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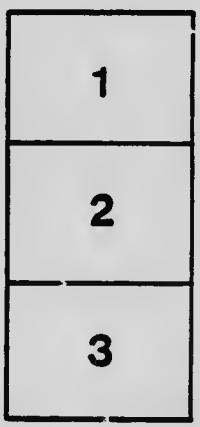

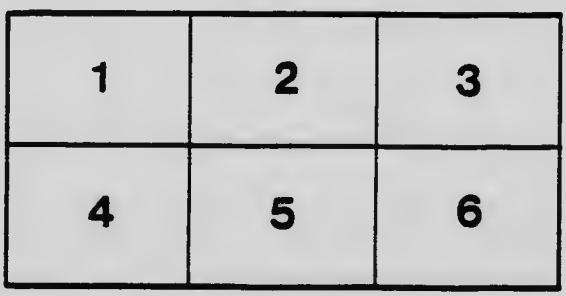

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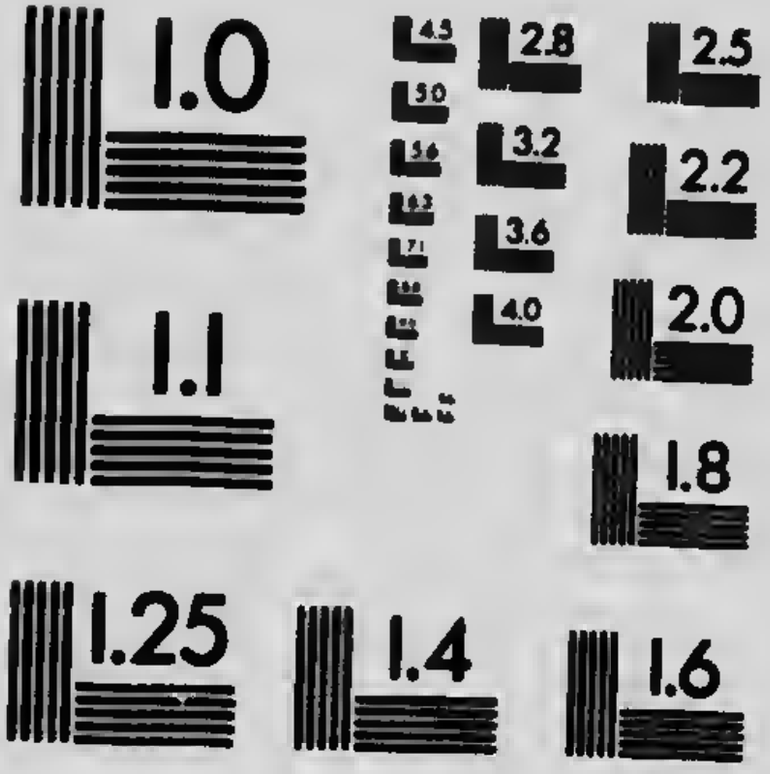

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EXPERIMENTAL FARMS

J. H. GRISDALE, B.Agr., Director.

H. T. GÜSSOW, Dominion Botanist

DIVISION OF BOTANY

LATE BLIGHT AND ROT OF POTATOES

Caused by the fungus *Phytophthora infestans*, de Bary.

BY

PAUL A. MURPHY, B.A., M.R.C.S.I.,

Assistant in charge of the Field Laboratory for Plant Pathology, Charlottetown, P.E.I.

CIRCULAR No. 10

Published by authority of Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa ont.

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OTTAWA, February 1, 1916.

To the Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit herewith, for your approval, Circular No. 10, entitled "Late Blight and Rot of Potatoes," which has been prepared by Mr. Paul A. Murphy, Assistant in charge of the Field Laboratory for Plant Pathology at Charlottetown, P.E.I.

The subject treated of is a most important one, especially to the potato growers of Quebec and the Maritime Provinces, and I would recommend a wide distribution of this circular, in order that the efficacious preventive measures given herein may become generally known as soon as possible and heavy annual losses thereby avoided.

I have the honour to be, sir,
Your obedient servant,

J. H. GRISDALE,
Director, Dominion Experimental Farms.

DIVISION OF BOTANY,
CENTRAL EXPERIMENTAL FARM,
OTTAWA, January 27, 1916.

J. H. GRISDALE, Esq., B.Agr.,
Director, Experimental Farms,
Department of Agriculture, Ottawa.

SIR,—I have the honour to transmit herewith a manuscript entitled "Late Blight and Rot of Potatoes" caused by the fungus *Phytophthora infestans*, prepared at my request, by Mr. Paul A. Murphy, B.A., M.R.C.S.I., Assistant in charge of the Field Laboratory for Plant Pathology, Charlottetown, P.E.I.

Late Blight is recognized as one of the most destructive plant diseases in the world. In certain years it has caused incalculable losses; yet these can be reduced to a minimum by thorough and timely spraying with Bordeaux mixture. Experience and experiments have shown again and again that when this is done according to the clear and simple instructions given by Mr. Murphy in this circular, this practice is a profitable one every year and a very profitable one in years when Late Blight is prevalent.

I would respectfully recommend the publication of this manuscript as Circular No. 10 of the Experimental Farms publications.

I have the honour to be, sir,
Your obedient servant

H. T. GÜSSOW,
Dominion Botanist.

LATE BLIGHT AND ROT OF POTATOES

Caused by the fungus *Phytophthora infestans*, de Bary.

BY

PAUL A. MURPHY, B.A., M.R.S.C.I.,

Assistant in charge of the Field Laboratory for Plant Pathology, Charlottetown, P.E.I.

Few plant diseases are so widespread and destructive as the Late Blight of potatoes, and although it is not so dreaded nor so destructive, apparently, now as when seventy years ago in Europe it exerted such an influence on the course of the history of the world, it is still probably surpassed by few diseases in the loss which it occasions.

Symptoms.

Late Blight is so-called because it appears after the leaf blight due to the fungus *Alternaria Solani* which passes by the name of Early Blight. The two may be easily distinguished. The Early Blight is prevalent in July, and the spots which it causes are characteristically dry, brown, and marked with a series of concentric rings. The Late Blight makes its appearance later on, in August and September as a rule, although it is always present long before it is generally noticed. The first spots are usually on the lower leaves or on the stems. They are dark brown to purplish black in colour, sometimes surrounded by a ring of light green, and they have a water-soaked appearance. In fine weather they dry up and become brown. If the weather be moist they increase in size and number and may involve the whole plant causing it to die in a few days and fall into a peculiarly evil-smelling mass.

On the lower surface of the leaves, the blight spots present the appearance of being covered with mildew, particularly around the margin of the dead areas. If the weather is dry, this feature will be absent. The mildew is made up of myriads of spores of the fungus and of the minute stalks which bear them. Spores, as they are called, may be likened to seeds, the purpose of which they serve. It is through them, when washed down into the soil by heavy rain, that infection is carried to the tubers.

An infected tuber is characterized by livid-coloured, slightly shrunken areas on the surface which are abnormally hard. The flesh inside is mottled here and there with brown spots (see Plate, Fig. A) spreading around the margin in the early stages and later involving the whole tuber. The Late Blight Rot is typically a dry one, but it sometimes happens that other organisms gain an entrance through the spots which have been killed by the blight and cause a soft rot. This may be seen in wet seasons at digging time. On the other hand, the amount of Late Blight Rot visible when the crop is dug is often slight, even though the tops were severely attacked, whereas it

(A) A potato cut through showing effects of "Late Blight" in tuber after storage. (Photo H. T. Gussow).

(B) Four rows of potatoes showing control of "Late Blight" by spraying. Note all tops dead in front without spray and all tops green in back which have been sprayed. (Photo J. A. Clark).

shows up afterward during storage. In every such case the tubers carried the germ of the rot within them from the field. If the temperature of the cellar is low, the parasite may remain practically dormant in them during the whole winter, ready to destroy the tuber, however, when the temperature rises. This rot passes by a variety of names, of which "Dry Rot" is perhaps the commonest, although it is incorrect. Late Blight Rot is preferable.

Life History of the Causal Organism.

The cause of the disease is the fungus *Phytophthora infestans*. As the name "fungus" indicates, the parasite is of the nature of a mould. It is made up of colourless, thread-like, branching strands, so small that they are invisible to the eye, which burrow in the leaf and in the tuber. It passes the winter in the tubers in a semi-dormant condition, if the temperature be low. Some of the tubers in which it has hibernated are cut and used for seed and the fungus under favourable conditions grows into the sprouts. The great majority of them it kills off so that they never produce a plant, but a few manage to struggle on into dwarfed plants, the fungus growing up with them and ultimately producing a crop of spores on their stalks and leaves. These spores are so small that they are blown about by the wind, and when they alight on a potato leaf, if there be moisture enough for them to germinate, they sprout in a curious way. The contents of the spore break up into about a dozen fragments and emerge through an opening, which now appears in the wall, and begin swimming actively about in the little drops of water on the leaves. These little bodies, which move about like animals, are called swarm spores. After awhile they come to rest and each germinates by putting out a small tube. This germ tube, as it is called, has the power of penetrating the leaf and causing a spot of blight. The spore itself, under certain conditions, germinates in this way direct, without the production of swarm spores, and it too can infect a leaf.

These three processes of spore formation, germination and infection can take place only in the presence of sufficient moisture and a suitable temperature. Both spores and swarm spores are quickly killed by drought and sunlight. This partly explains why it is that, although the fungus is present in isolated plants from the time they reach the surface of the ground, it does not spread to any extent until a month, or perhaps two, later. Another reason may be that the plant is more susceptible at and after blossoming time than in its earlier stages.

But although the blight is not observable for the first two months of the plant's growth, it is established in little centres here and there under favourable circumstances to produce a crop of spores which the wind will scatter all over the field. The rapidity with which this can take place, an attack appearing from nothing and from nowhere, as it were, is well known. Recent investigation has shown, however, that there are centres of infection unobserved in the field and the actual spread of the disease from them has been noted. It was formerly thought that the disease lived in the soil, yet this is hardly likely.

When a spore germinates on a leaf and infects it, the strands of the parasite grow through its interior, feeding on the contents of the cells which it sucks out and kills. A dead area results which we know as a blight spot. This grows larger and

larger as the disease spreads out from the original point of infection, killing the leaf as it goes. Then if the weather is moist, as the fungus luxuriates on the dead cells it goes to seed. On the lower side of the leaf of the potato plant there are innumerable breathing pores of a very minute size. Through these the parasite sends out one or more branched stalks on which the spores are borne. It is this crop of spores and stalks which is often so thick as to be visible to the eye in the form of a white mildew. The spores readily drop from the stalks which bear them when they are ripe. Some of them are borne by the wind to healthy leaves, perhaps in other fields, and some are washed down by the rain into the soil. If even one of the minute swarm spores comes in contact with a tuber, it can pierce its skin and set up the Late Blight Rot in it. Thus the cycle is completed. If that tuber be planted next season it may communicate the disease to the plant which arises from it, and one plant is sufficient to contaminate the whole crop.

Losses Due to the Disease.

The annual loss due to this cause all over the world is incalculable. In the United States it was placed some time ago at $36,000,000, and in some years it is greatly in excess of this. Thus it is said: "Ten million dollars would be a conservative estimate of the loss to New York potato growers alone in 1912, and the loss each year from 1903 to 1905 was even greater." Experience in Canada is not yet sufficiently extensive to form a general estimate, but in the year 1915, when Late Blight was admittedly severe, the loss in yield in Prince Edward Island was probably not less than 2,000,000 bushels, representing a value of $1,000,000. This entirely neglects the loss during storage. The amount of damage caused all over Eastern Canada would be about on the same scale, if anything rather more than less.

CONTROL.

Late Blight can be controlled almost perfectly by spraying the potatoes about five times with Bordeaux mixture made up of six pounds of copper sulphate (bluestone), four pounds of quicklime and forty imperial gallons of water.

For particulars as to making Bordeaux see back of this bulletin, where they are placed for convenience in reference.

The first application should be made about the middle of July, and the treatment must be continued every two weeks or so until the middle of September. No set rule can be laid down, however, as to the date when spraying should begin, because it varies so much in different locations and seasons, but with a little experience there is no difficulty in fixing it. It is sometimes recommended to make the first application when the plants are six to eight inches high, or about the time when it is necessary to begin using poison for the potato beetle, and both of these are fair guides.

For putting on the spray over large areas, a horse-power sprayer, capable of keeping up a continuous pressure of not less than one hundred pounds, gives the best results. Several firms in Canada have such machines on the market, the price being about $75 to $100. A machine of this kind should spray four rows and have three nozzles to a row, two to spray upwards from between the rows and one to spray downwards.

For those who grow on a somewhat smaller scale, an outfit consisting essentially of a barrel fitted with a hand pump, the whole to be placed on a cart, will be the most useful. A sprayer of this type to cover four rows can be obtained for $40 complete, exclusive of the cart. The pump, nozzles and hose can also be got separately, the farmer supplying the cask. The pump alone costs $15 and care should be taken not to get too small a size. Without a good pump, good pressure is impossible, and good pressure is the first requisite for good spraying. Satisfactory work can be done, by the exercise of care, with these machines, but naturally they are not so effieient as the horse-power outfits. Machines to be carried on the back or in the hand, while they do excellent work, are only suitable for garden patches.

Those intending to purchase spraying machines are urged to communicate with the nearest Experimental Farm or the Dominion Botanist, Central Experimental Farm, Ottawa, when further advice will be given.

The aim should be to spray before rainy periods, not after. Once the spray dries it is not easily washed off. Infection takes place during moist weather and spraying acts only as a preventive of infection. It is incapable of checking the spread of the disease once it has got into a leaf. For the same reason the first application should be made before the blight appears. Further, since the aim is to prevent infection, and since infection can take place on any part of the plant, the whole plant must be covered with the mixture. This is not as difficult as it sounds, and with a little care it can be successfully accomplished. Nevertheless, it cannot be too strongly urged that *thoroughness in spraying pays and half measures are merely a waste of time and money.*

Spraying must be continued throughout August and part of September, even though the vines close in and cover the ground between the rows. Not as much harm as might be expected will be done by the wheels, and the increase in yield and soundness of the crop will much more than compensate for whatever little loss there may be. It would be well, however, to make the rows at least thirty inches apart. Most experiments show that this is the best distance, a fact which is borne out by the practise of the best growers.

Fifty gallons may be enough to apply to an acre for the first spraying, when the tops are small. Thereafter it will be necessary to apply each time from seventy-five to one hundred gallons or even more.

The nozzle for the delivery of the spray is an important item. It should send the mixture out in the form of a fine mist, the finer the better. The practice sometimes followed of pumping the spray out through a hose without a nozzle is extremely wasteful and almost useless.

Profit from Spraying.

Experiments have shown that from five to seven very thorough sprayings carried on over a period of ten years increased the yield at the average rate of 97.5 bushels per acre.* In some of these years there was no Late Blight, yet the increase was always large enough to make the undertaking profitable. Five very thorough sprayings in Prince Edward Island in 1915 gave an increase of 97 bushels of marketable

*At the New York State Experiment Station, Geneva, N. Y.

potatoes per acre over unsprayed plots. The cost of spraying on a field scale should not exceed $1 per acre per spraying, and even at the present high price of materials it should not exceed $1.60. On a smaller scale it might cost $2, but even if it did the increase in yield would still make it profitable.

The following table gives the cost of spraying on a large scale with a horse-power machine. The price of materials is that current in 1915 and is quite excessive:—

ITEMS IN COST OF SPRAYING ONE ACRE OF POTATOES ONCE WITH BORDEAUX MIXTURE OF STRENGTH OF 6.4.40 AT THE RATE OF 75 GALLONS PER ACRE.

11¼ pounds copper sulphate at 11 cents	$1.24
7½ pounds lime at 1 cent	0.075
Three-quarters hour labour for man at 16 cents	0.12
Three-quarters hour horse labour at 10 cents	0.075
Depreciation on sprayer	0 10
	$1.61

If we take the cost to be $1.61 per acre for every spraying and if spraying be done five times the total cost will be $8.05. The profit from the spraying experiment on Prince Edward Island, where the increase was 97 bushels per acre, was over $34 per acre, in spite of the fact that, as it was merely an experiment and all the work was done by hand, the spraying cost more than $14 per acre. If a farmer cannot expect to spray so thoroughly as to obtain an increase of 97 bushels he should not aim at less than fifty. Even if the price of potatoes were as low as 25 cents per bushel he would still have a profit of $4.45, and it is not unlikely in such a case that this figure would convert the growing of that acre of potatoes from a loss into profit.

Preparation of Bordeaux Mixture.

The mixture recommended consists of 6 pounds of copper sulphate (bluestone), 4 pounds of quicklime and 40 gallons of water. This strength is commonly denoted by the formula 6:4:40. Bordeaux mixture must be made up freshly each time it is used. On the other hand the copper sulphate and lime may be each dissolved in water and kept separately for an indefinite period, and this course is recommended. Suppose an acre is to be sprayed five times at the average rate of 75 gallons of spray per acre there will be required during the course of the season 56¼ pounds of copper sulphate and 37½ pounds of lime. It is recommended that as much of these materials be prepared in strong solution at the beginning of the season as the size of the vessels available will allow. These should be of wood—kerosene barrels or molasses puncheons answer admirably. Copper sulphate or Bordeaux mixture should not be placed in iron vessels because of their corrosive action on that metal. Wood, brass, copper and earthenware are safe to use.

(a) Stock Solution of Copper Sulphate.

Have on hand at least two barrels or puncheons, and, assuming that one of them will hold so much, fill it with 60 gallons of water. Tie up 60 pounds of copper sulphate in a bag or a piece of canvas and suspend it just beneath the surface of the water until it dissolves. There will then be one pound of copper sulphate in every gallon of the liquid, and for every pound required it will be only necessary to measure out a gallon. Cover the barrel to prevent evaporation.

(b) Stock Milk of Lime.

Place 50 pounds (about two-thirds of a bushel) of quicklime into the other barrel and slake it gradually. Be careful not to "drown" it. When it has all crumbled, stir it up with water into a paste and then fill the barrel up to the fifty gallon mark. A gallon of this liquid therefore contains one pound of lime. Provide this vessel with a cover also.

To make 40 gallons of spray proceed as follows: Run 30 gallons of water into the tank of the spraying machine, add 6 gallons of the stock solution of copper sulphate and stir well. Mix up the stock milk of lime thoroughly and draw off four gallons, running it through a strainer to keep back the coarser particles. Then stir up the copper sulphate in the spray tank again, and while stirring add the lime. Never mix the concentrated copper sulphate solution and the strong milk of lime and dilute afterwards, because the spray made in this way is not so good.

The cloudy blue liquid which results is Bordeaux mixture. It must not contain excess of copper sulphate in proportion to lime, otherwise the foliage will be burned. If the lime is *quick* (*not air-slaked*) and reasonably pure there is little danger of this happening, but the spray should always be tested with a solution made by dissolving half an ounce of potassium ferrocyanide in half a pint of water. Add a drop or two of this to spray and if the Bordeaux turns distinctly brown where the drop strikes, more lime is needed.

The poison for the Colorado beetle may be applied along with the Bordeaux as often as may be necessary. Either Paris green or arsenate of lead, or a combination of both, may be used. Arsenate of lead sticks better but the other is quicker in action, so that it is safer to use both. Half a pound of Paris green and a pound and a half of lead arsenate to 40 gallons of spray will prove effective in most cases unless the attack is very severe, in which case these quantities should be increased by a half.