, oat agar supported the greatest growth at all temperatures and potato dextrose the least.

At present no attempt can be made to assign these cultures to species. According to the groupings of species of *Alternaria* as made by Elliot (Am. Jour. Bot., Vol. 4, pp. 439-475), and Mason (Annotated account of fungi received at the Imperial Bureau of Mycology, Kew, Surrey, List II, Fasc. I), all the strains obtained from wheat readily fall into the *A. tenuis* group.

FUNGOUS FLORA OF WHEAT CROWN AND ROOTS

This study is an attempt to determine the number and kinds of fungi inhabiting the crowns and roots of wheat grown in various parts of the western provinces. The general procedure was the same as last season except that isolations were made only at the seedling, heading, and stubble stages of the crop instead of at monthly intervals. From these three isolations it is believed that a fairly good survey of the fungi present was obtained. The isolation pieces were given a thorough washing in sterile water before plating. Plots of Marquis and Kubanka wheat were sown at the following Dominion Experimental Farms and Laboratories: Morden, Winnipeg, Indian Head, Swift

Current, Saskatoon, and Edmonton. A representative sample consisting of fifty plants was collected and sent in by some member of the staffs of the above-mentioned stations. This co-operation is gratefully acknowledged.

The isolations obtained from the Saskatoon plots are given in table 58. Fifty pieces from the crowns and fifty pieces from the roots of each wheat variety were plated as soon as the samples were collected.

TABLE 58.—RESULTS IN PERCENTAGE OF ISOLATIONS FROM MARQUIS WHEAT GROWN AT SASKATOON IN 1929

Date	Stage	Crown					Roots				
		Total fungi	*Helm.*	*Fus.*	*Alt.*	*Rhiz.*	Total fungi	*Helm.*	*Fus.*	*Alt.*	*Rhiz.*
June 7	Seedling	66	0	40	0	6	94	0	62	0	0
July 18	Heading	42	16	12	0	0	28	0	8	2	0
Sept. 16	Stubble	102	44	46	0	0	100	6	36	0	0

Results in percentage of isolations from Kubanka wheat grown at Saskatoon in 1929

Date	Stage	Crown					Roots				
		Total fungi	*Helm.*	*Fus.*	*Alt.*	*Rhiz.*	Total fungi	*Helm.*	*Fus.*	*Alt.*	*Rhiz.*
June 7	Seedling	76	0	46	0	2	118	0	60	12	0
July 18	Heading	92	36	28	2	6	92	0	36	4	2
Sept. 16	Stubble	126	58	68	2	0	68	10	36	0	0

From the seedling sample a rather large number of fungi were obtained among which *Fusarium* isolations predominated over *Helminthosporium (H. sativum* type). *Helminthosporium* was rarely isolated in any number from roots. Later in the season, however, *Helminthosporium* isolations increased as a rule much more than *Fusaria*. Similar detailed records were obtained for all stations but it is not thought necessary to present them at this time.

A comparison of the total *Helminthosporium* and *Fusarium* isolations recorded for each station throughout the season can be seen in tables 59 and 60.

TABLE 59.—TOTAL PERCENTAGE OF *Helminthosporia* AND *Fusaria* ISOLATED FROM MARQUIS WHEAT GROWN AT THE VARIOUS STATIONS

Station	Crown		Roots	
	Helminthosporia	*Fusaria*	*Helminthosporia*	*Fusaria*
Morden	24·6	34·6	8·6	40·6
Winnipeg	10·0	41·3	3·3	30·0
Indian Head	13·3	31·3	0·6	15·3
Saskatoon	20·0	32·6	2·0	35·3
Edmonton	2·0	32·6	0·6	0·9

TABLE 60.—TOTAL PERCENTAGE OF *Helminthosporia* AND *Fusaria* ISOLATED FROM KUBANKA WHEAT GROWN AT THE VARIOUS STATIONS

Station	Crown		Roots	
	Helminthosporia	*Fusaria*	*Helminthosporia*	*Fusaria*
Morden	19·3	15·3	6·6	26·0
Winnipeg	7·3	39·3	2·6	18·0
Indian Head	26·0	32·3	9·3	20·0
Saskatoon	31·3	50·3	3·3	44·0
Edmonton	3·3	32·0	0·0	19·3

With the exception of Morden every station shows a much lower percentage of total isolations than it did last year (see our report for 1928). This is possibly associated with the general dry season of 1929 and it is hoped that a complete analysis of the weather data will be possible when the results of this investigation are finally summarized. The large number of *Fusaria* isolated have been grouped and are being studied. This season's work did not show clearly that there were any great differences in types of *Fusaria* isolated from the various samples. A small number of isolations of *Rhizoctonia* were made from samples from all the locations. A *Botrytis* was isolated from the roots of Kubanka wheat grown at Indian Head.

Seed Wheat Discolorations

The studies on seed wheat discolorations and abnormalities have been continued. Some field experiments were run but these were merely of an informative nature and were not extensive.

Histological studies of normal and abnormal grains have been given most attention during the past year.

Normal Kernels.—The development of the wheat kernel from fertilization to maturity has been followed and the various stages illustrated. From the standpoint of diseases caused by parasites, the formation of the testa and the thickening of the epidermis, are of particular interest. It would appear that after the soft dough stage it would be difficult for the fungus to penetrate beyond the testa, even if it had passed the epidermal layer. The mature grain is well protected against most parasites.

Basal Glume-rot (Bacterium atrofaciens).—Histological studies reveal large pockets of bacteria in the parenchyma of the pericarp at the embryo end: there was no evidence of bacterial invasion beyond the testa and the embryo tisues appeared normal.

Scab (Fusarium spp.):—Kernels so severely affected that they resemble mummies, show the mycelium of the fungus in all tissues, pericarp, aleuron, endosperm and embryo. Such kernels never germinate. When a kernel is moderately affected, the fungus is particularly well established in the aleuron. Spreading from the crease towards the dorsal region, it appears to enter the embryo through the scutellum and is soon well established there. The endosperm is invaded later.

Black Point or Smudge, (Helminthosporium sativum and probably other fungi).—The work on this type is only in the preliminary stages.

Piebald.—This condition appears to be entirely an affection of the endosperm; the embryo in all of our examinations was normal in appearance. When thin sections are ground down the cracks or fissures (mentioned by Percival and others) in the endosperm radiating out from the crease can be readily seen.

Frost Injury.—There are different degrees of frost injury depending upon the stage of development and exposure to frost. Kernels showing a crinkled or blistery appearance were considered in these investigations. When prepared slides are examined the wrinkling of the pericarp is of course noted, and it is seen also that the parenchyma tissues are somewhat ruptured, in many cases the epidermis of the pericarp appears to be torn completely away from the other tissues. What appeared to be lesions were noticed occasionally in the tissues of the embryo.

Green Kernels.—The various shades of green noticed in some kernels are, it is believed, due to the remains of chloroplasts of the chlorophyllous layer or cross layer. Normally these disappear as the grain matures. Any condition which interferes with normal ripening may produce green grains. When the pericarps of such grains are examined, the cloroplasts in the cross layer are readily observed. Also other indications of immaturity can be noted, such as a few cloroplasts in the parenchyma of the pericarp and masses of tiny starch grains in the same tissues, especially over the embryo and in the crease region.

Pink Kernels.—Frequently kernels showing various shades of pink to red coloration appear in samples. This should not be confused with the pink spore mass of the scab fungus. The embryo and endosperm, with the exception of signs of immaturity, are normal. The coloration appears to be in some part of the pericarp and further studies are needed in order to determine its significance.

Root-rot Survey for 1929

The staff of the laboratory carried on the survey in a manner similar to that of last season, no special trips were made, but observations of our regular root-rot study fields and following up inquiries made it necessary to cover all the important crop districts of Saskatchewan. The extremely dry weather interfered greatly with the diagnosis of these diseases. The following is a summary of the results:

Total fields visited and reported—	
Wheat	481
Oats	96
Barley	70
Rye	16
Flax	3
	666

Table 61.—Distribution of Root-rot Types and Severity in Different Cereals

Crop	Root-rot type	Trace	Slight	Medium	Severe	Total
Wheat	A. Take-all	49	15	5	7	76
	B. Pre-maturity blight	17	3	0	1	21
	C. Browning	35	42	16	2	95
	D. *Helm.* and *Fus*	111	142	95	16	364
	Normal					59
Oats	B	1	1	0	0	2
	D	10	31	5	1	47
	Normal					47
Barley	A	1	0	0	0	1
	B	1	0	0	0	1
	C	2	5	1	0	8
	D	19	19	6	0	44
	Normal					22
Rye	C	1	0	0	0	1
	D	2	11	0	0	13
	Normal					3
Flax	Normal					3
	Totals	249	269	128	27	807

The outstanding difference this season was the predominance of "D" type. Good cases of pre-maturity blight were difficult to distinguish as in general the dry weather caused the plants to ripen rapidly. There were not as many cases of take-all reported but in all probability the symptoms were masked by lack of rain.

Three fields of flax were examined and reported normal. A sample of flax was received from Swift Current which apparently was suffering from root-rot, but the extent of the injury was not determined.

There were 481 fields of wheat examined and in these the percentage distribution of types are as follows:—

Fields having 1 type	297 or 61·7%
" 2 types	122 or 25·3%
" 3 types	7 or 1·4%
" 4 types	
" 0 type	58 or 11·6%

In comparing the estimation of damage for the past two seasons and for all types, the records are as follows:—

——	1928	1929
Total number of cases	531	807
	per cent	per cent
Number injury	18·9	16·5
Injury trace	40·1	31·0
" slight	27·1	33·3
" moderate	10·7	15·9
" severe	3·2	3·3

ROOT-ROT FIELD INVESTIGATIONS

Last season nineteen fields supposedly suffering from a chronic root-rot condition were selected for a survey study to cover a period of years. This season all of these fields were visited and careful notes made. One field was dropped from our list as being unsuitable, while three new fields were added. These twenty-one fields are scattered over the province and represent fairly well the various crop districts. Other fields will be added from time to time until in all probability a total of twenty-five are selected.

The very general dry weather this season interfered greatly with diagnosis so that taking notes on the various fields was a difficult task. Plans of each field were drawn up and will be useful in compiling the data obtained to date. There were no outstanding relations noted except the general prevalence of *Helminthosporium* and *Fusarium* type of lesions. It is not thought necessary to report here the mass of detailed notes obtained so far.

General Notes

For the past three seasons some tests were carried out in the greenhouse and field, the object of which was to study the reaction of the wheat plants when the root system is injured by artificial means. These tests were merely of an exploratory nature but the results have proved so interesting that it was thought wise to study the data carefully, to see if it could be interpreted in the light of root-rot symptomatology. It is hoped that the details of these tests can be collected and published as a separate paper. It was determined that when the seminal roots are amputated or the subcrown internode severed before crown roots were well established, the plants suffer a great shock and often die. When crown roots are amputated the injury is about in proportion to the number of roots lost. Plants which recover, show the ill effects of the injury throughout the remainder of their period of growth, never completely recovering from the setback brought on during the shock period. There is some evidence to show that crown root injuries tend to encourage maturity, while injuries upon the subcrown internode or seminal roots, cause a delay in ripening. Such reactions are of interest, for certain of the root rot diseases appear to influence the plants in a similar manner.

Our test on moisture in wheat in relation to the fungous content, viability and so forth was cut down considerably this year because of the very dry season. Enough samples were run, however, to maintain continuity and it is hoped to enlarge this test in the near future.

Smut Investigations

(I. L. Conners)

The experiments in 1929 were limited to a study of recent methods of controlling wheat bunt and the smuts of oats by seed treatment.

Wheat Bunt

Bunt in durum wheat continues to be a serious disease in this crop. Approximately five per cent of all the durum wheat inspected by the Dominion Grain Inspection Service in Winnipeg was graded "smutty" in 1928, and, of a large number of samples examined personally, 75 per cent showed at least traces of bunt. In addition many farmers have reported that they found it difficult to control bunt in durum wheat. In the experiments conducted in 1928 bunt balls were present in the grain when it was treated. Under these circumstances only the formalin steep treatment, where the grain was immersed in the formalin solution and the bunt balls floated out, satisfactorily controlled the bunt. The amount of bunt that developed in the remaining plots strongly suggested that the other treatments were unreliable. For these reasons experiments on a somewhat larger scale were carried out this year at Brandon, Man., and Indian Head, Sask., in co-operation with the Dominion Experimental Farms at these places.

Mindum wheat from the previous year's experiment was used for seed. The seed was inoculated with bunt spores at the rate of one part of smut to 400 parts of seed by weight. Bunted heads of the wheat had been collected at the close of the previous experiment. These were crushed in a mortar and the spores were passed through a 200-mesh sieve to free them from chaff and awns. The spore load of 1:400 here used completely fills the limited brush of the durum wheat seed and gives a scarcely noticeable coating of spores over the rest of the seed. As the brush of the seed of common wheat is more extensive a heavier spore load must be used to make the inoculation comparable.

As the bunt balls tend to remain intact in durum wheat some of the treatments were duplicated, using inoculated seed that also contained unbroken bunt balls. For this purpose bunt balls from the same source as the spores were added to a portion of the inoculated grain at the rate of 2 parts of balls to 100 parts of seed by weight. By count this rate was equivalent to almost $4\frac{1}{2}$ bunt balls per 100 seeds.

An examination of the spores from 25 heads taken individually showed that the bunt was due entirely to *Tilletia Tritici*.

After inoculation the seed was treated as follows:—

(1) *Formalin Sprinkle*.—Through the kindness of the Chemistry Department, Manitoba Agricultural College, Winnipeg, Man., the formalin used in these experiments was analyzed by them for the writer. Analysis showed that it contained 38·4 per cent of formaldehyde. The standard formalin solution of 1 pint of formalin to 40 gallons of water was made up to strength. Instead of sprinkling the seed with the solution, the seed to be treated was placed in an Ehrlenmeyer flask of suitable capacity and 12·5 cc. of formalin solution were added for each 100 grm. of seed. This is equivalent to $\frac{3}{4}$ gal. of formalin solution per bushel. The flask was then corked and shaken until the seed was evenly wetted. The amount of liquid was sufficiently limited so that the seed would readily absorb it all. After a thorough shaking the seed was transferred to a beaker, and was covered with filter paper previously moistened with the formalin solution. The seed was then allowed to stand four hours, after which it was spread out to dry.

(2) *Dust Treatments.*—The dusts were applied at the rate of 3 ounces per bushel. The seed was shaken with the dust in an Ehrlenmeyer flask until the seed was evenly coated. Three dusts were used, namely:—

Deloro copper carbonate is a brand of copper carbonate containing 20 per cent of copper. It is manufactured by the Deloro Chemical Co., Toronto, Ont.

Mococo copper carbonate is a brand containing 50 per cent copper, i.e. it is a commercially pure copper carbonate. It is manufactured by the Mountain Copper Co., San Francisco, Calif.

Ceresan. The active principle of Ceresan is ethyl mercury chloride. This dust is manufactured by I. E. du Pont de Nemours Co., Inc., Wilmington, Del.

(3) *Concentrated Solution Treatments.*—The organic mercury compounds were first used in dilute watery solutions. The seed was soaked in the solution from one-half to two hours. Through the absorption of considerable water the seed in consequence was difficult to dry. On the other hand these compounds were costly when applied as dusts. The worker also found the application of the dust to the seed and the subsequent sowing of the treated grain disagreeable, and frequently dangerous to his health. Moreover the dust treatments did not give consistent results. Gassner (cf. Rev. Appl. Myc. 6:278-9, 1927) sought to combine the advantages of the two types of treatment by using more concentrated solutions of the compounds and applying smaller quantities of liquid. For treating seed on a large scale, revolving drums, similar to those used in applying dust fungicides, must be used so that the liquid may be spread quickly and uniformly over the surface of the seeds. Gassner reported considerable success in the control of wheat bunt by this method.

Four organic mercury compounds were applied by this method. Half of one per cent solutions were used throughout. The seed was placed in an Ehrlenmeyer flask for treatment, 5 cc. of the liquid were added, and the flask was shaken immediately. The shaking was continued until the liquid was distributed as an even film over the seed surfaces. The seed was then transferred to a beaker, where it was covered for one hour. After treatment the grain appeared as dry as seed treated by the formalin sprinkle method, and, in practice, could be sown at once without drying. Two of the organic mercury compounds, Germisan and Tillantin, are preparations well-known in Germany. Du Pont No. 12 and Semesan are du Pont products.

The above treatments were carried out on the smutty grain. In addition, the formalin sprinkle and the dust treatments were repeated, using the smutty grain containing bunt balls.

Besides the above experiment with durum wheat, another experiment was conducted in which these treatments were repeated using smutty common wheat. Ceres wheat from the 1928 crop was inoculated with bunt spores at the rate of one part of smut to 250 parts of seed by weight. The bunt material was from the same source as used in the durum wheat. As it has been abundantly proved for common wheat that the bunt balls must be removed before or during treatment if the treatment is to be effective, the part of the experiment where bunt balls were added to the seed was not included.

The seed was treated at the Dominion Rust Research Laboratory, Winnipeg, Man. A part of each lot of treated seed was sent to the Dominion Experimental Farms at Brandon, Man., and Indian Head, Sask., where it was sown.

Each lot of treated seed was sown in single rod-rows in quadruplicate, at the rate of 20 gram. per rod-row for durum wheat and 15 gram. for common wheat respectively.

The percentage of bunt was estimated by making two counts of 100 heads each from each row and recording the number of bunted heads. The percentage for each treatment was, therefore, based on a count of 800 heads. In order to detect with certainty infected heads in durum wheat, a section of each row was cut out with a sickle, the required 200 heads counted out, and then the heads in groups of two or three were cut through several times with shears. The results of these experiments are shown in table 62.

Weather conditions were unusually favourable for the development of wheat bunt this past season in western Canada. The season permitted early sowing when the soil temperature was comparatively low, and, in addition, no rain fell during the early part of the growing period. In the untreated plots 50 to 60 per cent of the heads of the durum wheat were infected, while 20 per cent of bunt developed in the common wheat. As is shown in Table 62, the formalin sprinkle treatment most effectively controlled bunt, but, under the unusually favourable conditions for its development, a small amount of bunt occurred even with this treatment. Of the dusts, Ceresan gave quite satisfactory results. As this fungicide has not been previously tested, so far as I am aware, in Western Canada; and, as it has proved satisfactory against oat smuts, as also in experiments to be reported later, it deserves to be tested further against these smuts. Mococo copper carbonate was almost as effective as Ceresan, while the Deloro brand failed to control the bunt in durum wheat. These results agree with those of last year. In previous experiments with common wheat, brands of copper carbonate such as Mococo, which contain 50 per cent copper, have given but slightly better control than brands of only 20 per cent copper content, but the difference has never been considered sufficient to warrant the recommendation of brands of the first mentioned class, on account of their greater cost. In the light of these experiments, however, only Mococo and similar brands containing 50 per cent copper may be recommended for the control of bunt in durum wheat.

Table 62.—Control of Bunt in Durum and Common Wheats by Seed Treatment

Treatment	Percentage of bunt in			
	Durum wheat		Common wheat	
	Brandon, Man.	Indian Head, Sask.	Brandon, Man.	Indian Head, Sask.
Bunt balls absent—				
Formalin sprinkle	1·5	0·1	0·8	0·1
Dust treatments—				
Deloro copper carbonate	10·6	12·5	1·4	5·0
Mococo copper carbonate	1·8	2·8	0·4	0·9
Ceresan	1·4	0·8	1·6	1·9
Untreated (check)	64·3	51·8	21·0	20·4
Concentrated solution treatments—				
Germisan	6·9	2·8	2·5	2·9
Du Pont No. 12	9·1	3·4	4·8	3·3
Semesan	41·4	18·0	9·1	11·3
Tillantin	3·0	1·3	1·8	2·5
Untreated (check)	67·0	52·1	19·4	20·6
Bunt balls present—				
Formalin sprinkle	4·3	0·3	....	....
Dust treatments—				
Deloro copper carbonate	20·5	17·3	....	....
Mococo copper carbonate	14·5	19·3	....	....
Ceresan	6·3	3·9	....	....
Untreated (check)	59·9	55·0	....	....

The results obtained with the organic mercury compounds, where the seed was treated with concentrated solutions of the compounds in water, were disappointing. Tillantin and Germisan can hardly be considered effective under the exacting conditions of these experiments, but, by increasing the concentration of the solution or the amount of liquid applied, these fungicides may prove effective. It is very doubtful whether Du Pont No. 12 or Semesan could be used successfully.

The addition of bunt balls to the smutty grain greatly impaired or completely destroyed the value of the seed treatment. Nor is it to be supposed that the quantity of bunt balls that was added was excessive. Samples of smutty durum wheat having an equal or greater content of bunt balls have been frequently observed. This experiment proves conclusively that durum wheat is no exception to the rule that the bunt balls must be removed from the grain, if seed treatment is to be successful. Their removal can be only accomplished by careful fanning before treatment, or by immersing the grain in a liquid fungicide and floating out the bunt balls.

In addition to the above experiments on the control of bunt in common wheat, several other fungicides were tested in an experiment at Charlottetown, P.E.I. As very little bunt developed in the untreated rows there, the results are worthless.

LOOSE AND COVERED SMUTS OF OATS

Seed treatment experiments in the control of covered smut of oats and, to a limited extent, of loose smut also have been conducted in the Prairie Provinces for several years. Similar experiments have been carried out independently at some of the Dominion Laboratories of Plant Pathology in Eastern Canada. This year these experiments were replaced by a uniform series of experiments with both smuts under the direction of the writer. Nine places co-operated in carrying out the experiments, viz., the Dominion Experimental Farms at Brandon, Man., and Indian Head Sask.; and the Dominion Laboratories of Plant Pathology at Edmonton, Alta.; Saskatoon, Sask.; Ottawa, Ont.; Ste. Anne de la Pocatière, P.Q.; Fredericton, N.B.; Kentville, N.S.; and Charlottetown, P.E.I. The seed was inoculated and treated at the Dominion Rust Research Laboratory, Winnipeg, Man. The co-operating stations sowed the seed and took care of the plots. In addition the various laboratories made the smut estimates and collected other data on the experiments.

Longfellow oats from the 1928 experiment at Indian Head were used for seed. They were treated by the standard formalin steep method, and then spread out to dry. The following day the seed was thoroughly washed in three changes of water to remove all traces of the formalin, and then thoroughly dried. This precaution was taken to insure that the seed was free of any previous contamination of smut.

As loose smut of oats is more prevalent in Eastern Canada than in the West, collections of both loose and covered smut from the two regions were used in these experiments. As far as possible the seed to be sown in a given province was inoculated with smut from that province. Five collections of loose smut were used in the experiments. These were labelled as follows: No. 1 from a field near Kentville, N.S., showing 24 per cent of loose smut and 10 per cent of covered; No, 2 from Fredericton, N.B.; No. 3 from Charlottetown, P.E.I.; No. 4 from the smut plots, Winnipeg, Man.; No. 5 from a field at Ste. Anne de la Pocatière, showing 12-15 per cent of smut. The three collections of covered smut used originated as follows: No. 6 at Kentville, N.S., from the same field as No. 1; No. 7 from Fredericton, N.B.; and No. 8 from the smut plots, Winnipeg. Collections 3 and 8 of loose and covered smut respectively were from strains of two smuts which have been used extensively in previous experiments by the writer in the Prairie Provinces. A fresh collection of each strain was made each year for the next year's experiments.

As far as it could be determined by microscopic examination of the spores each collection appeared to be composed entirely of *Ustilago Avenae* or *U. levis*. As a further check, at Brandon and Indian Head the plots were examined for admixtures. In the experiment at Brandon using loose smut from Kentville, 11 per cent of the smutted heads were destroyed by covered smuts. In the other experiments at Brandon and Indian Head only traces of admixtures were observed.

Spore inoculum was prepared from each collection as follows: the smutted heads were crushed in a mortar and the spores were freed from the chaff by passing through a 200-mesh sieve. The spores from each collection were kept separately in dry well-stoppered bottles. After working with a collection, all utensils were thoroughly washed and dried to prevent the carrying over of spores from one collection to the next. Each lot of seed was inoculated separately, the spores being applied to the seed at the rate of one part of smut to 1,000 parts of seed by weight. The seed was shaken with the spores in a covered pail until the spores were evenly distributed on the seed. Sufficient water was then added to wet the seed, and the whole again vigorously shaken. The inoculated seed was kept moist for 24 hours, and then spread out to dry slowly. The recent work of Gage on these smuts suggested that this might be a satisfactory procedure. The seed was inoculated a month before it was treated.

The seed was treated as follows:—

(1) *Formalin Treatments.*—Formalin was used as a fungicide in two different treatments, which I have called the "sprinkle" and "spray" treatments respectively, although the details of the treatments have been modified to some extent. In the sprinkle treatment the usual formalin solution of one pint of formalin to 40 gallons of water used. The seed to be treated was placed in a flask and 22 cc. of the solution were added for each 100 gram of seed. This rate is equivalent to $\frac{3}{4}$ gal. per bush. The flask was shaken vigorously until the liquid was evenly distributed throughout the seed mass. The seed was then transferred to a vessel where it was kept covered for 4 hours with filter paper moistened in the formalin solution. After treatment the seed was spread out to dry.

In the spray treatment a formalin solution containing 1 pint of formalin to 8 gallons of water was made up. The seed was placed in a flask and 4·4 cc. of the solution were added for each 100 gram of seed. This quantity of the concentrated solution was used as it contained the same number of units of formaldehyde gas as 22 cc. of the standard solution used in the sprinkle treatment. The flask was then vigorously shaken until the seed was evenly wetted. The seed was then covered for four hours, after which it was spread out to dry.

(2) *Dust Treatments.*—The dust fungicides were used at the rate of 3 oz. of dust per bushel of seed. They were applied by shaking the seed with dust in a flask until the grain was evenly coated. Two dusts were used, viz., Smuttox and Ceresan.

Smuttox is the trade name, adopted by the Grasselli Chemical Co., Cincinnati, Ohio, for a dust prepared by mixing formalin with infusorial earth. Their product was used in these experiments. Ceresan is a Du Pont dust, which was also used against wheat bunt.

(3) *Concentrated Solution Treatments.*—These treatments do not need to be discussed at length, as considerable space has already been devoted to them

under a similar heading above (see page —). Germisan, Du Pont No. 12, and Semesan were the organic mercury compounds used. Half of one per cent solution was applied to seed, at the rates of 4, 8, and 12 cc. per 100 gram. of seed respectively, and one per cent solution at the rate of 8 cc. per 100 gram. The seed to be treated was placed in a flask, the required amount of solution added, and the flask shaken, until the liquid was evenly distributed over the seed. The moist seed was kept covered for one hour, and then spread out to dry.

The formalin and dust treatments were included in every experiment, but only one organic mercury compound was tested by the concentrated solution method at each station, except at Brandon and Indian Head, where all three were included.

The results of the seed treatment experiments for the control of the loose and covered smuts of oats are given in tables 63 and 64, respectively. The amount of smut that developed in the untreated check rows varied greatly at the different stations, although the same method of inoculation and, in many instances, the same spore material were used at more than one station. In general, at the stations in the Prairie Provinces smut development was good, while at the Eastern stations smut did not develop sufficiently in the check rows to make the results from these experiments of more than confirmatory value. These experiments show conclusively that the formalin sprinkle and spray treatments controlled both smuts satisfactorily, eliminating the smut entirely in most instances. The dust fungicides, Ceresan and Smuttox, were both highly efficient. Several dusts have been tested by the writer in former years in experiments for the control of covered smut in common oats, and in no instance were the results as promising as they are here. The volatile nature of the active principle in each of these two dusts probably accounts for their effectiveness in oats, where the caryopses are enclosed by the glumes.

The concentrated solution treatments with Germisan, Du Pont No. 12, and Semesan were unsatisfactory. None of the treatments with Du Pont No. 12 and Semesan effectively controlled these smuts. Of the four treatments, in which Germisan was used, the latter two may have been said to have held the smuts in control, reducing the infection on the average to about one per cent.

Two lots of 100 seeds each of each treatment were sown in rows in the open at Charlottetown, P.E.I., Fredericton, N.B., and Ste. Anne de la Pocatière, P.Q., and the percentage germination recorded. The results show that these fungicides cause no injury to the germination of the seed, the treated seed germinating in every case almost as well as the check.

Rod-rows of the two experiments at Ste. Anne de la Pocatière, P.Q., were harvested and the yields determined. The probable error of each experiment was calculated by the deviation from the mean method. The difference in yield between the check and any one of the treatments, or between any two treatments, would not be considered significant, as the greatest difference in the yield of any two treatments was 2·2 times the probable error of the difference.

Thanks are due to the Laboratories and Experimental Farms which co-operated in conducting the experiments here reported.

TABLE 63.—CONTROL OF LOOSE SMUT IN OATS BY SEED TREATMENT

Treatment	Percentage of Smut									
	Kentville, N.S.	Fredericton, N.B.	Charlottetown, P.E.I.	Ste. Anne de la Pocatière, Que.	Ottawa, Ont.	Brandon, Man.	Indian Head, Sask.	Saskatoon, Sask.	Edmonton, Alta.	Average
Formalin treatments—										
Sprinkle	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
Spray	0·0	0·0	0·0	0·3	0·0	0·0	0·0	0·3	0·0	0·1
Dust treatments—										
Smuttox	0·0	0·0	0·0	0·1	0·1	0·1	0·0	1·1	0·0	0·2
Ceresan	0·0	0·0	0·0	0·4	0·4	0·0	0·1	1·0	0·8	0·3
UNTREATED (check)	1·4	0·5	2·8	2·3	2·9	13·5	15·4	21·1	13·8	8·2
Concentrated solution treatments—										
Germisan 0·5 per cent sol., 4:100	1·4	......	......	2·1	......	6·9	7·3	16·5	......	6·8
" 0·5 " 8:100	0·3	......	......	0·1	......	2·1	2·6	7·9	......	2·6
" 0·5 " 12:100	0·2	......	......	0·1	......	0·4	0·5	2·9	......	0·8
" 1·0 " 8:100	0·3	......	......	0·1	......	0·1	0·3	2·3	......	0·6
UNTREATED (check)	2·1	......	......	4·3	......	13·6	14·9	19·0	......	10·8
Du Pont No. 12 0·5 per cent sol., 4:100	......	7·1	......	......	......	9·5	7·9	......	12·6	9·3
Du Pont No. 12 0·5 per cent sol., 8:100	......	2·9	......	......	......	3·4	5·1	......	10·0	4·3
Du Pont No. 12 0·5 per cent sol., 12:100	......	2·8	......	......	......	2·4	1·6	......	4·5	2·8
Du Pont No. 12 1·0 per cent sol., 8:100	......	2·3	......	......	......	3·8	2·5	......	4·0	3·2
UNTREATED (check)	......	1·5	......	......	......	17·5	17·4	......	12·0	12·1
Semesan 0·5 per cent sol., 4:100	......	......	12·6	......	9·8	12·8	7·4	......	......	10·6
" 0·5 " 8:100	......	......	5·7	......	10·8	5·1	12·9	......	......	8·6
" 0·5 " 12:100	......	......	4·2	......	5·4	2·4	3·5	......	......	3·9
Semesan, 1·0 per cent sol., 8:100	......	......	6·0	......	7·3	1·6	5·4	......	......	5·1
UNTREATED (check)	......	......	10·4	......	8·8	14·4	12·3	......	......	11·5
Collection of Smut used	No. 1	No. 2	No. 3	No. 5	No. 5	No. 1	No. 5	No. 4	No. 4	......

TABLE 64.—CONTROL OF COVERED SMUT IN OATS BY SEED TREATMENT

Treatment	Percentage of Smut									
	Kentville, N.S.	Fredericton, N.B.	Charlottetown, P.E.I.	Ste. Anne de la Pocatière, Que.	Ottawa, Ont.	Brandon, Man.	Indian Head, Sask.	Saskatoon, Sask.	Edmonton, Alta.	Average
Formalin treatments—										
Sprinkle	0·0	0·1	0·0	0·3	0·1	0·1	0·0	0·3	0·0	0·1
Spray	0·0	0·1	0·0	0·1	0·0	0·0	0·0	0·3	0·0	0·1
Dust treatments—										
Smuttox	0·1	0·0	0·3	0·9	1·0	0·0	0·5	6·3	1·4	1·2
Ceresan	0·3	0·3	0·0	0·5	1·1	0·1	1·0	0·9	3·8	0·9
UNTREATED (check)	2·0	5·4	6·6	7·0	23·5	14·8	16·5	19·5	31·5	14·1
Concentrated solution treatments—										
Germisan 0·5 per cent sol., 4:100	1·1	......	......	6·4	......	11·5	13·3	14·8	......	9·4
" 0·5 " 8:100	0·4	......	......	2·4	......	2·3	4·9	8·4	......	3·7
" 0·5 " 12:100	0·2	......	......	1·0	......	0·9	1·6	3·1	......	1·4
" 1·0 " 8:100	0·2	......	......	1·3	......	0·3	1·0	2·8	......	1·1
UNTREATED (check)	1·5	......	......	6·0	......	16·8	15·3	21·0	......	12·1
Du Pont No. 12 0·5 per cent sol., 4:100	......	10·9	......	......	......	11·7	15·5	......	23·8	15·5
Du Pont No. 12 0·5 per cent sol., 8:100	......	5·4	......	......	......	5·5	5·6	......	25·0	10·4
Du Pont No. 12 0·5 per cent sol., 12:100	......	4·5	......	......	......	3·1	4·3	......	13·5	6·4
Du Pont No. 12 1·0 per cent sol., 8:100	......	4·4	......	......	......	1·6	4·5	......	14·6	6·3
UNTREATED (check)	......	11·5	......	......	......	15·0	19·3	......	33·0	19·7
Semesan 0·5 per cent sol., 4:100	......	......	9·9	......	19·0	13·6	16·4	......	......	14·7
" 0·5 " 8:100	......	......	12·4	......	21·6	7·1	12·0	......	......	13·3
" 0·5 " 12:100	......	......	9·3	......	12·6	5·0	7·8	......	......	8·7
" 1·0 " 8:100	......	......	10·4	......	14·1	7·4	11·0	......	......	10·7
UNTREATED (check)	......	......	16·9	......	21·6	16·8	17·1	......	......	18·1
Collection of Smut used	No. 6	No. 7	No. 8	No. 8	No. 8	No. 6	No. 8	No. 8	No. 8	......

SECTION IV

INVESTIGATIONS OF THE DISEASES OF FRUITS AND VEGETABLES

REPORT OF THE DOMINION PLANT PATHOLOGICAL LABORATORY, SUMMERLAND, B.C.

(R. H. McLarty, Officer in Charge)

ZINC CHLORIDE IN THE CONTROL OF FIRE BLIGHT

J. C. Roger

The investigation, as to the effectiveness of zinc chloride in the control of fire blight, has been carried on for two consecutive seasons. Last year the results were somewhat conflicting, but did not altogether refute the efficiency of this method of control. Consequently, it was thought advisable to make further tests in orchards in Penticton this year.

With the assistance of the provincial horticultural staff, the cankers on trees in several orchards were painted as they appeared during the growing season, with 43 per cent zinc chloride.

Fig. 30.—Showing how the suspected area is treated to check the spread of fire blight.

Some different effects of this treatment on cankers were observed during the summer months. The best results were obtained when the diseased area was painted soon after the infection took place. Whereas, if a canker had become so long established, that it completely girdled the limb or trunk, this treatment did not prove satisfactory. Twigs or small limbs, less than 1½ inches in diameter, were generally killed off by the penetration of the zinc chloride. In cases, however, where a larger limb was endangered by an infected smaller twig, the twig and suspected area were painted over and the spread of the blight checked (fig. 30). When a running canker girdled a limb, loaded with fruit, zinc chloride generally dried up the ooze, allowing the branch to remain until after harvest time, without causing further infection throughout the orchard. The ability of this solution to check fire blight in pear trees varied, even in trees of the same variety and grown under similar conditions. Therefore, further trials will have to be made before general recommendations can be given for the practical use of zinc chloride in controlling fire blight in orchards.

THE RESISTANCE OF CERTAIN PEAR SPECIES AND VARIETIES TO FIRE BLIGHT

The experiment to test out the resistance to the fire blight organism (*Bacillus amylovorus* (Burr.) Trev.) of certain species and varieties of pears has been carried on at the Summerland laboratory for a number of years. The species and variations were secured in 1923, 1924 and 1925 by obtaining, from different sources, scions from supposedly resistant pears and grafting them on *Pyrus ussuriensis* stock. The S.P.I. varieties were procured from M. B. Waite, United States Department of Agriculture, the "Lih" pears were secured from Mr. Parsons, West China, and the remaining scions were collected from apparently resistant trees throughout the valley.

These pear varieties were inoculated with the pathogene during the seasons of 1924, 1927 and 1928, the results of which have already been tabulated in the 1928 Annual Report of the Dominion Botanist. Inoculations were made during the past season on May 22, 1929, and the results are shown in table 65.

TABLE 65.—RESISTANCE OF PEAR SPECIES AND VARIETIES TO FIRE BLIGHT ORGANISM *(B. amylovorus)*

Inoculations were made on May 22, 1929

Species or variety	Number of inoculations made	Number of inoculations taking	Remarks
Patten	5	5	Took freely.
Flemish Beauty	6	5	Took freely; 4 cases of natural infection.
Rimes Pineapple	19	0	No infection.
S. P. I. 49489	7	0	No infection.
S. P. I. 49490	11	0	No infection.
S. P. I. 49492	10	0	No infection.
S. P. I. 49494	4	0	No infection; 1 free-running, natural infection.
S. P. I. 49495	4	0	No infection.
S. P. I. 52461	7	0	No infection.
S. P. I. 52462	6	0	No infection.
S. P. I. 52464	7	0	No infection.
Muh Kua Lih	2	2	Took fairly freely.
Ruh Shiang Lih (The Scented Pear)	8	0	No infection.
Siao Huang Lih (The Little Yellow Pear)	7	0	No infection.
Ta Huang Lih (Big Yellow Pear)	7	0	No infection.
Suan Lih (The Sour Pear)	5	3	Took fairly freely.
Pyrus assuriensis	4	0	No infection; natural infection in the main trunk of the tree has caused a large canker.
Seedling Pear from Sicamous	8	0	No infection.

BORDEAUX SPRAY FOR THE CONTROL OF BLOSSOM BLIGHT IN PEARS

Much progress could be made towards the eradication of fire blight if there was a reliable method to check the active blight centres, which are established in pear orchards, when the blossoms become infected. For when the bacterial exudate from these sources is washed down by rains, the infection rapidly advances into the leaves, twigs, branches, and sometimes the main trunk of the tree. Midwestern orchardists were fairly successful in checking this initial infection of bacteria in apple trees, by applying, at blossom time, a weak solution of Bordeaux spray. Considering the evident advantages of such a preventive measure, the laboratory at Summerland determined to experiment with Bordeaux sprays, in an attempt to control blossom blight and check the advance of the disease in pear orchards. With the assistance of the Provincial Horticultural Department an orchard was secured at Penticton in which to try out the efficiency of this spray.

The orchard consisted of an equal number of trees of each of the following varieties: Anjou, Flemish, and Bartlett, which were severely infected with blight in 1928. During the winter, the usual commercial practice of removing all cankers was carried out. The orchard was divided into three similar plots each containing 80 trees, which, in the spring, were treated severally as follows:—

Plot 1 was sprayed with Bordeaux 3-4-40, when the trees were in the late pink and again when in full blossom.

Plot 2 did not receive any spray but was left as a check.

Plot 3 was sprayed with Bordeaux 3-4-40, when the trees were in full blossom only.

After the fruit had set, a careful examination of the blossom clusters failed to reveal any marked difference in the amount of initial infection on the three plots. Furthermore, the later spread of the disease was in direct proportion to the amount of primary infection. These observations would indicate, that spraying with Bordeaux was not effectual in controlling Fire Blight in this orchard.

However, as these test plots suffered no serious outbreak of the disease, as did the adjacent orchards, it will be necessary to continue this experiment another year in order to thoroughly investigate this method of control.

ANTHRACNOSE SPRAY EXPERIMENTS IN SALMON ARM

In last year's annual report, a full account was given in explanation of a spray experiment for the control of anthracnose in Salmon Arm. Observations this spring disclosed the following results on the comparative efficiency of the three treatments:—

In Plot 1, which was sprayed on August 14 with Burgundy mixture and again on October 10 with Bordeaux 4-4-40, the disease was commercially well controlled, but for a residue deposited on the fruit by the first spray. The unusually dry weather, which prevailed before harvest time, necessitated the washing of all the apples shipped from this plot.

In Plot 2, which was sprayed with Bordeaux 3-5-40, with the addition of 2 per cent oil, the spread of the disease was fairly well checked. The fruit, however, in this case, was coated with an oily deposit which rendered imperative the wiping by hand of every apple before shipping. The use of this spray, while the apples are still on the trees, would be decidedly unprofitable.

In Plots 3 and 4, which were dusted with colloidal sulphur dusts, obtained from two different sources, no apparent control was observed, as evidenced by comparison with the check trees.

Although there would appear to be a distinct decrease this year in the spread of anthracnose in the Salmon Arm district, the unusually dry fall may have been the contributing factor. Therefore, a new series of spray tests are being tried out, which were applied just after the first general dissemination of the spores. It is to be hoped that the results from this endeavour will materially assist in effectualy controlling any severe outbreak of the disease in the future.

PERENNIAL CANKER

(a) *Survey.*—A careful survey of the southern districts, commenced in 1928, has revealed the fact that the wide distribution of perennial canker is not confined to the northern sections of the Okanagan Valley. The disease first began to attract attention when it was recognized in 1924 at Okanagan Centre, and later when it was found to be prevalent in Winfield, Kelowna, Oyama, and Vernon. It was not discovered in the districts south of Kelowna, where it had been previously rare or absent, until the summer of 1928, when several affected trees were located in Summerland. Consequently, the necessity was emphasized of examining the apple sections where the infection had apparently not occurred. A careful estimation of the prevalence and spread of the disease was requisite before any practical recommendations could be given for its control.

During the winter of 1928-29 the districts of Kaleden, Keremeos, Summerland, and Penticton were surveyed. As the nature of the disease required a thorough tree to tree inspection, local orchardists were appointed to carry out the field work, under the supervision of the provincial horticultural staff. When infected or doubtful trees were found they were tagged, and their location was carefully charted on a card. A member of the Laboratory Staff examined the suspected trees in order to verify or disprove the presence of the fungus.

As revealed by the results of the survey, the disease is present, but not severe, throughout the inspected districts. Infected orchards were found in all sections of the districts, but, the average number of affected trees per orchard was usually less than ten. From observations of the various cankers, the number of rings would indicate that the disease has been established for several years. This survey is being continued this year in the districts of Westbank, Peachland, and Naramata. The detailed results of the progress made during the past season are given in table 66.

TABLE 66.—RESULTS OF PERENNIAL CANKER SURVEY OF SUMMERLAND, PENTICTON, KALEDEN, AND KEREMEOS DISTRICTS

Name of variety	Name of district	Number of trees in the district	Number of trees showing one or more cankers	Percentage infection
Cox's Orange	Summerland	1,189	17	
	Penticton	1,381	10	
	Kaleden	260	....	
	Keremeos	65	....	0·93
Spitzenberg	Summerland	2,943	53	
	Penticton	4,542	14	
	Kaleden	151	....	
	*Keremeos	1,817	6	0·77
Baldwin	Summerland	997	11	
	Penticton	342	....	
	Kaleden	....	....	
	Keremeos	481	....	0·60
Rome Beauty	Summerland	3,186	3	
	Penticton	3,135	23	
	Kaleden	287	....	
	Keremeos	394	....	0·37

TABLE 66.—RESULTS OF PERENNIAL CANKER SURVEY OF SUMMERLAND, PENTICTON, KALEDEN, AND KEREMEOS DISTRICTS—*Concluded*

Name of Variety	Name of district	Number of trees in the district	Number of trees showing one or more cankers	Percentage infection
Yellow Newtown	Summerland	14,518	82	
	Penticton	6,837	8	
	Kaleden	3,875	2	
	Keremeos	2,025	....	0·34
Wagener	Summerland	9,369	8	
	Penticton	12,869	5	
	Kaleden	1,303	....	
	Keremeos	1,722	....	0·05
Wealthy	Summerland	2,696	1	
	Penticton	2,461	1	
	Kaleden	25	....	
	Keremeos	248	....	0·04
Winesap	Summerland	1,871	1	
	Penticton	6,412	5	
	Kaleden	1,861	....	
	Keremeos	3,762	....	0·04
Jonathan	Summerland	21,462	11	
	Penticton	19,267	5	
	Kaleden	2,167	....	
	Keremeos	5,785	....	0·03
McIntosh Red	Summerland	15,248	4	
	Penticton	12,356	3	
	Kaleden	531	....	
	Keremeos	1,540	....	0·02
Winter Banana	Summerland	1,802	1	
	Penticton	2,086	....	
	Kaleden	315	....	
	Keremeos	354	....	0·02
Delicious	Summerland	8,694	4	
	Penticton	13,586	....	
	Kaleden	317	....	
	Keremeos	5,595	....	0·01
Other varieties	Summerland	24,625	43	
	Penticton	9,949	31	
	Kaleden	424	....	
	Keremeos	3,863	....	0·18
Total	....	242,990	352	0·14

*Since this survey several more of the trees in this district have been reported as having perennial canker.

(b) *The Influence of Frost on the Spread of Perennial Canker.*—Observations would indicate that cold winter temperatures and resulting freezing of the callus are conducive to perennial canker. Growers, in whose orchards the disease has long been established, have noticed that the local increase in the amount of infected bark was greater after a severe winter. So apparently definite and consistent was the association of freezing temperatures and the spread of the disease, that many of them have attributed the development of the canker to frost alone. In the investigations carried on by the Summerland laboratory, it has been observed that low temperatures influenced the progress of the disease by presumably producing a temporary condition in the tree, favourable to the growth of the causal fungus. Consequently, an experiment was determined on to test out the relationship between the severity of the winter and the extent of the spread.

A plan was decided upon whereby a number of cankers would be effectively protected from frost during the winter. By examining the protected and exposed cankers in the spring, comparisons of the spread could then be definitely made. A Yellow Newtown tree was selected, which showed a large number of cankers heavily infested with woolly aphis. In the early autumn of 1928 a box was build around the tree, and filled with sawdust which covered the trunk and lower branches to the height of 8 feet. Two feet below the surface of the sawdust a minimum thermometer was placed to record the lowest temperature that would occur in the protected area around the tree. In April, when the spread of new infection is usually discernible, the box was removed. The thermometer recorded 32° F. plus a fraction, so therefore, all portions of the tree that were as equally insulated must have been free from frost. The following facts were noted:—

(*a*) In the protected area thirty-six cankers were examined and showed no increase in the spread of the fungus. In one, however, a thin black line indicated primary infection.

(*b*) In the area between the thermometer and the surface of the sawdust, the cankers showed varying degrees of spread of infection.

(*c*) In the area above the sawdust, the cankers showed 100 per cent, spread of infection.

The results of this experiment substantiate the observational evidences that a close relationship exists between low winter temperatures and the subsequent advance of the fungus.

CROWN ROT

The increase of crown rot in the orchards of the Okanagan Valley caused the laboratory to determine its prevalence and importance. In order to adequately investigate the extent of this particular disease, the earth from the crown and upper root system of every tree would have to be removed (fig. 31).

FIG. 31.—Illustrating the removal of the soil from the roots of a crown-rotted tree in order to investigate the extent of the rot.

By this method a complete, extensive survey in one season was not considered feasible. Therefore, several orchards only, in each district were inspected, and from the results it was estimated that this disease has destroyed at least 2 per cent, of the trees annually, in every district throughout the valley.

In the course of this inspection observations were made to discover, if possible, any apparent symptoms above ground of the disease. The invariable presence of bronze or dull red leaves was noticed on practically all affected trees during the months of September, October, and November. Bronzed foliage was also found on trees, whose crowns were free from disease, but suffered from some form of root killing. By making use of this fairly reliable indication of crown rot to generally examine an orchard, only closely inspecting the crowns of the doubtful trees, the labour and time would be greatly reduced in carrying out a thorough survey. Following this procedure, a more accurate estimate of the extent of the disease will be made next fall.

During this inspection characteristics of the form and occurrence of crown rot were observed. The type of rot responsible for the most widespread destruction of apple trees, attacks the tree just below the ground surface, usually advancing up on the trunk involving the bark and cambium tissue. The lesion area may only be a few inches in extent or it may completely girdle the crown of the tree, but, as a general rule, it seldom extends more than a foot and a half above or below ground. The rot may appear at any time during the growing season, but when it occurs after July, the diseased tissue is not easily distinguished from the healthy bark. At this time, and throughout the remainder of the season, there is usually no discoloration of the outer bark, and no crack is formed to separate the rot area from the surrounding healthy tissue. However, the under bark layers, when cut into, have a brown, watersoaked appearance, and the extent of the rot can be determined by removing the outer bark.

Several general physical factors were evident in all cases. Some varieties appeared to be more susceptible to this disease than others, but so far inspection work has been insufficient to justify the arrangement of a graded list, showing their degree of resistance. However, of the commercially important varieties, Spitzenberg seemed to be the most susceptible, and Wagener the most resistant. A super-moisture condition invariably prevailed during some period of the growing season in the soil surrounding affected trees. Whenever an extreme case of this condition of poor drainage and improper aeration occurred, as in orchards, where depressions retained for a time the irrigation water, trees growing in this area eventually developed serious crown rot. Furthermore, the disease was much more general in districts where an ample supply of water is obtainable than in those where there is a shortage. It was noted also, that late ripening orchards showed more crown-rotted trees, than did those which ripened thoroughly before going into the winter. From these observations, it may be deduced that unfavourable physical conditions are responsible for a weakening in the bark tissues at the crown of a tree.

Remedial Measures.—In an endeavour to alleviate the severity of this very difficult problem, experiments are being carried out in a series of control orchards throughout the valley. In these orchards, all trees are thoroughly inspected for crown rot twice a year. Physical conditions which may possibly have a bearing on the occurrence of the disease are noted, and in a few orchards where it is possible these factors are remedied, and a control orchard established. In all the orchards under treatment, the crown and upper root system of the affected trees are exposed to the air, the rot area is cleaned out, and the best known methods of relief are applied.

In the experiments which have been carried on at Winfield for a number of years, inarching has given slightly more promising results than the other methods of control (fig. 32). Although inarching is effective it is not sufficient to cope with the ever-increasing seriousness of the disease. Therefore, in the control orchards, established at Summerland and Penticton, the practice of exposing, disinfecting, and inarching will be continued, but in addition an effort will be made to control adverse physical factors.

PHYSIOLOGICAL DISORDERS

A complex problem is undertaken by the investigator, in endeavouring to check the occurrence of the various physiological disorders in apple and other fruit trees in the Okanagan Valley. The laboratory at Summerland has, since its establishment, made field observations and carried on experiments in connection with some of the more serious of these, namely, die-back, drought spot and corky core, as reported in the 1927 Annual Report of the Dominion Botanist. Climatic conditions, types of soil, and cultural practices have to be taken into consideration when attempting to rectify any physiological disturbance. However, distinct progress was made towards a solution of the problem, when rootlet killing was found to be definitely associated with these troubles. This was reported in 1927.

FIG. 32.—Inarched tree, illustrating seedlings after two years' growth.

Rootlet killing often results in this valley from a drought, or super-moisture state prevailing in the soil at some time during the growing season. In irrigated sections it would appear to be an easy matter to regulate the soil moisture. But the extreme variability of the retentive powers of the soil, due to the variations in formation found in different orchards and parts of orchards, renders the proper application of water a difficult task. Correcting the drought condition and maintaining an optimum moisture content of the soil in the test orchards at Salmon Arm first demonstrated the practicability of this method of control. Further investigations in other districts have since corroborated this evidence.

In 1928 a series of control orchards were established throughout the valley. In conjunction with our field investigations, an advisory service, inaugurated at the request of the growers, was continued in practically all these orchards.

The increase this year of die-back, drought spot, and corky core, general in all sections of the Okanagan, was most pronounced, however, in the districts from Summerland north, where the control orchards are located. In last year's report these orchards were described in detail. The following observations were made this year:—

Orchard No. 1.—Previous to 1927, this orchard was affected with corky core, principally owing to drought conditions. The water, obtained from a small spring, was insufficient for irrigational purposes, therefore, the removal of half the trees was recommended and carried out. A decided improvement took place in 1928, but was not so noticeable in 1929.

Orchard No. 2.—In 1922 the crop on this orchard was a total loss from die-back, drought spot, and corky core. Moist deficiency was responsible for their occurrence. The orchard had not been irrigated, but on the advice of the Summerland Laboratory, a system was installed in 1926, and regular applications of water have been made each growing season since. As a result, there has been a steady yearly improvement noted, until in 1929 the orchard was entirely free from any form of the disease, although it was exceptionally severe in other orchards in the district.

Orchard No. 3.—Super-moisture conditions, responsible for the incidence of die-back, drought spot, and corky core in this orchard, were relieved in 1926 by a system of drainage. The 1928 and 1929 crops of apples were free from the trouble, and the tree growth was vigorous and healthy.

Orchard No. 4.—An excess of moisture is known to be the primary factor in causing a severe form of die-back, drought spot, and corky core in this orchard. In this case it has proved difficult to correct the prevailing super-moisture condition, and as yet no improvement has been observed.

Orchard No. 5.—An extreme drought condition, which, owing to the type of soil, was hard to prevent, favoured the presence of considerable corky core in this orchard. In 1927, however, more systematic irrigation, together with better cultural methods, relieved the situation somewhat. A consequent improvement was noted in the fruit in 1928. But in 1929 observations disclosed that corky core was still present in portions of the orchard.

Orchard No. 6.—Super-moist soil was responsible for die-back, drought spot, and corky core in this orchard, and although this condition was partially controlled in 1927, it has proved difficult to entirely correct. An increase in vigour of growth, noted in 1928, did not continue to show during 1929, but a subsequent increase of drought spot and corky core was evident.

Orchard No. 7.—The condition of super-moisture, causing all forms of the trouble in this orchard, has been partially remedied since 1928. In 1929 a slight increase in vigour of growth was observed.

Orchard No. 8.—Die-back, drought spot, and corky core were prevalent in this orchard, due to excessive moisture in some sections and deficiency in others. The conditions have been alleviated to a certain extent by more carefully controlling the irrigation. In 1929 the progress of the disease was notably retarded.

Orchard No. 9.—This orchard was taken over in 1927, when super-moisture was evidently responsible for the occurrence of drought spot and corky core in the fruit, and a lack of vigour in tree growth. More systematic irrigation gave promising results the following year, but although vigorous growth continued, corky core was still present in 1929.

The general increase of the disease throughout the valley was reflected in several of the control orchards; in those where it has been difficult to maintain an optimum soil moisture during the growing season, and in others where the control has only been effectual for a year or two. In the orchards, however, where the soil moisture has been well regulated for at least three years without serious variation as, in the orginal test orchard at Salmon Arm, the alleviation of die-back, drought spot, and corky core is evidence of the effectiveness of this remedy.

DROUGHT SPOT OF APRICOTS

This disease, which was first reported in 1927, occurs in all sections of the Okanagan Valley where apricots are grown. The trouble is characterized by the appearance, on the skin of maturing fruit, of small reddish-brown, scale-like markings (fig. 33). The spots are irregular in shape and vary in size from minute specks to blemishes, which sometimes involve the whole side of the fruit. In severe cases the fruit cracks and shrivels, but usually the many small marks are only skin deep. In either event the apricots are unmarketable. It has also been observed that the disease may appear on the whole tree, or it may be confined to some branches only.

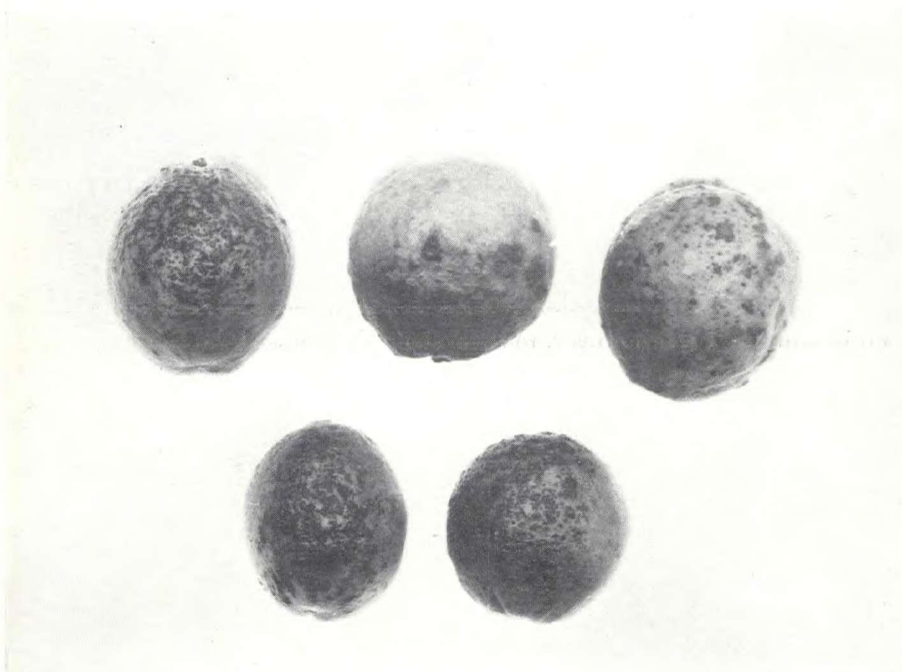


FIG. 33.—Typical drought spotted apricots.

From observations and experiments this russeting of the fruit appears to be physiological in origin. Attempts have failed to isolate any organism from the diseased material. Consequently, investigations were made to determine if possible, the influence of physical factors which are known to contribute to the occurrence of drought spot in apples in the Okanagan. An orchard of five acres in Naramata, where one hundred per cent of the trees were affected in 1927, was taken over for experimental purposes. During the latter part of the growing season, two extreme water conditions were to be found in this orchard. All the trees, regardless of whether the soil moisture was excessive or deficient, suffered seriously from rootlet killing. As the system of irrigation practised was principally responsible for the moisture conditions, a new plan was laid out in 1928. With the assistance of an augur, determinations were made regularly so that an optimum soil moisture condition was maintained throughout the orchard.

In the crop produced in 1928, the improvement was slight, but the rootlet killing was much less severe. During the 1929 growing season, the irrigation was again carefully controlled. The crop harvested this year, however, was the largest produced since the orchard was planted, and was, moreover, practically free from drought spot. That is, out of 16 tons of fruit, less than 50 pounds were culled, and drought spot was not entirely responsible for this. Observations disclosed that orchards, adjacent to this experimental plot, and others in the same district, were affected by the disease to a greater degree than in previous years.

In this experiment the conditions of drought and super-moisture were relieved by proper irrigation, the consequence of which was a remarkable decrease in the amount of rootlet killing. Rootlet killing in this orchard was a primary factor in the occurrence of this disease. It is worthy of notice that these results are in accord with those obtained from similar experiments in drought spot of apples, carried out by the Summerland Laboratory. In the case of apples, however, a longer period than two years of even soil moisture would appear to be necessary, before any apparent improvement in the fruit would be observed.

INVESTIGATION OF APPLE INJURY FROM MILDEW AND SPRAY BURNING

Apple powdery mildew in the Okanagan causes a decided reduction in grade of a certain percentage every year of the more highly coloured varieties of apples. The peculiar russet netting on the surface of the fruit detracts from its appearance and in severe cases affects the quality of the apple (fig. 34). In a normal year if the spread is not checked there is usually sufficient mildew to produce a substantial loss in some districts. In exceptional seasons, however, the culled fruit has amounted to as much as 50 per cent of the total crop. In recent years, the importance ascribed to the production of fruit for fancy packs has been a stimulus to the grower to attempt to successfully retard the advance of the disease in his orchard.

A perplexing problem confronts the orchardist when he finds that the recognized control measure, that is spraying with lime sulphur 1-50, russets the apples in much the same way as the mildew (fig. 35). As a result of prevailing climatic conditions the severity of the disease varies from year to year. In a season when heavy infection occurs, this spray, when properly applied, considerably alleviates the amount of injury. The following season, however, the attack may be light, and from a comparison of crops, harvested from sprayed and unsprayed orchards in such a year, observations have revealed that the amount of burning by this spray sometimes offsets the benefits derived from its use. Therefore, an experiment was planned by the Summerland laboratory to estimate the percentage of marked apples from these two injuries, and to test out the efficiency of iron sulphate, when added to the regular lime sulphur spray, in reducing the amount of spray burning.

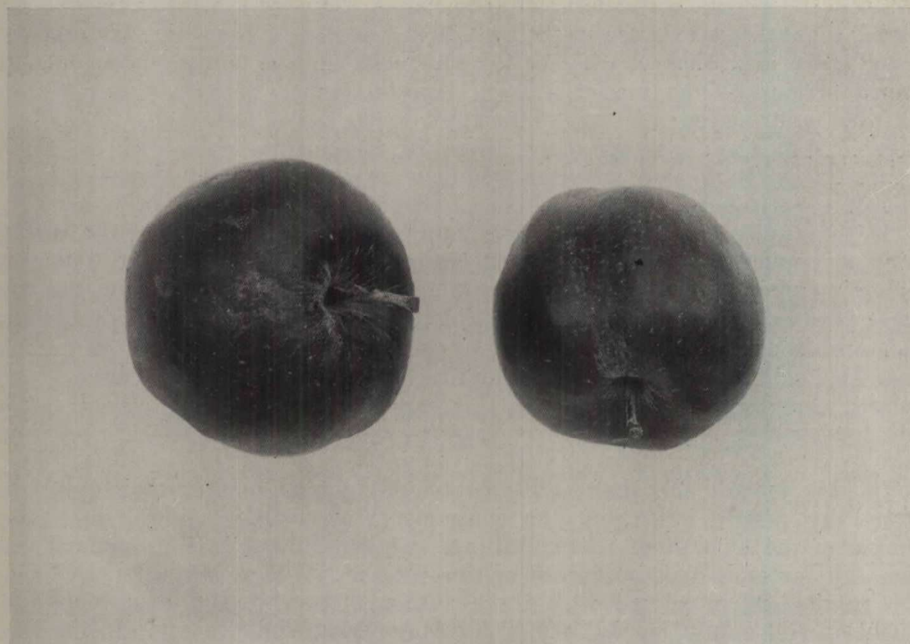


FIG. 34.—Mildew marked apples.

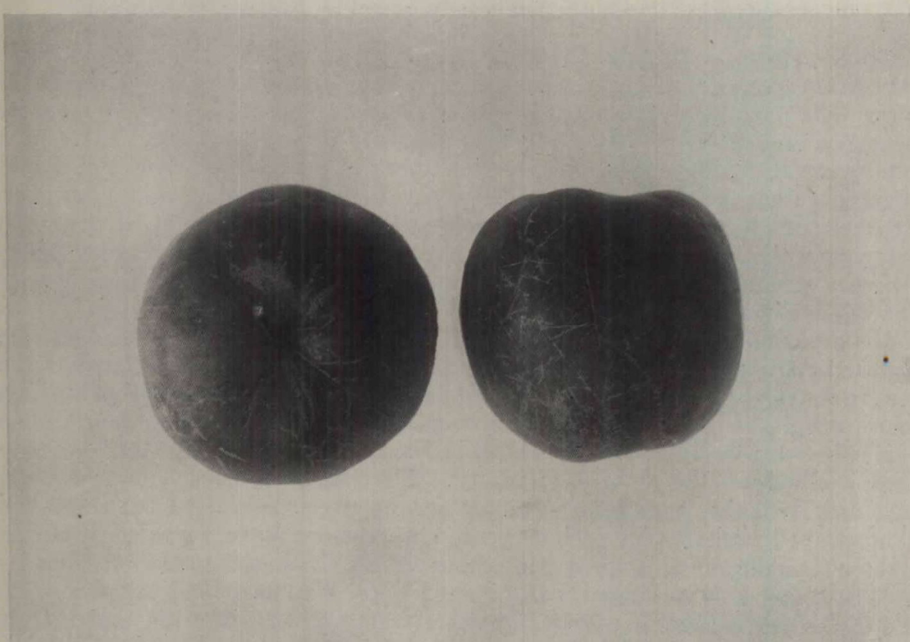


FIG. 35.—Spray burn on apples.

In Penticton, a block of twenty-three Jonathan trees was secured for experimental purposes, in an orchard equipped with a stationary spray machine. The trees were divided into five plots which received the following treatment:—

Plot I, consisting of two check trees, was left unsprayed throughout the season.

Plot II, consisting of four trees, was sprayed only with water four times, commencing on May 8 with intervals from five to seven days between the applications.

Plot III, consisting of six trees, was sprayed in both the pink and calyx stages of development, with lime sulphur 1-50, arsenic of lead 1-40, spreader, and iron sulphate 1-125.

Plot IV, consisting of six trees, was sprayed in both the pink and calyx stages, with lime sulphur 1-50, arsenic of lead, 1-40, and spreader.

Plot V, consisting of five trees, was sprayed in the pink stage only, with lime sulphur 1-50, arsenic of lead 1-40, and spreader.

By examining and counting the apples harvested from these plots, the amounts of injury from mildew and spray burning were compared and charted. This experiment also demonstrated the effectiveness of lime sulphur spray in controlling mildew, and the following points of interest were noted:—

1. The infection of the disease was not severe, even on the check trees.
2. The trees sprayed with water showed equal slight amounts of mildew and burning. The total damage, however, was greater than on the check plot.
3. The addition of iron sulphate to the spray on Plot III materially decreased the amount of burning as compared with that on the plots sprayed with ordinary lime sulphur, and gave good mildew control.
4. The regular lime sulphur spray would be unprofitable to apply unless in a year when the mildew infection was more severe than this year.

PERCENTAGE *of* MARKED APPLES *on* TREES SPRAYED *for* APPLE MILDEW

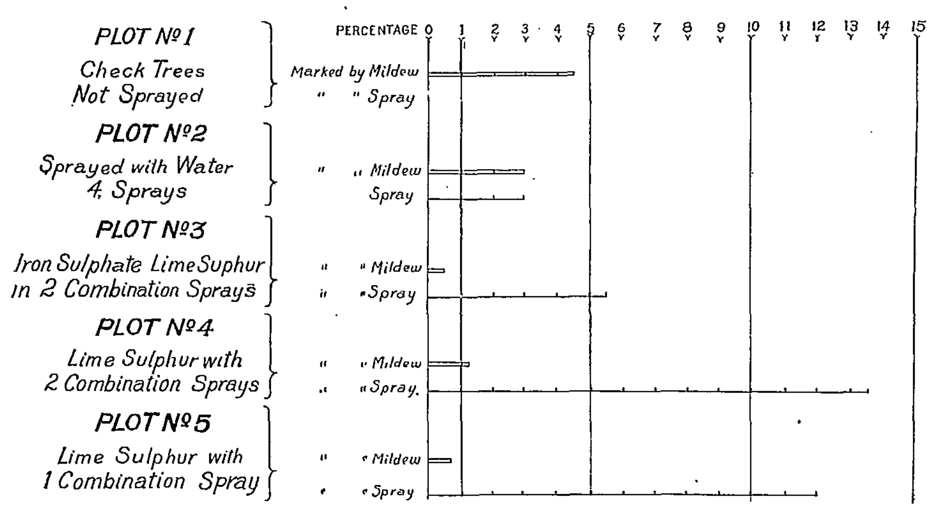


Chart 1.

From the foregoing tests it may be deduced, that the usual lime sulphur applications to check the spread of mildew may seriously injure the crop. Also, the caustic action of the sulphur may not be altogether responsible for the burning, as shown on the plot sprayed with water only. Furthermore, the addition of iron sulphate to the ordinary lime sulphur spray, while substantially reducing the amount of injury, does not entirely eliminate the burning. Therefore, it is planned to carry on a more extensive investigation using other forms of sulphur, which under the Okanagan climatic conditions may be more suitable for the control of apple powdery mildew.

APPLE SCAB

The severity of apple scab infection is influenced by the temperature and moisture conditions prevailing during the period of ascospore expulsion. The cool, humid weather, sometimes prevalent in the northern sections of the Okanagan Valley, is favourable to the spread of the disease and necessitates the practice of control measures. During the growing season of 1928, although spraying with lime sulphur was general, the scab infection was not successfully checked. As the success of the spray depends on its application immediately after the first ascospore discharge, the Provincial Horticultural Branch requested the assistance of the laboratory to determine the opportune date for spraying in the spring of 1929.

The method followed, in order to time the initial ascospore discharge, was to place spore traps in infected orchards in the districts of Winfield, Oyama, and Vernon. Old leaves which contained abundant perithecia were held down on the ground by placing thin wooden labels 3 mm. thick along the tips and bases of the leaves. Microscopic slides, smeared with a thin film of white vaseline or castor oil, were placed over the exposed fruiting bodies, with the ends resting on the labels and firmly held down with large headed nails. The spore traps, most of which were set up on April 24, were examined regularly, but it was not until May 1, after a heavy rainfall, that the first ascospores were expelled.

TABLE 67.—ASCOSPORE DISCHARGE—SPRING, 1929

Locality	Date spore traps were set up	Dates of ascospore discharge	Remarks
Vernon	April 24, 1929	May 1, 1929	Ascospores fairly numerous.
		May 3, 1929	Ascospores fairly numerous, some spores were germinating.
Oyama	April 24, 1929	May 1, 1929	Ascospores numerous; many spores were germinating.
		May 3, 1929	Ascospores numerous; many spores were germinating.
Winfield	April 24, 1929	May 1, 1929	Ascospores fairly numerous.
*Salmon Arm	April 30, 1929	May 2, 1929	Ascospores numerous.
		May 3, 1929	Ascospores numerous; some spores were germinating.

*Diseased leaves were collected and sent to Vernon where the tests were made under conditions similar to those in the other districts.

Although the infection was very light this year, it may not have been altogether the result of the spray schedule followed, as the fall of 1928 was exceptionally dry which possibly hindered the widespread development of the perithecia. It is proposed to continue this work, so that in a year of probably serious infection, growers will be timely informed of the correct dates for scab sprays.

Vegetable Diseases

(G. E. Woolliams)

CLUB-ROOT OF CABBAGE

(*a*) *Control of the Disease with Lime.*—During the summer of 1928, a severe outbreak of cabbage club-root appeared at Armstrong, which is the principal centre of cabbage production in the Okanagan Valley. It was, therefore, considered advisable to obtain information concerning the efficiency of lime in the control of the disease under local conditions, and a test, in co-operation with the Provincial Horticultural Branch, was begun this year.

The tests are being made in part of a field in which nearly all of the plants were diseased last year. As early in the spring as possible, burnt lime was placed in small piles in the field where it was left until it was air slacked. When the action was completed the lime was carefully spread over the field and ploughed in on May 10. As the acidity of the soil was fairly high (about PH. 5·7) a liberal application of lime at the rate of 3 tons per acre was made. A late variety of cabbage, the Danish Ballhead, was used, and the plants were not set out in the field until June 9.

Although the lime was not applied until fairly late in the spring, the use of the chemical showed beneficial results. On October 2nd, there was a decided contrast in the appearance of each plot (figs. 36 and 37). As shown in tables 68 and 69 there was an appreciable check in the severity of infection in the lime plot and a still greater improvement in the percentage of commercial heads.

TABLE 68.—EFFECT OF APPLICATION OF LIME AT THREE TONS PER ACRE ON INFECTION OF CABBAGE WITH CLUB-ROOT, ARMSTRONG, B.C., OCTOBER 2, 1929

—	Limed			—	Unlimed		
	Total number of plants	Number of plants	Per cent		Total number of plants	Number of plants	Per cent
Healthy......	515	154	29·9	Healthy......	490	84	17·2
Diseased......		361	70·1	Diseased......		407	82·8
			100·0				100·0

TABLE 69.—EFFECT OF APPLICATION OF LIME AT THREE TONS PER ACRE ON PERCENTAGE OF COMMERCIAL HEADS OF CABBAGE INFECTED WITH CLUB-ROOT. ARMSTRONG, B.C., OCTOBER 2, 1929

—	Limed			—	Unlimed		
	Total number of plants	Number of plants	Per cent		Total number pf plants	Number of plants	Per cent
Commercial...	 515	386	75·00	Commercial...	 490	203	41·40
Non-commercial.	....	129	25·00	Non-commercial.	....	287	58·60
			100·00				100·00

(*b*) *The Viability of Spores of Plasmodiophora Brassicæ on Cabbage Seed.*—During the past season a test was made to determine for what length of time cabbage seed, infected with the spores of *Plasmodiophora Brassicæ* Woron. may transmit club-root.

FIG. 36.—Cabbage growing on unlimed soil with the club-root organism, showing wilted and stunted plants affected with disease.

FIG. 37.—Cabbage growing on limed soil infected with the club-root organism, showing little wilting and increased productiveness. Compare with Fig. 36.

Cabbage roots affected with club-root were used as a source of inoculum. The tissue was soft and severely rotted with the disease and contained many mature spores of the pathogene. After being carefully washed to remove the soil from the surface, the roots were crushed with a pestle and mortar and mixed with a little distilled water. The liquid containing the spores was filtered through absorbent cotton and the filtrate was used to thoroughly moisten cabbage seed which was immediately dried on blotting paper. The inoculated seed was stored under ordinary conditions and after 37 days some of it was planted in a flat containing soil free of the pathogene. After 77 days the roots of the cabbage plants were examined, and only 19 were affected with club-root and 75 were apparently healthy.

Alter the inoculated seed had been stored for 138 days, a second lot was sown similarly to the first. After the plants had grown for 50 days, an examination of the roots was made and all of the 150 plants appeared to be healthy. It would appear that when cabbage seed inoculated with the spores of *Plasmodiophora brassicæ* is stored under ordinary conditions, the spores remain viable for only a comparatively short time.

FUSARIUM BULB-ROT OF ONIONS

(*a*) *The Effect on Soil Treatments on the Disease.*—During the past season further tests have been made to study the effect of soil treatments on the development of fusarium bulb-rot. The tests were made in a field which had been planted to onions continuously for at least 20 years, and which was so severely infected with the pathogene that the heavy losses from the disease made the production of this commodity no longer profitable.

The plots, which were one-sixtieth of an acre in area, were so situated beside an irrigation flume that the irrigation water could not come in contact with infected soil before it was applied nor could it pass from one treated area to another. In this way any possibility of reinoculation of the plots with the causal fungus was obviated. The chemicals were used in the solid form rather than as a liquid and, when necessary, were ground into a coarse powder before application. After the ground had been prepared for seeding, the powder was evenly broadcasted over all the area and raked into the soil. The different chemical treatments were as follows:—

TABLE 70.—CHEMICAL TREATMENTS USED FOR FUSARIUM BULB-ROT OF ONIONS

Plot No.	Treatment	Rate of application per acre
		lb.
1	Check—no treatment	....
2	Check—no treatment	....
3	Copper sulphate	750
4	Copper sulphate	510
5	Check—no treatment	....
6	Copper sulphate	255
7	Potassium bichromate	510
8	Potassium bichromate	255
9	Potassium bichromate	125
10	Check—no treatment	....
11	Hydrated lime and magnesium carbonate	1,020
12	Ferrous sulphate	1,020
13	Hydrated lime	2,000
14	Check—no treatment	....
15	Common salt (sodium chloride)	4,000
16	Check—no treatment	....

The onion seed, which was the Yellow Globe Danvers variety, germinated well and the stand of seedling onions was very good. Unfortunately, the field became infested with wireworms, and their activities reduced the stand to a large extent. The use of copper sulphate, hydrated lime, hydrated lime and magnesium carbonate, and ferrous sulphate did not show any evidence of having a harmful effect on the onion crop. The use of potassium bichromate and common salt, however, appeared to be toxic to the plants and prevented growth. During the growing season all the diseased plants were pulled and counted as they appeared in the plots, the final count being made when the crop was harvested in September. The results of the different soil treatments are shown in table 71. None of the treatments showed any appreciable control this year.

(*b*) *Susceptibility of Varieties and Species of Onions to Fusarium Bulb-rot.* —The majority of pathogenic fungi show a distinct variation in their ability to infect different varieties of their host plant. This variation is usually the starting point for the selection or breeding of resistant varieties, which is the most efficient method for the control of plant diseases. With respect to fusarium bulb-rot of onions as it occurs in the Okanagan valley, no data concerning the susceptibility of different varieties of onions is available. As this information would be of value a number of American varieties and species of onions were grown this year in "fusarium sick" soil.

The seed and bulbs were planted on April 8 in three replicated rows of 20 feet each. During the summer records of any diseased bulbs found were kept and when the crop was harvested on September 3, counts of both healthy and diseased bulbs were made. The results are presented in table 72.

TABLE 71.—EFFECTS OF DIFFERENT SOIL TREATMENTS IN THE DEVELOPMENT OF FUSARIUM BULB-ROT

Plot No.	Treatment	Rate per acre	Counts of diseased bulbs removed from the field			Total number of affected bulbs	Total number of healthy bulbs	Percentage diseased bulbs
			July 26	Aug. 21	Sept. 6			
		lb.						
1	Check—no treatment	....	15	8	20	43	134	24·23
2	Check—no treatment	....	25	31	39	95	327	22·51
3	Copper sulphate	750	36	39	44	119	405	22·71
4	Copper sulphate	510	30	31	26	87	401	17·82
5	Check—no treatment	....	16	22	19	57	286	16·61
6	Copper sulphate	255	19	15	12	46	212	17·82
7	Potassium bichromate	510	0	0	0	0	15	0·00
8	Potassium bichromate	255	1	1	1	3	29	9·37
9	Potassium bichromate	125	8	11	7	26	125	10·59
10	Check—no treatment	....	21	18	9	48	173	21·72
11	Hydrated lime and Magnesium carbonate (1:1)	1,020	31	54	33	118	707	14·30
12	Ferrous sulphate	1,020	9	31	30	70	668	9·48
13	Hydrated lime	2,000	15	40	35	90	744	10·79
14	Check—no treatment	....	10	42	43	95	961	9·00
15	Common salt (sodium chloride)	4,000	0	5	3	8	104	7·14
16	Check—no treatment	....	1	5	30	36	642	5·31

TABLE 72.—SUSCEPTIBILITY OF VARIETIES AND SPECIES OF ONIONS TO FUSARIUM BULB-ROT. SEASON, 1929

Variety	Source of seed	Total number of diseased bulbs found during season	Number of healthy bulbs	Per cent infection
Yellow Globe Danvers	J. Spall, Kelowna, B.C.	35	299	10·4
Yellow Bermuda	Stokes Seed Co.	0	163	0·0
Yellow Dutch or Strasburg	Livingston Seed Co.	*3	172	1·7
Southport Yellow Globe	" "	21	172	10·8
Ailsa Craig	" "	15	316	4·5
Prizetaker	J. Harris Seed Co.	21	310	6·3
Australian Brown	" "	*11	439	2·4
Riverside Sweet Spanish	Stokes Seed Co.	*4	336	1·1
Mammoth White Globe	J. Harris Seed Co.	*2	412	0·4
Southport White Globe	" "	33	321	9·3
Southport Red Globe	" "	38	216	14·9
Large Red Wethersfield	" "	29	278	9·4
Early Large Red	" "	28	180	13·4
White Welsh	" "	0	406	0·0
Chives	K. McDonald & Sons, Ltd.	0	66	0·0
Leek-Large Musselburgh	Livingston Seed Co.	0	307	0·0
Potato Onion	Dupuy & Ferguson	9	75	10·7
Shallots	" "	6	203	2·8
Garlic	" "	0	48	0·0

TOMATO BREAKDOWN

During the summer of 1928 the occurrence of breakdown of the tomatoes at Keremeos caused a loss to the growers of at least 25 per cent of the crop. In previous years, according to statements of some of the local growers, the disease had been observed but only to such a slight extent as to be of no economic importance. Breakdown apparently is not restricted to field conditions, for the same season it was reported as occurring on tomatoes growing in greenhouses at Kelowna and the vicinity of Victoria.

The most readily recognized symptom of the disease is the occurrence, on the mature fruit, of soft, mushy areas measuring anywhere from $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. They may be found anywhere on the surface of the fruit, but the majority are found near the calyx end. The tissue in these areas is often a darker red than that of the remaining unaffected portions. The affected regions have a watersoaked appearance and to the touch are soft and watery. When they are rubbed with the fingers the epidermis breaks and the tissue beneath runs out in a watery stream. Badly affected fruit is almost useless for canning since the majority of the tissue is lost during peeling.

All varieties would appear to be susceptible to the disease. It occurred mostly on Earliana, which is the principal variety grown in the field, but it was also found on Chalk's Early Jewel, John Baer and Bonny Best.

The disease was present throughout practically all of the Keremeos district, regardless of the various cultural conditions. It was found on all types of soil, ranging from very gravelly to heavy clay loam, acid or alkaline in their reaction. Affected plants occurred on virgin soil, fertilized or unfertilized, heavily or lightly irrigated, and on fields where rotation of crops had been practised or successive crops of tomatoes grown.

During the summer of 1928 there prevailed at Keremeos an unusual, prolonged period of warm days, with maximum temperatures of 100° F. or over, accompanied by sudden drops in temperature at night. As this appeared to be the only likely environmental factor that might influence the development of the plants it was considered that high temperatures during the day accompanied by comparatively cool temperatures at night might possibly influence the occurrence of the disease. The maximum and minimum temperatures* for this period, together with the meteorological records for the warmest periods during the summers of 1927 and 1929 are as follows:—

TABLE 73.—MAXIMUM AND MINIMUM TEMPERATURES

1927				1928				1929			
Date	Max.	Min.	Range	Date	Max.	Min.	Range	Date	Max.	Min.	Range
July	°	°	°	July	°	°	°	July	°	°	°
17.......	95	59	36	21.....	95	65	30	28.....	94	63	31
18.......	94	63	31	22.....	99	65	34	29.....	99	66	33
19.......	90	59	31	23.....	101	70	31	30.....	100	66	34
20.......	90	59	31	24.....	102	69	33	31.....	100	61	39
								Aug.			
21.......	96	59	37	25.....	100	69	31	1.....	95	62	33
22.......	99	61	38	26.....	105	70	35	2.....	95	61	34
23.......	101	66	35	27.....	102	69	33				
24.......	102	70	32	28.....	102	64	38				
25.......	98	65	33	29.....	92	65	27				
26.......	97	68	29	30.....	92	61	31				

Investigational Work.—During the past season an experiment was begun to determine whether tomato breakdown could be induced by a short exposure of the plant to extremes of high temperatures during the day and comparatively cool temperatures at night.

Earliana tomato plants which had been previously trained to develop two main branches from near the base of the stem, were set out on May 30 in a field fertilized with barnyard manure. The soil was a clay loam with an alkaline reaction (PH 8·6) on which onions had been grown the preceding year.

The temperatures were raised artificially by placing over one-half of the tomato plant a large glass cage. The other part of the plant was not treated and served as a check. The cages used were 4 feet square and 3 feet high and were fitted with ordinary glass on the tops and sides. Ventilation could be effected by opening vents placed at the base of each side of the cage and also by either raising or removing the top sash.

The plants, in groups of four, were exposed to high temperatures for a period of five days at different stages of growth. While the treatments were carried on, temperature records (including maximum and minimum) were made ten times daily both in the cages and in the field. For comparative purposes, records of relative humidity, soil temperature and evaporation were also kept. Temperatures of over 100° F. were obtained, on the average, between the hours of 12 a.m. and 4 p.m. The highest temperature obtained at any time was 116° F., but the average maximum temperature was between 100° F. and 110° F. Minimum temperatures at nights averaged between 50° F. and 60° F. so that a range of over 50° F. was usually obtained each day. The plants were treated as follows:—

Lot O, plants No. 1, 2, 5 and 6; July 23-July 27.
Lot P, plants No. 9, 10, 13 and 14; July 30-Aug. 4.
Lot Q, plants No. 19, 20, 23 and 24; Aug. 5-Aug. 9.
Lot R, plants No. 3, 4, 11 and 12; Aug. 11-Aug. 15.

The fruit on both the treated and check portions of the vines, was picked at maturity and tested for relative firmness as soon afterwards as possible.

* These records were kindly supplied by Mr. F. Napier Denison, Superintendent of Dominion Meteorological Service, British Columbia Division.

The tests were made by using an improvised pressure tester that could indicate breaking points on the peeled surface of the fruit of from 15 to 175 grams (fig. 39). The comparative firmness of the different fruits was obtained by determining the lowest weight required to puncture the peeled flesh when the weight was dropped from a height of one-sixteenth of an inch. Tests were made at four different points on the surface of the tomato and the lowest pressure was recorded.

FIG. 38.—Glass cage set up in position over one-half of a tomato plant to expose it to high temperatures during the day, showing arrangement of the maximum and minimum thermometer, hygrometer, soil thermometer, and atmometer used in the tests. Note the untreated, check portion of the vine at the left.

Results

1. The Relation of Breaking Point to the Time Elapsed Since Application of Heat.—As indicated in chart 2, tomatoes were picked from the vines from 6 to 49 days after they were exposed to high temperatures and the breaking points of fruit from both the treated and untreated (control) parts of the plants were determined. The results show (*a*) that tomatoes exposed to high temperatures have a lower breaking point, that is, are softer, than those exposed to more uniform temperatures; (*b*) that there is a decided parallelism in breaking points between the fruit from both treated and untreated portions of the plant, and (*c*) that there is a general tendency toward softer fruit as the season advances.

2. The Relation of Harvesting at Different Stages of Maturity to Softening Fruit at Full Maturity.—Mature tomatoes at all stages of ripeness from red ripe to green were picked and divided into forty groups as shown in chart 3. The fruit was stored in a warm room and when it became fully ripe, the breaking point was determined. From the results it would appear that early or late picking does not affect the eventual softening of the fruit and that the tendency of fruit to soften develops at an early stage of growth.

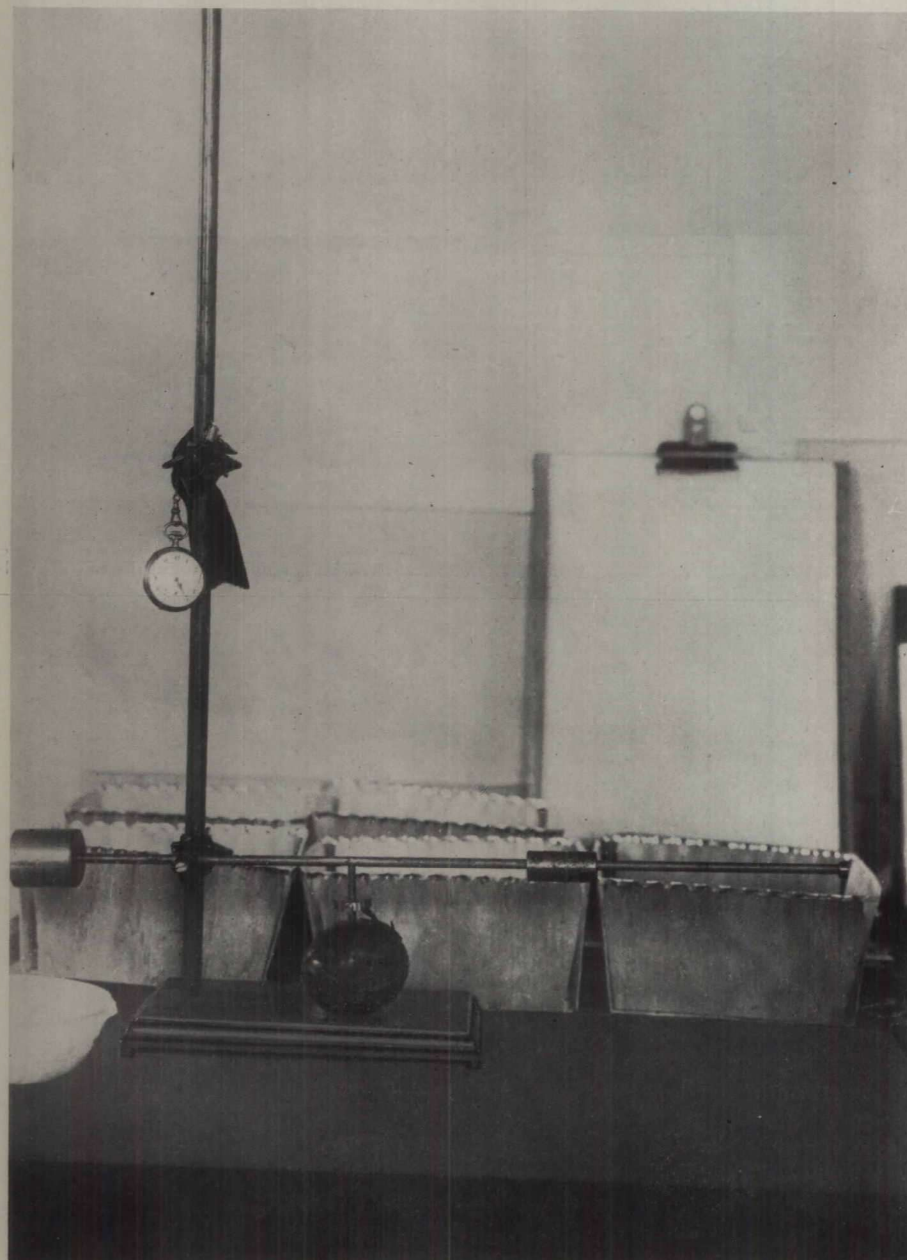


FIG. 39.—Instrument used to determine the breaking point or firmness of the tomato fruit.

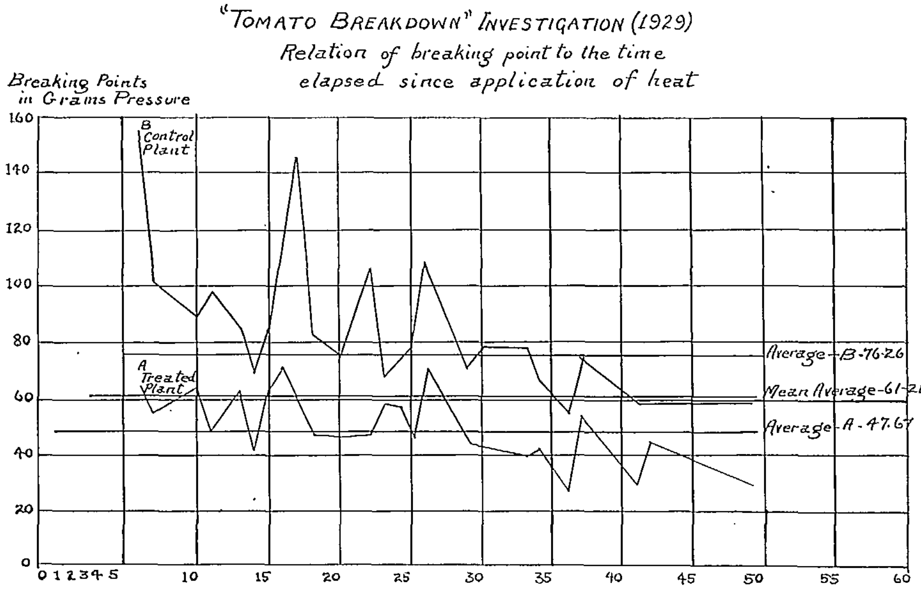


Chart 2.

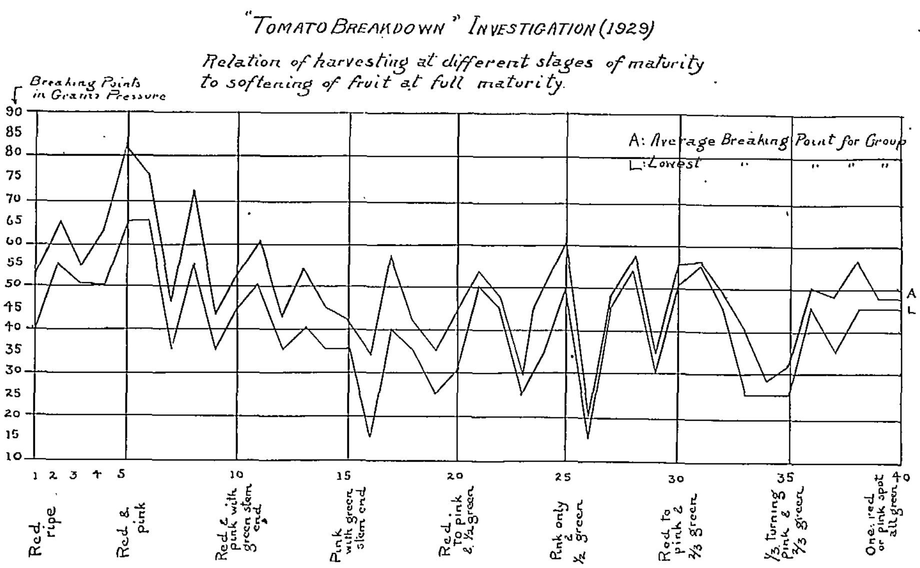


Chart 3.

Control of Cucumber Scab (*Cladosporium cucumerinum* Ell. & Arth.)

(D. J. MacLeod, Fredericton, N.B.)

Cucumbers have been grown successfully in the Saint John Valley for the past two decades. While the quantity of production is governed by and restricted to local demand, the crop is becoming more important each year.

During certain seasons, the yields are materially reduced on account of the prevalence of diseases. Among the most important of these is cucumber scab, caused by the fungus *Cladosporium cucumerinum* E. & A., which has been a serious limiting factor in the production of this important crop during the past fifteen years. In view of the importance of the disease, preliminary experiments were carried on in **1929** for the purpose of developing control measures for this malady, applicable to local conditions.

A brief description of the disease is as follows: The leaves, stems and fruit, particularly the latter are attacked. Affected leaves develop a light green water soaked area on the upper and lower epidermis. As the fungus becomes established, the affected tissue dies and takes on a brownish yellow colour. Affected areas usually enlarge and frequently coalesce finally involving the entire leaf surface.

FIG. 40.—Scab, (*Cladosporium cucumerinum*) on cucumber, showing incipient and advanced stages of the disease.

Lesions similar to those on the leaves occur on the stems. Incipient stages on the fruit appear as gray slightly sunken areas, approximately one sixteenth of an inch in diameter. The canker thus formed becomes darker with age and the collapsed tissue more and more depressed until a pronounced cavity is formed. This cavity is lined with a dark green velvety layer of the becomes darker and by late fall it has become perfectly black. It remains like this until the following spring when the knot usually extends its boundaries (fig. 41).

Isolations.—Investigations regarding the life-history of the organism were begun by attempting to isolate the organism from living knots. About 150 isolations have been made to date from both plums and cherries. The early isolations were made chiefly from the conidia-spores of the fungus. Later ones were made directly from the stromatic tissue of the knot itself. In the majority of cases where pure cultures were obtained from the above isolations there resulted a form which developed black pycnidia. This form has been tentatively placed in the genus *Coniothyrium* and may possibly be the pycnidial form of the black knot organism. Among other forms which appeared in the cultures was a *Cephalothecium* sp. and a *Verticillium* sp. Close observations showed that both of these species are saprophytic probably on the stroma of the knot itself.

Ascospore Discharge.—Ascospores of *Dibotryon morbosum* (Schw.) Theiss & Syd. are generally considered to be the cause of primary infection in the spring but nowhere in the literature concerning black knot appear any data concerning the time or period of ascospore discharge. It was therefore deemed advisable to obtain some information regarding this factor in order that a correct spray schedule could be drawn up.

Spore traps were set out on February 26 for this purpose. These consisted of lightly-vaselined slides retained a short distance from the surface of the knot. These were replaced by fresh slides after every shower. The earliest discharge recorded was on March 23. Discharge continued after every rainfall until June 25, after which date no further discharge was recorded. Pycnospores belonging probably to the same fungus as those in the cultures attributed to *Coniothyrium* sp. were discharged along with the ascospores during most of the period of discharge.

Growth of Knots on Plum Trees.—Thirty-three knots were tagged and their features recorded in March, 1929. At this time the average size of the 33 knots was 3·8 inches long, by 0·6 inches wide. Seven months later in October at the end of the growing season these same knots averaged 6·1 inches by 0·9 inch, in diameter. During one growing season they had increased 60 per cent in length and 50 per cent in diameter.

Infection Experiments.—Inoculations with the various fungi isolated from knots were made to ascertain the pycnidial form or forms of the organism and to demonstrate if possible, the development of knots from artificial inoculations.

Table 75 gives a list of the inoculations carried out to date. Since previous investigators were practically all unsuccessful in reproducing the disease artificially, it was obvious that special attention must be given to the method of inoculation. It was thought that lack of moisture during the incubation period might have been responsible for the negative results so far obtained, so it was decided to conserve moisture as much as possible for several days after the inoculations were effected. Consequently, inoculations were all wound with moistened blotting paper which was then covered with cotton cloth which had previously been immersed in a warm fifty-fifty mixture of paraffin and vaseline. This cloth proved to be quite waterproof and prevented evaporation from the blotting paper. Later, however, this cotton was replaced by oiled paper. Previous to inoculation all twigs were washed with mercuric chloride 1-1000 and afterwards with sterile water.

TABLE 75.—INOCULATIONS CARRIED OUT IN AN ENDEAVOUR TO PRODUCE BLACK KNOT ON PLUM TREES

Date of inoculation	Organism	Method of inoculation	Number of inoculations	Remarks
July 29, 1929	Coniothyrium..	Injured;* no covers......................	10	No knots as yet.
Aug. 13, 1929	....	Injured and inserted bits of knot stroma; covered.	10	Knots developed.
" 27, 1929	Coniothyrium..	Injured; placed culture tubes over cut-off twigs.	2	No knots as yet.
" 27, 1929	Cladosporium...	Injured; placed culture tubes over cut-off twigs.	2	No knots as yet.
" 29, 1929	....	Injured and inserted bits of knot stroma; covered.	8	Knots developed.
" 30, 1929	Coniothyrium..	Injured; covered.........................	5	No knots as yet.
Sept. 10, 1929	Coniothyrium..	Injured; (celluloid covers)...............	8	No knots as yet.
" 11, 1929	Coniotyhrium..	Injured; covered.........................	5	No knots as yet.
	Coniothyrium..	Uninjured; covered......................	5	No knots as yet.
" 11, 1929	Coniothyrium..	Injured; covered.........................	3	No knots as yet.
	Coniothyrium..	Uninjured; covered......................	3	No knots as yet.
" 11, 1929	Check..........	Injured; covered, no inoculum...........	10	No knots as yet.
" 16, 1929	Coniothyrium..	Injured; covered.........................	5	No knots as yet.
" 17, 1929	Coniothyrium..	Injured; covered.........................	5	No knots as yet.

* NOTE.—Injured means a slit was made in the bark and inoculum inserted therein.
† NOTE.—Inoculated on sweet cherry.

It will be noticed that on September 10, eight inoculations were made, over which were placed celluloid covers. These were used in order that sunlight might reach the inoculations and that they might be watched over a period of a year or more without exposing them to contamination from outside sources. The covers were made in the following way: A strip of celluloid about 8" long was rolled in the form of a cylinder about $1\frac{1}{2}$" in diameter. The longitudinal seam in the cylinder was sealed with ether. After slipping the cylinder over the top of the twig and down to the inoculated portion both ends of the open cylinder were plugged with moist sterile sphagnum moss. The sphagnum was moistened one a week for three weeks subsequent to inoculation.

From table 75 it will be observed that in the inoculations where bits of young knot stroma were used as the inoculum and kept covered for a period of over 14 days, typical knots developed. In the experiment carried out on August 13, three covers were removed 7 days subsequent to inoculation. Seven days later, three more were removed. To date these six inoculations have shown no outward sign of knots. The remaining four with covers still attached, all developed typical knots. It will be noticed that the remaining inoculation experiments were carried out well towards the end of the growing season. It seems quite definite that there must of necessity be cambial activity in order that knots may develop either artificially or naturally. The result is that the majority of inoculations were carried out so late in the season that it would not seem possible to obtain visible results as yet. A number of these already appear promising but it is too early to state anything definite concerning them. Investigations aiming at improved control measures are also under way, but as yet there is nothing to report.

Spur Blight of Raspberries*

(L. W. Koch.)

Investigations concerning this disease were continued during the current year with regard to the following: taxonomic position of the spur bligth fungus; spore discharge; leaf infection and control measures.

*The work on spur blight has been a co-operative project between this laboratory and the Department of Botany, University of Toronto."

mycelium of the causal fungus. Sometimes a viscid substance is exuded in drops from the affected parts. Where this exudation is generally present, it is often referred to as gummosis. Occasionally the lesions coalesce forming spots of one-half an inch or more in diameter.

The causal fungus is composed of greenish coloured mycelium, short simple conidiophores with ovoid one-celled spores, borne terminally. In leaf lesions, knots of hyphae collect in the stomatal cavity and the conidiophores arise from these knots and protrude through this opening. The organism thrives best in humid, warm weather, 77° being the temperature for optimum growth.

The experiment proper consisted of six plots comprising one-tenth of an acre each. Five of these received applications of the different fungicides tested, while the sixth serving as a check received no treatment. Each plot contained fifty hills of cucumbers, with an average of from three to five plants in each hill. The project was conducted in duplicate, and the plots were so arranged as to include as far as possible variations due to unknown or uncontrolled causes.

The season of 1929 was quite unfavourable for the development of cucumber scab, due to the unusually hot, dry weather conditions obtaining during the months of July and August. Nevertheless, a sufficient amount of the disease occurred, to afford a comparison of the fungicidal merits of the different strengths of Bordeaux spray and dust mixtures tested for the control of this disease under such extraordinary conditions. Each treated plot received two applications of fungicide. The fungicides were applied by means of a Niagara hand duster and a Fairbanks-Morse hand sprayer.

The first evidence of the disease was recorded on August 8 in the check plot. No disease appeared in the treated plots until August 14 when a few slightly affected plants were observed in the (20-80) copper-lime-dust plot.

The following table (74) includes a list of the fungicides compared, together with the percentages of disease recorded on September 19.

TABLE 74.—CUCUMBER SCAB CONTROL—COMPARISONS

Fungicide	Foliage injury	Percentage of disease		
		Slight	Moderate	Severe
Bordeaux Spray (2-6-40)	None	6	3	1
" " (3-6-40)	None	8	2	0
" " (4-6-40)	Slight	20	9	5
" " (5-6-40)	Slight	22	15	2
" " (4-4-40)	Slight	12	5	2
Copper-lime dust (20-80)	Slight	18	10	5
Check		26	15	4

The foregoing results demonstrate some useful possibilities in the direction of controlling cucumber scab under local conditions by means of spraying. Bordeaux mixture prepared according to the (2-6-40) and (3-6-40) formulae produced the best results, as indicated by the fact that no copper injury and less disease occurred in the plots, so treated. Slight foliage injury occurred in the plots treated with (4-6-40), (5-6-40) and (4-4-40) Bordeaux spray and (20-80) copper-lime dust, which indicates that these fungicides cannot be used with safety on cucumber foliage. A noteworthy feature of the entire experiment was that all the plants which received fungicidal treatment remained vigorous for three weeks longer than those in the check, thus giving a greater yield towards the end of the season.

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

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

Black Knot of Plums and Cherries

(L. W. Koch)

During the past several years black knot has become increasingly prevalent in the Niagara Peninsula and growers are becoming alarmed at the damage caused by this disease. It was therefore decided to carry on some investigations with a view to ascertaining the reason for the increased prevalence of this fungus. It soon became manifest also that the life history of the organism is very imperfectly known and since the ultimate object of the investigations was better control, work on all of the above phases was begun. This investigation was commenced late in the present season and hence there is very little to report this year.

SYMPTOMS.—Black knot first becomes manifest as a swelling of the branch in the spring after growth commences. The bark ruptures and the cracks become straw-coloured. In the late spring the swelling becomes covered with an olive-green velvet-like pile. This velvety surface soon disappears, the knot

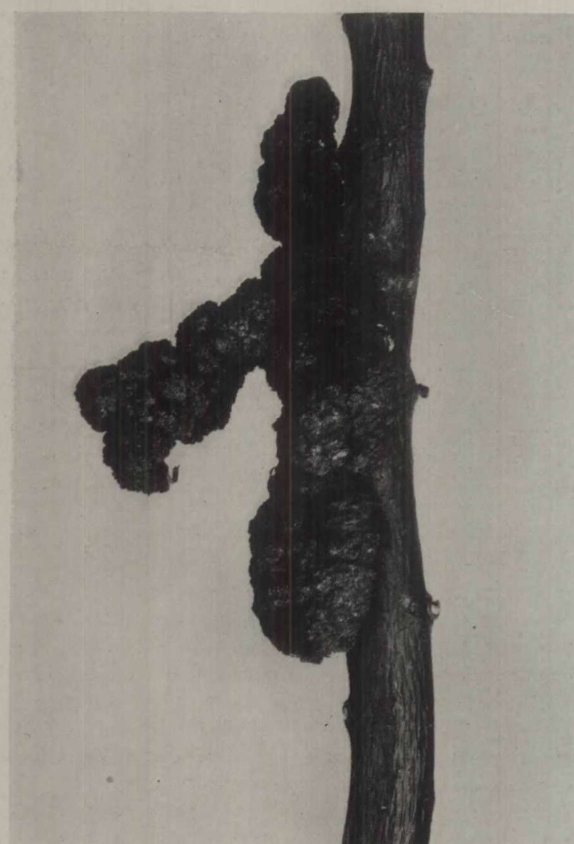


FIG. 41.—Black knot on plums.

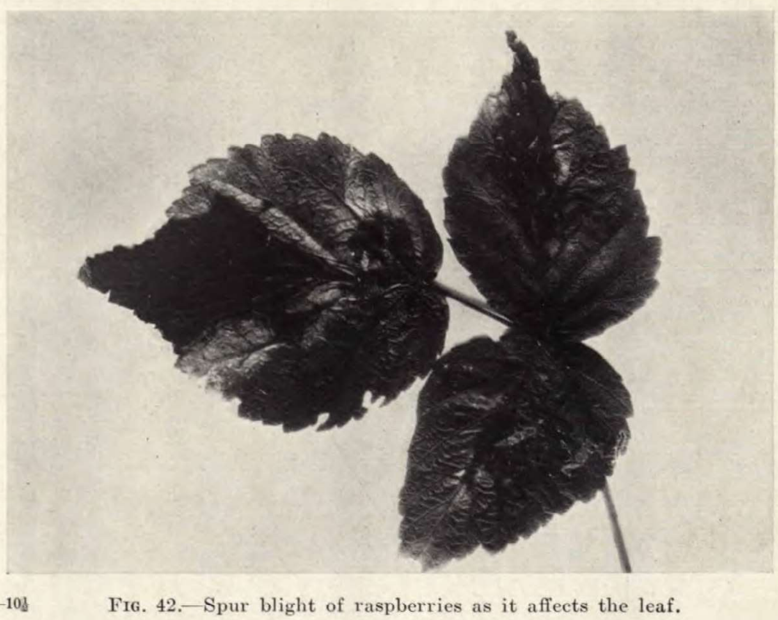
Examinations of the spur blight perithecia at various times have now definitely proven that instead of assigning the fungus to *Mycosphaerella rubina* (Pk.) Jacz., as has been the case for the past 36 years, it ought to be attributed to *Didymella applanata* (Niessl) Sacc., hitherto a European species attacking raspberries.

Regarding the imperfect stage of spur blight in America, both a *Phoma* sp. and a *Coniothyrium* sp. have been held responsible. We are now able to state definitely as a result of inoculations and isolations that the *Phoma* sp. is the only imperfect stage of *D. applanata* (Niessl) Sacc. The *Coniothyrium* sp. has been definitely proven to be the imperfect stage of a different fungus, namely *Leptosphaeria coniothyrium* (Fcl.) Sacc.

Spore traps were set out on May 2 to ascertain the period and amount of ascospore discharge. Attempts were then made to correlate the meteorological data available with the ascospore discharges. The ascospores were observed to discharge between May 7 and July 7. Of the various meteorological factors, rainfall was obviously the most important one. The results indicated that generally speaking, the rate of discharge varied directly with the amount of rainfall provided all the perithecia or ascospores concerned were of the same degree of maturity.

During the summer of 1929, one hundred and thirty leaves of the Cuthbert, Ohta and Herbert varieties were inoculated chiefly with spore suspensions of the *Phoma* stage. Infection of various degrees developed on fifty four of these, thereby definitely establishing the leaf infection ability of the spur blight fungus. Leaf infection becomes apparent first as small spherical brown areas generally associated with a vein. These enlarge, extending more rapidly along the vein axes than in the mesophyll tissue. In time the infected area becomes more or less irregular in outline commonly becoming triangular in shape with the widest portion towards the margin of the tip of the leaf. Fig. 42 shows a naturally infected Herbert leaf with each leaflet infected.

Regarding control measures, the results of the two years spraying experiments are presented in table 76. Bordeaux mixture was employed in the ratio of 3:5:40 to which 2 pound whale oil soal was added to serve as a spreader.



20437—10½ FIG. 42.—Spur blight of raspberries as it affects the leaf.

TABLE 76.—SUMMARY OF RESULTS OF BORDEAUX SPRAYING EXPERIMENTS TO CONTROL SPUR BLIGHT

Variety	Date	Unsprayed portion			Sprayed portion					
		Number of canes	Number of diseased canes	Number of lesions	Number of sprays applied	Dates of application	Number of diseased canes	Number of lesions	Per cent control by diseased canes	Per cent control by lesions
Herbert	1928	100	95	550	1	May 30	21	42	77·9	92·4
Cuthbert	1928	200	166	1,228	1	May 30	23	38	85·0	96·9
Cuthbert	1929	200	27	56	1	May 28	12	14	55·6	75·0
Cuthbert	1928	200	166	1,228	2	May 30 June 12	18	26	88·6	98·7
Cuthbert	1929	200	27	56	2	May 28 June 14	8	11	70·0	80·4
Cuthbert	1928	200	166	1,228	3	May 30 June 12 June 27	23	26	86·1	97·9
Herbert	1929	100	58	94	3	May 28 June 14 July 6	26	32	55·3	66·0
Brighton	1929	100	70	128	3	May 28 June 14 July 6	23	34	67·2	73·5

The results presented in the table (76) above indicate that spur blight can be fairly successfully controlled by the use of Bordeaux spray. During the past two years we have had no injury of the raspberry foliage by the Bordeaux mixture. In some seasons however, Bordeaux is apt to cause some injury to the foliage. We observed cases of this in 1924. It is our intention therefore to find a spray material for raspberries that will not cause injury and at the same time will be a good fungicide. All of our present fungicides, particularly lime sulphur, bordeaux and wettable sulphur, are apt to cause injury in some seasons.

Various Spraying Demonstrations and Field Experiments

(G. C. Chamberlain).

(a) Cherry leaf spot (*Coccomyces hiemalis* Higgins)

During the past two years, sour cherry orchards throughout the district have been severely affected with leaf spot, or as it is sometimes called, Shot hole or Yellow leaf. This infection resulted in heavy defoliation, in some cases, complete defoliation early in the season. In such cases, the crop was nil. Spraying practices were apparently ineffective in controlling this disease and for this reason, as well as the fact that there is considerable uncertainty as to the proper spray materials to use on the sour cherry, a study of the leaf spot disease has been inaugurated. Mr. W. H. Bunting kindly placed at our disposal a sour cherry orchard, for this purpose. We are very grateful indeed to Mr. Bunting for his co-operation. The orchard had been for two years very severely affected with leaf spot. The orchard, comprising 166 trees, was divided into eight blocks and treated as follows (Table 77):—

Table 77.—Treatment of Different Blocks

Block	Material	Application	Remarks
A	Lime sulphur	Shucks spray Colour spray 2 weeks spray	
B	Bordeaux	Shucks spray Colour spray 2 weeks spray	
C	Bordeaux and $3\frac{1}{2}$ pounds aluminium sulphate.	Shucks spray Colour spray 2 weeks spray	
D	Bordeaux Lime sulphur	Shucks spray Colour spray 2 weeks spray	Bordeaux applied only at time of shuck spray.
E	Lime sulphur Lime sulphur Lime sulphur Bordeaux	Shuck spray Colour spray 2 weeks spray After harvest	Bordeaux applied after harvest.
F	Bordeaux Lime sulphur Lime sulphur	$\frac{3}{4}$ petal fall Colour spray 2 weeks	Bordeaux applied only at time of $\frac{3}{4}$ petal fall.
G	Lime sulphur	$\frac{3}{4}$ petal fall Colour spray 2 weeks spray	
H	No sprays	Check block	

Note.—Lime sulphur was 1 to 40 strength and Bordeaux was 3-6-40 strength.

The season proved distinctly unfavourable for the leaf spot fungus as no infection developed in the check blocks of the orchard which previously had been so severely affected. This was the situation generally throughout the Peninsula. Leaf spot was conspicuous by its absence this year. No results as to the effectiveness of the various spray applications in controlling leaf spot fungus could therefore be obtained from this experiment. The study of the leaf spot disease will be continued next year.

The effect of the spray applications on the production and size of fruit is shown in the following table:—

Table 78.—Effect of Spray Applications

Block	Size of fruit, diam. 32nd of inch*	Weight per 5,000 cherries	Production in 11 quart baskets of 5 trees in each block
		lb.	
A	23·41	36¾	12
B	23·32	39¼	13
C	23·07	36¼	13
D	24·55	43	13
E	23·20	37	15½
F	23·75	41½	13⅛
G	23·76	41	11⅔
Check	23·83	39	9¼

* Figures in column 1, average of 1,000 cherries.

The orchard produced a fair crop of cherries in spite of the fact that for two years the trees had lost their foliage prematurely as a result of leaf spot.

The cherries from Bordeaux sprayed trees were again smaller in diameter than those from lime sulphur sprayed trees, as has been shown in our Annual Reports for the last five years. A comparison of the diameters of cherries from Blocks A and G with B will demonstrate this. In this connection it is interesting to note that the cherries from Blocks D and F (Bordeaux and lime sulphur) compared very favourably with lime sulphur blocks A and G. This would tend to point out that a single bordeaux spray at shucks time does not decrease the size of the cherries if the later applications are made with lime sulphur. It must be understood of course, that these results are for one year only and therefore must be repeated over a periol of years before any definite conclusions can be arrived at.

In Block C, aluminium sulphate was added to the regular Bordeaux to test the effect of this material in combination with Bordeaux spray. The smallest cherries were harvested from this block although the difference in diameter was but small. Also the greatest defoliation occurred in this block. We received a report of one other instance where lime sulphur combined with aluminium sulphate caused serious yellowing and drop of leaves.

Yellowing of the leaves and leaf drop occurred in all blocks to some extent. This yellowing appeared suddenly on June 17th and disappeared with the dropping of affected leaves. It was thought that the cause of this yellowing was due to the drought conditions and weakened vigour of the trees. No fungus was isolated from affected leaves and with rain the yellowing disappeared. Later in the season yellowing reappeared, following a second period of drought.

The extent of yellowing and leaf drop in the various blocks on September 11th is shown in table 79.

Table 79—Percentage of Trees of various Blocks Showing Different Degrees of Yellowing of Leaves

Block	Per cent normal green foliage	Yellowing and defoliation							
		15%	25%	40%	50%	65%	75%	90%	100%
A	52·9	23·5	17·6	0	0	0	5·8	0	0
B	0	0	27·2	0	50·0	0	22·7	0	0
C	0	0	0	4·7	27·6	0	33·3	14·2	0
D	7·1	10·7	25·0	7·1	39·2	3·5	7·1	0	0
E	11·5	15·3	46·1	3·8	23·0	0	0	0	0
F	40·7	11·1	25·9	0	22·2	0	0	0	0
G	47·6	0	19·0	0	33·3	0	0	0	0
H	0	12·5	12·5	0	37·5	0	25·0	12·5	0

At this time the best block was undoubtedly Block A, a lime sulphur sprayed block. Block B, copper sprayed, and Block C, copper with aluminium sulphate, showed considerable yellowing and defoliation. Earlier in the season this greater yellowing of the leaves in the copper sprayed blocks was also noted. In the blocks receiving one application of copper during the schedule, little difference was noted on the occurrence of leaf yellowing.

The spraying demonstrations on cherries this year again point out that Bordeaux mixture causes a dwarfing of the fruit. This has been clearly demonstrated each year for the past six years. From the experiments outlined above, lime sulphur has caused less defoliation than Bordeaux. Of course it is to be pointed out that these results, in so far as defoliation is concerned, are for one year only and must be repeated over a period of years before definite conclusions can be drawn. Observations made during the past five years would tend to bear out this, however. It is particularly interesting to note that the blocks receiving a Bordeaux spray at shucks time followed by lime sulphur in the later sprays had very little defoliation.

(*b*) FALL SPRAYING OF PEACHES FOR CONTROL OF LEAF CURL

(*Taphrina deformans* (Berk.) Tul.)

The practice of fall spraying to control leaf curl of peaches has been discouraged somewhat on account of two reported cases of severe injury to the buds and twigs. However, it is quite true that fall spraying has many distinct advantages over spring spraying provided it is safe. During the last five years there have been two severe epidemics of leaf curl due to the fact that weather conditions in early spring would not permit the spraying of peach orchards in time. In such seasons, fall spraying, if found to be safe, would save the industry many thousands of dollars. With this object in mind the St. Catharines laboratory has started a comprehensive study of peach leaf curl fungus, paying particular attention to the possibility of fall spraying for its control. We are particularly anxious to ascertain the set of conditions that may produce injury with fall spraying in order to be able to avoid them if possible in the future. With this object in mind a series of sprays is contemplated for each month of the dormant season. For this present year, however, we have to report only for the regular fall spray as practised in other years, and the results of which are given below in table 80.

TABLE 80—FALL SPRAYING OF PEACHES

Block	Date of application	Material	Per cent of leaf curl. May 20, 1929	Number of peaches, 10 trees	Remarks
A	Dec. 12, 1928	Lime sulphur 1–8	4·9	5,421	
B	April 9, 1929	Lime sulphur 1–15	24·9	1,766	Buds burst exposing ⅛″ green tissue.
C	April 13, 1929	Bordeaux oil	12·3	2,592	Buds burst blossoms showing white.
D	No spray		62·1	No harvest.	

This season was particularly favourable for leaf curl infection. The check block suffered practically complete defoliation as a result of curl infection. The results obtained are therefore very striking. The spring applications were applied later than is recommended, but as early as the condition of the land would permit. In fact, very little spraying had been done in the district at the time of these applications. As seen from the above, fall spraying increased the crop by 2,829 peaches. In an orchard of say 1,000 trees, the increase on this basis would amount to 282,900 peaches. Truly a stupendous increase. However, it must be clearly understood that these results are for one year only and that no injury whatever resulted from the fall spraying. The injury this year resulted from spring spraying in the sense that spring spraying was too late to effect control. Fall spraying this season was entirely satisfactory. Fall spraying, along with spring spraying, for leaf curl will be a yearly program at the St. Catharines laboratory until something of a more definite nature is known concerning the possibilities of injury from fall spraying. It is interesting to note from the above table that Bordeaux oil gave better control than lime sulphur, even although the Bordeaux was applied four days later.

(c) SPRAYING EXPERIMENTS FOR THE CONTROL OF SCAB ON PEACHES

Scab, or black spot of peaches, is becoming more serious each year. It has been found difficult to obtain good control of this disease by the present spray schedule. The following experiment using various spray materials was carried out in an endeavour to find a better fungicide for scab control. However, very little scab was present this year, and therefore no clear-cut results were obtained. This experiment shall be continued over a period of years. We shall also endeavour to improve the spray schedule itself, basing such improvements on the life history of the fungus.

TABLE 81—SPRAYS USED FOR SCAB ON PEACHES

Block	Material	Applications
A	Lime sulphur 1–50 Aluminium sulphate 3½ pounds	Shucks. 2 weeks later.
B	Wettable sulphur 7½ pounds to 40 gallons	Shucks.
C	Wettable sulphur 7½ pounds to 40 gallons	Shucks. 2 weeks later.
D	Zinc sulphate 4 pounds Zinc sulphate, 3½ pounds Hydrated lime, ½ pound Casein.	Shucks. 2 weeks later.
E	Check	No sprays.

The shucks applications were applied June 11 and the two weeks spray June 24. Zinc sulphate is a new spray for peaches and was first tried in Indiana. This spray material proved easy to make up and to apply and is very promising as a spray for peaches. The results of this experiment are shown in the following table (82). A block of Elberta peaches was used.

TABLE 82—RESULTS OF SPRAYING FOR PEACH SCAB

Block	Per cent clean	Per cent light scab	Per cent medium scab	Per cent severe scab
A	83·0	13·7	2·6	0·6
B	66·6	24·2	5·5	3·5
C	83·8	11·1	3·7	1·2
D	89·2	8·0	2·2	0·4
E	76·0	18·4	4·3	1·1

The season was not favourable to heavy scab infection, although light scab infection developed late in the season. No scab infection was noted on the fruit on July 20. Fruit showing one to five pin point scab spots was recorded as light scab infection; five to ten spots, medium infection; over ten, severe infection. The results show that zinc sulphate (Block D) gave the best results in controlling scab. Lime sulphur (Block A) and wettable sulphur (Block C) also gave good control. No injury from the use of lime sulphur 1-50 and aluminium sulphate was to be noted. In Block B, where wettable sulphur was applied at the time of the shucks only, no control was obtained. Zinc sulphate has promise as a foliage spray for peaches. The cost per 40 gallons of spray material was 76½ cents, compared to a cost of 43 cents for a similar amount of wettable sulphur spray. The addition of calcium caseinate to the zinc sulphate spray gives added spreading and sticking quality to the spray.

(d) SPRAYING EXPERIMENT FOR THE CONTROL OF APPLE SCAB (*Venturia inoequalis* Aderh.)

The young McIntosh block of apples was sprayed as follows:—

TABLE 83—RESULTS OF SPRAYING FOR CONTROL OF APPLE SCAB

Block	Material	Application	Date	Per cent leaf infection Sept. 19, 1929
A	Lime sulphur 1–40	1. Delayed dormant	April 24	1·8
		2. Pink	May 11	
		3. Calyx	May 28	
		4. 3 weeks	June 24	
B	Bordeaux 3–3–40 Wettex	1. Delayed dormant	April 24	2·3
		2. Pink	May 11	
		3. Calyx	May 28	
		4. 3 weeks	June 24	
C	Check	No sprays		11·0

The season was not favourable for heavy scab infection. The leaf lesions recorded were largely those of late infection. There is not sufficient difference in the two sprayed blocks to draw any conclusions. The previous year in a like experiment it was found that Wettex applied for the later applications did not protect the fruit from the late infection nearly as effectively as lime sulphur.

This year with scab infection less general the same tendency is seen. During the last two seasons spraying demonstrations have shown that in substituting Wettex for lime sulphur or Bordeaux there has been less foliage injury but control of scab has not been as satisfactory.

(e) The Susceptibility of Various Varieties of Apples to Scab Infection

The different blocks of various varieties of apples all received similar treatment for scab control which was the same as in Block A of the McIntosh block. The percentage of scab infection present on the foliage of these young trees on September 19 is shown in the following table:—

Table 84—Percentage of Scab Infection

Variety	Sprayed blocks, per cent scab on foliage	Check blocks, per cent scab on foliage
Melba	3·1	4·5
Hume	2·4	17·1
Joyce	3·4	5·6
Courtland	6·3	20·0
Fameuse	1·1	3·3
Northern Spy	0·9	10·1
Delicious	1·0	8·6
Duchess	1·6	11·4
Baldwin	4·5	24·4
Greening	9·0	*
McIntosh	1·8	11·0

*Trees replaced.

Inspection and Certification of Raspberry Stock

This work was again carried on from this laboratory. The stock of nurserymen and growers received two inspections and aid in roguing. In other cases inspections were made only upon request. A total of 120 inspections were carried out comprising approximately 200 acres of raspberries. As a result of these inspections, 30 growers including the nurseries were given certificates for disease-free stock.

Ascospore Discharge of *Venturia Inaequalis*

(G. C. Chamberlain.)

During the past six years, while conducting spraying experiments to control scab disease of apples, observations were made on the periods of ascospore discharge. These data are recorded here along with temperature and precipitation record since there appears to be a striking correlation between environmental factors, particularly temperature, and discharge of ascospores over a number of years.

The data were secured from over-wintered leaves of the McIntosh variety showing abundant perithecial production. These leaves were kept out-of-doors placed in position on a gunny sack, to prevent splashing of mud, and held in position by nails. Above the leaves were placed microscopic slides smeared with vaseline. These slides were changed and examined after every period of rainfall from the time that ascospores were seen to be mature until no further discharge was noted. The relative amount of discharge occurring was noted as being light, medium or heavy. The ascospores were generally found adhering to the slides in clumps and the frequency and size of the clumps provided a means of judging the intensity of discharge.

TABLE 85—ASCOSPORE DISCHARGES

—	1924	1925	1926	1927	1928	1929
Date of initial discharge	May 16*	May 1	May 19	May 4	April 21	April 20
Number of discharges	11	11	12	17	14	15
Date of first major discharge	June 6	May 7	May 19	May 23	May 17	April 28
Date of final discharge	June 28	June 28	June 26	June 26	June 27	June 25
Number of days in discharge periods	43	58	38	53	67	66

* Actual initial discharge not obtained in 1924.

In comparing the mean temperatures of the months preceding ascospore discharge with the initial ascospore discharges, a striking correlation is apparent as will be seen from table 86.

TABLE 86—CORRELATION BETWEEN TEMPERATURE AND ASCOSPORE DISCHARGE

Year	October	November	December	Average mean temperature	Initial ascospore discharge	
					Date	Year
1923	47·8	38·2	35·4	40·4	May 16	1924
1924	52·3	40·8	24·6	39·2	May 1	1925
1925	44·0	38·4	27·4	36·6	May 19	1926
1926	50·5	39·8	25·3	38·5	May 4	1927
1927	55·1	44·3	30·1	43·4	April 21	1928
1928	53·8	41·3	34·1	43·0	April 20	1929

NOTE.—Ascospore discharge in any year is to be compared with the temperature of the fall months preceding, that is, the discharge of 1925 is dependent upon the fall temperatures of 1924.

From the above table it is apparent that there exists a correlation between the mean temperature of the fall months and the date of initial ascospore discharge the following spring. For instance in both 1928 and 1929, initial ascospore discharge took place on April 20 and April 21 respectively and the temperature for the fall months preceding was 43.4 and 43.0 respectively. In other words, the highest fall temperatures were in 1928 and 1929 and these temperatures were followed in turn, by the earliest ascospore discharges. Conversely the lowest fall temperatures were experienced in 1925 and 1926, namely, 36.6 and 38.5 respectively, which were in turn, followed by the latest ascospore discharges, namely, May 19 and May 4 respectively. This points out a striking correlation which may be found to be of some value from the standpoint of control. The following chart (fig. 43) shows this correlation very clearly.

When the mean temperature of the winter months, January, February and March are compared no such correlation is apparent as can be seen from table 87 below.

TABLE 87—CORRELATION BETWEEN TEMPERTURE AND ASCOSPORE DISCHARGE

Year	Mean temperatures			Average mean temperatures	Initial ascospore discharge	
	January	February	March		Date	Year
1924	21·0	19·4	30·2	23·5	May 16	1924
1925	21·5	28·6	36·2	28·7	May 1	1925
1926	25·0	22·9	23·6	23·8	May 19	1926
1927	24·4	29·7	37·1	30·4	May 4	1927
1928	26·6	26·4	31·9	28·3	April 21	1928
1929	24·0	22·6	37·9	28·1	April 20	1929

There does not appear to be any correlation here between the winter months of January, February and March and time of ascospore discharge. In this respect, our records do not bear out the contention of Howitt & Evans*, who say "The mean temperature of the winter months, especially of January, February and March has a marked influence upon ascospore development and primary discharge in the spring in *Venturia inaequalis*."

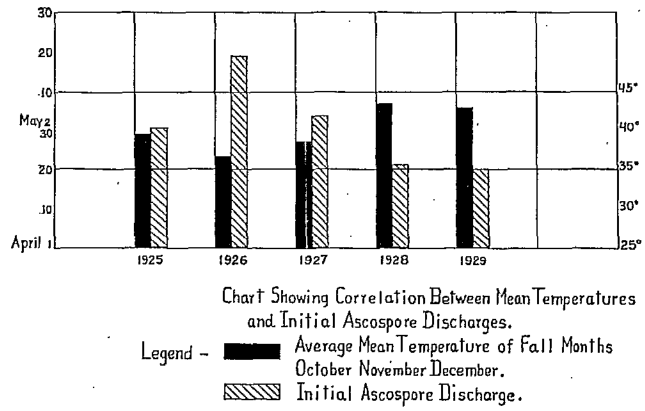


FIG. 43.—Correlation between temperature and ascospore discharge.

However, when the mean temperature for the six months preceding ascospore discharge is compared as above, the same correlation is apparent as when the fall months (October, November and December) alone are compared. Table 88 brings this out clearly. Howitt & Evans* also found a correlation between this six months period and time of initial discharge.

TABLE 88—CORRELATION BETWEEN TEMPERATURE AND ASCOSPORE DISCHARGE

——	1924	1925	1926	1927	1928	1929
Mean temperature for October	47·8	52·3	44·0	50·5	55·1	53·8
Mean temperature for November	38·2	40·8	38·4	39·8	44·3	41·3
Mean temperature for December	35·4	24·6	27·4	25·3	31·0	34·1
Mean temperature for January	21·0	21·5	25·0	24·4	26·6	24·0
Mean temperature for February	19·4	28·6	22·9	29·7	26·4	22·6
Mean temperature for March	30·2	36·2	23·6	37·1	31·9	37·9
Average mean temperature for Oct., Nov., Dec., Jan., Feb. and March	32·0	34·0	30·2	34·5	35·8	35·6
Date of initial discharge	May 16	May 1	May 19	May 4	April 21	April 20

From the above it would appear that the temperatures of the fall months play a more important part in connection with ascospore discharge than do the temperatures of the winter months, January, February and March. This is borne out by the fact that although the six months period (October, November, December, January, February and March) shows a correlation as noted above, there is no such correlation with the winter months (January, February and March), whereas there is a definite correlation between the temperature of the fall months (October, November and December) and ascospore discharge. This correlation for the fall months is identical with that for the six months period. It would therefore appear as though fall months were the more important in influencing ascospore discharge.

* Howitt, J. E. & Evans, W. G., Preliminary report of some observations on Ascospore Discharge and Dispersal of Conidia of *Venturia Inaequalis* (Cooke) Wint. Phytopathology, Vol. XVI, August, 1926.

Undoubtedly precipitation is an important factor in perithecial production. Records for the past six years show that ascospore discharge in Ontario is directly associated with periods of rainfall. It would appear from our observations as though the temperature of the fall months plays its part in the early stages of perithecial production and then as maturity approaches, precipitation is the all-important factor related to actual discharge periods. This is brought out to some extent at least by a comparison of the following tables (89 and 90):—

TABLE 89—PRECIPITATION, OCTOBER, NOVEMBER AND DECEMBER

—	1924	1925	1926	1927	1928	1929
Precipitation, rain, Oct., Nov., Dec.	....	2·31	6·15	7·28	9·33	7·60
Precipitation, snow, Oct., Nov., Dec.	....	8·75	8·00	13·50	2·50	2·00
Total as rain	8·92	3·185	6·95	8·630	9·58	7·80
Date of initial discharge	May 16	May 1	May 19	May 4	April 21	April 20

A study of this table does not bring out any definite correlation between rainfall and ascospore discharge. On the other hand a study of the precipitation for the winter months in comparison with dates of initial ascospore discharge suggests a definite correlation. This is brought out in table 90 below.

TABLE 90—PRECIPITATION, JANUARY, FEBRUARY AND MARCH

—	1924	1925	1926	1927	1928	1929
Inches of precipitation, rain	....	4·58	2·63	4·69	4·72	5·64
Inches of precipitation, snow	....	21·75	24·25	19·25	27·50	24·50
Total as rain—1 inch snow = $\frac{1}{10}$ inch rain	7·87	6·755	5·055	6·615	7·470	8·090
Date of initial discharge	May 16	May 1	May 19	May 4	April 21	April 20

As noted above, the greatest rainfall occurred in 1928 and 1929 when also the earliest ascospore discharge took place. In 1926 and 1927 the least rainfall was experienced and here also the ascospore discharge was delayed the most. This suggests a correlation between rainfall of winter months and ascospore discharge of spring. This correlation is brought out clearly in diagram form in the chart below (fig. 44).

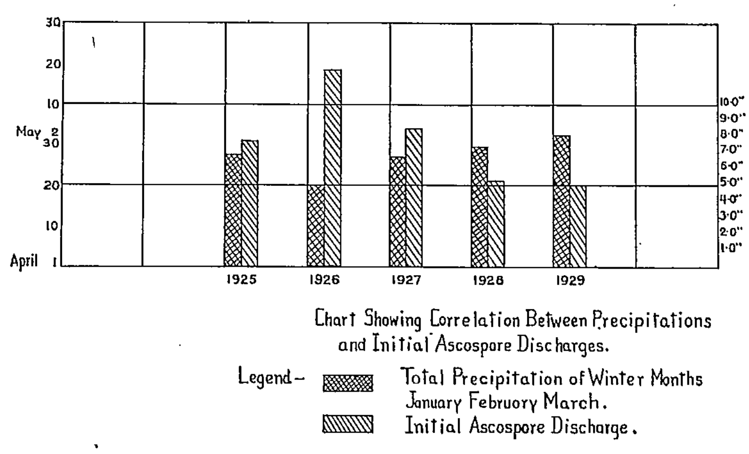


FIG. 44.—Correlation between precipitation and initial ascospore discharges.

In comparing the rainfall for the six months period as was done for temperature, there does not appear to be any constant correlation between precipitation and ascospore discharge. Following the same reasoning here, as was outlined above for temperature, it follows that the precipitation of January, February and March has a more direct connection with ascospore discharge than has the precipitation of October, November and December. It therefore follows from the above that a fairly definite correlation can be shown between the mean temperature of October, November and December and ascospore discharge on the one hand, and between precipitation during January, February and March and ascospore discharge, on the other.

In explanation, it might well be that temperature is the more important factor in the early stages of perithecial formation and differentiation but once the final stages of maturity are approached, moisture may then become of greater importance. It is definitely known for instance, that the actual discharges in the spring depend upon precipitation. This is clearly shown by fig. 45 which gives the ascospore discharges for the years 1925 to 1929 as related to precipitation. It is to be noted that in every case discharge takes place during a period of precipitation.

Some instances have been noted where rainfall took place with no ascospore discharge resulting. In these cases the perithecia were likely temporarily exhausted of mature ascospore and hence no discharge. There is no direct correlation between amount of rainfall and intensity of discharge. Heavy discharges sometimes follow light rainfalls, and conversely, light discharge sometimes follows heavy rainfalls. Sufficient rainfall to thoroughly wet the leaves appears to be all that is necessary to cause discharge. See Figure 45.

There is a great variation in the number and intensity of discharges. Some years the major discharges are early, while in other years they are greatly delayed. This was quite marked in 1924 when the heaviest discharge occurred on June 13, just four days after the calyx stage of the host. In 1929 the period of major discharge occurred shortly after the host was in the delayed dormant stage. When the period of major discharge occurs early in the development of the host, the control of scab is more difficult.

In this connection it is interesting to note that in those seasons of greater rainfall (January, February and March) the major ascospore discharges in most cases have taken place earlier than in seasons of less rainfall. The following table (91) points this out. The year 1928 is, however, an exception.

Table 91—Rainfall and Major Discharge Periods

—	1924	1925	1926	1927	1928	1929
Rainfall	....	6·755	5·055	6·615	7·470	8·090
Initial discharge	May 16?	May 1	May 19	May 4	April 21	April 20
Major discharge	June 13	May 7	May 31	May 23	May 17	April 28

For instance, in 1929, the season of greatest rainfall, the major discharge was the earliest, namely, April 28. In 1926 the season of least rainfall, the first major discharge was the latest, namely, May 31. In 1925 and 1927 the rainfall was quite comparable being 6·755 and 6·615 inches and the first major discharge was May 7 and May 23, respectively. In 1928 with a rainfall of 7·470 inches (the second greatest rainfall), the first major discharge took place May 17. In this year the correlation does not hold true because the rainfall for 1928 was greater than in 1925, yet the major discharge was delayed ten days. The reason for this delay was that no rain fell from April 30 until May 17 (see fig. 45), hence there was no possibility of ascospore discharge

Strawberry Root-Rot

(A. R. Walker)

Work on the strawberry root-rot was resumed at the St. Catharines laboratory the second week in May. The investigations of the two preceding years had indicated that certain lines of approach were most promising. These aspects of the problem were continued and new ones added.

During the season of 1928 a number of plants of Glen Mary and Wm. Belt varieties were inoculated with either *Fusarium* sp. or *Ramularia* sp. In either case the inoculum consisted of a culture obtained by making isolations from diseased plants.

The much larger number of organisms used for inoculations the previous year was reduced to these two because these two only occurred frequently in isolations and they had already given considerable promise in previous tests. Both strawberry patches used for these inoculations had been set out in the early summer of that season.

A few of these plants had gone down and reisolations gave positive results during 1928. Little or no additional positive evidence was obtained at the first examination for 1929, i.e., on May 8. However, about the first of June more plants began to succumb. These earliest symptoms were confined to a few plants but the death rate increased until it reached a maximum early in the third week of June. The disease naturally occurring, reaches its maximum severity about the last week in June. Thus the inoculated over-wintered plants fell down earlier than plants contracting the trouble naturally.

Of the thirty-two plants inoculated with *Ramularia* sp., twenty-four went down before the end of the 1929 season. Six plants were alive and apparently healthy. The identity of two plants was in doubt. Reisolations were made from ten of these diseased plants. Several isolations were usually made from each plant so that in all forty-two isolations were made. Of these forty-two reisolations, twenty-six were positive. Perhaps the most interesting results in this connection were that the twenty-six positive isolations were so distributed that each of the ten plants used for reisolation gave at least one *Ramularia* culture. Thus 75 per cent of the inoculated plants were casualties, and 100 per cent of the plants used for reisolation yielded positive results in at least one case.

Twenty plants had been inoculated with *Fusarium*. Sixteen of these died, two were still alive and two of uncertain identity. Isolations were made from four of these. Two of these yielded *Fusarium* sp. and two *Ramularia* sp. In both cases the *Ramularia* came from the roots. Thus 50 per cent of these yielded *Fusarium* and 50 per cent *Ramularia*.

Fifty-two plants were used as checks. Thirty-four of these died, twelve lived to the end of the season and six were unidentified, i.e., 65 per cent were casualties.

Isolations were made from crowns and roots of plants which had contracted the trouble naturally. The majority of these plants were of the Glen Mary variety from the plot at the farm. A few were from Wm. Belt plants from a similar plot, while some were made from diseased plants obtained from grower's plots.

These isolations yielded mostly cultures of *Ramularia* sp. or *Fusarium* sp. In this respect the results were in accord with those obtained during the two former seasons work on this problem. By making isolations from forty plants, sixteen cultures yielded *Ramularia* sp., fourteen yielded *Fusarium* sp. and eight yielded a sterile mycelium, i.e., forty per cent of the infected plants yielded *Ramularia* sp. and thirty-five per cent gave *Fusarium* sp. The remainder of the organisms were mostly a mucor, bacteria or eelworms.

An examination of these two series shows that plants contracting the disease naturally, yielded more *Ramularia* cultures than any other organism. Still more striking is the high percentage of *Ramularia* isolated from diseased plants inoculated with this organism. However, a large number of plants yielded other organisms. It appears that if an organism be responsible either: (1) more than one organism is capable of causing the trouble—the less virulent, sparingly occurring forms being able to attack weakened plants only, or (2) one organism is the primary cause but the technique employed did not detect all the organisms in every diseased plant. Some of the forms isolated rather sparingly were only secondary. The latter view is quite tenable because isolations were made from small sections only, of the diseased roots; since a large part of the root system of each plant was discarded it would be easily possible to miss the real pathogen in many cases.

Runners from healthy plants were allowed to set in pots filled with soil from different sources. These soils might be conveniently grouped into two classes: (1) sterilized garden soil, (2) soil taken from around the roots of diseased plants from badly infested fields.

The plants growing in sterile soil all remained healthy throughout the season and produced a good crop of berries. Those growing in unsterilized soil suffered a 27.5 per cent casualty and the remaining plants produced a much smaller crop. Soil from several pots of each group was examined for organisms by the poured plate method.

Isolations made by pouring plates from nine pots of soil yielded *Ramularia* sp. from four pots, *Fusarium* sp. from two, *Penicillium* from six, *Rhizopus* from seven and bacteria in every case. There seemed to be little difference between the sterile soil and the suspected soil in this connection. However, the so-called sterile soil had been sterilized and set out in the field in August of the previous year. Hence, it was quite to be expected that the "sterile" soil would be almost or quite as abundant in organisms as the unsterilized. The hope that perhaps an organism not common in soil might be found more plentifully in the suspected soil was not realized.

Samples of soil for analysis were taken (*a*) from pots of sterile soil which had produced a good crop this year, (*b*) from the pots containing suspected soil and which had been found so satisfactory for growing strawberries, and (*c*) from the unsterile soil of the field which had produced a crop of Wm. Belt strawberries this season. These samples were chemically examined through the kindness of the Dominion Chemist. The results of the analysis are as follows (table 93):—

TABLE 93—RESULTS OF CHEMICAL ANALYSES OF SAMPLES OF SOIL

Number	PH	Moisture	Loss on Ignition	Soluble in HC1	Insoluble in HC1	Nitrogen
		%	%	%		%
1. Sterile potted soil........	7·85	2·48	5·79	5·29	86·44	0·185
2. From fields..............	7·57	1·13	4·15	4·38	90·04	0·150
3. Suspected potted soil.....	7·62	1·29	3·91	4·35	90·45	1·25

There appears to be nothing in these results which would suggest that the chemical composition of the soil was an important factor. Perhaps the higher organic content indicated in column III of the sterile soil accounted in large part for the higher moisture content of the same soil. This higher moisture content would, no doubt, tend to produce a better crop in the sterile soil. However, it could hardly be expected to account for a 50 per cent casualty among the plants growing in the suspected soil and no casualties among the plants growing in sterile soil.

between these dates. If a rainfall had occurred between these dates there would most likely have been a discharge. This suggests that it is unsatisfactory to attempt to correlate the major discharges, or in fact any discharges after the initial discharge, with any precipitation that may take place in January, February or March. With the initial discharge it is different because as our records show, the seasons with greatest rainfall mature their ascospores the earliest and therefore with the first rainfall of late April or early May, discharge will take place.

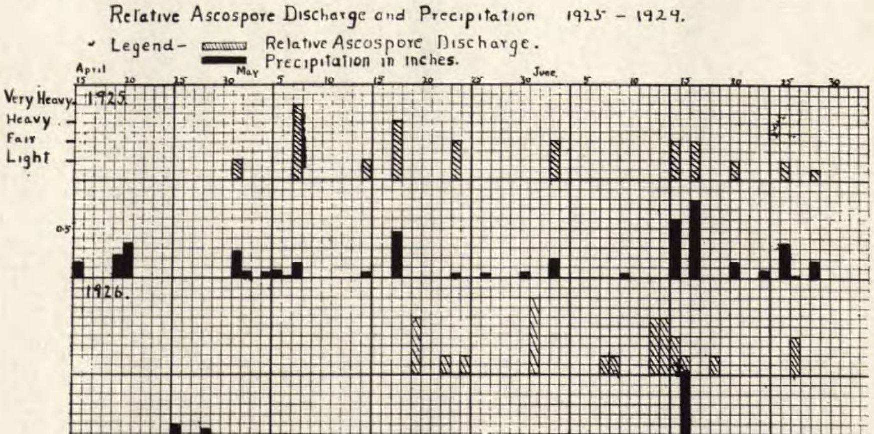


FIG. 45.—Relationship of ascospore discharge to precipitation.

This is clearly pointed out by the following data. In 1928 the first discharge took place on April 21, accompanied by rain, of course. However, a goodly sized rainfall occurred on April 19—two days before—but no ascospores were discharged. The spores were evidently immature. It is to be recalled that in this year, 1928, when early ascospore discharge occurred, heavy precipitation took place in January, February and March. Now let us compare with this the conditions in 1926 when ascospore discharge was considerably later—May 19—and less precipitation was experienced in January, February and March. The first ascospore discharge occurred May 19, just 27 days later than in 1928. Yet in 1926 there were several heavy rainfalls previous to that occurring on May 19 when discharge took place. To be exact, rainfalls were experienced on April 21 (the identical date of first discharge in 1928), April 25, April 28, May 2, May 4, May 7, May 10 and May 11, yet in no case did discharge take place. Why not? Simply because the spores were not mature. Why were they not mature? Simply because the temperature conditions in October, November and December were not as favourable for perithecial growth as they were in October, November and December in 1928, and in addition the smaller precipitation of January, February and March did not hasten differentiation or maturation of the perithecia to the same extent as the greater precipitation in 1928 did. The result was delay in initial ascospore discharge. The records for the past six years show that although ascospore discharges always accompany rain periods, it does not follow that all rainfalls are accompanied by discharge. This points out that other factors besides rainfall play a part in ascospore discharge.

In this connection it should be pointed out that although there appears to be a definite correlation between fall (October, November and December) temperature and precipitation (January, February and March) on the one hand and initial ascospore discharge on the other, it would appear that all discharge periods taking place after the initial discharge (including major discharge) are largely dependent upon rainfall at time of discharge.

In comparing the time (table 91) of initial ascospore discharge of the fungus with the developmental stages of the apple, we find the following:—

TABLE 92—COMPARISON OF INITIAL ASCOSPORE DISCHARGE WITH THE DEVELOPMENTAL STAGES OF THE APPLE

—	Delayed dormant	Pink	Calyx	Initial ascospore discharge
1924	May 8	May 23	June 8	May 16?
1925	April 29	May 16	June 1	May 1
1926	May 8	May 21	June 4	May 19
1927	April 19	April 29	May 12	May 4
1928	April 28	May 12	May 29	April 21
1929	April 24	May 11	May 28	April 20

NOTE.—Dates for host development are mean for the period.

It is apparent from the above that ascospore discharge bears, over a period of years, no direct correlation with the host development. That is, for three years (1924, 1926 and 1927) primary ascospore discharge took place anywhere from 8 to 15 days after the middle of the delayed dormant period. In two years, 1928 and 1929, the primary discharge took place 7 to 4 days respectively before the host was in the delayed dormant stage. In 1925 the first discharge practically coincided with the delayed dormant stage of the host. From the standpoint of control the most important initial spray in 1925 should have been the delayed dormant; in 1926 the pre-pink, no delayed dormant necessary; in 1927 the pink, no delayed dormant necessary; in 1928 the delayed dormant and in 1929 the delayed dormant. These statements are based entirely on the above records and point out the advisability of basing spray schedules on other than host development alone, i.e., ascospore discharge and precipitation data.

The positive results obtained by inoculating plants in the crown with *Ramularia* spores, as indicated above, were rather encouraging this year. It was, therefore, decided to continue this method for another year. Therefore, a number of plants of the Glen Mary variety, which had just been set out during the summer, were inoculated by placing *Ramularia* spores in an incision in the crown. Plants with similar incisions were left as checks.

However, the high percentage of casualties among the check plants this year suggested that the treatment was too severe for them. Hence a series of inoculations was set up without making incisions in the plants. Young, healthy looking plants were dug and the soil removed from the roots in water. Only plants which then showed a good healthy root system were kept. The roots were dipped in 1/1500 mercuric chloride solution for a short time, rinsed in distilled water and then dipped into a suspension of *Ramularia* spores in water. The plants were at once set in a pot of sterile soil which had just been saturated with water. These potted plants were kept watered for two weeks—at first sheltered from the sun under a greenhouse bench and later in the field with the pots down to the rim in the soil.

Quite a number of these plants collapsed within a few weeks of being set out. Checks as well as inoculated plants went down so the organism perhaps had no bearing on these early casualties. It seems more probable that the treatment given the plants was too severe—especially as the weather was hot and dry at that time. Many of these early casualties were replaced giving the roots a shorter exposure to the bichloride solution. Thus a good many of these inoculated plants were left to overwinter.

This type of root inoculation is to be continued in the greenhouse during the winter using plants grown from sterilized seed in sterile soil. Thus it will be possible to largely eliminate the probability of pre-experimental infection and at the same time avoid the necessity of exposing the roots to the violent treatment of sterilization. Moreover, even when sterilization is resorted to there is no reasonable guarantee that the healthy appearing roots are not already in early stages of the malady when the plants have been raised under ordinary soil conditions.

Early last season five hundred Wm. Belt plants were set out at different depths of planting. This was done as pointed out in the report on last summer's work, to determine if variations, from the established rules for planting, by careless workmen might reduce the vigour of plants sufficiently to be a predisposing factor in root-rot.

During the latter part of the first season indications from runner production were that the normal planting would yield the best rows, deep planting next and shallow planting the poorest rows. However, observations were continued on these rows throughout the present season with results as shown in the following table (94):—

TABLE 94—RESULTS FROM DIFFERENT DEPTHS OF PLANTING

—	Number of plants living July 27, 1928	Number of plants living May 8, 1929	Rate increase in number of plants	Number of boxes berries picked 1929	Boxes per 100 plants living as on May 8
Normal planting	103	1,549	15·1:1	45·5	44
Deep planting	111	2,163	19·4:1	68·75	62
Shallow planting	106	2,002	18·9:1	60·5	57

NOTE.—One row of the normal depth planting had fifty-one healthy plants on July 27 last. Twenty-eight of these were inoculated with *Ramularia* or were used as checks. This would naturally mean a considerable reduction in vitality of these plants. Hence, it is only to be expected that the normal planting would suffer a little by comparisons. With this discrepancy explained the marked similarity of the corresponding figures for the two extremes, i.e., deep planting and shallow planting indicates that within the range of depth variations used there was very little influence on the plants. Since these extremes of planting allow for variations of one inch it would seem that when planting is done following the usual standards with a fair degree of care the depth is perhaps not a factor. Certainly no significant variation in the amount of root-rot was observed under these experimental conditions.

One-half of each row in the above mentioned plot of Wm. Belt plants was mulched. The other half of each was left to winter over unprotected. However, the results obtained from the experiment were very confusing. Whether the straw mulch were put on too thickly or left on too late in the spring or what, is difficult to say. Whatever the cause, the very first observation in spring revealed that the unprotected portion was much more vigorous than the protected one. This difference was evident throughout the year. The number of plants living in each part of the patch on May 8, illustrates the peculiar results. There were 3,727 in the non-mulched end and only 1,987 in the mulched end.

The survey of strawberry fields during 1928 indicated that perhaps the trouble remained in the soil from one crop to another. To check up this point soil from various sources was potted and strawberry runners were trained so that young plants would set in the pots. These plants were overwintered under ordinary field conditions unprotected.

During the season 1929 it was observed that the plants growing in the check pots with sterile soil were much healthier from the first of the season than those growing in pots containing soil from diseased fields. This discrepancy increased as the season progressed. The results from these potted plants are given in the following table (95):—

TABLE 95.—RESULTS FROM POTTED PLANTS

Suspected soil, lot	Total number plants used	Good healthy plants on				Very weak plants on				Dead plants on				Per cent of casualties	Total number berries picked	Number of berries per plant alive on July 15
		May 8th	May 27th	June 21st	July 15th	May 8th	May 27th	June 21st	July 15th	May 8th	May 27th	June 21st	July 15th			
No. 1	9	2	0	0	1	1	2	1	1	3	2	3	3	33	2	0·34
No. 2	19	7	3	0	0	5	6	10	14	0	0	2	2	10	55	3·2
No. 3	12	5	0	2	1	2	3	3	2	0	1	3	6	50	44	7·3
Total suspected lots	40	14	3	2	2	8	11	14	17	3	4	8	11	27·5	101	3·5
Sterile soil	15	9	12	10	12	2	1	0	0	0	0	0	0	0	100	6·7

A noteworthy point brought out by 3rd and 4th columns of figures is that even if the number of dead plants is not very high in the suspected soil as in No. 2, a large number of plants still living are in a very weak, unhealthy condition.

The diseased plants which appeared in the suspected soil were removed as soon as observed and isolations were made from them. In all cases *Ramularia* sp. were isolated along with other organisms in some cases.

In conclusion it may be stated that indications are strongly in favour of assigning the cause of the strawberry root-rot as found in the Niagara district, to the Ramularia sp. isolated so frequently.

Peach Canker Investigations

(R. S. Willison)

Owing to the fact that this investigation was not taken over by the writer until late in the summer, little beyond a preliminary survey of existing conditions and the planning of future experiments has been done. However, in the course of the second annual survey of the recently planted peach orchard, some interesting information has come to light. The purpose underlying this annual survey is the collection of accurate data concerning the history of individual trees in the plantation, their growth from year to year, reaction to various treatments, etc. It is understood, of course, that it is impossible to draw definite conclusions from the observations of a single season, but, at the same time, it is possible to follow the general trend of those observations. The results of the survey in its various phases will be discussed briefly below.

The new peach orchard consists of a number of variety blocks of ten trees each and a large block of Elbertas, containing 240 trees. The latter, for experimental purposes is subdivided into a number of plots. One (20 trees) had cultivation stopped and a cover crop of clover planted in it, on June 15, about a month before the usual time for sowing cover crop. The remainder had the cover crop planted on July 22nd; a plot of 15 trees with clover and the rest with rye. In the latter is a block of 50 trees specially selected for freedom from wounds and blemishes at time of setting out. These trees proved to develop more satisfactorily than the rest of the orchard. While in the southeast corner poor drainage conditions gave rise to an irregular patch of unthrifty trees. Spray and disinfection experiments were also carried out on the plot receiving the late rye cover crop.

GROWTH

The diameters at the base and summit of the main stem were measured and the former compared with the diameters recorded in the summer of 1928. From these facts the percentage of increase in diameter was calculated. For the purpose of comparison, twenty to twenty-four trees in representative blocks of trees were used. The results are given in table 96.

TABLE 96—PERCENTAGE OF INCREASE IN DIAMETERS OF TREES

Description of block (Elberta variety)	Number of trees	Lowest increase in diameter	Highest increase in diameter	Average increase in diameter
		%	%	%
Early cover crop (average trees)	18	38·9	175·0	121·0
Average trees	24	74·1	211·1	138·5
Late cover crop—				
Stock specially selected for freedom from blemishes	24	100·0	255·6	165·5
Trees in block not doing well, on account of poor drainage	24	20·0	140·0	70·7

WOUNDS

(a) Pruning Wounds.—As the trees of the young orchard were only whips last year, this year's pruning consisted chiefly of the decapitation of the main stem. Thus it was easy to make a record of the progress of healing of the pruning wounds. Wherever pruning was close to a lateral branch, i.e., no stub left, the wound showed signs of closing by August and in practically every case the callus had grown up well over the edge of the wound. On the other hand, where even a short stub was left, healing was hindered, the callus rarely succeeding in growing over the edge of the stub and many showed symptoms of canker. Measurements were made of the unhealed portion, of the amount of dying back, or of size of cankers, in terminal pruning wounds. In the blocks in which disinfectants were applied to pruning wounds, the percentage of dying back is higher and healing is delayed. White lead, in particular, seems to be decidedly toxic to callus. However, once the white lead is separated from the living tissue by a thick layer of dead cells or cork, healing proceeds.

TABLE 97—SUMMARY OF OBSERVATIONS MADE ON PRUNING WOUNDS—VARIETY ELBERTA

Treatment	Healing or healed		Dying back (not cankered)		Cankerous in appearance		Total
	No.	Per cent	No.	Per cent	No.	Per cent	
Disinfected with Florium (5%)............	4	40	6	60	0	0	10*
Disinfected with Agrisol (5)...............	3	30	6	60	1	10	10*
Disinfected with White Lead..............	3	12	19	76	3	12	25
Disinfected with Neutrum Tar............	1	20	3	60	1	20	5*
Total disinfected.......................	11	22	34	68	5	10	50
Not disinfected; selected stock............	11	44	8	32	6	24	25
Not disinfected: ordinary stock...........	72	38	94	49·5	24	12·5	190

* The total number of cases in each of these groups is too small for these percentages to be strictly representative, therefore comparison between different disinfectants should not be made. For the same reason, the totals for the disinfected trees were also inserted in the table.

Judging by the figures for this year, it would appear that the advantages gained by disinfection are not great enough to offset the time, trouble and expense of application, in the case of small wounds. As yet we have no data concerning the effect of disinfection of large wounds.

(b) Cultivation and Mechanical Injuries.—Many of the trees suffered from these types of injuries (usually deep scrapes and bruises) during the early part of the current season. Measurements of these wounds were made in August and again in the early part of November, at the beginning of the dormant period. In the interval, some had healed completely, others had increased in size. The data obtained are summarized in table 98.

TABLE 98—CULTIVATION AND MECHANICAL INJURIES

Varieties	Healed completely		Healing, i.e., decreasing in size		Not changed		Increasing in size	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Elberta..........................	70	71·4	23	23·5	3	30·6	2	2·04
Other varieties....................	27	33·0	41	50·0	9	11·0	5	6·0
Total.........................	97	53·9	64	35·5	12	6·7	7	3·9

(c) Wounds made May 6, 1929.—These were made with a scalpel and consisted almost entirely of scarifications or longitudinal slits to the cambium, with a few pruning wounds, where laterals were removed. The scarifications were all healed by August 20, with one exception, and that was closed by the end of the season. The pruning wounds are all healing well, with a vigorous callus. Two or three were left as short stubs. These have died back somewhat, but have a strong callus around the base of the stub.

SURGICAL EXPERIMENTS

A number of well-established cankers on old trees were cleaned out early in April and treated in various ways.

78 not disinfected.
3 disinfected with 5 per cent florium.
3 disinfected with 5 per cent agrisol.
3 disinfected with florium, followed by white lead.
3 disinfected with agrisol, followed by white lead.
3 disinfected with florium, followed by black tar (neutrum).
3 disinfected with agrisol, followed by black tar.
3 disinfected with white lead alone.
2 disinfected with black tar alone.

Both white lead and black tar appear to be toxic to living tissues, for the callus is separated from these disinfectants by a very thick corky layer and, in general, is not so well developed as it is in cankers either not treated or disinfected with florium or agrisol. Several of the cankers treated with white lead and with tar have extended appreciably beyond the treated area. In no case, as yet, has the callus of the current season completely overgrown the canker.

COMPARISON OF GROWTH, ETC., ON EARLY AND LATE COVER CROP PLOTS

At the time of the survey of the young peach orchard in August, a marked difference was observed in the foliage and amount of new growth on the trees of two plots: the one with early cover crop and the other with late. These observations made it seem worth while to make a more detailed comparison of the trees subjected to these two types of cultivation. Some of these differences are shown in table 99.

TABLE 99—EFFECT OF EARLY AND LATE COVER CROP

——	Early cover crop (planted June 15)	Late cover crop (planted July 22)
Foliage in August and September.	Pale green, with reddish tinge. Little or no new growth.	Deep green, vigorous looking, with paler green of new growth, in considerable abundance.
Leaf fall	Beginning to fall, October 18, 1929	Leaves green, on outside of tree and yellow towards inside, latter almost ready to drop, October 18, 1929.
	About ⅔ fallen; October 24, 1929; remainder, sere and yellow.	Beginning to fall, October 24, 1929.
		October 26, 1929; leaves ½ ± off; remainder green. The odd tree on low ground is defoliated more than ⅔, leaves yellow.
	November 2, 1929; leaves practically all fallen.	Leaves ⅔–¾ fallen, November 2, 1929.
Buds (terminal)	Beginning to form in August. Well developed by middle of September.	Began to form about middle of September and were well developed by October 10, 1929.

For the purpose of determining the development of the new wood grown during the summer of 1929, seven trees in each plot were selected at random. On these trees each twig was measured and classified into primary, secondary and tertiary growth. Primary growth is current season wood from lateral or terminal buds which have overwintered. Secondary growth refers to laterals developed from primary current season shoots. Tertiary growth refers to laterals developed from secondary shoots. An analysis of the figures obtained showed several interesting differences. As would be expected, the twigs which had begun to grow in the spring, i.e., the primary growth, did not show so marked a difference as those which developed later. But even here more progress was made on the late cover crop. In both plots there was a considerable development of shoots from buds which evidently had lain dormant until well on into the summer before beginning to grow. Such shoots measured between ½ and 6 inches, with the majority between 3 and 4 inches. However, in the late cover crop plot this type of growth is more abundant. The secondary growth was much greater in both number and length of twigs on the trees with the late cover crop, for here the measurements lay between ¼ and 18 inches, with the majority between 3 and 9 inches, while in the early cover crop block length ranged from ¼ to 12 inches, with the majority between 2 and 6 inches. But it was in the tertiary growth that the most striking difference became evident. In the seven trees of the early block there was only one tertiary twig, with a length of 2 inches. On the other hand, there were 71 tertiary twigs on the seven trees of the late block, ranging from ½ to 11 inches in length, with the majority between 2 and 6 inches.

This all points to growth later in the season on the part of the trees with the late cover crop, resulting in a greater amount of woody growth and probably in the delayed arrival of the dormant condition. It remains to be seen which type of cultivation makes the trees best fitted to withstand the rigours of winter and whether early maturity is preferable to vigorous woody growth, in so far as prevalence of peach canker is concerned.

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

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

Apple Scab (*Venturia inaequalis* Aderh.)

Seasonal Development.—Seasonal conditions in the early part of the year approximated the fifteen-year average with January and February providing a little more preciptation and March and April a little less. May was a month of heavy precipitation with a total of 6·52 inches recorded at Kentville compared with a five-year average of 2·23 inches. In temperature and hours of sunshine May was also above the average for that month. With the exception of the first few days, June was comparatively "dry" and July and August were also subnormal in precipitation. September exceeded the fifteen year average in rainfall by 1·63 inches, whereas the month of October was 1·84 inches below the average.

Apple leaves collected March 22 following three days of mild weather were examined for perithecial development. Those from favourable conditions contained large perithecia with asci developed about one-third their normal length and full of undifferentiated protaplasm. By April 5 some perithecia were found showing eight nuclei per ascus with the asci about two-thirds normal length. Another collection of leaves on April 16th provided perithecia containing a few differentiated spores.

On April 26 following a rainfall of about four-tenths of an inch and with a mean temperature for the day of 51·5°F. collections were made which contained well differentiated mature ascospores. No proof of ejection was obtained at Kentville on this date but such may have taken place in some orchards in the Valley. Collections from the Berwick and Waterville districts, at this time, contained perithecia with mature spores. None were found in collections made in other parts of the Valley until May 1st.

The first recorded spore discharge occurred at Kentville on May. The buds were beginning to break and were practically at the green tip or delayed dormant stage of development. Spore ejections were recorded at Kentville on twenty-two days between May 2 and June 17 inclusive. The most severe ejections occurred between May 27 and June 2. The apple trees during this period were in the full pink or early bloom stage.

At Middleton conditions were but slightly different from those at Kentville. The first recorded ascospore discharge occurred May 4 and the heaviest ejections were observed between May 15 and 20 with a second severe period on June 1 and 2. There were twenty-three days between May 4 and June 26 on which spore ejections were recorded. The rainfall in both May and June was less than that recorded in Kentville during the same period.

The first current season infection was found about 20 days after the first discharge of ascospores. By June 20 unsprayed trees had as high as 40 per cent of their foliage affected with scab.

Three applications of a standard spray before bloom followed by two after bloom gave good control of scab in the majority of orchards. The importance of very thorough applications immediately preceding bloom was emphasized again this year by the heavy ascospore ejections which took place between May 15 and June 2. The period of tree development from the pink stage until petal fall has been the most critical one in Nova Scotia during each of the past five years. Ascospore ejections occurring after the middle of June—the average time of petal fall—are seldom of much consequence. If the grower has been successful in preventing foliage infection from spore discharges up to petal fall it is seldom necessary to make more than two spray applications after bloom to protect the fruit from scab for the remainder of the season.

Late Infection.—Late infections of apple scab resulting in the "pin-head spot" symptoms appeared in some orchards this year. This condition usually accompanies seasons of super-normal precipitation in August or September and occurs in orchards which have more or less scab on the foliage and are either close planted or dense in their growth. September 1929 was favourable for the development of late scab and unless the fruit and foliage had been well protected with fungicides throughout the season and exhibited little or no scab at this time, a spread of the disease was to be expected.

There appeared to be no difference in the standard spray mixtures in their relative efficiency to prevent late scab infection. The thoroughness of applications made during the spring and early summer appear to have more influence on the control of late scab than the actual materials used.

Observations on Scab Control with Reference to Spore Discharge.—In connection with the experimental spray plots at Middleton efforts have been made in the past and again in 1929 to secure counts on the percentage of scab on foliage as well as harvest records on the fruit and to correlate the information with the presence of ascospore inoculum. During the past year there was a total of 109 plots in the orchards. Record has been kept of the time of each application, and the weather conditions prevailing.

In comparing the percentage scab on the foliage in plots sprayed with the same materials on different dates, it was again quite evident that applications made one to three days before ascospore discharges were more effective in controlling scab than those made one or more days after the discharges. In one or two of the pre-blossom applications on some plots the materials were applied on the same day that spore ejections were recorded. These plots without exception show better control than those which were not sprayed until two or more days after the spore ejection.

This can be well illustrated by two series of plots which had three pre-blossom applications of the same materials using Bordeaux mixture as the fungicide. Six plots sprayed May 9, 16 and 27 had an average of 1.19 per cent scabbed leaves in a total count of 20,000 leaves. Four plots sprayed May 10, 18 and 30 had an average of 3.28 per cent scabbed leaves in a total count of 8,000 leaves. A heavy spore ejection on May 15-16th marks the only difference, in the two series, with respect to the presence of ascospore inoculum near the time of spray applications. It is apparent that the applications on the six plots on May 16 prevented most of the probable infection from that particular spore discharge whereas the applications on the four plots on May 18, two days after the spore discharge, were evidently responsible for double the amount of infection, as shown by the scabbed leaves.

COMPARISON OF THE STANDARD NOVA SCOTIA SPRAY SCHEDULES

There are three standard spray calendars recommended to the Nova Scotia apple growers. These may be briefly summarized as follows (table 100):—

TABLE 100—STANDARD SPRAY SCHEDULES

Time	Materials		
	No. 1	No. 2	No. 3
No. 1. Delayed dormant. When the tips of the more advanced buds have opened.	Bordeaux 2-4-40, with 1½ pints nicotine sulphate per 100 gallons.	Lime sulphur 1 gallon to 40 gallons, nicotine sulphate 1½ pints per 100 gallons.	Lime sulphur 1 gallon to 40 gallons, nicotine sulphate 1½ pints per 100 gallons.
No. 2. Pre-pink. When blossoms show pink at tips.	Bordeaux 3-10-40, 1 pound arsenate of lime, to 40 gallons.	Lime sulphur 1 gallon, arsenate of lead 1 pound, to 40 gallons.	Aluminium sulphate 3½ pounds, lime sulphur 1 gallon, arsenate lime ¾ pound to 40 gallons.
No. 3. Pink. Just before blossoms open.	Bordeaux 3-10-40, 1 pound arsenate of lime, to 40 gallons.	Lime sulphur 1 gallon, arsenate of lead 1 pound to 40 gallons.	Aluminium sulphate 3½ pounds, lime sulphur 1 gallon, arsenate of lime ¾ pound per 40 gallons.
No. 4. Calyx. Just after blossoms have fallen.	Wettable sulphur 30 pounds, arsenate lead 2½ pounds, per 100 gallons.	Lime sulphur 1 gallon to 60 gallons, arsenate of lead 1 pound to 40 gallons.	Aluminium sulphate 3½ pounds, lime sulphur 1 gallon, arsenate of lime ¾ pound per 40 gallons.
No. 5. Ten days after the previous application.	Bordeaux 3-10-40, 1 pound arsenate of lime to 40 gallons.	Lime sulphur 1 gallon to 60 gallons, arsenate of lead 1 pound to 40 gallons.	Aluminium sulphate 3½ pounds, lime sulphur 1 gallon, arsenate lime ½ pound per 40 gallons.
No. 6. Ten days after the previous application (if needed).	Bordeaux 3-10-40........	Lime sulphur 1 gallon to 60 gallons.	Aluminium sulphate 3½ pounds, lime sulphur 1 gallon per 40 gallons.

KENTVILLE, N.S.—The three recommendations were used on a series of spray and dust plots conducted by the Experimental Station, Kentville, this year. Observations on grading and classification of blemishes were carried on by the staff of the laboratory. For the purpose of comparing the three regular schedules a summary of the observations on five varieties of apples—Fameuse, McIntosh, Wagener, Gravenstein, and Bishop Pippin—is given. Each plot received an application of Bordeaux oil (3 per cent oil) for the delayed dormant spray in place of the calendar recommendation. The fifth spray on Calendar No. 1 plot was wettable sulphur in the same proportions as No. 4 spray of that calendar. In all other respects the calendars were carried out as given. Sprays were applied on all plots either the same day or the following day.

Table 101 gives a summary of the condition of the fruit at harvest. The column "percentage clean" includes all fruit free from insect or disease injury but may include some slightly russetted fruit which would not be objectionable in barrel grades. Percentage of 1's and 2's is for barrel grades. Scabby fruit is classified under three headings A, B, and C. A includes fruit with a total scabbed area not over one-quarter inch in diameter; B, not over one-half inch in diameter; C, over one-half inch in diameter. It was observed that the majority of "C" scab apples were the result of early season infection. The "B" scab included mostly mid-season infection or fruits having a large number of small late infection areas. The "A" scab fruit was almost entirely late infection, frequently called "pin-head spot." The column of total scab is given for convenience. From two to four barrels of apples were examined of each variety from each scab plot.

Table 101.—Spray Calendar Plots, Kentville, N.S., 1929

All figures are percentages and the average of five varieties—Gravenstein, Fameuse, McIntosh, Wagener, Bishop Pippin

Spray calendar	Clean	No. 1's and 2's	Scab			
			A.	B.	C.	Total
No. 1	76·2	67·6	4·8	1·0	0·6	6·5
No. 2	84·5	72·4	4·4	0·9	0·3	5·6
No. 3	80·5	72·2	6·4	0·9	0·5	7·8
Check	12·7	37·1	38·1	12·9	27·2	78·4

There is little difference in the amount of total scab in the three plots. Calendar No. 3 has a slightly higher percentage of scab than the two older Calendars, Nos. 1 and 2. This is not exceptional but the condition is usually offset by the higher percentage of clean apples, i.e., apples free from all blemish. The aluminium sulphate-lime sulphur mixture with calcium arsenate as an insecticide is superior to Bordeaux mixture with either calcium or lead arsenate as an insecticide in the control of biting insects but it is not always as good a fungicide. The insecticidal value largely accounts for the high percentage of clean apples in No. 3. The same comment applies to No. 2 as the lime sulphur-lead arsenate is usually superior to Bordeaux and an arsenate as an insecticide.

Somerset, N.S.—Another comparison of the three standard spray calendars was made in an orchard at Somerset. The spraying was done by the Entomological laboratory, Annapolis Royal. Five applications were given each plot. Counts on foliage infection were made on June 22 and August 9 to determine the percentage of scabbed foliage and the average number of spots per infected leaf.

Table 102 presents a summary of the data relating to scab control and includes the readings taken on the fruit at harvest. The foliage counts were taken on four varieties and the fruit counts on three varieties—Stark, Golden Russet, and Wellington. It was necessary to eliminate harvest records on the fourth variety on some plots owing to the trees being on boundary rows between plots. All the counts recorded were from centre trees in the plots, in order to eliminate any possible effect from sprays drifting from one plot to the other.

TABLE 102.—SPRAY CALENDAR PLOTS, SOMERSET, N.S., 1929

Spray calendar	Foliage, 22-6-29		Foliage 9-8-29		Fruit			
	Per cent scab	Spots per leaf	Per cent scab	Spots per leaf	A.	B.	C.	Total
1	0·9	1·2	1·6	1·2	0·6	0·6	1·4	2·8
2	1·4	1·1	2·2	1·3	1·4	0·7	0·7	2·9
3	1·2	1·1	2·3	1·3	1·1	0·6	0·8	2·5
Check	18·4	2·0	20·8	3·3	3·9	7·8	52·7	64·4

Table 102 shows no significant differences in the total scab on the three sprayed plots. The Bordeaux calendar No. 1 appeared to control scab on the foliage better than either of the other two calendars but it is doubtful whether the data obtained would prove to be significant if such factors as leaf drop and spray injury could also be taken into consideration.

MIDDLETON, N.S.—The three spray calendars were also compared in adjacent large plots at Middleton during the season. Applications were made the same day on each plot. There were eight days between the first and second sprays, twelve betweeen the second and third, fourteen between the third and fourth, and twenty days between the fourth and fifth.

One series of foliage scab counts were made on June 19 on these plots. Two or three thousand leaves per plot were used. The difference between each count of 1,000 leaves on the same plot was so slight that the figures given below may be taken as significant of the true condition of the foliage on that date.

Table 103 gives a summary of the observations on the prevalence of scab on these plots both on the foliage in June and on the fruit at harvest.

TABLE 103.—SPRAY CALENDAR PLOTS AT MIDDLETON, N.S., 1929

Spray calendar	Foliage 19-6-29		Fruit			
	Per cent scab	Spots per leaf	A.	B.	C.	Total
1*	3·6	1·3	6·5	1·5	1·0	9·0
2	1·7	1·3	6·3	1·8	0·2	8·4
3	0·7	1·3	6·6	2·2	0·6	9·6
Check	23·7	2·3	8·0	12·3	77·6	98·0

*This plot was given wettable sulphur in the fifth spray in place of Bordeaux.

It is evident that there is little to choose between the three standard calendars offered. No. 3 is a comparatively new one and is being used by a considerable number of growers. It has the advantage of lime sulphur in producing better finish on the fruit than copper sprays and causes practically no injury to foliage under normal conditions. It can be used drenchingly and under conditions of atmospheric humidity in which the two other calendars would cause severe injury. This mixture is not recommended for sections having less summer precipitation than Nova Scotia.

BORDEAUX AND OIL AS FUNGICIDES

On account of the increased use of oil for the delayed dormant spray in some orchards in Nova Scotia, the question has arisen as to the necessity of using a fungicide with the oil. In order to assist in answering this question a series of small plots were used on which sprays were applied, containing Bordeaux alone, Bordeaux and oil, and oil alone.

The results of one season's observations are offered herewith. Further tests will be carried on another year. Each plot received three pre-blossom applications and one after-blossom. On June 20, counts were made on the amount of apple scab evident on 1,000 leaves of each plot. The number of spots on each infected leaf were also noted as this information gives an added conception of the prevalence of scab on the various plots. A summary of the information obtained is given in table 104.

TABLE 104.—BORDEAUX AND OIL

Materials used before bloom		Per cent scab on foliage	Average number spots per leaf
3 Bordeaux		0·8	1·0
2 Bordeaux	1 lead	2·0	1·9
2 Bordeaux—oil	1 lead	4·0	1·4
1 Bordeaux	2 lead	2·2	1·8
1 Bordeaux—oil	2 lead	4·7	1·6
2 Oil	1 lead	15·5	1·7
1 Oil	2 lead	23·0	2·4
No spray		27·0	2·7

These data tend to show that the Bordeaux-oil sprays are not so efficient fungicides as Bordeaux alone and that oil alone is decidedly inferior to Bordeaux-oil as a fungicide.

A fungicide is necessary at the delayed dormant stage as ejections of ascospores are occasionally experienced even before this spray is applied and in each of the past five years—the only years in which records have been taken—important spore ejections were experienced before the pre-pink or second regular spray was applied. It is evident that in 1929 the sprays of oil alone were not sufficient to provide fungicidal protection during these infection periods. The Bordeaux-oil is preferable to oil alone when used in a delayed dormant stage. If the oil is used when the trees are truly dormant a combination fungicide spray would be unnecessary.

SECTION V

INVESTIGATIONS OF THE DISEASES OF POTATOES AND FIELD CROPS; POTATO CERTIFICATION SERVICE

Experiments with "Spindle Tuber" Disease of Potatoes

(W. Jones)

The spindle tuber disease of potatoes is quite prevalent in the Province, particularly in the Netted Gem and Burbank varieties. Under British Columbia conditions it is characterized by the following general symptoms: lateness in emerging from the soil after planting, erect and spindling type of growth, with leaves set at a narrow angle to the stem. The leaves are stiff, show slight rugosity, are reduced in size and often show a darker green colour than those of healthy plants (figs. 46 and 47). Typical tubers of the diseased plants are cylindrical or spindling in shape, often pointed at both ends and possess numerous conspicuous eyes (figs. 48 and 49). The symptoms vary with different varieties, thus with the round types such as the Green Mountain and Irish Cobbler varieties the tubers assume a cylindrical shape whereas with the long type such as the Netted Gem and Burbank varieties they assume a more spindling shape. When grown in soil of a loose texture, with ample organic and moisture content as well as a good supply of nutrients the tubers may assume a more normal shape than where grown under poor soil conditions.

FIG. 46.—Netted Gem variety. Left, spindle tuber plant. Right, healthy plant.

The above symptoms, although generally characteristic of a typical diseased plant are not all reliable for identification. It has however been found by field and greenhouse experiments that late emergence of the plant is the most constant symptom of the disease (fig. 50). Thus in the seed plot it is important to rogue out all plants that are late in emerging from the soil.

In a series of pot experiments containing different soils, it was found that diseased plants assumed a more normal type of growth of foliage when grown in sand amply supplied with nutrients. When the nutrients in the latter were washed out, the plants developed an erect, spindling type of growth. With the further addition of nutrients the foliage again assumed a more normal appearance.

FIG. 47.—Healthy and spindle tuber plants of the Netted Gem variety grown under similar conditions. A. Healthy plants. B. Spindle tuber plants.

FIG. 48.—Upper row, tubers from spindle tuber plants of Netted Gem variety grown in irrigated silt soil. Lower row, healthy tubers from same soil.

This spindling type of plant growth has been observed in the Netted Gem and Burbank varieties in the silty soils of the irrigated sections of the interior where continuous cropping has deprived the soil of its natural fertility.

The above observations indicate that the chief controlling factor in normal foliage growth of the potato plant is a constant supply of nutrients. The physical nature of the soil is a subsidiary factor in maintaining this supply. Hence the difficulty of detecting the spindle tuber disease under unfavourable soil conditions.

The colour of the foliage of young diseased plants also varied considerably in different soils. Most workers have reported that the foliage of spindle tuber plants have a deeper green colour than those of healthy ones. It was found in pot experiments, that where the plants were grown in burnt peat, the leaves had a very deep green colour, whereas in ordinary peat and loam the colour was approximately the same as that of healthy plants grown under similar conditions. This points again to the unreliability of colour symptoms in the identification of the spindle tuber disease in the field.

FIG. 49.—Upper row, tubers from healthy plants of Netted Gem variety grown in non-irrigated loam soil. Lower row, tubers from spindle tuber plants grown in non-irrigated loam soil.

These difficulties can be overcome by rigid selection of typical healthy plants of the variety to be grown in the seed plot and by roguing all plants that are late in emerging from the soil.

Further experiments were carried on on the influence of the spindle tuber disease on the physiology of the host by the determination of the dry weight and ash content of healthy and diseased tubers, and also by comparing the electrical resistance of the tubers and the juice from healthy and diseased tubers. The tubers used belonged to the Netted Gem variety grown in the Kamloops district.

It was found that most tissues of healthy tubers had a higher resistance than similar tissues of diseased tubers. The freshly expressed juice from healthy tubers was also found to have a higher resistance than that from diseased tubers. The mean specific resistance of 25 healthy tubers taken at the lateral periderm was found to be 3683±55, and the mean specific resistance of diseased tubers was found to be 3107±45, a significant difference of 576±71 ohms. This difference, however, was not constant for all the individual tubers to warrant the use of this method for detecting diseased tubers. In the dry weight and ash determinations it was found that the percentage of dry weight and the percentage of ash in fresh weight was slightly higher in healthy than in diseased tubers. The difference, however, was not significant.

FIG. 50.—Showing the difference in the emergence of sprouts from spindle tubers and healthy tubers planted at the same time and under similar soil conditions. Upper row: Cut sets from spindle tuber plants of Netted Gem variety. Lower row: Cut sets from healthy plants of Netted Gem variety.

Laboratory Studies of Rhizoctonia

(W. Jones)

Pure cultures of the rhizoctonia disease of potatoes were made from sclerotia obtained from tubers from different parts of the Province. Twenty five of these strains have been used and also one strain of rhizoctonia isolated from alfalfa.

Growth Rate Studies

Growth studies were made on plates using standard synthetic media containing the following ingredients:—

Glucose	2	per cent
Ca $(NO_3)_2$	0·1	"
KH_2PO_4	0·05	"
$MgSO_4$	0·02	"
NaCl	0·002	"

The different strains were grown at constant temperatures of 5-7° C., 25° C. and 30° C., and their growth characteristics noted. It was found that the factors of colour of colony, zonation and sclerotial formation were too variable to be taken as means of differentiation of the different strains.

TABLE 105.—MEAN DIAMETER OF FIVE COLONIES OF EACH OF THE DIFFERENT RHIZOCTONIA STRAINS AFTER 96 HOURS GROWTH AT 25° C.

No.	cm.	No.	cm.
15	7·6	78	7·6
49	5·1	79	5·0
51	7·8	80	7·2
53	7·1	81	6·5
61	7·5	82	6·5
62	7·7	83	7·1
63	7·5	84	7·3
71	7·5	85	7·4
72	6·8	90	5·9
73	8·5	91	7·2
74	8·0	92	6·0
75	7·8	....	....
76	7·1	....	....
77	7·8	....	....

Table 105 shows the mean diameter of five colonies of each of the different rhizoctonia strains after 96 hours growth at 25° C. This temperature is the approximate optimum for the organism. It is apparent from the results that the growth of different strains vary considerably, thus Nos. 79 and 49 being 5 and 5·1 centimeters respectively and Nos. 74 and 75 being 8 and 8·5 centimeters respectively. The normal growth of the colony on the plate is circular and even in outline. Sometimes a colony from one strain would assume an irregular outline. All colonies of No. 79 exhibited this characteristic growth. With this latter strain the type of growth was sparse and hyaline, quite distinctive in character from all the other strains.

All the different strains grew at 5-6° C. There was great variation in the rates of growth at 30° C., thus the diameter of one colony after 5 days was 6 centimeters whilst another colony of the same strain was 0·5 centimeters. This indicates that 30° C. is the approximate upper critical growth temperature for the rhizoctonia organisms.

At 5-6° C., the same variation in growth rates was observed as at 30° C. At this low temperature growth was consistently slower than at 30° C. Mycelial growth was generally visible macroscopically about the seventh day. This however was very variable, even with the same strain. There was no consistent difference between the growth rates of the different strains at this low temperature.

Rhizoctonia, which had been isolated from alfalfa was incubated at 5-6° C. It was found that after 30 days there was no trace of mycelial growth in 3 out of 4 inoculations made from the same strain. When the former were transferred and incubated at 25° C., growth proceeded normally. It was hoped that the absence of growth at 5-6° C. would serve as a means of differentiating alfalfa rhizoctonia from that of potato. However, since one alfalfa rhizoctonia colony showed a slight growth at this temperature, this means of differentiation is not absolutely reliable.

Inoculations were made from colonies of the different strains which had been growing over 30 days at 5-6° C. and these were grown at 25° C. This experiment was triplicated with the different strains, the intention being to find out whether the growing of the organisms at a low temperature would have any effect on subsequent growth at a higher temperature. The conclusion obtained from the data is that the change from a low to a high temperature has no significant effect on the growth rate of the rhizoctonia organism.

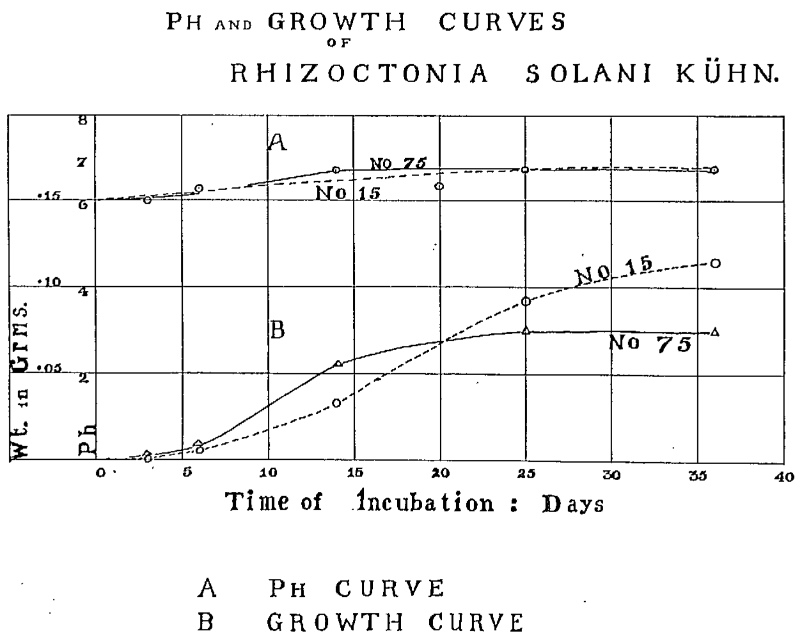


FIG. 51.—A. PH Curve of *Rhizoctonia Solani* Kühn. B. Growth Curve of *Rhizoctonia Solani* Kühn.

The above observations seem to indicate that the optimum temperature of about 25° C. is the most reliable temperature at which growth studies can best be made.

Further studies were made to determine the optimum pH of the organism. It was found that the optimum pH is around 6·7 for the majority of the different strains. Figures A and B show the pH and growth curves of No. 15 and 75 grown in the liquid standard synthetic media at 25° C.

After some of the strains had been growing for 7-9 days in the standard synthetic media at 25° C., 10 c.c. of distilled water was poured into each plate and stirred up. The pH of this water was taken colourimetrically. The resulting pH for all the strains corresponded fairly favourably with the optimum pH of the organism when grown in liquid culture. Thus, after 6 to 9 days growth, the pH of 10 different strains taken this way varied between 6·1 and 6·8, the initial pH being 6·0. This is a very simple method of differentiating some organisms on plates, thus the pH of sclerotinia sp. taken this way is around pH 3·7.

It has already been found in the laboratory that the rhizoctonia from alfalfa and potato possess diastatic activity. Two cultures of each species were grown in liquid synthetic media using 2 per cent starch instead of glucose. The diastatic curve was followed by determining the quantity of sugar present periodically. The results show that there is considerable diastatic activity in both species. The rhizoctonia from potato, however, showed a consistently higher diastatic activity than that from alfalfa. At the end of 20 days the solution left in the flasks gave a negative test with iodine showing that the starch had been completely hydrolysed. At the end of this period the total acids, as determined by titration against standard alkali had increased considerably with both species. Greater acid, however, was produced by the species isolated from potato.

Summary

1. The optimum growth temperature of *Rhizoctonia solani Kühn,* from potato is around 25° C.
2. The approximate upper critical growth temperature of *R. solani* from potato is around 30° C.
3. Growth studies of Rhizoctonia sp. can best be made at the optimum growth temperature.
4. The approximate critical lower temperature of *Rhizoctonia crocorum Pers.* from alfalfa is around 5-6° C.
5. The optimum pH of *R. solani,* is around pH 6·7.
6. *R. solani Kühn* from potato and *R. crocorum Pers.* from alfalfa possess diastatic activity.
7. *R. saloni Kühn* from potatoes has higher diastatic activity than that of *R. crocorum Pers.*

Rhizoctonia Disease of Potatoes

(W. Jones)

The rhizoctonia disease of potatoes is prevalent in most sections of the province and is becoming serious in the older potato growing districts. It reduces the yield and also causes reduction in the percentage of marketable tubers.

The majortiy of the commercial growers practise dipping of the seed, mainly with corrosive sublimate. This helps, but does not check the disease in the older potato growing districts.

To gain further information on the nature of the fungus in relation to its environment, the following work was done.

Soil samples from districts where rhizoctonia was serious and where very slight were collected and the pH of these were determined colourimetrically in the laboratory. The results are given on table 106.

Table 106.—Rhizoctonia in Soil Samples

Rhizoctonia, plentiful	District	Rhizoctonia slight	District
pH 5·4	Huntington	pH 6·5	Alberni.
pH 5·0	Lulu Island	pH 6·2	Shawnigan.
pH 5·2	"	pH 6·2	Mt. Lehman.
pH 5·3	"		
pH 5·1	"		

Analysis of the table shows that the disease is most serious where the pH of the soil ranges between pH 5-5·4. The disease is less prevalent where the pH range is above 6. Further data will have to be gathered before a definite conclusion can be arrived at. This is rather at variance with the optimum pH of the organism when grown in standard media, the optimum being around pH 6·7, varying slightly with different strains.

At the suggestion of Dr. W. Newton an attempt was made to ascertain whether water extracts of soils would support the growth of the rhizoctonia organism without the addition of nutrients.

It was found that the organism grew on all such extracts taken from soils where the percentage of rhizoctonia was high and where low. The growth was sparse and no sclerotia developed after 15 days' growth. There was no significant difference between the growth rates on soil extracts where the rhizoctonia was slight and where severe.

The above results show that the fungus can grow saprophytically in the soil solution, so that after the potato crop has been harvested it may continue to grow in the soil. The fungus has also been found in the laboratory to grow at 5° C., the rate varying with different strains. This shows that the fungus can grow during the winter in the soils of the Coast regions.

These results seem to indicate that the best way to control the rhizoctonia disease of potatoes is to practise good husbandry. Land that is too sour should be limed and a fall crop should be sown as soon as the potatoes are harvested. Further field experiments must be conducted in order to determine which is the best fall crop to sow to counteract the influence of the rhizoctonia. At present fall rye is recommended.

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY, STE. ANNE DE LA POCATIÈRE, P.Q.

(H. N. Racicot, Officer in Charge)

PHOMA ROT OF TURNIPS

In October, 1928, Mr. R. Proulx, Inspector of Illustration Stations for eastern Quebec, brought specimens of diseased turnips to the Laboratory for identification of the disease. It occurred on three Illustration Stations, one in Dorchester county, and two in Bonaventure county. In November, after the turnips had been harvested, the percentage of affected turnips was determined. On one of the Illustration Stations in Bonaventure about 33 per cent of the turnips were affected, and about 10 per cent on the other two Stations. The seed used in sowing the fields on these Illustration Stations had been imported from Europe.

Mr. B. Baribeau, District Inspector identified the disease as Phoma rot of turnips caused by *Phoma Lingam* (Tode) Desm. In order to verify his conclusions he made pure cultures of the organism, and inoculated turnips grown in the greenhouse, and reproduced the disease. He re-isolated the organism again from these inoculated turnips.

Some interesting observations were made during these studies. Very young turnips inoculated with the disease did not show any symptoms before they were at least 2 to 3 inches in diameter. On larger turnips it took 18 days or more for the symptoms to appear after inoculation. The first symptom was a light brown spot situated anywhere from the surface of the soil, to the crown of the turnip, but most frequently near the crown. There the spot kept getting deeper and darker, and by the time the depression was well marked, it had turned violet to black in colour. There was always an area of brown scaly tissue surrounding the spot or depression, marking off the diseased from the healthy tissue. As the disease progressed the centre of the spot became brownish again, shrivelled and split, which often permitted the entrance of secondary parasites causing the turnips to rot. The brownish centre of the spot, or canker-like tissue, became covered with small round, black pycnidia, which produced very numerous spores. Spore measurements gave the size of the conidia as 2·5-4·5 x 0·9-2·2. Turnips grown in the greenhouse, inoculated both by wounding and without wounding and with both material from a pure culture on potato dextrose agar, and material from a diseased turnip, developed the disease. Diseased material mixed with the soil infected young turnips transplanted into it, but healthy seed sown in such soil produced healthy plants. Twenty-one varieties or turnips grown in the field were inoculated during the summer. Part of the inoculations were made with a sterile needle, and part by sprinkling a suspension of spores on the turnips. Only a few turnips became infected by the latter method of inoculation. Eight varieties showed infection: Bangholm Purple Top, Prize Purple Top, Improved Yellow Swede, Bangholm, Canadian Gem, Best of all, Dales' Boschilde and Kangaroo. The use of clean seed and of crop rotation would apparently control this disease effectively.

BEAN MOSAIC

The results of the experiment to determine the field and seed transmission of bean mosaic are given in table 107.

TABLE 107.—THE RESULTS OBTAINED IN 1929

Row	Percentage germination	Percentage mosaic	Yield per acre
			bush.
(1) 1	68	2·2	24·3
2	67	2·0	28·3
3	67	2·2	33·4
4	57	41·9	15·0
5	68	5·7	23·4
6	63	33·3	18·7
(2) 7	74	0·0	....
8	84	0·0	....
9	86	0·0	....
10	83	0·0	....

The experiment was planted in duplicate, in rows 50 feet long, and with 100 White Pea beans in a row. Rows 1, 2, 3 and 5 were planted with healthy seeds, and rows 4 and 6 with mosaic seeds. Rows 7, 8, 9 and 10 were planted with seed harvested in 1928 from rows 1, 2, 3 and 5 respectively.

Observations during six years showed that in 1924 and 1925, no current season symptoms developed on beans in rows planted next to mosaic rows, but that seeds harvested from such rows showed about 12 per cent mosaic the following year. In 1926, mosaic symptoms were so masked by dull weather conditions that no observations could be made. In 1927, 1928 and 1929, current season symptoms appeared in rows planted with healthy seeds next to rows planted with mosaic seeds, and that seeds harvested from these rows produced some mosaic plants. Also seed from mosaic plants did not always produce mosaic plants when planted; but the percentage of mosaic plants from such seed varied from 5 to 55. From this it is seen that, (1) bean mosaic is transmitted from plant to plant in the field, probably by insect carriers, and that (2) it is carried not only through the seed, but probably through pollen from diseased plants.

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

(D. J. MacLeod, Officer in Charge)

CLUB ROOT OF TURNIPS (*Plasmodiophora Brassicae Work.*)

Further advances were made this season in the direction of developing varieties or strains of swedes which are sufficiently resistant to club root to be of commercial value under the conditions obtaining in the province.

During 1929, 84 varieties of swedes and two varieties of fall turnips were tested on soil heavily infested with the club root organism. Fifty-eight of the varieties included in the test showed 100 per cent severe infection, all of which are not listed in this report for the sake of economy of space.

The following table (108) includes a list of the other varieties and strains tested, together with a record of their behaviour towards club root in each case.

TABLE 108.—CLUB ROOT OF TURNIPS—VARIETIES TESTED

Variety	Percentage of club root					
	By number			By weight		
	Free	Slight	Severe	Free	Slight	Severe
Bangholm Studsgaard (4108)	3·3	2·6	94·1	3·9	3·5	92·6
Bangholm Studsgaard (5018)	0·5	3·1	96·4	1·5	3·2	95·3
Bangholm Studsgaard Trifolium	4·2	1·2	94·6	2·7	1·7	95·6
Bangholm Studsgaard D.L.F.	1·6	1·3	97·1	1·5	2·1	96·4
Bangholm Studsgaard Charlottetown (1927)	7·0	1·7	91·3	4·9	2·8	92·3
Bangholm Dupuy and Ferguson	2·3	3·6	94·1	3·5	2·8	93·7
Bangholm Lyngley D.L.F.	1·8	1·8	96·4	3·0	2·9	94·1
Bangholm Pajberg v. Trifolium (1926)	1·0	1·9	97·1	1·3	0·6	98·1
Bangholm Pajberg v. Trifolium (1928)	3·3	2·4	94·3	4·6	1·3	94·1
Bangholm Kalvre Selection K	15·6	1·3	83·1	14·3	1·6	84·1
Bangholm Herning (24-2)	17·3	2·1	80·6	17·0	1·6	81·4
Bangholm Herning (6)	8·3	2·6	89·1	13·3	2·4	84·3
Bangholm Herning Denmark (1)	14·5	3·4	82·1	15·6	2·8	81·6
Bangholm Herning Denmark (2)	16·6	3·1	80·3	14·5	4·1	81·4
Bangholm Nappan 1927	4·6	4·1	91·3	4·5	3·4	92·1
Bangholm Nappan (original)	6·3	1·4	92·3	6·3	2·1	91·6
Wilhelmsburger (1927)	10·5	3·4	86·1	10·1	2·3	87·6
Wilhelmsburger (1928)	9·5	7·1	83·4	8·3	6·9	84·8
Wilhelmsburger D.L.F. (1928)	12·3	4·1	83·6	11·0	5·6	83·4
Elephant, Suttons	6·3	2·4	91·3	6·0	3·6	90·4
Improved Yellow Swedish	6·3	3·4	90·3	4·0	4·4	91·6
White swed , Bruce (1928)	76·1	17·8	6·1	71·6	19·8	8·6
Maiturnip Marienlyst, D.L.F.	96·4	3·6	0·0	95·7	4·3	0·0
Fynsk Bortfelder, Hartmann	1·6	12·3	86·1	1·0	13·6	85·4
Kangaroo, Ewing	0·2	2·4	97·4	0·5	3·1	96·4
Halls Westbury, McDonald	5·0	3·6	91·4	2·5	4·9	92·6

Among the foregoing there are certain varieties and strains which manifest a fair degree of resistance to club root even on the heavily infested soil used for the test. Stecklings from all of these are being retained to provide seed another season for further selections possessing high degrees of resistance. Ample numbers of these stecklings will be handed over to the Dominion Experimental Station where breeding work with the view to developing varieties and strains of swedes resistant to club root is now under way.

Table 109 is a record of the behaviour in 1929 of certain selections made during the past five years.

TABLE 109—CLUB ROOT OF TURNIPS—VARIETIES TESTED

Variety	Percentage of club root					
	By weight			By number		
	Free	Slight	Severe	Free	Slight	Severe
Bangholm Herning (X2)	37·4	41·9	20·7	36·8	44·1	19·1
Bangholm Herning (X3)	41·4	37·6	21·0	47·2	43·2	9·6
Bangholm Herning (X6)	29·6	64·8	5·6	27·9	66·8	5·3
Bangholm Herning (X7)	41·4	19·6	39·0	44·6	20·4	35·0
Bangholm Herning (X9)	41·0	39·4	19·6	43·4	40·9	15·7
Bangholm Studsgaard (X8)	47·8	27·8	24·4	46·8	28·6	24·6
Bangholm Studsgaard (X1)	26·4	31·4	42·2	23·9	32·7	43·4
Bangholm Nappan (X17)	26·7	16·9	56·4	26·6	17·8	55·6
Wilhelmsburger (X15)	54·8	17·4	27·8	51·7	18·4	29·9
Wilhelmsburger (X16)	49·6	31·9	18·5	47·2	36·1	16·7
White Swede (X4)	67·1	27·6	5·3	67·8	31·8	0·4

The results enumerated in the foregoing table show that a number of these selections continue to maintain a high degree of resistance to club root. It is quite apparent, however, that none of these manifest a tendency towards increasing their resistance to the disease from year to year. This seems to indicate that these strains of swedes after proceeding to a certain stage of selection reach a point where no further progress towards disease resistance is made. The most outstanding among these swedes is White Swede (X4) which possesses excellent yielding qualities but has too high a dry matter content. These features render this variety unfit for human consumption but not unsuitable for the feeding of live stock. Owing to the fact, however, that the bulk of the swede crop grown in this province is utilized for the feeding of live stock, there seems to be some useful possibilities for this selection which is highly resistant to a disease considered the most serious limiting factor in the production of this important crop.

During this season, upwards of 150 crosses were made at the Dominion Experimental Station by Mr. J. M. F. Mackenzie, utilizing material from the several selections enumerated in the foregoing table. These will be given a rigid test for resistance to club root in 1930 at this laboratory.

DUSTING VS. SPRAYING OF POTATOES.

This experiment was conducted as in previous seasons, which completes six years work on the comparison of the relative efficiencies of copper-lime dust and Bordeaux mixture in the control of foliage diseases of the potato. This season also completed four years study of a comparison of the fungicidal values of copper-lime dust, Bordeaux mixture and Burgundy mixture. A new fungicide recently developed in Nova Scotia by Kelsall and Hockey designated as the lime-sulphur, aluminum sulphate spray mixture, was included in the test in 1929.

The copper-lime dust, Bordeaux and Burgundy mixtures were prepared according to standard methods using the (20-80), (4-4-40) and (4-5-40) formulæ, respectively. The lime-sulphur aluminum sulphate mixture was prepared as recommended by the originators of this fungicide, using 3½ pounds of aluminium sulphate (crystal powder) and 1 gallon of lime-sulphur (sp. gr. 1·3 to 1·32) to 40 gallons of water.

The exceptionally hot and dry weather conditions prevailing during the growing season precluded the development of late blight, but early blight was generally severe. Thus, no opportunity was afforded for comparing the respective merits of the fungicides, included in the test, in so far as the control of late blight is concerned, but an excellent chance was presented for testing their efficiencies in the control of early blight, together with their general behaviour under such abnormal weather conditions.

The following table (110) includes a list of the fungicides compared, number of applications, total metallic copper, and estimated yield per acre in each case:—

TABLE 110—DUSTING VS. SPRAYING—APPLICATIONS AND YIELD, 1929

Fungicide	Number of applications	Total metallic copper per acre	Yield per acre
			bush.
Bordeaux spray (4-4-40)	6	13·01	232·9
Burgundy spray (4-5-40)	6	13·92	208·1
Copper-lime dust (20-80)	6	14·61	207·8
Lime-sulphur aluminum sulphate spray (3½-1-40)	6	....	198·8
Check (poison only)	6	....	200·4

Observations on the occurrence of the disease on the vines were as follows: Early blight was first observed in mild form in the check plot on August 6. On August 12 this disease showed moderate infection in the check plot and was uniformly present in mild form in all the other plots on this date. No late blight occurred on the foliage or tubers in any of the plots during the season. On September 7 the foliage in the check, copper-lime dust, lime-sulphur aluminum sulphate and Burgundy plots showed advanced stages of maturity while that treated with Bordeaux mixture appeared quite vigorous on this date and remained green for nearly a week later.

The following includes in tabulated form (111) the percentage of disease recorded on August 27 and total yield in each case:—

TABLE 111—DUSTING VS. SPRAYING—COMPARISONS, 1929

Fungicide	Early blight on the vines			Late blight on the vines			Late blight rot in the tubers		Yield per acre
	Slight	Moderate	Severe	Slight	Moderate	Severe	By weight	By number	
	%	%	%	%	%	%	%	%	bush.
Bordeaux spray (4-4-40)	9·3	40·3	50·4	0·0	0·0	0·0	0·0	0·0	232·9
Burgundy spray (4-5-40)	6·4	35·6	39·3	0·0	0·0	0·0	0·0	0·0	208·1
Copper-lime dust (20-80)	2·7	11·4	74·1	0·0	0·0	0·0	0·0	0·0	207·8
Lime-sulphur aluminum sulphate spray (3½-1-40)	13·0	10·0	77·0	0·0	0·0	0·0	0·0	0·0	198·8
Check (Poison only)	1·6	9·7	80·3	0·0	0·0	0·0	0·0	0·0	200·4

Considering the respective values of the several fungicides in so far as control of early blight this season is concerned, their effectiveness in order of merit is as follows:—

Burgundy spray.
Bordeaux spray.
Copper-lime dust.
Lime-sulphur aluminum sulphate spray.
Check (lime and calcium arsenate only).

Summarizing the results obtained, Burgundy spray mixture was slightly superior to all the other fungicides included in the test as a control for early blight. Lime-sulphur aluminum sulphate was only slightly better than the check, while the copper-lime dust was slightly inferior to Bordeaux mixture in the control of this foliage disease. In so far as production of tubers is concerned, the plot treated with Bordeaux mixture showed the highest yield, while the lime-sulphur aluminum sulphate plot yielded less than the check. This was due to the fact that severe burning of the foliage resulted from the use of this new fungicide, which interrupted normal growth. The copper-lime dust compared favourably with the Burgundy spray mixture in so far as yield was concerned, while the Bordeaux spray mixture was slightly superior to both in this respect. It is interesting to note, however, that none of the fungicides tested adequately controlled early blight under the conditions obtaining in 1929.

These results also contribute some noteworthy information in regard to the effect of early blight on the yield of tubers from plants affected with this disease. Perusal of the foregoing data shows, that while early blight may occur in severe form on the foliage, the amount of reduction in the yield of tubers does not consistently correspond with the degree of injury seemingly produced on the attacked foliage. These, together with a similar set of results obtained in 1924 apparently warrant the assumption that early blight does not interrupt the normal activity of the plant sufficiently to be considered a serious limiting factor in the production of tubers from plants so affected.

These results also demonstrate that the plants treated with Bordeaux mixture maintained a vigorous appearance for a week longer than those which received applications of the other fungicides, including the check. This, together with the fact that there was a fair increase in total yield in favour of the Bordeaux mixture during the season points to a greater physiological response on the part of the potato plants to this fungicide.

The new fungicide included among those tested in 1929 is a comparatively recent development which has given promising results in experimental trials in the control of apple scab in Nova Scotia. The results obtained from trials with this fungicide as a control for foliage diseases of the potato in 1929 were not exceedingly fruitful because severe burning of the foliage occurred and early blight was inadequately controlled. Further trials using different ratios of the ingredients of this new fungicide will form part of the experiment in 1930.

EXPERIMENTAL TRIALS WITH BURGUNDY MIXTURE IN THE CONTROL OF FOLIAGE DISEASES OF THE POTATO

In 1887 Masson proposed the neutralization of copper sulphate with washing soda (sodium carbonate) instead of quick lime for the preparation of Bordeaux mixture. This substitute proved a satisfactory spray which has since received the name of Burgundy mixture from the district in France in which it was first employed.

The merits of Burgundy mixture have long been known in other countries, particularly Ireland, where it is widely used in the control of potato blight (*Phytophthora infestans* (Mont.) de Bary). In Canada however, Burgundy mixture has been employed only to a limited extent as a fungicide for potato diseases, on account of the severe foliage injuries resulting from its use from time to time. The injuries produced, it is now believed, were largely due to the inferior brands of sodium carbonate used in its preparation.

In view of the fact that superior brands of sodium carbonate can now be purchased in this province, together with the fact, that satisfactory results have been consistently obtained with Burgundy mixture elsewhere, a study was undertaken in 1927 for the purpose of testing the merits of this fungicide under New Brunswick conditions.

The test carried out in the usual manner in comparison with Bordeaux mixture, which is widely used at the present time, as a control for foliage diseases of the potato.

The project was carried on in 1929 in exact accordance with the plan outlined in 1927, a full account of which appears in the annual report of this laboratory for that year.

The following includes in tabulated form (112) the results obtained during 1929, together with those from tests carried on in 1927 and 1928 for comparison:—

TABLE 112—BURGUNDY MIXTURE—COMPARISONS

1927

Fungicide	Early blight on the vines			Late blight on the vines			Late blight rot in tubers		Yield per acre
	Slight	Moderate	Severe	Slight	Moderate	Severe	By weight	By number	
	%	%	%	%	%	%	%	%	bush.
Bordeaux mixture.........	31·0	0·8	0·0	18·9	4·6	0·0	2·0	4·7	239·5
Burgundy mixture........	3·1	1·5	0·1	20·5	3·4	0·4	1·8	1·6	306·2
Check (poison only).......	0·0	4·0	0·0	0·0	2·0	98·0	24·2	20·0	215·2

1928

Fungicide	Early blight on the vines			Late blight on the vines			Late blight rot in tubers		Yield per acre
	Slight	Moderate	Severe	Slight	Moderate	Severe	By weight	By number	
	%	%	%	%	%	%	%	%	bush.
Bordeaux mixture.........	4·7	23·8	26·5	5·2	13·7	46·6	1·3	1·4	304·8
Burgundy mixture........	5·6	22·1	21·6	3·4	5·2	34·6	0·7	0·9	312·6
Check (poison only).......	15·1	21·0	54·0	0·0	3·8	96·2	3·6	3·4	151·0

1929

Fungicide	Early blight on the vines			Late blight on the vines			Late blight rot in tubers		Yield per acre
	Slight	Moderate	Severe	Slight	Moderate	Severe	By weight	By number	
	%	%	%	%	%	%	%	%	bush.
Bordeaux mixture.........	9·3	40·3	50·4	0·0	0·0	0·0	0·0	0·0	232·9
Burgundy mixture........	6·4	35·6	39·3	0·0	0·0	0·0	0·0	0·0	208·1
Check (poison only).......	1·6	9·7	80·3	0·0	0·0	0·0	0·0	0·0	200·4

In 1929, no late blight appeared in any of the plots but early blight was generally severe. Temperatures were unusually high and the humidity exceedingly low during the months of July and August. These extraordinary conditions afforded an excellent opportunity for a comparison of the efficiencies of the two fungicides in the control of early blight as well as their direct stimulating effects on the potato plants.

The results obtained in 1929 confirm in considerable measure those from trials conducted in 1927 and 1928 in so far as the control of early blight is concerned, further demonstrating that Burgundy mixture compares favourably with Bordeaux mixture in the control of this foliage disease. The plants treated with Bordeaux mixture remained green for a week longer than those treated with Burgundy mixture and those in the check. This result together with the fact that there was a fair increase in the total yield in favour of the Bordeaux mixture during this season, points to a greater physiological response on the part of the potato plants to this fungicide.

A series of tests were also conducted with the view to determining the ratio of copper sulphate and sodium carbonate necessary for the preparation of the most practical and efficient Burgundy spray mixture. The following includes in tabulated form (113 and 114) a list of the different formulæ tested, together with the results obtained in 1928 and 1929:—

TABLE 113—BURGUNDY MIXTURE—COMPARISONS, 1928

Ratio of copper sulphate and sodium carbonate	Percentage of diseases						Foliage injury	Yield per acre
	Early blight			Late blight				
	Slight	Moderate	Severe	Slight	Moderate	Severe		
								bush.
2-2-40	14·6	21·9	23·1	3·4	14·1	42·4	Slight	139·3
2-3-40	7·4	16·4	33·1	7·6	21·3	36·1	None	145·7
3-3-40	18·1	31·6	27·4	13·1	26·6	28·9	Slight	153·0
3-4-40	42·9	46·8	41·2	21·9	34·9	29·6	None	154·2
3-5-40	38·5	17·9	38·9	28·7	41·4	31·7	None	148·8
4-4-40	21·3	14·1	22·1	14·4	16·3	21·7	Slight	146·6
4-5-40	41·3	17·4	29·4	9·4	34·2	22·8	None	165·4
4-6-40	13·9	24·8	21·4	21·3	16·9	16·4	None	157·6
4-7-40	19·7	21·6	14·9	16·2	29·7	19·3	None	162·0
4-8-40	24·4	24·3	17·6	8·1	11·6	21·5	Slight	142·6
5-5-40	29·4	17·8	22·4	14·6	31·6	14·8	Slight	147·6
5-6-40	31·8	28·1	31·1	21·8	16·7	29·9	None	148·4
6-6-40	14·6	29·6	29·6	6·4	14·4	24·4	Slight	151·4
6-7-40	38·3	18·2	28·5	21·1	9·1	31·3	None	154·1
Check	14·8	24·8	51·4	0·0	4·3	84·1	None	102·6

TABLE 114—BURGUNDY MIXTURE—COMPARISONS, 1929

Ratio of copper sulphate and sodium carbonate	Percentage of disease						Foliage injury	Yield per acre
	Early blight			Late blight				
	Slight	Moderate	Severe	Slight	Moderate	Severe		
								bush.
2-2-40	28·4	30·6	40·3	0·0	0·0	0·0	Slight	204·6
2-3-40	19·6	14·7	37·4	0·0	0·0	0·0	None	207·4
3-3-40	50·1	20·8	20·9	0·0	0·0	0·0	Slight	201·4
3-4-40	20·4	60·1	21·6	0·0	0·0	0·0	Slight	217·6
3-5-40	15·9	55·2	31·8	0·0	0·0	0·0	None	208·6
4-4-40	15·7	45·9	21·9	0·0	0·0	0·0	Slight	206·4
4-5-40	15·6	31·6	13·9	0·0	0·0	0·0	None	224·8
4-6-40	24·8	17·7	19·6	0·0	0·0	0·0	None	227·0
4-7-40	27·4	11·8	34·7	0·0	0·0	0·0	None	229·0
4-8-40	19·1	23·2	29·4	0·0	0·0	0·0	Slight	214·6
5-5-40	35·1	14·3	21·3	0·0	0·0	0·0	Slight	222·1
5-6-40	21·2	34·4	17·2	0·0	0·0	0·0	None	223·7
6-6-40	41·3	17·1	31·1	0·0	0·0	0·0	Slight	209·7
6-7-40	14·1	31·9	29·6	0·0	0·0	0·0	None	226·8
Check	0·0	14·6	81·0	0·0	0·0	0·0	None	201·6

The foregoing results demonstrate that in as far as fungicidal efficiency, freedom from foliage injury and economy of materials are concerned, the (4-5-40), (4-6-40) and (4-7-40) are the most satisfactory combinations of copper sulphate and sodium carbonate for the preparation of Burgundy mixture. Burgundy mixture prepared according to the (2-2-40) (3-3-40) (4-4-40) (5-5-40) and (6-6-40) formulæ produced slight burning of the foliage in each case due to an insufficient amount of sodium carbonate to neutralize the copper sulphate. Slight burning also occured in the case of the (4-8-40) formula due to the sodium carbonate itself, which is capable of producing an injury to the foliage, if present in amounts exceeding that included in the ratio expressed by the formula (4-7-40). Such an injury is produced particularly when unusually high temperature and humidity obtain. Thus, it is apparent that proper proportions of copper sulphate and sodium carbonate must be used in the preparation of Burgundy mixture to prevent foliage burning. Results from additional tests carried on, revealed that while it is quite important to have a proper balance of the two ingredients of this fungicide, the greatest danger rests in the purity of sodium carbonate used, because certain brands of this chemical contain impurities, such as sodium sulphate, which are capable of causing a burning of the foliage regardless of how well the mixture is prepared. Observations from tests in connection with the use of Burgundy mixture on a commercial scale showed that while the limits within which the ingredients can be mixed to avoid foliage injury seem somewhat restricted, nevertheless this fungicide can be prepared safely under ordinary field conditions with no other precautions than those ordinarily exercised in the preparation of Bordeaux mixture.

When copper sulphate and sodium carbonate are mixed in the proportions ordinarily used in the preparation of the most satisfactory Burgundy mixtures, a bulky blue precipitate composed of basic copper carbonate forms, which, gradually changes on standing in the mixed liquid, after at least eighteen hours to a granular, dense, green compound known as malachite ($Cu_2(OH)_2CO_3$) which has no fungicidal value. With this information at hand it occurred that Burgundy mixture might possibly break down in such a manner after its application to the leaves of the plant. In order to secure information on this subject, potato leaves and carefully cleaned microscope slides were sprayed with Burgundy mixtures prepared according to the (4-5-40), (4-6-40), (4-7-40), (5-5-40), and (6-6-40) formulæ. Ten leaves and as many slides were treated with the fungicide prepared according to each formula. An equal number of these were kept under the humid conditions obtaining in the greenhouse and the dry conditions existing in one of the laboratory rooms. Microscopic examinations were made on each treated leaf and slide at three day intervals to ascertain the condition of the fungicide. Malachite was readily detected by its dense green, vitreous, botryoidal structure, loosely adhering to the treated surfaces, while the basic copper carbonate which largely constitutes the active principle of the fungicide was easily recognized by the blue amorphous mass uniformly and tenaciously adhering to the leaves and slides. These results tend to show that under the conditions of the experiment, which simulated in considerable measure those obtaining in the field during an average season, no change from the active constituent of the fungicide (copper carbonate) to the inactive malachite (basic copper carbonate) occurred within a period of six weeks. This indicates, that while Burgundy mixture readily undergoes such a change in vitro, no such reaction takes place on the leaves of the potato within the period the fungicide is ordinarily required to be active.

The results obtained from these series of experiments on the use of Burgundy mixture as a control for foliage diseases of the potato demonstrate some practical possibilities in the use of this fungicide for controlling early and late blight under the conditions obtaining in this province. A few of the noteworthy features which commend the use of this fungicide in preference to Bordeaux mixture are as follows:—

(1) Its fungicidal value in the control of early and late blight is superior to that of Bordeaux mixture.

(2) There is no sediment left in the sprayer such as is commonly the case with Bordeaux mixture, which clogs the feed pipes and nozzles, thus, always permitting unrestricted action of these parts.

(3) It adheres longer to the foliage of the plants and is not so readily washed off by rain.

(4) It does not stain the foliage to the same extent as Bordeaux mixture, thereby affording readier detection of especially the mild forms of mosaic, which are frequently obscured by the heavy lime precipitate in the latter.

On the other hand, however, Burgundy mixture presents the following objections:

(1) It does not appear to stimulate the potato plants to the same extent as Bordeaux mixture.

(2) The cost of preparation is slightly greater than that of Bordeaux mixture.

(3) It cannot be combined with the brands of lead arsenate commercially used.

(4) Sodium carbonate which is always free from undesirable impurities is more difficult to obtain than lime.

THE USE OF GYPSUM FROM LOCAL DEPOSITS IN THE CONTROL OF POTATO SCAB

(*Actinomyces scabies* (Thaxt.) Güssow)

Results from a preliminary experiment conducted at this laboratory in 1928 suggested some practical possibilities in the use of gypsum from local deposits as a preventive for common scab of the potato. In view of this, the project was continued in 1929 in greater detail, embodying chiefly, a plan proposed by the Dominion Chemist.

The experiment proper consisted of 5 one-hundredth acre plots, in duplicate. The distance between the plots was 3 feet in each case. Every plot was bounded on each of its four sides by a buffer row of potato plants, upon which no observations were made, for obvious reasons. The spacing interval for the plants was 18 inches and the distance between the rows 36 inches. The plots were systematically distributed to ensure greater uniformity of soil differences and competition. Scab infected but otherwise healthy seed of the Green Mountain variety was used.

The entire area set aside for the experiment (including the checks) received a dressing of commercial fertilizer, consisting of Ammo-phos, (20-30 grade), 186 pounds per acre and muriate of potash, 160 pounds per acre. The Ammophos was substituted for acid phosphate because it does not contain calcium sulphate (or gypsum) which is frequently present as an impurity in the brands of acid phosphate used commercially.*

* In the manufacture of commercial acid phosphate, one ton of ground rock phosphate is treated with about one ton of sulphuric acid, and the resulting material consists chiefly of monocalcium phosphate and calcium sulphate (land plaster) together with all the impurities contained in the original material.

$Ca\ (PO_4)_2+2H_2SO_4=CaH_4(PO_4)_2+2CaSO_4$ (Hopkins: Soil Fertility and Permanent Agriculture, 1910.)

The following includes in tabulated form (115), a list of the materials used and results recorded at harvesting time.

TABLE 115—GYPSUM AS A CONTROL FOR POTATO SCAB—COMPARISONS

Treatment	Percentage of common scab						Yield per acre	
	By number			By weight				
	Free	Slight	Severe	Free	Slight	Severe	Under 3 ounces	Over 3 ounces
							bush.	bush.
Gypsum, 500 pounds.........	39·0	39·4	21·6	39·0	42·0	19·0	51·2	110·4
Gypsum, 1,000 pounds.........	42·0	37·3	20·7	46·3	34·0	19·7	45·2	120·9
Gypsum, 2,000 pounds.........	59·1	24·8	16·1	62·5	20·0	17·5	47·7	112·3
Ground limestone, 2,000 pounds	26·7	45·1	28·2	39·3	43·2	27·5	50·9	111·6
Check (no treatment).........	36·1	42·8	21·1	35·3	41·2	23·5	49·4	114·8

These results confirm in considerable measure, those obtained from a preliminary experiment conducted in 1928, further demonstrating that the gypsum used, produced, when applied at the maximum rates, conditions slightly unfavourable for the growth of the scab organism. Gypsum applied at the rate of 500 pounds per acre appeared to have little or no suppressing effect on the development of scab. In this connection it is interesting to bear in mind that approximately 400 pounds of gypsum are applied as an impurity in the phosphoric acid ingredient of the average ton of commercial fertilizer used for potatoes. A study of the cumulative effect of gypsum from this source will form a part of the experiment in 1930 and subsequent years.

A noteworthy feature of the results obtained in 1929 is that there is no indication of reduced yields due to increased scab infection.

The project will be continued over a period of years in order to determine the cumulative effect of the gypsum originally applied.

CLUB ROOT OF SWEDE TURNIPS

(J. F. Hockey, Kentville, N.S.)

During 1929 facilities were made available to grow some stecklings, saved from our own 1928 crop, in the farm greenhouse. Seed was obtained from sixteen plants representing nine strain selections. The seed was all selfed. This seed together with the seed obtained by selfing plants in the field in 1928 provided the material for planting approximately sixty plots of swedes on inoculated soil. This area had been heavily manured in the autumn of 1928 with manure obtained from feeding clubbed turnips. The disease subsequently developed on susceptible varieties in all parts of the plots.

All pure line selections which developed club root on more than one or two secondary roots or had gone down with dry rot (*Phoma Lingam* (Tode) Desm.) were discarded with the exception of a strain of Westbury Selection which was originally selected for slight resistance. This latter strain has been used in reciprocal crosses and the progeny is being followed carefully.

The most promising selections made in the past five years are from the Herning strain Bangholm and Wilhelmberger. The Studsgaard Bangholm was also fairly resistant to club root but went down badly with dry rot.

Stecklings from ten pure line selections represent the most promising of those grown on inoculated soil in 1929 and are all that were saved for future trial. Seeds were obtained from fifteen strains of the selections made in 1928.

The roots of that crop were photographed and described and the progeny will be followed for several generations, or until such time as the type, colour, etc., are fixed or the selection discarded.

The selection and hybridizing phases of the project are being conducted in co-operation with the Dominion Agrostologist.

SEED POTATO IMPROVEMENT

(W. K. McCulloch, District Inspector, Kentville, N.S.)

Investigational work with potatoes was continued during the season of 1929 as follows:—

THE EFFECT OF CONTINUOUS SELECTION ON THE SHAPE OF THE TUBERS OF POTATOES

The variety used was the Garnet Chili.

Selections were made from the 1923 crop for planting in 1924, and, at the same time, counts were made of the percentage of tubers of good shape in the 1923 crop, or foundation stock.

The following table (116) gives the percentage of good shaped tubers in the foundation stocks, and in the progeny of the selected seed for the six seasons.

TABLE 116—EFFECT OF SELECTION ON THE SHAPE OF GARNET CHILI TUBERS

Grower	Per cent of tubers of ideal shape for the variety						
	Before selection	After selection					
	1923	1924	1925	1926	1927	1928	1929
1. E. Jennings	21·6	56·0	26·0	54·3	34·0	48·0	41·0
2. R. K. Loughead	40·0	40·2	35·0	59·5	47·5	60·3	49·1
3. A. Kent	38·6	50·9	35·0	55·0	47·5	58·8	57·1

The above table exhibits a peculiar alternation of high and low percentages but as each low percentage is a gain over the preceding low one the results up to the present time show a gradual improvement in the shape of the seed.

The soil of No. 1 is a medium loam with a stiff subsoil. The soils of No. 2 and No. 3 are sandy loams with fairly good natural drainage.

For the greater part of the growing season dry conditions prevailed, but towards the end, the soil was soaked with heavy rains which condition no doubt was responsible for the large amount of second growth and roughness on the tubers, in the districts where this experiment was carried on.

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 or the progeny of one tuber. Since 1924, when this work was started, many lines have been discarded and many new ones started. At the present time 108 tuber lines are being grown and 25 of these are each the progeny of a single tuber planted in 1924. Sufficient seed was thus obtained to plant the tuber lines in 1925. Table 117 gives the average percentage of virus diseases (chiefly mosaic), and also the average yield per hill (less weight of seed) for five years, of these 25 tuber lines.

TABLE 117—AVERAGE PERCENTAGE OF VIRUS DISEASES AND YIELD PER HILL

Line No.	Average for five years, 1925–1929	
	Per cent of Virus diseases	Yield per hill (less weight of seed)
		lb.
8. Bliss Triumph	13·0	1·99
9. "	2·0	1·74
45. "	4·6	1·95
46. "	1·0	1·70
47. "	10·8	1·54
48. "	10·0	1·63
59. "	5·6	1·60
61. "	6·2	1·59
62. "	7·4	1·64
121. Green Mountain	7·0	1·97
122. "	5·0	1·61
126. "	0·2	1·70
129. "	0·0	1·64
146. "	1·2	1·75
147. "	4·4	1·64
153. "	7·0	1·98
168. Irish Cobbler	0·4	1·54
170. "	3·0	1·63
176. "	2·0	1·39
190. "	3·0	1·47
193. "	2·0	1·43
195. "	1·0	1·52
199. "	1·0	1·40
209. "	1·4	1·33
211. "	2·0	1·35

This investigation is concerned chiefly with the maintenance of foundation stock seed potatoes. Foundation stock may be defined as seed potatoes that can be depended on with reasonable certainty to reproduce Certified Seed Potatoes the following year. The greatest problem in the growing of Certified Seed Potatoes is the control of virus diseases. No potatoes are certified if they contain over 1 per cent of the virus diseases such as leaf roll and mosaic at the final field inspection. And owing to the rapidity with which these diseases are spread a crop showing over 0·3 of one per cent can not be considered safe for foundation stock. It will be seen, then, from table 117 that under the environmental conditions at Kentville it was possible only to maintain 8 per cent of the tuber lines at the standard of foundation stock, and 24 per cent as certified seed during the 5 years under discussion.

The above results are borne out by the practical experience of the Inspection Service. It has been found that in certain districts with environmental conditions of soil and climate similar to those at Kentville the virus diseases spread so rapidly that new seed must be imported every year in order to maintain the standard of certified seed.

On the other hand, it has been found that there are other districts with different environmental conditions where it is much easier to control the virus diseases of the potatoes. For example, seed from Bliss Triumph tuber lines of Kentville was planted in certain sections of Pictou and Colchester counties in 1926 and maintained there as certified seed, more or less under ordinary farm conditions, with an average per cent of virus diseases for 4 years as follows: Pictou county 0·08, Colchester county 0·25. Also, on North Mountain in Kings county, the propagation of foundation stock of the Green Mountain and Irish Cobbler varieties has been attended with great success.

While it would appear that foundation stock cannot advantageously be produced under the environmental conditions at Kentville a glance at the average yields per hill will show that excellent crops of commercial potatoes can be grown under such conditions. The mean of the average yields, namely, 1·70 pounds per hill of Bliss Triumph, 1·75 pounds per hill Green Mountain, and 1·45 pounds per hill Irish Cobbler are equivalent to 440, 457 and 378 bushels per acre respectively, allowing for 10 per cent of hills missing or rogued-out.

Certain conditions of temperature and rainfall may be cited as favourable directly or indirectly to the production of certified seed potatoes, but the best procedure to follow in order to find out the suitability or otherwise of a district is to obtain the best seed possible and plant it in a well-isolated and well-cared-for seed plot.

TEST OF MATERIALS IN THE SEED TREATMENT OF POTATOES

Table 118 gives the results of a test of materials for seed treatment of potatoes.

With the exception of plots 3 and 4 the seed used was practically clean. In plots 3 and 4 the seed tubers were severely infected with common scab, hence the doubling-up of the treatments in these plots.

In the case of the materials Dipdust, No. 664 and Cal-K, the potatoes were pre-wetted.

Practically no difference was noted in the time of emergence of the plants, and little difference in the vigour of the various plots during the growing season.

Last year sulphur and mercuric chloride occupied first and second place respectively in the test. This year a combination of the two gave the largest yield of clean tubers of marketable size.

TABLE 118.—TEST OF MATERIALS IN THE SEED TREATMENT OF POTATOES, KENTVILLE, N.S., 1929

Plot	Treatment	Per cent scab	Per cent rhizoctonia	Yield per acre		Total
				Small (clean)	Marketable (clean)	
				bush.	bush.	
1	None	83·25	2·25	8·0	35·33	298·6
2	Flowers of sulphur dusted on cut sets at rate of 2 pounds per barrel of sets	74·87	....	9·6	58·6	272·0
3	Mercuric chloride, 4 oz. in 30 gallons for one hour and flowers of sulphur on cut sets	70·71	....	25·0	59·33	288·0
4	One pint formaldehyde in 30 gallons for one hour, and flowers of sulphur on cut sets	75·41	4·58	4·0	44·0	240·0
4a	One pint formaldehyde in 30 gallons water, 1 hour	91·86	....	....	18·6	229·0
5	None	90·97	....	13·0	....	144·0
6	Sulphur, same as in Plot 2	90·40	....	14·3	....	149·3
7	Dip dust (commercial, seed disinfectant)	93·10	1·07	9·0	....	154·6
8	Mercuric chloride, 4 oz. in 30 gallons water, 1 hour	81·73	....	25·3	....	138·6
9	Formaldehyde as in Plot 4a	100·00	....	....	....	154·6
10	No. 664. (Commercial disinfectant)	92·46	....	13·6	....	181·3
11	Cal-K. (Commercial disinfectant)	100·00	....	....	....	176·0

REPORT OF THE DOMINION LABORATORY OF PLANT PATHOLOGY. CHARLOTTETOWN, PRINCE EDWARD ISLAND

(R. R. Hurst, Pathologist in Charge)

LATE BLIGHT OBSERVATIONS IN 1929

The marked contrast between temperature and rainfall in the years 1928 and 1929 afforded an opportunity for studying the occurrence of late blight in relation to weather conditions. The fact that late blight thrives in cool climates and is uncommon in the south is evidence that low temperatures favour the development of blight and, conversely, that it is inhibited by high temperatures.

Records at the Charlottetown laboratory show that late blight has been worse in years of heavy rainfall and low temperatures in September as illustrated by conditions in 1928 when blight was general by September 16, a month of heavy precipitation and low temperatures as compared with the same period in 1929,* featured by subnormal rainfall and by periods of warm dry weather.

In September, 1928, an outbreak of blight was reported on the thirteenth day, following three nights of comparatively low temperatures (fig. 52). Heavy rain followed with higher temperatures whilst a moderate outbreak of blight prevailed until September 23, when it became severe and widespread, continuing until the potato tops were dead.

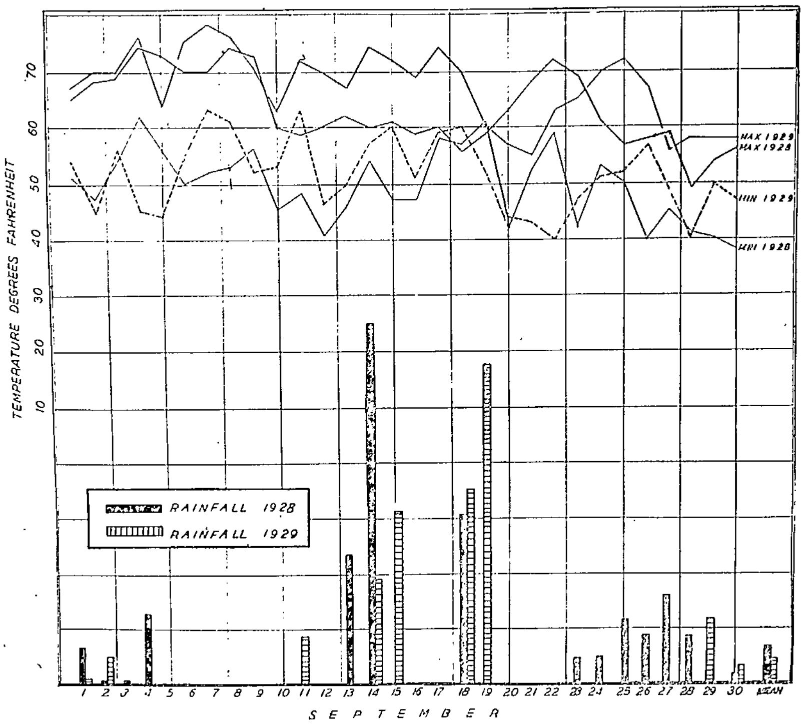


FIG. 52.—Weather correlations for the months of September, 1928-29.

In 1929 blight was not recorded until September 21 after a short period of heavy rain and low temperatures (fig. 52). At this time it was expected that the disease would develop rapidly, however, it was apparently held in check by a week of dry warm weather. During this period digging began and the harvested crop escaped the outbreak of blight which took place the first week of October after a period of low temperatures and rain.

Our knowledge of this apparent correlation between low temperature, precipitation and blight incidence introduces the question of forecasting blight epiphytotics. The time may come when it will be possible to do this, in a degree, at least. Nevertheless, at present we do not favour recommendations which have to do with a restricted spraying program, except possibly in the case of early maturing varieties which may be harvested before the blight appears. Experience shows that in Prince Edward Island blight occurs every year. In 1929 blight was not a factor in the production of Irish Cobblers, which, because of dry weather, matured within the ninety day period, Green Mountains on the other

* Monthly Bulletin of Agricultural Statistics, Vol. 22, No. 254, 1929, p. 381, Agricultural Branch, Ottawa.

hand, made excellent growth late in the season when blight was developing. At this time it was spreading rapidly in the unsprayed potato plots at the laboratory. Subsequent observations showed that a high percentage of blight-rot existed in the crop harvested from these unsprayed plots. On the other hand, in every case where regular spraying had been accomplished no rot occurred. This valuable evidence demonstrates conclusively that departure from the regular spraying schedule is unsatisfactory where late maturing varieties are concerned.

DEPTH OF SOIL COVERING IN RELATION TO LATE BLIGHT TUBER ROT

It has been commonly noticed that tubers under severely blighted plants have escaped rot, when one would naturally expect to find considerable infection. Observations have shown that such instances consistently occur when the tubers have a liberal covering of soil due to the method of cultivation known as ridging.

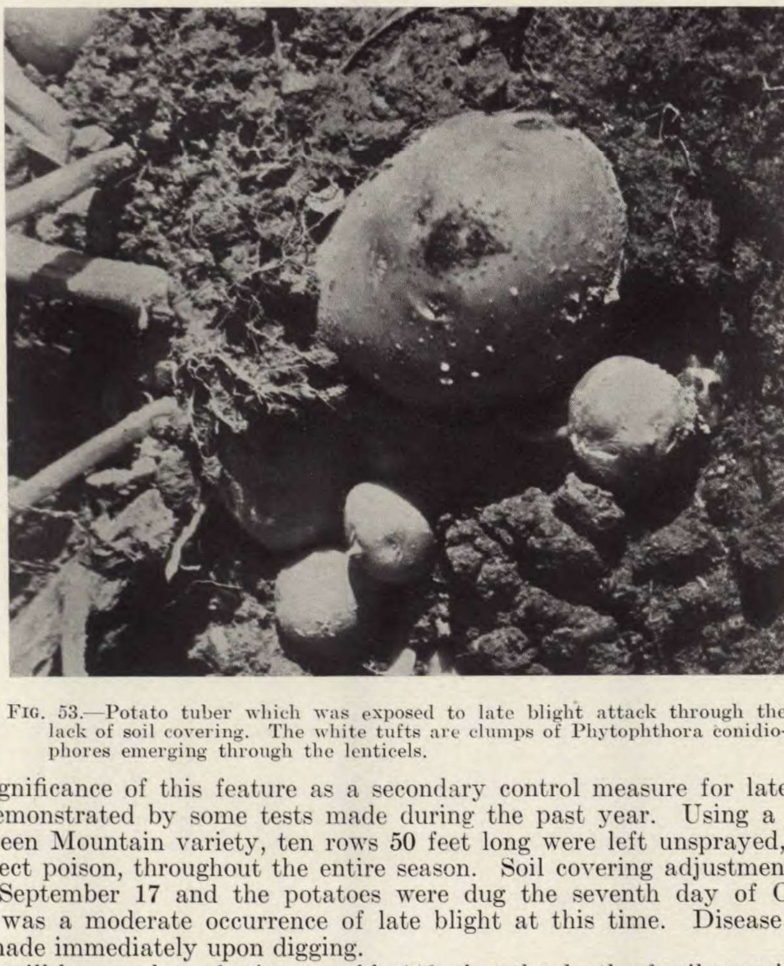


FIG. 53.—Potato tuber which was exposed to late blight attack through the lack of soil covering. The white tufts are clumps of Phytophthora conidiophores emerging through the lenticels.

The significance of this feature as a secondary control measure for late blight was demonstrated by some tests made during the past year. Using a plot of the Green Mountain variety, ten rows 50 feet long were left unsprayed, except for insect poison, throughout the entire season. Soil covering adjustments were made September 17 and the potatoes were dug the seventh day of October. There was a moderate occurrence of late blight at this time. Disease counts were made immediately upon digging.

It will be seen by referring to table 119, that the depth of soil covering may be regarded as an important factor from the standpoint of blight-rot occurrence. It is shown that potatoes from which the soil had been removed contracted blight-rot (Fig. 53) to the extent of 58½ per cent, and it is evident also that a thin covering of soil affords the tubers but little protection against the Phytophthora spores. Similarly it will be seen that infection did not occur with a soil covering of 1½ to 3½ inches.

TABLE 119.—LATE BLIGHT CONTROL BY DEPTH OF SOIL COVERING

Row number	1	2	3	4	5	6	7	8	9	10
Soil covering in inches	No soil	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
Percentage infected tubers	$58\frac{1}{2}$ (sunburned)	$21\frac{3}{4}$	$12\frac{1}{2}$	3	$\frac{1}{2}$	....	....	....	....	....
Percentage sound tubers	$41\frac{1}{2}$ (sunburned)	$78\frac{1}{4}$	$87\frac{1}{2}$	97	$99\frac{1}{2}$	100	100	100	100	100

THE QUESTION OF SPREAD OF LATE BLIGHT ROT FROM DISEASED TO HEALTHY TUBERS IN STORAGE

In seasons when late blight is common it is generally the experience that considerable rot occurs in stored potatoes. Unconfirmed reports have been to the effect that the disease spreads from tuber to tuber during the storage period. While this appears as a logical explanation it neglects the fact of the possibility of infection by viable spores carried on tubers from the field. Furthermore, incipient stages of rot may be overlooked and when detected in storage transmission of the disease from infected to healthy tubers is offered wrongly as an explanation.

Heald* states that there may be some spread from infected tubers to sound ones either in the soil or in storage, if sufficient moisture is present. Murphy† on the other hand, found no evidence to support this view.

During the storage period of 1928 and 1929 experiments bearing upon this question were conducted using tubers showing slight, moderate and severe infection (Fig. 54).

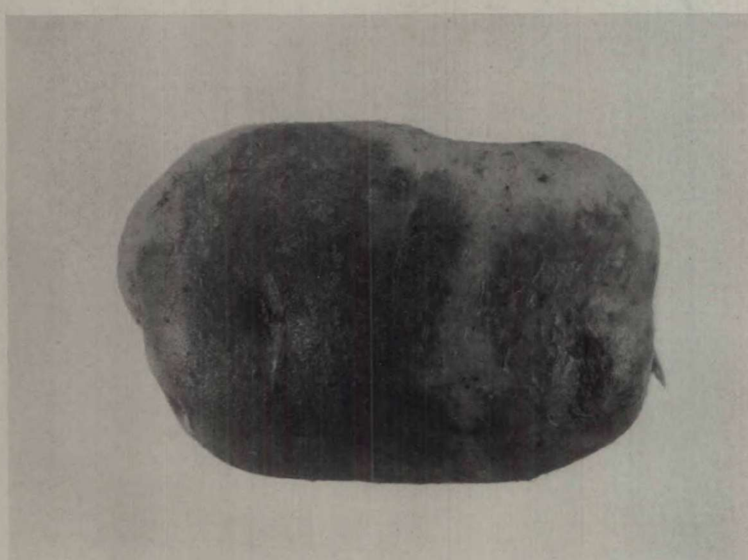


FIG. 54.—Late blight tuber rot showing the early or autumn stage of severe infection. The surface over the infected area is not sunken at this stage.

* Heald, Manual of Plant Diseases, p. 402.

† Murphy, Paul A. The Sources of Infection of Potato Tubers with the Blight Fungus, Phytophthora infestans. Scient. Proc. R.D.S. Vol. XVI, No. XXIX.

Healthy and diseased tubers were placed together in bags in storage from October 18 to April 30 as follows:—

(*a*) 900 tubers showing slight infection from blighted tops.
900 tubers showing no infection and treated 1½ hours with bichloride of mercury 1-1000.

(*b*) 900 tubers showing moderate infection.
900 tubers showing no infection and treated 1½ hours with bichloride of mercury 1-1000.

(*c*) 900 tubers showing severe infection.
900 tubers showing no infection, and treated 1½ hours with bichloride of mercury 1-1000.

(*d*) 900 tubers showing moderate infection.
900 tubers showing no infection, untreated.

The uninfected tubers were selected for freedom from disease, cracks, cuts and bruises. To prevent the occurrence of blight infection from viable conidia carried from the field, uninfected tubers, with the exception of test D, were soaked in a solution of bichloride of mercury (1-1000) for 1½ hours. They were then rinsed with pure water to prevent any subsequent inhibiting effect of the corrosive sublimate upon the organism which would be associated with the spread of blight from tuber to tuber. During the storage period the temperature ranged between 33° F. and 40° F. The tubers used in these tests were dug from unsprayed plots on October 1, and placed in storage October 8.

Table 120 summarizes the results obtained. There is very slight evidence that late blight was transferred from diseased to healthy tubers, as instanced in the cases of tests A and C, when one and three tubers respectively contracted blight rot. There was no evidence of spread in test B. In test D, however, composed of diseased and untreated sound tubers, disease tubers increased to the extent of 5.3 per cent. Such evidence would indicate that in the case of test D where sound tubers were untreated infection very likely resulted through the agency of viable conidia which were carried from the field into storage rather than by spread from diseased to sound tubers. It is likewise equally evident that under conditions of good storage, where the conidia were destroyed by seed treatment, the chances of spread were slight.

Table 120.—Spread of Late Blight Rot in Storage, 1928–29

Test	Tubers stored	Healthy	Late blight rot	Per cent spread
A	900 sound 900 diseased	899	901	0·11
B	900 sound 900 diseased	900	900	0·0
C	900 sound 900 diseased	897	903	0·33
D	900 sound 900 diseased	852	948	5·3

Practical Applications.—Based upon the foregoing considerations the following recommendations are suggested as timely protective measures against loss from blight.

1. Practise the regular spraying schedule in years of normal precipitation. In exceptionally dry years it is reasonably safe to forego spraying early maturing varieties.
2. Deep covering of soil or ridging is a distinct advantage where late blight is a factor.
3. Under good storage conditions there is no appreciable spread of late blight from healthy to sound tubers.

DATE OF DIGGING AND RHIZOCTONIA CONTROL

Previous investigations* have shown that Rhizoctonia control in potatoes is closely associated with the date of digging. However, experience has shown that early digging exposed the immature tubers to injury during the harvesting operations and subsequent handling. Recommendations therefore must be made on a basis of the ability of such potatoes to survive storage conditions, as well as upon their value for purposes of seed and table use. During the past two seasons these points were incorporated into the date of digging experiments. Adopting the practice followed in previous years the experiments were conducted with Irish Cobblers and Green Mountains. The land was known to be heavily infested with Rhizoctonia, and the digging dates, seven in number were represented by three replications, arranged to give uniform spacing throughout the plot.

The results which are condensed in table 121 show that early digging reduced the amount of Rhizoctonia in 1928, when the late season was featured by comparatively low temperatures and heavy rains. On the other hand in 1929, a season of comparatively high temperatures and little rain, Rhizoctonia did not appear until August 6, making earlier digging useless as a control measure for this disease. Referring again to table 121 it will be seen that in both years an appreciable loss was sustained by the practice of early digging, a feature which must be given due consideration when summing up the merits of early digging. Disregarding the figures obtained on September first and eighth, it will be seen that there was an important appreciation in yield on the digging dates represented between September 15 and October 13, inclusive. Balanced against any advantage gained by early digging to overcome the Rhizoctonia factor it is a question whether such a practice would be justified. Taking the case of Green Mountains in 1929, very profitable gains were made by late digging. This distinct difference was not apparent in the case of Irish Cobblers. In 1929 this variety matured well within the 90-day period and yields were comparatively light.

TABLE 121.—DATE OF DIGGING IN RELATION TO RHIZOCTONIA CONTROL

Digging date	Percentage Rhizoctonia				Yield per acre*							
	1928		1929		G.M. 1928		G.M. 1929		I.C. 1928		I.C 1929	
	G.M.	I.C.	G.M.	I.C.	Mark.	Culls.	Mark.	Culls.	Mark.	Culls.	Mark.	Culls.
					bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.
Sept. 1	1	4	0	0	179	101	177	85	142	83	165	88
" 8	3	4	0	0	190	102	182½	100½	143½	106½	128	92
" 15	10	15	0	0	225	97	191	101	221	87	131	91
" 22	21	40	0	0	247	96	201	109	253	99	198	103
" 29	25	43	0	0	264½	65½	251½	92½	281	78	241½	100½
Oct. 6	47	60	0	5	274½	81½	254½	83½	304	96	243	78
" 13	48	64	3	7	271	79	251	76	301½	97½	241	81

*Average of 4 replications.

INVESTIGATIONS OF SEED POTATO TREATMENTS

(In co-operation with the Fredericton Laboratory)

A brief review of our knowledge of seed treatment methods shows that a new field was opened to mercury compounds when Bolley, in 1890, demonstrated the value of mercuric chloride and recommended its use as a control for common scab of potatoes. Until 1912 mercuric chloride was the only com-

* Division of Botany Reports for 1925 and 1927.

pound of mercury employed by plant pathologists. Since then, preparations of organic mercury have been introduced and these have been increasing in favour. It is claimed that they retain their fungicidal value in spite of constant usage and that they are effective to the last drop.

The experimental plan followed in 1929 was essentially the same as in previous years. However, all treatments were applied to uncut sets and two unsuccessful organic mercury compounds were replaced with new ones, namely, Cal K. and 664. 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. Seed-pieces were each 1½ ounces in weight and had one eye. All tubers intended for treatment were presoaked for two hours in water.

The various treatments were applied as follows:—

I. Improved Semesan Bel. (1:20) by weight.

II. Cal-K. (1:40) by weight.

III. No. 664. (1:68) by weight.

IV. Dipdust (1:20) by weight.

V. Formalin (cold) 1 pint to 25 gallons water for 1½ hours.

VI. Formalin (hot) 2 pints to 25 gallons water for 3 minutes at 122° F.

VII. Mercuric chloride (cold) 4 ounces to 25 gallons water for 1½ hours.

VIII. Mercuric chloride (hot) 4 ounces to 25 gallons water for 3 minutes at 122° F.

IX. Mercuric chloride (dip) (1:40) by weight.

X. Mercurous chloride (hot) 8 ounces to 25 gallons for 3 minutes at 122° F.

XI. Mercurous chloride (dip) (1:20) by weight.

XII. Mercurous chloride (cold) 8 ounces to 25 gallons water.

XIII. Infected seed untreated.

XIV. Disease free seed untreated.

RESULTS

(*Rhizoctonia*)

Table 122 summarizes the results obtained at Fredericton. It will be seen that, while Rhizoctonia was not severe even in the untreated checks, a definite measure of control was afforded by No. 664, mercuric chloride dip, hot mercurous chloride, and hot formalin, the percentage of efficiency being 100, 98·3, 98·2, and 97·2, respectively (column 3, table 122). From point of yield this order would be changed, with first place going to mercuric chloride used as a dip. Making further comparisons on a basis of yield and disease control, there is evidence that Dipdust, cold formalin and mercurous chloride dip were unsatisfactory. Referring to column 5, table 122, there will be noted a marked irregularity of results, with a predominance of low percentages of slight infections. The fact that untreated infected seed produced the second highest percentage infection is interpreted as a strong indication of fungicidal efficiency in favour of the treatments represented by low percentages of slight infection.

Analysing the results of the Charlottetown Rhizoctonia experiments, we find that severe infection was uncommon (column 7, table 123), the highest count being 2·4 per cent in the case of cold mercurous chloride. Again, in column 5 of the same table we observe that slight infection developed over a range of 0·9 per cent to 14·6 per cent. The occurrence, however, of 4·7 and 14·3 per cent infection in untreated infected and uninfected seed respectively makes it difficult to assign any definite values for the various treatments.

TABLE 122.—SEED TREATMENT FOR RHIZOCTONIA, FREDERICTON, 1929

Treatment	Number of Tubers									
	Free		Slight		Severe		Under 3 ounces		Over 3 ounces	
		%		%		%		%		%
Improved Semesan Bel....	141	80·1	34	19·3	1	0·6	100	56·8	76	43·2
Cal-K....................	219	96·9	7	3·1	0	0·0	127	56·2	99	43·8
No. 664..................	192	100·0	0	0·0	0	0·0	103	53·6	89	46·4
Dipdust..................	201	86·3	32	13·7	0	0·0	127	54·5	106	45·5
Formalin (cold)..........	209	95·0	11	5·0	0	0·0	122	55·5	98	44·5
Formalin (hot)...........	176	97·2	5	2·8	0	0·0	91	50·3	90	49·7
Mercuric chloride (cold)....	207	83·5	39	15·7	2	0·8	120	48·4	128	51·6
Mercuric chloride (hot)....	179	96·8	6	3·2	0	0·0	102	55·1	83	44·9
Mercuric chloride (dip).....	236	98·3	4	1·7	3	0·0	125	52·1	115	47·9
Mercurous chloride (hot)...	220	98·2	4	1·8	0	0·0	124	55·4	100	44·6
Mercurous chloride (dip)...	183	95·3	9	4·7	0	0·0	110	57·3	82	42·7
Mercurous chloride (cold)..	127	62·3	77	37·7	0	0·0	101	49·5	103	50·5
Infected seed untreated....	1,004	71·4	400	28·4	3	0·2	730	51·9	677	48·1
Disease free seed untreated.	1,604	96·1	65	3·9	0	0·0	827	49·6	842	50·4

TABLE 123.—SEED TREATMENT FOR RHIZOCTONIA, CHARLOTTETOWN, 1929

Treatment	Number of Tubers										
	Free		Slight		Severe		Under 3 ounces		Over 3 ounces		Per cent stand
		%		%		%		%		%	
Improved Semisan Bel..........	210	98·6	2	0·9	1	0·4	99	46·5	114	53·5	100
Cal-K..........................	215	92·3	15	6·4	3	1·3	107	45·9	126	54·1	100
No. 664........................	230	97·5	5	2·1	1	0·4	110	46·6	126	53·4	100
Dipdust........................	228	90·8	21	8·4	2	0·8	99	39·4	152	60·6	99
Formalin (cold)................	221	87·7	30	11·9	1	0·4	100	39·7	152	60·3	100
Formalin (hot).................	240	86·3	32	11·5	6	2·2	112	40·3	166	59·7	96
Mercuric chloride (cold)........	237	84·6	41	14·6	2	0·7	110	39·3	170	60·7	100
Mercuric chloride (hot).........	251	86·0	40	13·7	1	0·3	101	34·6	191	65·4	99
Mercuric chloride (dip)..........	222	90·2	21	8·5	3	1·2	110	44·7	136	55·3	100
Mercurous chloride (hot).........	236	87·1	33	12·2	2	0·7	106	39·1	165	60·9	100
Mercurous chloride (dip).........	240	90·2	22	8·3	4	1·5	99	37·2	167	62·8	97
Mercurous chloride (cold)........	249	85·3	36	12·3	7	2·4	104	35·6	188	64·4	100
Infected seed untreated..........	1,564	94·2	78	4·7	19	1·1	601	36·2	1,060	63·8	100
Disease free seed untreated......	1,429	84·4	243	14·3	22	1·3	702	41·4	992	58·6	97

RESULTS

(Common Scab)

The results obtained from seed treatments for common scab were striking, particularly at Fredericton, as shown in table 124, where it is seen that in no instance was 100 per cent control obtained. Considering the severity of scab infection on a percentage basis the order of merit was indicated (column 7, table 124) for five treatments as follows, mercuric chloride dip, mercurous chloride dip, No. 664, Cal-K, and hot mercurous chloride, the percentage of infection being respectively 1·4, 1·6, 3·2, 5·0 and 6·7. Arranging them according to the percentage of freedom from scab the order of merit (column 3, table 124) would be changed as follows: mercurous chloride dip, mercuric chloride dip, dipdust, hot mercurous chloride, and No. 664. It will be noted in this connection that the highest degree of efficiency is represented by 88·4 per cent. Again considering the severity of infection (column 7, table 124), hot mercuric chloride, improved Semesan Bel, cold mercurous chloride, and cold formalin gave poor control, their percentages of efficiency being respectively 43·7, 28·0, 20·0, and 18·0.

Table 124.—Seed Treatment for Scab, Fredericton, 1929

Treatment	Number of Tubers									
	Free		Slight		Severe		Under 3 ounces		Over 3 ounces	
		%		%		%		%		%
Improved Semesan Bel....	131	58·2	31	13·8	63	28·0	141	62·7	84	37·3
Cal-K....................	194	74·3	54	20·7	13	5·0	143	54·8	118	45·2
No 664...................	197	78·5	46	18·3	8	3·2	132	52·6	119	47·4
Dipdust..................	183	84·7	14	6·5	19	8·8	122	56·5	94	43·5
Formalin (cold)...........	156	57·4	67	24·6	49	18·0	152	55·9	120	44·1
Formalin (hot)............	161	76·7	15	7·1	34	16·2	140	66·7	70	33·3
Mercuric chloride (cold)....	189	72·4	47	18·0	25	9·6	127	48·7	134	51·3
Mercuric chloride (hot)....	87	45·8	20	10·5	83	43·7	93	48·9	97	51·1
Mercuric chloride (dip.)....	118	85·6	18	13·0	2	1·4	52	37·6	86	62·4
Mercurous chloride (hot)...	87	83·7	10	9·6	7	6·7	61	58·7	43	41·3
Mercurous chloride (dip.)...	114	88·4	13	10·0	2	1·6	71	55·0	58	45·0
Mercurous chloride (cold)..	149	67·7	27	12·3	44	20·0	132	60·0	88	40·0
Infected seed untreated....	662	40·8	362	22·3	597	36·9	815	50·3	806	49·7
Disease free seed untreated.	1,212	66·2	305	16·7	314	17·1	901	49·2	930	50·8

At Charlottetown the results were inconsistent and are therefore difficult to interpret. It is a matter of importance to note that both at Fredericton and Charlottetown untreated checks yielded a high percentage of scabby tubers. It would appear, therefore, that the soil given over to this experiment was contaminated with the organism responsible for the disease in question, a fact which would explain the absence of satisfactory control from any of the disinfectants used. At Charlottetown (column 7, table 125), it will be seen that considering the severity of scab on a percentage basis the order of merit was as follows: Improved Semesan Bel., Dipdust, cold mercurous chloride, hot mercurous chloride, Cal-K, and mercuric chloride dip, the percentage infection being respectively 1·1, 1·2, 3·6, 3·9, 4·0 and 5·2. Interpreting the same column of results from a demerit standpoint we have the following order: hot formalin, mercurous chloride dip, cold mercuric chloride, hot mercuric chloride and cold formalin. Arranging these treatments (column 3, table 125) with respect to freedom from scab the order of merit would be changed as follows: mercurous chloride cold, Improved Semesan Bel., mercurous chloride hot, Cal-K and cold formalin. In this instance the best efficiency is represented by 91·4 per cent.

DISCUSSION

While the results of these field tests are of great importance, we feel that further experimenting is necessary before definite recommendations may be made regarding the comparative fungicidal qualities of the various disinfectants engaging our attention. The value of such experimental evidence is governed largely by seasonal factors over which we have no control. Furthermore, we believe that the intelligent interpretation of field plot data is greatly dependent upon our ability to account for the toxic action of chemicals.

TABLE 125.—SEED TREATMENT FOR SCAB, CHARLOTTETOWN, 1929

Treatment	Number of Tubers									
	Free		Slight		Severe		Under 3 ounces		Over 3 ounces	
		%		%		%		%		%
Improved Semesan Bel	164	91·1	14	7·8	2	1·1	86	47·8	94	52·2
Cal-K	147	85·0	19	11·0	7	4·0	91	52·6	82	47·4
No. 664	199	84·3	21	8·9	16	6·8	118	50·0	118	50·0
Dipdust	198	79·8	47	19·0	3	1·2	104	41·9	144	58·1
Formalin (cold)	154	84·6	9	4·9	19	10·4	117	64·3	65	35·7
Formalin (hot)	99	69·7	21	14·8	22	15·5	41	28·9	101	71·1
Mercuric chloride (cold)	109	65·7	36	21·7	21	12·6	71	42·8	95	57·2
Mercuric chloride (hot)	115	73·7	22	14·1	19	12·2	63	40·4	93	59·6
Mercuric chloride (dip)	127	82·5	19	12·3	8	5·2	47	30·5	107	69·5
Mercurous chloride (hot)	164	90·6	10	5·5	7	3·9	122	67·4	59	32·6
Mercurous chloride (dip)	171	83·4	8	3·9	26	12·7	131	63·9	74	36·1
Mercurous chloride (cold)	201	91·4	11	5·0	8	3·6	119	54·1	101	45·9
Infected seed untreated	1,681	83·5	221	11·0	111	5·5	992	49·3	1,021	50·7
Disease free seed untreated	1,396	72·9	319	16·6	201	10·5	703	36·7	1,213	63·3

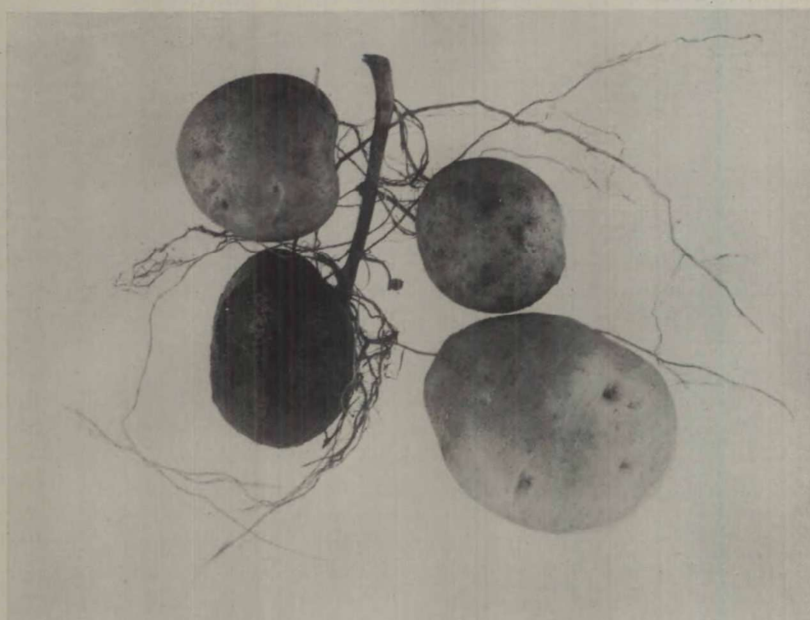


FIG. 55.—Mature tubers of a plant infected with leaf roll and illustrating the manner in which the seed-piece persists throughout the season.

INVESTIGATION OF VIRUS DISEASES

Work in connection with virus diseases of plants was restricted to making and recording observations. The following plants showing virus disease symptoms are to be included with the list compiled in 1928*:—

Rhubarb.	Pumpkin.
Broad-leaved dock.	Squash.
Buckwheat.	Wild cucumber.
Turnip.	Marigold.
White clover.	Lettuce.
Eggplant.	Potato (giant hill).

* Report of the Dominion Botanist for the year 1928.

Leaf roll—Persistance of Mother Set.—The persistance of the seed-piece has been frequently referred to as an indication of leaf-roll (fig. 55). Murphy says† in referring to this character: "The set from which a diseased plant springs commonly remains firm until the end of the season. This is not an invariable rule, however, and its occurrence is not confined to leaf-roll alone."

In the Charlottetown field plots during the past year the occurrence of leaf-roll in a number of potato varieties offered an opportunity of making observations on this point. The consistence with which the seed-piece remained intact throughout the growing season is well illustrated in the following list of varieties showing symptoms of leaf roll:—

Dooley	Seed piece intact.	
Dakota Red	"	
Early Rose	"	
Spaulding Rose	"	
Early Sunrise	"	(2 plants)
Irish Cobbler	"	
Green Mountain	"	
Rural Russet	"	
Extra Early Eureka	"	
Carmen No. 1	"	
Sunrise	"	
Carmen No. 3	"	(2 plants)
Bliss Triumph	"	
Wee McGregor	Seed pieces destroyed (2 plants)	
Manitoba Wonder	Seed piece destroyed.	

Such evidence would imply that while the parent set producing leaf roll plants generally persists, this character cannot be relied upon as a typical symptom of leaf roll nor peculiar to the disease. Out of forty-one mosaic plants examined five seed-pieces were found at the end of the growing season. Similarly, in the size of seed-piece tests conducted in 1929 at Charlottetown, 73 per cent of the whole seed tubers were uninjured at digging time.

SIZE OF POTATO SEED-PIECE

The results of five years investigation of this project have been published.* It was pointed out that the matter of using culls for seed purposes involved the question of virus disease development since it is generally agreed that there is a tendency towards the production of small tubers from plants infected with leaf roll and mosiac. Bearing in mind this factor, our observations led us to believe that as far as Irish Cobblers are concerned, the use of culls has certain merits. Green Mountains, however, in addition to being very susceptible to mosiac, are grown extensively for seed purposes. Hence it is important for us to have a knowledge of the manner in which this variety would respond to the practice of employing culls for seed stock.

The land used for this experiment in 1929 had not been in potatoes for several years. It was ploughed in November 1928, manure was applied at the rate of 15 tons per acre and in the spring of 1929 fertilizer was applied by machine at the rate of 1,560 pounds per acre, the chemicals being applied as follows:

Nitrate of soda	260 pounds
Sulphate of ammonia	400 "
Muriate of potash	300 "
Superphosphate	600 "

† Murphy, Paul A. Investigation of potato diseases, Bul. 44, Dom. Dept. Agr., p. 34. 1921.
*Reports of the Dominion Botanist for the years 1927 and 1928.

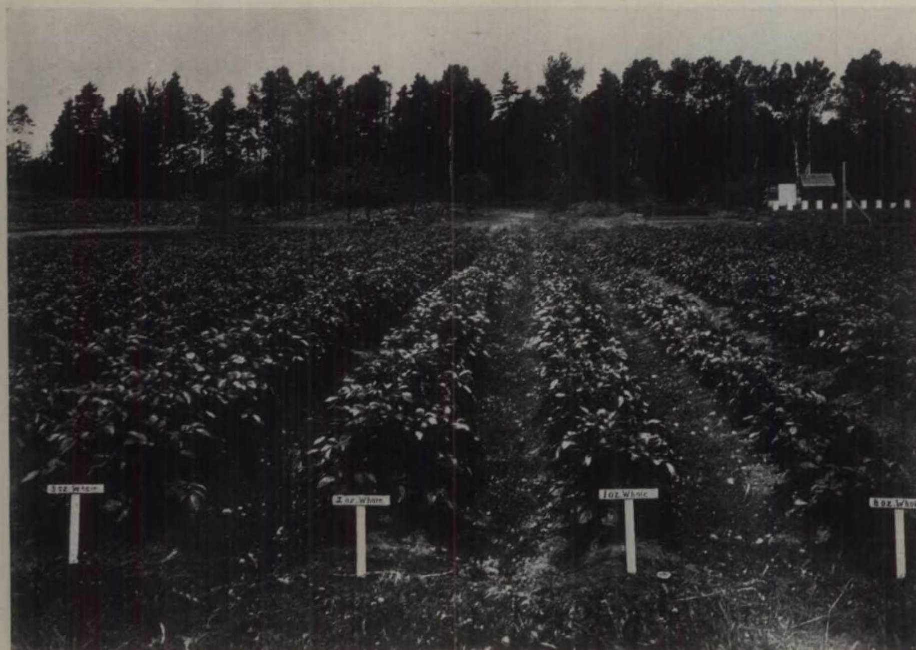


Fig. 56.—Size of seed piece experiment, Prince Edward Island. Note conformity of plant growth with size of seed piece. (Photo. by R. R. Hurst)

Fig. 57.—Size of seed piece experiment, Prince Edward Island. Note conformity of plant growth of size of seed piece. (Photo. by R. R. Hurst)

The culls and three-ounce tubers for seeding came from the corresponding size of seed-pieces obtained in 1928. The weights and nature of these were as follows:

Seed-piece	Weight in ounces.
Whole	3, 2, 1½, 1, and ½.
Cut	1½, 1, and ½.

The sets were spaced 12 inches in 100-foot rows which were 36 inches apart. The planting scheme comprised four replications and included buffer rows and ends. Diseased plants were rogued as observed and the loss in yield was compensated by calculating the average yield of a hill for each size of seed-piece involved. Seed-pieces were weighed with all possible accuracy. Planting was done by hand and the rows covered by hand hoeing. The plants were hilled when they appeared through the ground and again three weeks later. The crop was harvested the first week in October. All weighing was begun one month later in the laboratory storage basement. A high degree of accuracy was achieved by the use of egg balances. By means of this device all tubers three ounces and under were graded into groups. The tubers of each group differed in weight by a quarter of an ounce and were the progeny of the respective size of seed-pieces used for planting.

RESULTS.—Referring to table 126, it will be seen that comparatively low yields prevailed. The proportion of culls was high, a condition largely resulting from the seasonal conditions which were so unfavourable to the production of marketable tubers. Without deducting the tubers required for seeding, the order of merit approximates the results previously obtained with Irish Cobblers. However, on a basis of our previous experiments it must also be pointed out in this connection that we may expect conflicting results so far as yields are concerned. After two years of using culls for seed there has been no evidence of virus diseases. It should be noted that the history of this strain of Green Mountains records a trace of mosiac.

TABLE 126—SIZE OF POTATO SEED-PIECE, CHARLOTTETOWN, 1929

(Green Mountains)

—	Yield per acre															
	3 ounces whole		2 ounces whole		$1\frac{1}{2}$ ounces whole		1 ounce whole		$\frac{1}{2}$ ounce whole		$1\frac{1}{2}$ ounce cut		1 ounce cut		$\frac{1}{2}$ ounce cut	
	Marketable	Culls	Marketable	Culls	Marketable	Culls	Marketable	Culls	Marketable	Culls	Marketable	Culls	Marketable	Culls	Marketable	Culls
	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.
Replication—																
1	188·7	134·9	174·2	125·8	186·3	133·1	159·1	118·5	96·8	135·5	153·6	146·4	158·5	127·6	154·6	96·1
2	161·5	197·8	258·9	113·7	307·3	99·2	240·7	106·4	237·7	71·9	321·8	72·6	300·6	75·6	226·8	62·9
3	256·5	99·2	220·2	111·3	232·3	106·4	297·6	55·6	217·8	50·8	217·8	96·8	244·2	70·1	196·0	75·0
4	159·7	133·1	222·6	121·0	196·0	140·3	246·8	111·3	193·6	96·8	166·9	118·5	183·9	125·8	169·4	9·6
Total	766·4	565·0	875·9	471·8	921·9	479·0	944·2	391·8	745·9	355·0	860·1	434·3	887·2	399·1	746·8	243·6
Average	191·6	141·2	219·0	117·9	255·4	119·7	236·0	97·9	186·5	88·7	215·0	108·6	221·8	99·8	186·7	60·9
Order of merit (marketable)	6	....	4	....	2	....	1	....	8	....	5	....	3	....	7	....
Order of merit (Culls)	....	1	....	3	....	2	....	6	....	7	....	4	....	5	....	8

At present throughout the potato growing sections of Canada reference is being made to the question of providing a certification class for seed tubers below three ounces in weight. The instant this is accomplished the lowly cull is elevated to a position of importance hitherto enjoyed only by tubers three ounces or more in weight. Bearing in mind this advantage all culls from the size of seed-piece experiment this year were graded according to the size of seed-piece from which they originated. For example, the culls from the 3 ounce whole seed-piece were graded as follows: ½ ounce, 1 ounce, 1¼ ounce, 1½ ounce, 1¾ ounce, 2 ounces, 2¼ ounces, 2½ ounces, 2¾ ounces.

Experience has shown* that whole tubers weighing one or one and a half ounces return profitable results when used for seed purposes. Therefore, it would be of value to ascertain the size of seed-pieces which produce the greatest amount of culls approximating these weights. Information bearing upon this point is given in table 127. The seed-pieces weighing ½-ounce were the least profitable with respect to the production of useful culls (one ounce and over). Three ounce whole tubers, on the other hand gave the greatest number of usable culls and fewer ½-ounce tubers than the 2 ounce whole seed-piece. With such a high proportion of culls ranging in weight from 1 ounce to 2¾ ounces, the 3 ounce whole tuber may be accorded first position on a basis of one year's trial.

In view of the unfavourable conditions governing growth in 1929 it is not possible to compare conclusively the yields obtained. It is obvious, however, that further investigation of this phase will reveal some valuable information.

Table 127.—Size of Potato Seed-Piece 1929

(Green Mountain)

Size of set used	Number of marketable tubers*			Number of culls below 3 ounces*								
	3 ounces	3-12 ounces	Over 12 ounces	½ ounce	1 ounce	1¼ ounces	1½ ounces	1¾ ounces	2 ounces	2¼ ounces	2½ ounces	2¾ ounces
Whole set—												
3	26	209¾	0	131¾	51	85½	84¾	86¼	76¾	85¾	79¼	77½
2	18¾	179½	0	140¾	33¼	81½	72¾	77¼	64	77¼	67½	59¼
1½	21¾	198¾	0	129¾	41¾	68	79	72¾	74¾	76½	69¾	70¾
1	21¼	204½	0	82¾	27¼	59½	50	57¼	50¾	64½	51½	50¼
½	19¾	197¾	0	77	33	45¾	46	50	36	49¾	45¾	47¾
Cut set												
1½	26	191¼	0	103¾	32	51¾	66¼	56	48½	64½	73	59
1	20¼	213¾	¼	84¼	28	50	54½	50½	47	50	53¾	48¾
½	17	201	0	52	21¾	35¾	40	43¼	35½	42½	44	40½

*Average of 4 replications.

THE TOXICITY OF SEED POTATO DISINFECTANTS AS APPLIED TO THE VIABILITY OF RHIZOCTONIA SCLEROTIA

Investigational work in connection with seed treatment of potatoes has been confined largely to field experiments. While this procedure has its merits it would seem logical first to attack the problem in the laboratory and determine at the outset the degree of toxicity of the substance considered worthy to be used for disinfectants. Using corrosive sublimate, preliminary studies of this nature were reported in 1928,** when it was found that fungicidal effect ceased if the strength of the solution was reduced to 1-1250, which is 80 per cent of the recommended strength. During the past year a number of promising materials were submitted to similar tests. The following is a progress report only, since the work is not yet complete.

* Report of Dominion Botanist, 1927, pp. 199-203.

** Report of the Dominion Botanist for the year 1928.

Procedure.—The following list gives the preparations used. These were employed as dips and the proportions indicated were recommended by the manufacturers.

1. Improved Semesan Bel (1:20).
2. Cal. K (1:40).
3. Dipdust (1:20).
4. Sanoseed (1:50).
5. No. 664. (1:68).
6. 12-K (1:40).
7. E.M.S. (1:50).

Potatoes bearing rhizoctonia sclerotia were dipped in these solutions, (*a*) after presoaking 24 hours in water, (*b*) without presoaking. They were then dried at room temperature for three hours. At this stage half of the tubers were placed in moist chambers and from the remainder the sclerotia were removed with a sterile scalpel. In the first series of experiments these sclerotia were placed in sterilized Richards solution having the following composition:—

KNO_3	10·0 grams
KH_2PO_4	5·0 grams
$MgSO_4.7H_2O$	2·5 grams
Sucrose	50·0 grams
H_2O	1 litre

This method, however, while excellent for eliminating bacterial contaminations encouraged development and spread of Penicillium which apparently survived the process of disinfection. It was believed that the unavoidable agitation of the liquid medium was instrumental in scattering the Penicillium spores. This difficulty was overcome to a large extent by changing to a solid medium made up as follows:

Potato finely cut	250 grams
Dextrose	20 grams
Agar	17 grams
Distilled water	1 litre

The reaction was adjusted to pH 5·2.

Desiring to test the possibility that the effect of treatment is governed to a certain extent by the size of sclerotia, both small and large sclerotia were selected for culture plating. In diameter these were approximately ½ and 3 millimeters respectively.

Results.—It should be noted that the first series of laboratory tests were made with unusually soft sclerotia. Many had germinated. This was due, no doubt, to the fact that it was the month of June before the experiment was begun and it was impossible to obtain tubers with sclerotia unaffected by moisture and warmth. Such conditions, in addition to the contaminating influence of Penicillium referred to previously, rendered these preliminary tests of little value.

The figures tabulated in table 128 represent tests made with rhizoctonia infected tubers from the 1929 crop. Sclerotia were compact and appeared quite capable of surviving the winter in a viable condition. It would appear that by using the preparations indicated seed treatment was most effective when the sclerotia had been softened by presoaking.

TABLE 128.—VIABILITY OF RHIZOCTONIA SCLEROTIA TREATED WITH ORGANIC MERCURY COMPOUNDS USED AS DIPS

Disinfectant	Strength used	Percentage of viable sclerotia*			
		Presoaked 24 hours		Not presoaked	
		Large	Small	Large	Small
Improved Semesan Bel	1 : 20	10	0	21	0
Cal-K	1 : 40	3	0	2	0
Dipdust	1 : 20	8	0	18	0
Sanoseed	1 : 50	0	0	0	0
No. 664	1 : 68	0	0	0	0
12-K	1 : 40	0	0	0	0
E. M. S.	1 : 50	0	0	0	0
Check	No treatment	93	95	91	92

*Counts made 16 days after plating out.

Improved Semesan Bel used at a strength of 1:20 was lethal to small sclerotia while with large sclerotia it was 10 and 21 per cent efficient respectively for presoaked and not presoaked tubers. Dipdust compared favourably with Semesan Bel. It is natural to expect that an increase in the strength of these three compounds would make them more effective. Cal-K used at 1:40 seemed slightly better. Sanoseed, No. 664, 12-K and E.M.S. gave more promising results by apparently killing all of the sclerotia.

The foregoing data, while significant, must not be considered conclusive. In addition to developing a more dependable technique it is considered necessary to investigate the permanency of fungicidal effect; for the question naturally arises as to whether or not the destructive influence of the chemicals penetrates the entire sclerotial mass.

THE USE FOR SEED PURPOSES OF POTATOES PREVIOUSLY EXPOSED TO FREEZING TEMPERATURES

During the harvest and shipping seasons low temperatures make it difficult to handle potatoes without exposing them to frost injury, either in the field, in the bin, or in handling for transit. Frequently, because of frost, certified seed of excellent quality is disqualified at the shipping point or in the bin and the farmer naturally inquires into the possibilities for seed purposes of such stock. In case of severe freezing the potatoes rapidly disintigrate and are rendered unfit for ordinary use. With a view to determining the value, for seed purposes, of potato tubers affected by frost, experiments were conducted in 1928 and 1929 which gave some information of value. In addition, photographs have been obtained illustrating the various types of frost injury.

Authorities agree that the freezing point of potatoes is lower than the freezing point of water. In 1880 Müller-Thurgau,* who worked with different plants, found that potatoes froze at 30.21° F. By using the thermoelectric method of determining temperatures Wright and Harvey† found that early and midseason varieties have a higher freezing point than late varieties. It would seem reasonable to expect, therefore, that tubers should maintain excellent viability even when exposed to temperatures slightly above their normal freezing point.

EXPERIMENTAL PLAN.—During the winter of 1927 and 1928 Green Mountains and Irish Cobblers were exposed to chilling temperatures for different periods. In March the tubers were exposed on their sides in one layer in an open-top box on the north side of the laboratory at 3 p.m. It was not difficult

* Müller-Thurgau, Herman. Ueber das Gefrieren und Erfrieren der Pflanzen. In Landw. Jahrb. Bd. 9, p. 133-139, pl. 1-4, 1880.

† Wright, R. C., and Harvey, R. B. The Freezing Point of Potatoes as Determined by the Thermoelectric method. U.S.D.A. Bul. 895, 1921.

to obtain constant temperatures for the time periods represented in the tables. Longer exposures were not possible because of the temperature fluctuations occurring with the time of day. The box was equipped with a $\frac{1}{4}$ inch mesh wire bottom. After the time limit of each exposure the tubers were jarred by tossing them into a box to promote any freezing about to occur.‡ Such tubers were used for seed in a field test along with checks planted with sets from tubers which had been stored under normal conditions. Immediately before planting notes were taken on the degree of sprouting that occurred in the frost injured tubers. During the growing season observations were made on the plant developments and yields were calculated when the crop was harvested.

Results.—It will be seen by referring to table 129 that the lowest yields were obtained from tubers exposed for 65 minutes at a temperature of 26° F. Frost injury was apparent in this instance, a belief given further support by the fact that these tubers not only developed weak sprouts but also gave a poor stand of plants in the field (table 130).

Table 129—Frost Experiment, 1928

Exposure	Irish Cobblers				Green Mountains			
		Temperature	Yields per acre			Temperature	Yields per acre	
			Marketable	Culls			Marketable	Culls
		°F.	bush.	bush.		°F.	bush.	bush.
15 min.		26	298·0	68·1		26	304·6	121·4
20 "		26	265·6	120·4		26	290·5	115·4
35 "		26	288·3	101·3		26	296·5	107·6
45 "		26	261·8	106·4		26	302·4	95·8
65 "		26	201·6	76·1		26	219·6	101·3
	Check		239·5	89·4	Check		251·6	76·4
90 "		26	212·8	82·7		26	226·7	94·1
45 "		30	248·5	48·7		30	260·0	102·3
60 "		30	251·5	63·1		30	250·0	98·6
90 "		30	246·7	70·2		30	260·5	103·4
60 "		32	250·7	120·0		32	308·2	121·2
	Check		247·7	76·2	Check		261·2	84·3
75 "		32	256·0	74·1		32	310·0	106·5
105 "		32	268·0	101·0		32	273·7	98·4
20 "		29	251·2	64·1		29	260·0	96·4
35 "		29	282·2	91·0		29	274·6	87·3

Table 130.—Frost Experiment 1928, Germination and Stand

Exposure	—	Temperature	Condition of sprouts at seeding date		Percentage stand	
			Irish Cobbler	Green Mountain	Irish Cobbler	Green Mountain
		°F.				
15 min.		26	Good	Good	99	98
20 "		26	Good	Good	100	99
35 "		26	Fair	Fair	100	100
45 "		26	Fair	Fair	96	99
65 "		26	Poor	Poor	90 weak plants	81 weak plants
	Check		Good	Good	98	94
90 "		26	Good	Good	100	99
45 "		30	Good	Good	100	100
60 "		30	Good	Good	100	99
90 "		30	Good	Good	98	99
60 "		32	Good	Good	100	100
	Check		Good	Good	96	100
75 "		32	Good	Good	97	99
105 "		32	Good	Good	100	98
20 "		29	Good	Good	99	100
35 "		29	Good	Good	100	100

‡ Wright, R. C. and Taylor, G. F. Freezing injury to potatoes when undercooled. U.S.D.A. Bul. 916, 15 p. 1921.

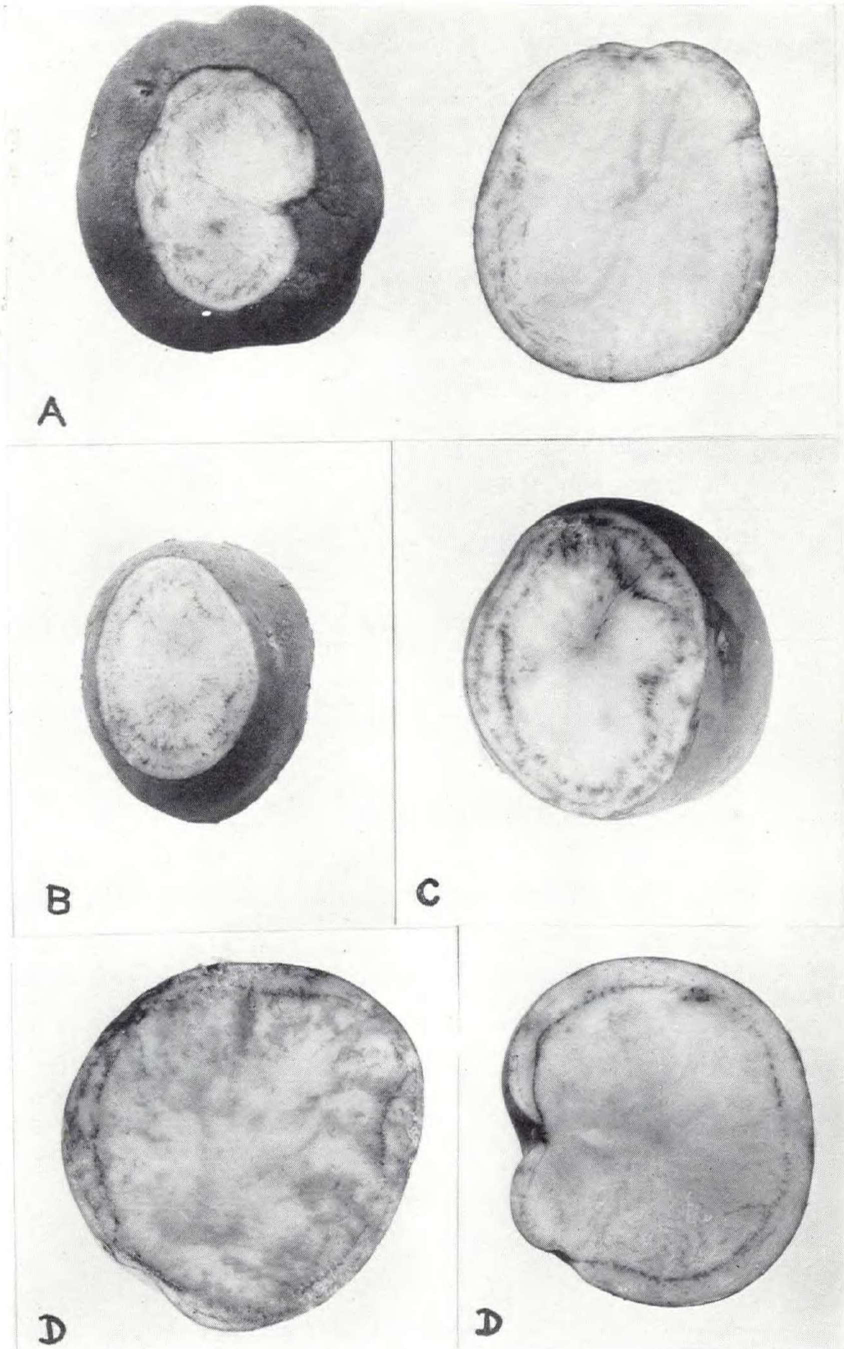


FIG. 58.—Frost injury to potatoes. A. Right, ring necrosis; left, same tuber sliced near surface. B. Net necrosis. C. Net necrosis, blotching and ring necrosis. D. Blotching; advanced ring necrosis.

It is evident that the tubers were injured when exposed for 90 minutes at a temperature of 26° F. (table 129), although by consulting table 130, it may be seen that the sprouts and stand were normal.

Under the conditions obtained it is evident that for short exposures, temperatures ranging from 29° to 32° F. have no harmful effect.

Types of Frost Injury

The foregoing investigations made it possible to observe the manner in which potato tubers were effected by frost. Inasmuch as there exists confusion as to the typical indications of frost injury, a brief reference to the subject seems appropriate.

While it is difficult to classify frost injuries produced, because of the merging of types, nevertheless, by carefully recording the observations it was shown that frost injury may be grouped under four general headings as follows:—

1. *Ring Necrosis.*—When tubers are exposed to frost for very short periods a faint ring appears. This may be associated with slight netting as illustrated in fig. 58*a*. This condition was pronounced when potatoes were exposed for 15 minutes at 14° F.

2. *Net Necrosis.*—This type of freezing injury occurred when tubers were exposed for 30 minutes at 14° F. Indications of the netting are seen in fig. 58*a*, and it is more clearly defined in figs. 58*b* and 58*c* .

3. *Blotching.*—Severe chilling produces the blotching shown in fig. 58*c*, the result of an exposure of 30 minutes at 12° F. This also illustrates ring necrosis. The type of blotching shown in fig. 58*d* was the result of an exposure for 2½ hours at 14° F. Ring and net necrosis are also clearly defined.

4. *Leaky Stage.*—This stage follows actual freezing. Upon cutting, such tubers seem to be normal in appearance but close examination shows them to be " waxy ". After exposure for a few hours at 70° F. the cut surfaces become brick red and later, black. When potatoes are injured in this manner they will become wet when the frost comes out. This gives rise to the wet potato sacks which are so common when shipments are made during cold weather.

BROWN-HEART OF TURNIPS

In the late growing season of 1928, there appeared in Prince Edward Island a turnip disorder which caused considerable financial loss to the farmers throughout the province. It was responsible for the disqualification of many car loads of apparently sound turnips and in the spring of 1929 it was a common sight to see fields of affected turnips which had been abandoned as useless in 1928. Likewise, many thousands of bushels of similarly affected turnips were thrown away in the spring.

Symptoms.—Brown-heart is detected by cutting into the turnip. In the field there is no outward indication of the disorder. Affected turnips seem sound and their growing tops present a normal appearance. Persons accustomed to handling turnips will detect light-weight specimens, and, while it is not an invariable rule, when sliced open these show the advanced stages of brown-heart. Symptoms are indicated by a definite brownish mottled area involving approximately two-thirds of the parenchyma (fig. 59). This occurs with great regularity in the lower half of the turnip. In other words, the part above ground is least affected. The point is illustrated in fig. 61 which shows one-half of a turnip cut in two from top to bottom. Note also the mottling. In advanced stages the definite brownish character is less evident and mottling practically disappears leaving a greyish-brown, dry punky mass in which cracks appear (fig. 60). It is at this stage that turnips are noticeably light in weight. Cooking renders affected turnips distinctly woody.

Cause.—There is no evidence that the condition known as brown-heart is caused by a parasite.

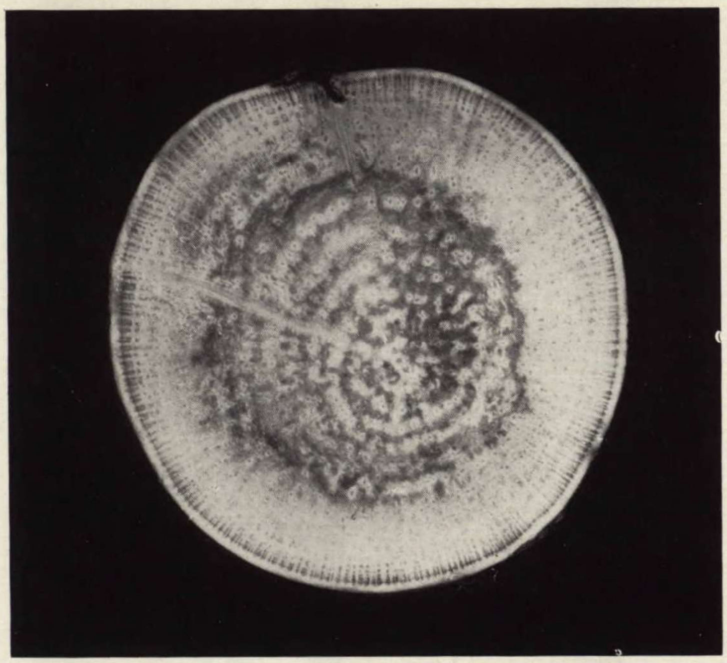


FIG. 59.—Brown-heart of turnips (note mottling).

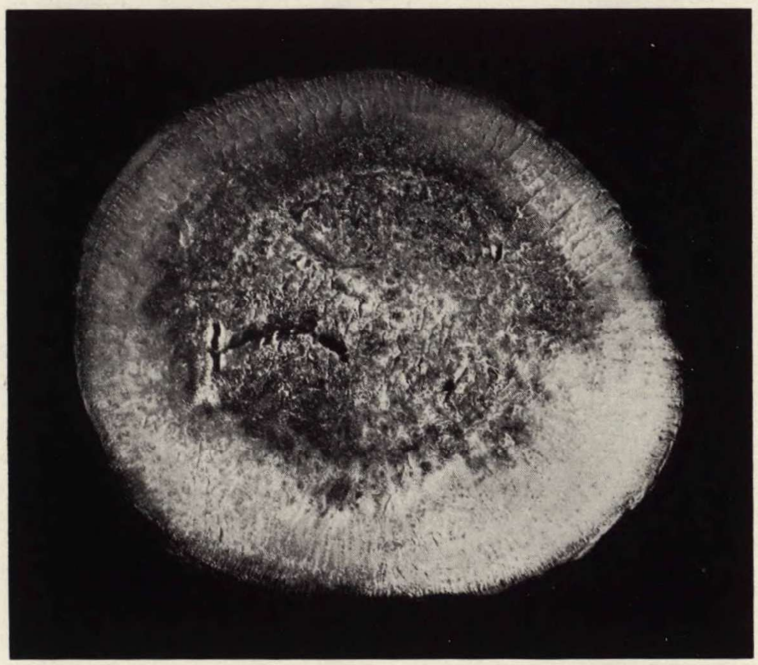


FIG. 60.—Brown heart of turnips showing advanced stage (note cracks).

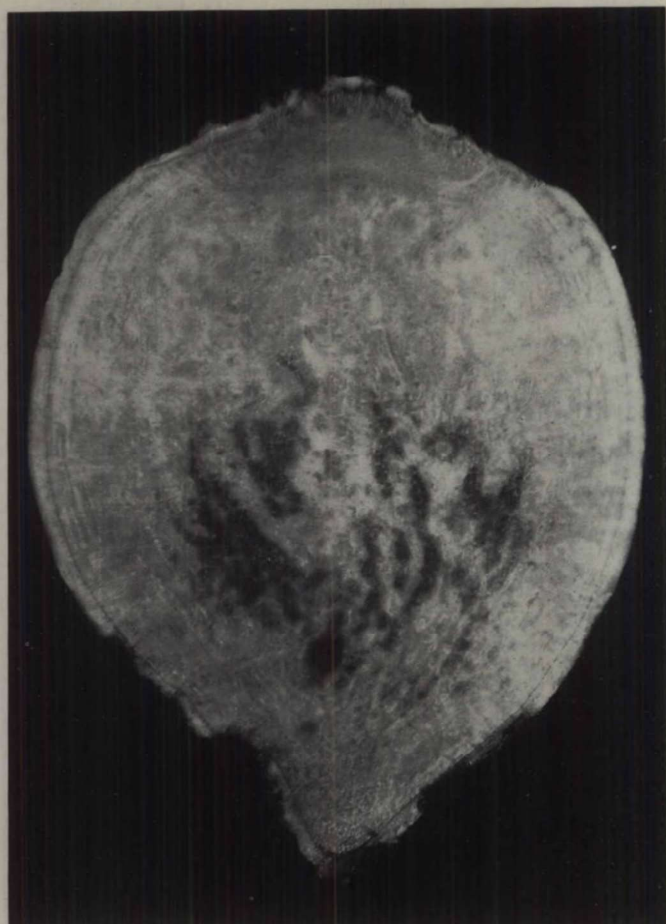


FIG. 61.—Longitudinal section through a turnip illustrating the manner in which brown-heart develops in the lower half or the part beneath the soil.

It is apparently a physiological condition induced by physical factors involving soil conditions.

INVESTIGATIONAL WORK.—When it was known that turnips were thus affected, a set of inquiries in the form of a questionnaire was sent to a number of turnip growers throughout the province. In this connection information was solicited as follows:—

VARIETY OR VARIETIES GROWN.

DATE OF SEEDING (Approximate).

DATE OF HARVESTING (Approximate)

SOIL CONDITIONS.—(1) Type of Soil.
(2) Drainage.
(3) Cultivation.

FERTILIZERS USED.—(1) Kind.
(2) Rates of Application.

MANURE USED.—(1) Rates of Application.

ROTATION PRACTISED.

PERCENTAGE OF TURNIPS SHOWING THIS TROUBLE.

PLEASE GIVE ANY FURTHER DETAILS CONNECTED WITH THE CULTURE OF YOUR TURNIP CROP.

Table 131 summarizes the information received from this source.

TABLE 131.—SUMMARY OF REPLIES TO QUESTIONNAIRE DEALING WITH BROWN-HEART OF TURNIPS

Questionnaire No.	Variety	Seeding date	Harvest date	Soil conditions: Soil type	Soil conditions: Drainage	Soil conditions: Cultivation	Fertilizer applications: Nitrate soda	Fertilizer applications: Sulphate ammonia	Fertilizer applications: Superphosphate	Fertilizer applications: Muriate potash	Fertilizer applications: Barnyard manure per acre	Rotation	Per cent disease
							lb.	lb.	lb.	lb.	tons		
1	Hazard's Improved......	June 1	Dec. 1	Sandy loam	Good......	Fall ploughed, scuffled, hoed.	200	200	600	200	10	Potatoes, wheat, clover.	75
2	" "	" 10	Nov. 1	"	"	" "	0	200	800	200	0	" "	75
3	" "	" 5	" 1	"	"	Spring ploughed, scuffled, hoed.	0	0	0	0	12	" "	5
4	" "	" 1	Oct. 1	"	"	Fall ploughed, scuffled, hoed.	0	0	500	0	7	Grain, hay, potatoes	0
5	Hazard's Improved and Millpond.	" 15	Nov. 1	Clay loam..	"	Fall ploughed, harrowed, hoed.	0	0	0	0	13	Hay, roots, pasture, grain.	0
6	" "	" 20	" 8	"	"	" "	200	400	600	300	0	Grain, hay, pasture	Trace
7	Millond..................	May 28	Oct. 15	"	"	" "	0	0	600	100	9	Oats, hay, pasture.	0
							200 pounds limestone						
8	Hazard's Improved......	June 12	Nov. 1	Sandy loam	"	" "	200	400	600	300	12	Potatoes, wheat, clover.	0
9	Magnum Bonum..........	" 18	Oct. 20	"	"	" "	0	200	800	250	0	Pasture, hay, grain, potatoes.	0
10	Millpond................	" 1	Sept. 25	"	Poor........								
	Hazard's Improved............	" 20	Oct. 30	....		" "	170	200	1,000	300	0	Potatoes, grain, hay	50
							(Both varieties affected)						
11	Bangholm................	" 1	" 15	Clay loam..	Poor........	" "	0	200	400	200	0	Potatoes, grain, hay	....
12	Hazard's Improved......	" 20	" 15	Sandy loam	"	" "	0	200	1,000	200	0	Potatoes, grain, clover.	80
13	Bangholm...............	" 10	" 15	"	"	" "	0	200	700	200	0	" "	50
14	Bangholm...............											Hay...............	98
	Hazard's Improved.....	" 25	Nov. 1	Clay loam..	"	" "	0	0	800	80	0	Pasture............	30
	Millpond................											Grain..............	50

In analysing the answers it would be impossible to establish dependable criteria as a basis for recommendations as to control methods. It is obvious that the disorder occurs regardless of the presence or absence of chemical fertilizers and barnyard manure, as indicated by the fact that turnips were affected to the extent of 75 per cent where chemical fertilizers were applied both with and without manure (Questionnaires 1 and 2, table 131).

Similarly, there seem to be no varietal tendencies, inasmuch as all three varieties (Hazards Improved, Millpond, Bangholm), were affected (Questionnaire 14, table 131).

Experimental Work.—Through the kind co-operation of Schaad Brothers at York, P.E.I., an experiment was conducted in 1929, for the purpose of securing dependable preliminary evidence of any relationship which might exist between brown-heart and the amount of plant food applied in the form of chemicals and barnyard manure, with and without lime, according to the following plan:—

Manure, Lime, and Fertilizer Experiment with Turnips

A. Using no manure with fertilizers and lime:—
- 1 ton ground limestone.. .. .. per acre
- 100 pounds nitrate of soda.. .. .. " "
- 400 pounds acid phosphate.. .. .. " "
- 40 pounds muriate of potash.. .. .. " "

B. Using manure with lime and fertilizers:—
- 10 tons manure.. .. .. per acre
- 1 ton ground limestone.. .. .. " "
- 100 pounds nitrate of soda.. .. .. " "
- 400 pounds acid phosphate.. .. .. " "
- 40 pounds muriate of potash.. .. .. " "

C. Using manure only:—
- 10 tons manure.. .. .. per acre

D. Using manure, fertilizers and no lime:—
- 10 tons manure.. .. .. per acre
- 75 pounds sulphate of ammonia.. .. .. " "
- 400 pounds acid phosphate.. .. .. " "
- 40 pounds muriate of potash.. .. .. " "

E. Using twice the quantity of manure with fertilizer and no lime:—
- 20 tons manure.. .. .. per acre
- 400 pounds acid phosphate.. .. .. " "
- 40 pounds muriate of potash.. .. .. " "

The field given over to this experiment had been under hay for several years and was pastured in 1928. In November the same year the sod was ploughed five to six inches deep. A heavy application of mussel mud was made 15 years previously. In the spring of 1929 the field was worked up several times with the spring toothed harrow. The third week in June plot A received an application of one ton of limestone which was worked in with the harrow. The last week in June plots A and B received 400 pounds acid phosphate and 40 pounds muriate of potash. These were worked in with the harrow. The manure was then applied and worked in with the hiller. Seeding was done on the first and second days of July. July 6 the fertilizers for plots D and E were applied and hoed in. Nitrate of soda was applied to plots A and B when the turnips were thinned. Two varieties were used namely, Hazards Improved and Millpond.

Results.—Growth was normal throughout the season and as was expected plot E with the 20 tons of manure showed the biggest tops, and where no manure was applied the tops were small.

When the turnips were well formed samples were taken from each plot. It was found that brown-heart occurred in plot A which had received the lime. There was no indication of the disorder in any of the other plots at that time. However, later observations showed that affected turnips were not only confined to one section of plot A but were abundant within a well-defined area, throughout the entire field and including a section of each plot. It is significant that the greatest number of affected turnips were found in plot A, which had received an application of limestone.

It was not possible to detect any varietal tendencies. Both varieties used were affected equally.

CONCLUSIONS.—The foregoing evidence supports the belief that soil factors largely govern the occurrence of brown-heart of turnips. While the available data are not convincing it would appear that lime and manure play an important part. Successful investigational work is contingent upon a knowledge of soil reactions, a phase which is receiving careful attention.

POTATO INSPECTION AND CERTIFICATION SERVICE

(John Tucker, Chief Inspector, Central Experimental Farm, Ottawa)

PROGRESS

Notwithstanding a reduction in the acreage of potatoes entered for inspection in 1929 as compared with 1928, the results of the year's operations, from the standpoint of crop value and the market demand for certified seed, were most satisfactory.

The number of applications for field inspection was 6,285. The number of fields listed was 8,841, for a total of 32,030 acres. All the fields which passed the first inspection received a second inspection, and a third inspection was made where considered necessary in the interest of the work.

A total of 24,307 acres passed all field inspections, or approximately 75·9 per cent of the total acreage offered for inspection. These results are considered very satisfactory, especially as the growing season was very dry over a large area of the Dominion.

PRODUCTION

Approximately 4,000,000 bushels of certified potatoes were produced in Canada in 1929. The demand for seed was exceptionally good but the supply was found ample to fill the demands of the trade, at reasonable prices.

Official tags were issued for 1,500,000 bushels of certified seed potatoes in 1929. Of these 300,000 bushels were for spring shipments from the 1928 crop, and 1,200,000 bushels were for fall shipments from the 1929 crop. The fall shipments were mostly for the export trade.

Less table stock was produced in 1929 than in the previous year, consequently the demand more nearly equalled the supply, and much better prices were in evidence. The higher value of table potatoes favourably influenced the seed prices, and the growers generally were better satisfied with the crop returns for 1929 than for the previous year when overproduction resulted in low prices for table potatoes and also adversely affected the seed prices.

As a result of the drought, the potato crop was practically a failure in the Prairie Provinces in 1929. Fields planted with certified seed gave better yields than the general run of seed and in consequence the Prairie growers are larger purchasers of Certified Seed than ever before. It is more evident each year that better yields of good quality potatoes can be obtained by planting Certified Seed, and the per bushel cost of producing potatoes is thereby materially reduced.

POTATO EXPORTS AND IMPORTS, 1929

The exports of potatoes from Canada in 1929 amounted to 7,145,246 bushels, valued at $6,227,948. The principal markets were the United States, Cuba, Panama, Newfoundland, British Guiana, Trinidad, Bermuda and Jamaica.

The total imports of potatoes into Canada in 1929 amounted to 1,189,200 bushels valued at $1,173,953, all from the United States. (From "Trade of Canada 1929." Published by the Department of Trade and Commerce.)

Included in the export figures are Certified Seed shipments to foreign countries, amounting to over 1,250,000 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 but the trade in Certified Seed is increasing very rapidly. (Special health certificates, issued by the potato certification staff, are required by the Cuban Government covering all importations of potatoes into Cuba.)

Several test shipments of Certified Seed potatoes were sent to Buenos Aires, South America, by the Markets Division of the Fruit Branch. The shipments were assembled at St. John, N.B., Montreal, Que., and Vancouver, B.C., the certification staff co-operating in locating and assembling some of the shipments. The crops obtained from the use of Canadian Certified Seed, by growers in the south, were most satisfactory, and these growers appear anxious to procure much larger quantities in 1930. The purity of varieties, vigour and the freedom from disease were apparently surprising to the South Americans who planted Canadian Certified Seed for the first time.

Canadian seed continues to give remarkably good results in the many potato areas in the United States to which large shipments have been sent.

INSPECTION STANDARDS, 1929

No change was made in the inspection standards in 1929 except to provide a small additional tolerance of 10 per cent for slight common scab and rhizoctonia in the tuber standard. It was evident at harvest time that seasonal conditions warranted this consideration which was provided as an emergency measure only, and it will not apply to succeeding crops unless considered absolutely necessary in the interest of the industry.

SUMMARIES OF FIELD INSPECTION WORK, 1929

Included in the two following tables (132 and 133) are summaries of the distribution and results of the work by provinces, and the average percentage of the principal diseases found in the fields inspected, passed, and rejected.

TABLE 132.—SUMMARY OF THE FIELD INSPECTION WORK BY PROVINCES—1929

Province	Number of applicants	Number of fields entered	Number of fields passed	Percentage	Total acres entered	Acres passed	Percentage
				%			%
Prince Edward Island	3,668	4,935	3,823	77·5	22,641	18,257	80·6
Nova Scotia	236	365	273	74·8	535	405	75·7
New Brunswick	325	651	392	60·2	2,850	1,665	58·4
Quebec	1,287	1,640	903	55·1	3,091	1,682	54·4
Ontario	416	536	431	80·4	1,739	1,405	80·8
Manitoba	33	73	71	97·3	256	254	99·2
Saskatchewan	103	166	140	84·3	331	226	68·3
Alberta	68	122	106	86·9	185	124	67·0
British Columbia	149	353	257	72·8	402	289	71·9
Total (Canada)	6,285	8,841	6,396	72·3	32,030	24,307	75·9

TABLE 133—PERCENTAGE OF DISEASE FOUND, BY PROVINCES

—	Prince Edward Island	Nova Scotia	New Bruns-wick	Quebec	Ontario	Mani-toba	Sas-kat-chewan	Alberta	British Colum-bia
	%	%	%	%	%	%	%	%	%
Average percentage of disease in total fields inspected—									
Blackleg	0·15	0·06	0·2	0·36	0·4	0·32	0·45	0·1	0·18
Leaf roll	0·01	0·3	0·1	0·17	0·33	0·06	0·14	0·11	0·02
Mosaic	0·59	0·5	2·1	1·82	0·15	0·05	0·3	0·06	1·27
Average percentage of disease in fields passed—									
Blackleg	0·08	0·07	0·1	0·16	0·28	0·25	0·14	0·01	0·03
Leaf roll	0·01	0·2	0·07	0·07	0·18	0·06	0·04	0·11	0·01
Mosaic	0·06	0·17	0·3	0·48	0·01	0	0·01	0·07	0·29
Average percentage of disease in fields rejected—									
Blackleg	0·39	0·04	0·3	0·6	1·3	2·6	2·61	0·55	0·49
Leaf roll	0·02	0·5	0·3	0·28	0·93	0·0	0·31	0·15	0·05
Mosaic	2·42	1·48	4·8	3·6	0·59	1·6	0·88	0·04	3·35

FIELD INSPECTIONS BY VARIETIES, 1929

It is evident from the number of inquiries received concerning the acreages of the different varieties of potatoes grown for certification that the following tabular (table 134) and graphical summaries (fig. 62), which illustrate this information in a concise way, should be of general interest.

The Irish Cobbler variety takes the lead in acreage grown for certification, by a wide margin, the next in importance being the Green Mountain variety. Most of the area planted of both of these varieties was in Prince Edward Island.

Ontario produced the next largest acreage of the Irish Cobbler variety, and Quebec of the Green Mountain variety. New Brunswick also had a large acreage of Green Mountains and lead in the production of Bliss Triumphs.

The Dooley variety was grown exclusively in Ontario. This variety is rapidly increasing in favour with the Ontario growers, and is largely replacing the Green Mountain variety as a late potato. It appears to be well adapted to Ontario growing conditions.

The Spaulding Rose variety was grown mostly in Prince Edward Island and is on the increase there. Several other varieties were grown in small lots, principally in the Western provinces.

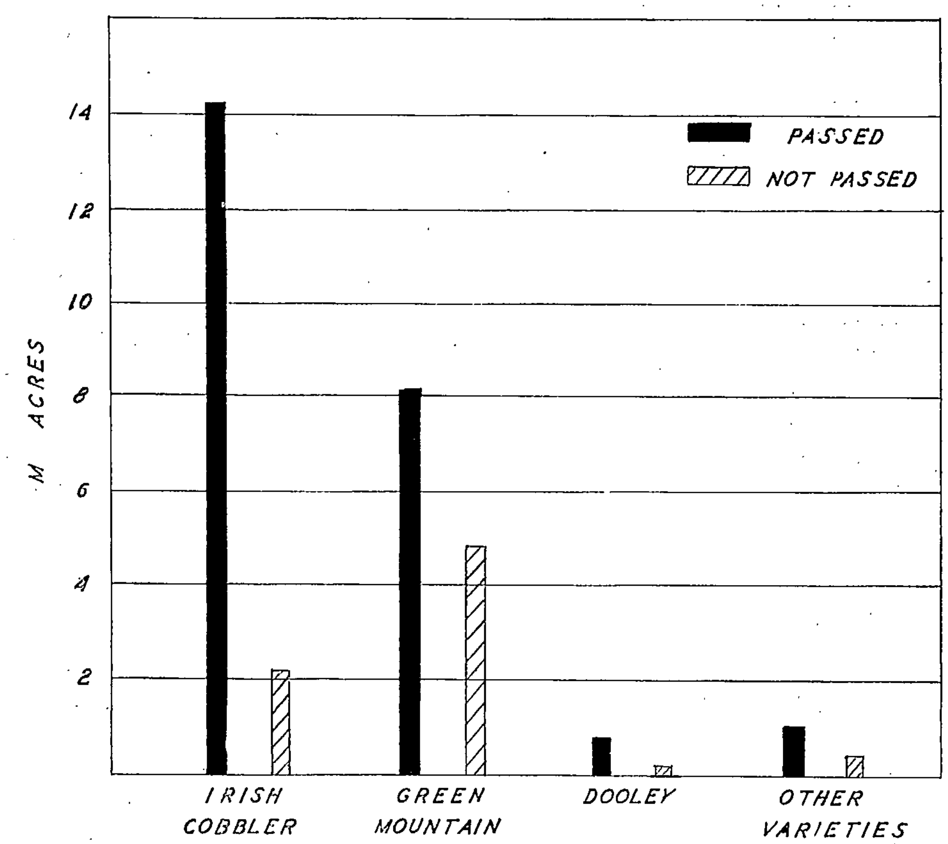
TABLE 134.—ACREAGES ENTERED FOR CERTIFICATION, AND ACREAGES PASSED

Variety	Acres entered	Acres passed	Percentage
			%
Irish Cobbler	16,506	14,268	86·4
Green Mountain	12,929	8,093	62·6
Dooley	1,044	876	83·9
Bliss Triumph	311	158	50·8
Spaulding Rose	193	179	92·7
Other varieties	1,047	733	70·0
Total	32,030	24,307	75·9

COMMENTS ON REJECTIONS

It is evident from a study of the following table (135) and graph (fig. 63) that it is not such an easy matter to produce certified seed potatoes as it might appear to the uninformed. Every year numbers of growers entering their fields for inspection for the first time, express surprise when their crops are rejected for certification. The impression they apparently held, that crops from certified seed are certain to pass field inspections, is unfortunately, not true. Diseases are continually making inroads into the crop, and unless carefully controlled throughout the growing season, will develop to an extent greater than that allowed in the standard for certification.

ACRES — PASSED AND NOT PASSED
BY VARIETIES



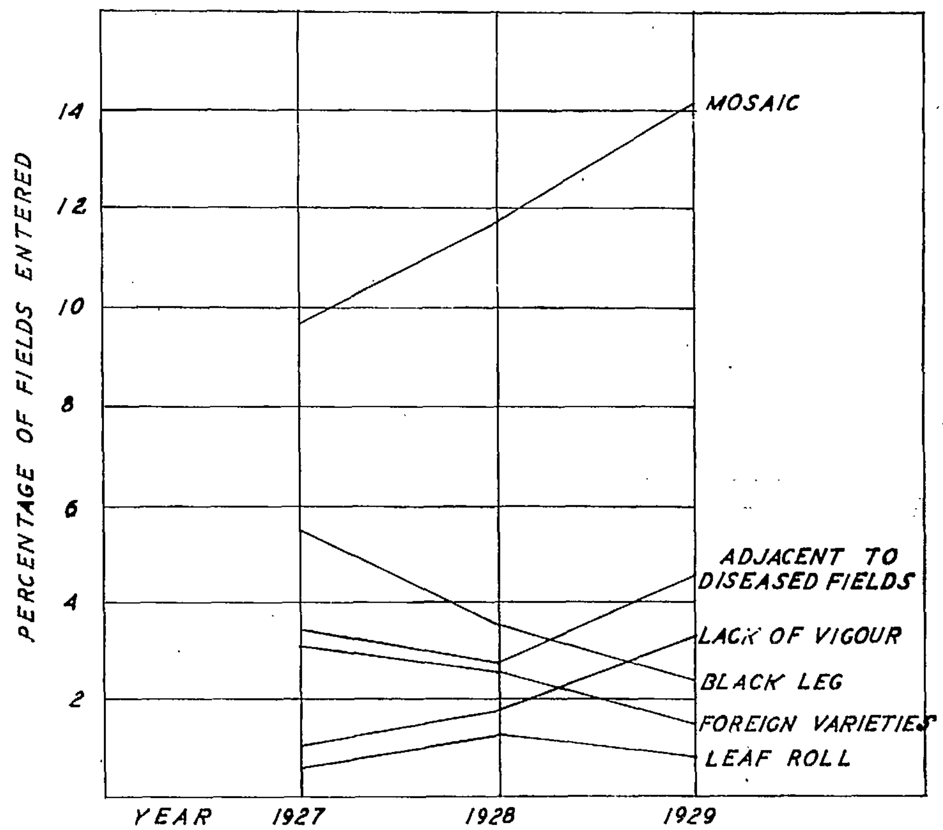
Considerable credit is due all those growers who have, by consistently roguing their plots for disease, practicing the best cultural methods, spraying or dusting for fungus and insect pests, produced seed potatoes sufficiently vigorous and free from serious diseases to warrant the official tag being placed on their product.

A total of 2,445 fields were rejected for various reasons as specified in the table. This represents 27.7 per cent of the fields entered for inspection, fields that were all planted with good seed but which at the end of the growing season did not conform to as high a standard as the field from which the seed originated. The need for continuing the certification work is evident if for no other reason than to hold to the minimum the inroad that diseases are making in the potato crop, and against which the certification work appears the most logical control measure possible for large scale operations.

Mosaic was directly responsible for 50.9 per cent of the total rejections. The graph shows the trend of this disease is toward more serious proportions. The disease is found to be most prevalent in the Green Mountain and Bliss Triumph varieties.

Leaf roll is fortunately on the down trend in every province and it is remarkable how much less this trouble is in evidence than than it was a few years ago, when it threatened potato production in many areas. In these areas the yields were very low, and leaf roll was found to be the principal cause. Certification work has been given due credit by many competent observers for reducing the amount of this trouble in potatoes.

FIELD REJECTIONS 1927–1929
GRAPH OF CAUSES



No less than 379 fields were rejected on account of being adjacent to diseases, that is to say, planted within 200 feet of potato fields having a high disease content. The danger of the spread of diseases by insect carriers has been well emphasized by the inspection service, and a large percentage of these rejections are due to carelessness in not observing the rule in this regard. In some instances it was found, however, that the seed grower had unwittingly planted his seed near a neighbour's table potatoes which contained much disease.

Black Leg was responsible for the rejection of 208 fields. This shows a considerable reduction from the previous year but might have been reduced still more if seed had been treated, and more careful roguing done in the field (as recommended in Pamphlet 105, New Series).

TABLE 136—NUMBER OF FIELDS REJECTED FOR CERTIFICATION IN 1929 WITH REASONS

Reason for rejection	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Totals	Percentage of total rejections
					*						%
Mosaic	512	20	208	441	14	......	5	......	45	1,245	50·9
Blackleg	88	1	16	36	48	1	11	3	4	208	8·5
Leaf roll	1	14	......	23	23	......	3	1	2	67	2·7
Foreign	62	6	7	35	4	......	3	2	12	131	5·4
Adjacent to disease	124	33	13	178	9	1	2	1	18	379	15·5
Lack of vigour	259	......	10	4	......	......	1	9	5	288	11·8
Poor cultivation and insect injury	27	15	1	9	4	......	1	......	......	57	2·3
Miscellaneous	39	3	4	11	3	......	......	......	10	70	2·9
Total rejections—Fields	1,112	92	259	737	105	2	26	16	96	2,445	100
Acres	4,384	130	1,185	1,409	334	2	105	61	113	7,723	

* Miscellaneous:— Rejections for causes not specified elsewhere i.e. Streak, Wilts, Late Blight.

FIG. 64.—A potato exhibit provides an opportunity for farmers to secure information on disease control, also desirable varieties and types to select for seed purposes.

OTHER ACTIVITIES OF THE SERVICE

In addition to the two inspections on the growing crop in the field, the tuber inspections on the harvested crop in storages, cellars, etc., and the final inspections on the graded crop at shipping points, there were several other activities undertaken by the inspectors as follows:

Planting of Demonstration plots in each province for the study of potato diseases, certified seed variety and strain tests, seed treatment demonstration, etc. (These plots were used principally for training new inspectors, but they also afford an excellent opportunity for potato growers to become acquainted with the diseases of the crop and to secure other useful information.)

Field days and potato tours for potato growers: These were mostly organized by the provincial officials of the Department of Agriculture and the local inspectors were requested to attend to point out the various diseases present in the fields, and to recommend control measures.

Junior Farmers' and Boys' Clubs plots: The inspectors co-operated as far as possible in judging and in recording the diseases on these plots. Over 300 such plots were inspected and judged by the seed potato inspectors in 1929.

The permanent inspectors were in demand in every province, at all special potato meetings. These requests were complied with in the interest of crop improvement work. (The chief inspector attended over forty such meetings during the year). Other activities included the judging of many of the standing field crop competitions, judging at fall fairs, and preparing and setting up exhibits at fairs (fig. 64).

The permanent inspectors were responsible for the issuing of health certificates for practically all seed and table potatoes for export. Many thousands of these certificates are required every year.

Summaries of Inspectors' Annual Reports

The following summaries of the annual reports submitted to headquarters by the senior and district inspectors in charge of the work in their respective districts, give a good outline of the work in general as carried on in each province.

PRINCE EDWARD ISLAND—S. G. Peppin, Senior Inspector, Laboratory of Plant Pathology, Charlottetown, P.E.I.

Plantings of certified seed potatoes were much reduced this year, due largely to the unsatisfactory prices obtained last year. The acreage planted to Irish Cobblers was reduced from 22,986 acres in 1928 to 14,626 in 1929, Green Mountains from 8,848 acres to 7,787 acres, and the number of applications for inspection from 4,629 to 3,668. The average acreage under inspection per grower in 1929 was 6 acres.

The growing season was similar to that experienced in 1921, drought continuing until late August. Early varieties suffered considerably except on good land. Very early and late plantings gave poorer returns than those from the plantings on the average date, namely June 1. Many factors, however, influenced the vine growth, i.e., date of planting, type of soil, amount of fertilizer, too close or too much cultivation during heat of day, etc.

Early and late blights, and black leg, were much less severe this year than last, while other field diseases occurred to about the same extent and intensity. Most growers sprayed with Bordeaux mixture, but less frequently than usual. Some burning of the vines resulted from spraying during the heat of day. In one case where the grower did not spray at all, 25 per cent of late blight rot developed in his crop in the fall.

Crop yields from Certified Seed varied from 100 to 450 bushels per acre. Irish Cobblers averaged 175 bushels, Green Mountains, 250 bushels, Spaulding Rose, 300 bushels per acre. About 60 per cent of the crops would grade Extra No. 1, certified.

Fall shipments of Certified Seed potatoes have been extremely heavy, aggregating well over one million bushels. These were shipped in twenty-four steamers, during a period of three months, making altogether the largest quantity of Certified Seed ever exported during the fall season. Priees were good, varying from $1 to $1.75 per bushel all season. Quality on the whole was very good.

The senior inspector received numerous calls for lectures or addresses at field gatherings, as well as at speeially arranged meetings in eo-operation with the Potato Growers' Assoeiation and the Provincial Department of Agrieulture.

NOVA SCOTIA—W. K. MeCulloch, Distriet Inspeetor, Laboratory of Plant Pathology, Kentville, N.S.

The acreage inspeeted in 1929 was 17 per eent less than the record one of 1928. Most probably this reduetion was due to the failure of the new growers of 1928 to get into the ehannels of trade in Certified Seed Potatoes.

The quality of the crop was high compared with that of previous years. In 1929, 75·7 per eent of the aereage entered, passed for eertifieation. Only ·3 per eent of the fields were rejeeted for Blaek Leg and 9·3 per eent for Virus diseases.

A very dry summer resulted in a light erop of early potatoes, but the heavy showers in September saved the late potatoes which yielded large erops. The Garnet Chili variety yielded from 275 to 385 bushels per acre, and the Green Mountain from 350 to 374.

Common Seab was a source of mueh trouble. Late Blight Rot was moderate to severe in erops where spraying had been only partially done. Well sprayed crops were praetieally free from Late Blight Rot.

Shipping inspeetions were made on 3,000 bushels of Green Mountain, 1,400 bushels of Irish Cobbler and 1,100 bushels of Bliss Triumph during the spring, from the 1928 erop. The Green Mountains were exported to Maine, U.S.A., for use as foundation stock.

Frequent shipping inspeetions were required during Oetober and November. A total of 5,000 bushels of Certified Bliss Triumph Seed Potatoes was shipped to Cuba, and 16,000 bushels of Garnet Chili to Bermuda. The latter quantity eonstitutes only two-thirds of what has been Bermuda's normal requirement in the way of seed, but having experieneed extremely adverse eonditions during the last two seasons, in the marketing of their erops the importers were reluctant to invest heavily in the higher-prieed seed of this season.

Last year the surplus of Garnet Chili was shipped to Cuba. Exeellent reports were obtained of the behaviour of the seed during the growing season but the yield was disappointing. This may diseourage further importations of this variety for seed purposes. Part of this same seed, planted in Clifton, N.S., gave as high as 385 bushels per aere. We hope for better results from the Bliss Triumph variety, for the Cuban trade.

In addition to the regular inspeetion work, the Inspeetors judged the fields of 60 growers in the Potato Crop Competition and 51 plots of the Junior Potato Clubs. Investigational work was continued at the Kentville Experimental Station.

NEW BRUNSWICK—C. H. Godwin, Distriet Inspector, Laboratory of Plant Pathology, Frederieton, N.B.

Out of 2,850 acres of potatoes inspeeted, a total of 1,665 aeres passed inspeetion. The rejection of 1,185 aeres was ehiefly due to Mosaie. Apparently blaekleg and leafroll are being redueed to some extent as less fields are rejected on that aceount than was formerly the case. Approximately 461,940 bushels of seed potatoes were inspected in the bins. Little difference was observed in the amount of tuber diseases over that of last year.

In spite of the dry season, the average yield for Certified Seed of all varieties was 277 bushels per acre. The Green Mountain variety gave an average yield of 289 bushels per aere.

The season was a good one for the seed trade as 210,000 bushels were sold, of which amount 140,000 were fully certified. The principal markets for New Brunswick Certified seed were Maine, Cuba, Quebec and North Carolina. A few carlots of seed were purchased by the Agricultural Societies within the Province, and were distributed amongst the members.

Work was continued on the improving of the Bliss Triumph variety for certification purposes, and a number of new areas were selected in which to grow this variety for foundation stock.

A survey of the truck growers potato fields was made during the growing season, and it was found that some of the varieties were wrongly named. Tubers from eightly-five different varieties were taken from these fields, and planted in a test plot. Many of them, however, had to be discarded later on account of disease.

An experiment was conducted in the laboratory, during the winter months, to ascertain why potatoes turned dark after being cooked. Five hundred tubers were tested, and it was found that chilling of the potatoes was one cause.

Assistance was rendered by members of the inspection staff, in judging fields entered in the field crop competition, and also at seed fairs. Lectures were given at short courses. An exhibit was displayed at some of the fall fairs by members of the inspection service, of potato plants and tubers affected with various diseases. An exhibit of fungicides for seed treatment, spray and dust materials was also displayed.

The valuable work of the district representatives, in promoting the use of certified seed potatoes to growers in their districts is cordially acknowledged.

QUEBEC—B. Baribeau, District Inspector, Laboratory of Plant Pathology, Ste. Anne de la Pocatière, Que.

The past season was unusually wet in this province during the late summer, a condition predisposing to late blight. This disease reached epidemic proportion late in August and early in September, resulting in a considerable reduction in the crop.

The number of applications requesting field inspection was greater than in 1928. The acreage entered for inspection increased by 179 per cent.

There is a slight increase in the amount of mosaic recorded in 1929 over 1928 for total fields inspected. The percentage of other diseases remains about the same as last year.

A total of 708 applications were received for tuber inspection. It is evident from the reports made at the time of bin inspection that tuber diseases remain practically the same as in 1928, with the exception of late blight and common scab which showed an average of 4.5 per cent and 5.1 per cent respectively. Rhizoctonia averaged 3.4 per cent. The greatest loss in grading for certification was due to late blight and scabs.

Shipments of certified seed potatoes within the province increased considerably in 1929 over past years. Small shipments amounting to 173 bushels in all, of Green Mountain certified seed, were exported to the Argentine.

In addition to the regular inspection work, the whole inspectional staff have had considerable judging to do, in field crop competition and also the competitions in the stored crop. They also acted as potato judges at county fairs, and have given demonstration on preparation of Bordeaux mixture, spraying, etc.

Assistance was given to the growers in roguing their seed plot and in selecting seed for future seed plots and exhibitions. Lectures were given at the Ste. Anne and Rimouski agricultural schools and at the agricultural short courses held throughout the province by the district representatives.

A number of potato varieties were collected for varietal studies. A potato disease nursery was maintained for educational purposes and for the training of the inspectors.

An encouraging and noteworthy feature in the potato industry of the province is the number of special potato warehouses that have been erected during the year by the potato growers' Co-operative Societies, affording much better accommodation and facilities for grading the crop than was previously obtainable. An improved demand for Quebec grown potatoes has resulted, and the growers are quite optimistic regarding the future.

We are glad to acknowledge the very valuable co-operation of many officials of the Provincial Department of Agriculture, more especially Messrs J. H. Lavoie, J. N. Albert and the Agricultural Representatives.

ONTARIO—O. W. Lachaine, District Inspector, care Horticultural Department, Ontario Agricultural College, Guelph.

Although there was a decrease in the acreage entered for inspection in 1929 as compared with that entered in 1928, it is gratifying to note that the percentage of fields which passed inspection rose from 75·8 per cent to 80·4 per cent, and that of the acreage passed from 72·4 per cent to 80·8 per cent of the totals entered. Practically all the regular seed potato producers stayed with the business. The decrease in the total acreage entered for inspection was largely due to smaller plots per grower.

In general the seed was planted later this season than usual. A dry summer in most districts resulted in a rather low average yield per acre. Insect pests, especially aphids and leaf hoppers, were very numerous, except in fields which were thoroughly sprayed or dusted with Bordeaux.

Quite a heavy loss of crop occurred at digging time from early frosts, which also led to further loss during storage. Rhizoctonia and Common Scab were present in the crop to a greater extent than usual, possibly due to lack of moisture.

The demand for certified seed continues to increase in this province. Spring shipments were disposed of in small lots direct to the consumer from the producer. Fall shipments were about normal and were mostly of the Irish Cobbler variety. A keen demand for seed is in evidence for next spring delivery and at good prices.

A new association, known as the Central Ontario Potato Growers' Association, came into being during the year. All their potatoes were shipped under a special grade name. High quality is featured. Present indications are that they will do an exceptionally good business. The demand for the potatoes sold through the association, far exceeded the supply. Good prices were obtained for table stock during the fall and this resulted in a large quantity of potatoes that were intended for seed, selling as improved table stock.

Other activities on the part of the inspectors included the planting of a demonstration plot, at St. Catharines; the roguing of tuber unit plots for the improvement of foundation seed stocks; potato "Field Days"; special lectures at potato meetings and at the agricultural short courses held throughout the province. Exhibits were prepared and set up at many of the fairs; and the inspectors judged the potato entries at various county and winter fairs.

The hearty co-operation of many members of the provincial Department of Agriculture, and others, who have consistently supported the Dominion seed-certification work in Ontario is cordially acknowledged.

MANITOBA AND EASTERN SASKATCHEWAN—J. W. Scannell, District Inspector, Experimental Farm, Indian Head, Sask.

The season was very unfavourable for potato growing, in the Prairie Provinces. The cold backward spring weather was followed by a summer of extreme drought. In many districts the potato crop received less than one inch of rainfall throughout the season, and in Manitoba the potato tops were frozen down by the middle of August. Despite these unfavourable conditions, certified seed yielded 75 to 100 per cent more than uncertified seed. The yields were all low but the percentage which graded Extra No. 1 certified seed was higher than usual. Generally speaking, the crop was uniform and smooth.

Over 4,500 bushels of Manitoba grown certified seed were shipped during 1929 and approximately 2,000 bushels sold locally. In eastern Saskatchewan approximately 250 bushels of certified seed were sold locally. Many carloads of certified seed were shipped in from New Brunswick, Prince Edward Island, Ontario, and other outside districts. These importations were necessary because the demand was greater than could be met by local growers. The price of certified seed was quite reasonable and more of this class of seed was planted on the Prairie Provinces than ever before.

In addition to the regular inspection work a trial plot was planted at Indian Head for the purpose of securing information on the disease content and the yielding qualities of many of the different strains of potatoes offered for certification. Over one hundred different lots were included in the test and much valuable data was secured. The Experiment on common scab and rhizoctonia of potatoes was continued under the direction of Dr. G. B. Sanford, Laboratory of Plant Pathology, Edmonton, Alta. Two new seed disinfectants were given a trial CAL-K and No. 664. Both materials appeared to reduce the amount of common scab somewhat, compared to the amount found in the check plots.

Western Saskatchewan and Alberta—J. W. Marritt, District Inspector, Laboratory of Plant Pathology, Edmonton, Alta.

It was a very dry growing season in the western Prairie Provinces in 1929, and consequently the potato crop was very light. On summer-fallow, where there was a reserve of moisture from the previous year, the crop was much better. It was very evident that fields sown with certified seed were by far the best.

The hot dry weather undoubtedly tended to mask the mosaic disease to a considerable extent, and the drying winds made this condition even worse. Leaf roll under these conditions showed up very plainly.

In western Saskatchewan most of the rejected fields were turned down on account of black leg and mosaic. In Alberta most rejections were due to lack of vigour, or to crop failure.

The dry condition of the soil, especially in Alberta, favoured the development of common scab and many of the larger lots had to be rejected for certification on that account. The combination of these unfavourable factors resulted in a scarcity of good seed in these districts and it was necessary to import several carlots to supply the requirements of the trade.

British Columbia—H. S. MacLeod, District Inspector, Laboratory of Plant Pathology, Saanichton, B.C.

There is a wide range of climatic conditions between different sections of this province. While many sections are not adapted to the production of seed potatoes of good quality, being too hot, and too dry, other districts are well suited to the production of high quality seed. Many purchasers of certified seed request that their orders be filled from certain localities, and frequently by certain growers. From observing the results obtained from seed from the various districts, when planted in other localities, and by a close study of the results obtained in the "seed test plot," much valuable information is secured regarding the quality of the seed that each district produces.

Not quite as many fields were entered for inspection as in the previous year. The low prices received for potatoes last year was probably the chief reason for this reduction. The slight decrease in the number of fields entered, however, was more than off-set by the increased interest shown in the work and in the better quality of the crop. This improvement is due largely to the better co-operation received from the growers, to the use of "seed plots" for maintaining "quality" foundation seed, and also to our standards being strictly enforced.

On account of the dry season, the potato crop was much lighter than usual. This shortage was unfortunate as there was an exceptionally good market for our potatoes in the Prairie Provinces, and prices were attractive.

The two most troublesome diseases of potatoes were Mosaic and Rhizoctonia, but they were not as prevalent, nor as severe as in each of the previous years. This decrease in Mosaic is due largely, we believe, to the improvement of our seed stocks. However, it is possible that, in some districts, this disease may have been masked in the plants owing to the hot dry weather. The decrease in Rhizoctonia may be due, to some extent, to the soil being warmer and containing less moisture, thus causing less growth of the disease organism. Spindle Tuber and Giant Hill were evident in some fields.

An experimental plot, of approximately 1½ acres, located on Lulu Island, was planted, with the object of securing all possible information regarding freedom from diseases, purity of variety, yielding qualities, etc., of seed stocks for certification.

The experiment, to determine the value of "Whole" versus "Cut" seed was continued. The results again appear to be all in favour of the seed planted "Whole"; under the conditions specified (figs. 56 and 57). Practically every year numerous complaints are heard of "Cut" seed pieces rotting when planted in the low lying wet soils, in this province, resulting in numerous "misses" in the fields, and reduced yields.

The results obtained in the plot this year were as follows:—

Yield in tons per acre	Marketable	Unmarketable	Total
Whole seed	8·34	1·92	10·26
Cut seed	6·22	1·60	7·82

The difference of over 2 tons per acre of marketable potatoes appears to indicate the advisability of planting whole seed rather than cut seed in soils that are rather cold and wet at time of planting. Those conditions are very typical of a very large portion of the potato growing area in this province. In 1928 this experiment indicated a wider difference in results. The ground was then more moist and colder.

Other activities of the staff included the judging of potatoes at several seed fairs, potato disease exhibits at the agricultural exhibitions, and special field demonstrations for growers at the potato Experiment Plot.

Change in the General Regulations in 1930

An important change in the general regulations under the Destructive Insect and Pest Act, P.C. 557, went into effect on March 12, 1930, as follows:—

GENERAL REGULATIONS

By Order in Council (P.C. 557) passed on March 12, 1930, Section V of the General Regulations was rescinded and the following substituted therefor:—

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, no person shall be allowed to sell or offer, advertise, expose or hold in possession for sale, any potatoes in any manner or form described or designated as certified, inspected, registered, selected, disease-free, or otherwise indicating their suitability for seed or seed purposes, unless such potatoes 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, to warrant them being classed into either of the two following grades, viz: Certified Seed Potatoes Grade Extra No. 1, or Certified Seed Potatoes Grade Small Size ($1\frac{1}{2}$-3 ounces only).

Certified seed potatoes must be contained in sacks, barrels or other containers, to each of which shall be durably attached a certificate in the form of an authorized official tag, issued by an inspector, and bearing the grower's name or number.

There has been persistent demand for the certification of small potatoes, and the regulations now provide a grade for them. The small seed planted whole is expected to become popular in those areas in which the seed piece rot of cut sets has caused heavy loss at crop.

The small size seed conforms to the same standards as Grade Extra No. 1, except for size, also not more than three per cent by weight shall be above or below the size specified. This grade is suitable only for commercial table stock production.

The Effects of Seed Treatment on Black-Leg

(John Tucker)

The treatment of seed potatoes is now a routine practice followed by many growers. It is intended principally as a control measure in reducing the amounts of common scab, rhizoctonia and blackleg diseases in the potato crop.

For the purpose of securing some information on the actual results in controlling blackleg that are being obtained by growers with their present methods of seed treatments, as practised on the farms under commercial conditions, it was decided to assemble all available data specifying the treatment used and the percentages of blackleg disease present (table 137). The growers supplied the former information, and the field inspectors employed on seed potato certification work, the latter.

There were 8,393 good reports used in compiling the following data, and these reports cover representative potato growing areas in every province.

TABLE 137—SEED TREATMENT AND BLACK LEG INFECTION, 1929

District	No treatment			Bichloride			Formalin		
	Total fields	Number of fields infected	Average per cent infection	Total fields	Number of fields infected	Average per cent infection	Total fields	Number of fields infected	Average per cent infection
			%			%			%
No. 1	2,244	862	0·93	2,357	630	0·70	78	32	1·0
No. 2	154	33	0·52	5	0	0	186	27	0·35
No. 3	582	370	0·56	2	1	0·50	30	16	0·75
No. 4	1,147	555	1·02	....	....	....	434	177	0·97
No. 5	259	209	1·17	182	116	0·57	88	68	1·04
No. 6	63	28	1·13	7	3	1·33	....	....	....
No. 7	91	22	1·71	19	4	1·25	51	19	2·09
No. 8	30	9	0·63	4	1	2·0	78	12	1·18
No. 9	120	19	2·44	126	13	1·27	56	3	0·56
Total	4,690	2,170	0·93	2,702	768	0·72	1,001	354	0·99

Average Loss of Crop

4,690 growers did not treat .... 0·42 per cent
2,702 growers treated with Bichloride .... 0·20 "
1,001 growers treated with Formalin .... 0·35 "

Much the same results were obtained in 1928 as the following figures indicate:—

1928 RESULTS

No. treatment.......	3,506 fields	Average infection..........	1·2 per cent Black Leg
Bichloride..........	2,858 "	"	0·73 "
Formalin...........	946 "	"	0·94 "
3,506 growers did not treat.		Average loss..............	0·57 per cent of crop
2,858 growers treated with bichloride.		"	0·21 "
946 growers treated with formalin.		"	0·32 "

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) The growing season in 1928 was generally considered a wet season, and in 1929 a dry season. The results for the two years are fairly uniform when this difference in seasons is taken into account.

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