Science.

THE POTATO DISEASE.

[*Phytophthora infestans* (Mont.), De Bary.]

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NOMENCLATURE.

This potato malady is known under many names, of which the following may be mentioned:—Blight, Late Blight, Potato Murrain, Potato Rot, Potato Mould, Downy Mildew, Brown Rust (Tasmania), La Maladie des Pommes-de-terre, Kartoffelkrankheit, Krautfaule, Knollenfaule, Aardappelzickte, Marciume della patate, Male de secco, La Peronospora, Phytophthora. Probably the last mentioned is to be preferred, since it has allusion to the most essential feature of the malady, the growth within the potato of a parasite—a fungus, first designated—by Montagne—*Botrytis infestans*, and now known as *Phytophthora infestans*, De Bary.

INTRODUCTION.

The fact of this disease occurring in Australia was discovered by the present writer, as well as first made known to the Department of Agriculture by him, on 18th May, 1909. This discovery related to its existence in a district near Brisbane, and had reference to a virulent potato affection brought under notice as occurring on a single farm, but actually more locally spread, by Mr. R. G. Ridgway. Subsequently, on 26th June, he similarly intimated that it was prevalent in potatoes that were being received in quantity from Tasmania, and that were affected by a malady, apparently identical with one that had already received there the descriptive name—"Brown Rust."

In the interval between the dates referred to, evidence was received that indicated that the Phytophthora disease already occurred throughout the large area of south-east Queensland, that extended from the southern border of the State northwards to beyond Gympie, and as far back as the coastal range in some places. The vigorous measures for its extermination, that were at once entered upon on its first discovery in Queensland, were accordingly, therefore, suspended.

The source whence this disease was derived can be alone conjectured. Prior to its existence in Tasmania having been discovered, this was attributed to New Zealand, in which *Phytophthora infestans*, already noticed there in 1904, had previously become generally established, the statistics of Queensland showing that, notwithstanding the embargo placed on potato importation from countries where it occurred, this colony had, to some extent, contributed to our market supplies. There, however, is now no necessity, perhaps, to seek its origin in seed potatoes emanating from the Dominion, in view of the knowledge referred to.

SYMPTOMS.

Although the destruction of the potatoes or tubers themselves may result from the disease, the first symptoms of its presence occur in connection with the parts above ground. When infection is first brought about there is no outward sign for a few days of this having taken place. There gradually arise, however, pale yellowish blotches on the leaf-blades, often separate from their margins, but usually at their points or along their

sides, and these, as they become more conspicuous, increase in size. From yellow they change by degrees to a deep dull muddy brown. Meanwhile the leaves thus affected may become misshapen and have their edges here and there turned upwards, so as to expose the under surfaces. Viewing one of these leaves from beneath, it will be observed that, immediately surrounding the blotch on all sides, there is an indistinct band of a pale-grayish colour, that becomes more apparent when it is held slantingly, and is apparently composed of some extremely fine dust-like matter. Attempting to look through it, it will be observed that, not only does the spot itself obscure the light, but that there is a dark zone beyond it, corresponding to the position of the gray fusiness beneath, suggesting that the presence of this, and the leaf-discolouration, are in some way connected. Usually, when the leaf-tips and sides are occupied by the dark-brown (almost black) patches, there is more or less surface-crumbling of the parts they occupy, and, should drying winds be experienced, these may become cracked and brittle, even before the full discolouration is effected. The spots, in fact, present their most characteristic appearance when the foliage is moist, especially before the night dew has risen. Whilst the atmosphere continues dry the fusiness referred to either does not appear at all or soon vanishes on this happening.

In fact, under these conditions, and with a humid atmosphere, the spots both increase in size and multiply until the entire leaf is brown and dead; and the leaf-stem, meanwhile having become brownish-coloured and translucent, droops too in the process of its succumbing.

A potato plant may be smitten in this way at any stage in its growth; although, if approaching maturity, it is more likely to become affected. Usually, in a plot or field of potatoes, the disease manifests itself in spots here and there in the first instance, the whole area being later affected. These spots usually mark the site of surface-depressions. In damp, muggy weather, when rain or fog is about and the sky overcast, these symptoms will be developed and become general in a potato area with remarkable rapidity, the field soon presenting an appearance of having been visited by severe frost, for sooner or later the "tops" are killed.

With regard, now, to the tubers or potatoes. The *Phytophthora infestans* being a parasite that attacks the plant at any stage of its growth, and being capable as is seen of killing the "top" or part of it above ground, the tubers on being removed from the soil—when this has happened—will be at the stage of development and size that has been reached at the time that this destruction has been brought about. There will be no crop of marketable tubers, such as culinary purposes require; a crop of immature potatoes of medium size; or ones such as are ordinarily harvested. This, however, will only happen when the manifestation of the disease on the foliage is followed for some days by dry or rainless weather, and the soil is of a light texture or approaches that description. (Note.—This is what actually was experienced in many places within the disease-infested area of Queensland, during the outbreak that has occasioned the preparation of this article.)

On the other hand, should these dry atmospheric conditions be replaced by more or less rain, the tubers themselves will also manifest symptoms of the presence of the disease. The earliest of these are practically indiscernible on a dark-skinned potato-tuber; but should a white or pink-red one be examined, it will—if affected—exhibit an ill-defined cloud-like patch, or patches, suggestive—by reason of the dark colour displayed—of a light bruise having been experienced. This symptom is especially brought to light when the surface of the tuber is made wet as in washing. In peeling the potato when preparing it for the

pot, the occurrence of surface discolouration will also be found now. More fully developed effects that may be seen in all kinds of potatoes, are —in one or more places—a discoloured death-like appearance of the surface, that presents also here and there shallowly impressed pits or dimpling. Then the peel may become dead, and sunken inwards to a slight extent, especially should the potato have been under conditions of dryness. Very frequently the skin of the potato covering these affected places will have become broken and partly removed; and it will always be found, if it be still *in situ*, that it is easily removable with the finger-nail; in fact, mere rubbing will often detach it. Immediately beneath the surface where these changes have been undergone the flesh of the potato will be found to have lost its white colour, that has given place to a brownish-yellow or yellowish-brown. This change is at first quite superficial, but eventually it will extend inwards for some distance, the tissue being at first densely mottled and then speckled with a brown rust-like colour. This is especially to be seen when the affected potato is cut across, the entire section being oftentimes girdled with a band, ragged internally, of uneven width of this peculiar hue that merges outwards with the tuber surface.

Should the potato, in which these symptoms due to the Peronospora disease are present, be kept dry, it will remain in the condition described, but in the damp soil, in the potato heap, in the pit, or even when bagged, decay will proceed, and it will be destroyed, becoming collapsed and filled with matter of a pap-like consistence.

These destructive changes, however, are not essential features in Phytophthora attack, it is merely the harbinger of them, the destruction of the surface tissue permitting them to be brought about by the entrance of soil-frequenting bacteria and moulds that are almost always associated with ordinary potato-rottenness; for the Phytophthora is a true parasite, only establishing itself in the sound tissue of the potato, and actually perishing for the most part when this undergoes these changes that constitute decay.

CAUSE.

If the fine powder-like substance that surrounds the spot due to the disease with a delicate gray band, occurring on the under surface of the leaf, be examined with a magnifying glass, it will be seen that it is composed of minute glistening particles of one size, these are fungus-spores or fungus-seeds, and with them and their growth the disease is brought about. They may appear in number to millions on a single leaf.

These spores or conidia (Greek for dust) readily become detached, float in the air, and are transported with its movements. They are capable of growing as may an ordinary seed, but—unlike it—in more than in one manner. Should they not have been long formed, and find themselves in a droplet of pure water (*e.g.*, rain water or dew), they give rise to further or secondary seeds or sporules, several of these arising from each of them, and these that are capable of movement in fluid and are thus termed zoo-spores (living seeds), eventually sprout. If on the other hand they have alighted in a nutrient fluid of sufficient strength, or are older, they produce sprouts directly themselves.

Now, these sprouts, or germ-tubes, on having issued from conidia, or from zoo-spores, that have arisen or have fallen on a potato leaf, can, under the circumstances in which they find themselves, penetrate through the skin of its surface into its interior, and—this having accomplished—send branches through the substance of which it is composed, producing the special colouration in so doing and the decay that we find in the blotch, that we regard as the first symptom of the disease.

If on the other hand the conidia are washed off the leaf during rain, the zoo-spores, entering with their liquid surroundings the soil, gain the tubers, and settling thereon send forth germ-tubes that penetrate the skins of these, and produce in them related changes also.

It is unnecessary, for the purpose of this paper, to describe the fungus on which the spores or conidia are developed, its appearance and mode of life in its vegetative condition within the substance of the leaf, or amongst the tissue cells that compose the more superficial parts of the tuber, that it has once entered. Nor need we dwell on how it lives, nor the nature of the destructive changes that this living involves, and that, in the case of the potato itself, afford the opportunity for the entrance and operations of more virulent substance-destroying organisms.

ESTABLISHMENT AND DISSEMINATION.

In dealing with the symptoms of the disease, allusion has already been made to the fact that, although the tuber be infected, it may exhibit little outward evidence of this being so, and that thereupon—as also when the fact of infection is quite manifest—tubers will remain, for a time at least, intact, and undergo no further change whether of the nature of decay or otherwise, when maintained under conditions of dryness. The Phytophthora disease is not, however, banished from them, the parasite that lends it its name living dormant in the narrow spaces between the cells that compose its tissue, ready to develop further when congenial circumstances arise. Thus, if a portion of such a potato be maintained, or find itself in a humid atmosphere, it will give rise to the same fungus and fungus conidia that we have seen occur in connection with the leaf spots. Without stopping to explain how this is brought about, it may be assumed, therefore, that a potato, or portion of a potato, harbouring the dormant vegetative form of the parasite will, when planted, originate in many cases disease in the living potato plant formed from its growth; and even, if left about—as when cutting affected potatoes for stock—may do so also.

That fresh centres of disease become established in this manner is an undoubted fact, the recognition of which has been the justification for the establishment of prohibition with respect to commerce in potatoes between disease-affected and disease-free countries. The smaller potatoes often used as seed are especially dangerous; not only has it been shown that these are especially subject to infection by the parasite by reason of their delicate skins, but to harbour it in an indiscernible state—in this dormant state—from one year to another, on account of the facility with which they dry.

As concerning persistence of the disease, the great variation in the time selected for planting potatoes even in a single Queensland locality, covering two months or more, and resulting in crops of widely different ages being grown at the same time, brings it about that in some districts there is an almost continuous growth of potatoes from one end of the year to the other, without any interval between winter and summer planting. This will probably prove conducive to the perpetuation of the Peronospora disease.

Again, when the spores or conidia find their way into the soil, they may meet with conditions, neither at once favourable to their growth nor conducive to their destruction, and so will persist for a while intact as old spores, or they may reach a nutrient pabulum in which they can at once grow. In either of these events they will give rise to freely-branching spawn threads (mycelia), that may subsequently infect potato plants with which they may come in contact. It may be understood then that, of two

potato crops that are grown successively on the same ground with a short interval between them only, one may prove a source of infection for the other. Old potato plants and potato refuse left on the land, as well as defective harvesting, may procure the same undesirable result.

When the disease is once present anywhere, and has developed the outward symptoms of its presence, it is readily disseminated by the wind, especially should humid conditions occur to promote the growth of the spores on these having been carried by it from diseased to healthy plants. During the course of this first Queensland outbreak, several instances were met with of a succession of attacks along the course of a prevalent wind. A remark that applies to both tomatoes and potatoes; that proved reciprocally infective one to the other. If other conditions conduce to render this agency for Phytophthora dissemination operative, the wind has evidently a great influence in effecting the distribution of the disease.

During the months of May and June the potato crops throughout the area visited by *Phytophthora infestans* were infested to an unusual degree by the smaller insects that subsist on cell-sap—*Jassidae* and *Aphides* especially—but it could not be definitely ascertained that they assisted in conveying the spores from one part of the plant to another, or from plant to plant.

When sound potatoes are stored with those that are diseased, the malady will extend from the latter to the former, especially if these have been deprived of soil by washing, or are moist. This finds its explanation in the fact that the disease-affected potatoes under these circumstances produce spores freely and an external vegetative growth of spawn threads (mycelia) that pass from potato to potato.

Conditions Affecting Phytophthora.

It is the experience of other countries that there occur at intervals seasons during which the Phytophthora disease asserts its presence with especial virulence and wide occurrence; and, on the other hand, ones during which it appears to be in almost complete subjugation. Endeavour has been made to define the character of these, and to prove that they are characterised by special meteorological conditions; but there is little consensus, in the opinions that are pronounced, with regard to this matter. Excessive humidity and precipitation with sudden changes of temperature, and the reverse conditions, are usually invoked to account for these attenuated and virulent outbreaks respectively.

It is usual to assume that warm and even hot conditions are favourable to the growth and development of fungus-parasites such as *Phytophthora infestans*. This is, however, in many cases an erroneous one. Thus it has been experimentally shown that the temperature conducive to the freest development to this potato parasite—or optimum temperature for *P. infestans*—is as low as 68 degrees Fahr., and that this ceases at 86 degrees Fahr. on the one hand, and at 44 degrees Fahr. about on the other. It has also been discovered that when subject to dry conditions, such as are often realised here, the conidia or spores, thick-walled though they be, readily perish, and they are not formed at all in a dry atmosphere or in one poor in oxygen. It has also been discovered that the vegetative portion of the fungus, even when contained within the tuber, succumbs when these are exposed to a temperature of 104 degrees Fahr. for three or four hours.

These relations between temperature and *Phytophthora infestans* encourage the belief that the disease will have a circumscribed range of occurrence in Queensland, and will, perhaps, also not greatly affect the summer crop.

It is now known that when the conidia or spores are placed in water, they produce their swarm spores for from four to six hours, commencing to do so after the first hour or two; and, that these will have come to rest, and have penetrated the leaf in from twenty to twenty-eight hours from the commencement of the experiment; and that it takes five or six days before a second generation of spores is produced. Accordingly, when a leaf spot exhibits the grayish white powder surrounding it on the under-leaf surface this time has elapsed since the infection its presence indicates.

If the air continues dry the spots may remain small and produce no spores at all for many days, but will do so in a few hours if the leaves are subjected to air saturated with aqueous vapour. This remark especially applies to the tomato, and explains the sudden extension of the disease when wet weather comes on in fields of both plants.

With regard to the traverse of the parasite within the tuber itself, there are grounds for concluding that the temperature, if high, but within the limits favoured by it, already mentioned, promotes its rapidity. Hecke, a German investigator, has, however, shown that, although the destruction of the tuber when once attacked is favoured by humidity, this is inimical to the growth of the Phytophthora fungus within it, that is hindered by the other organisms that thrive under these circumstances. And the writer has found that it is actually killed when subjected to the influence of the products of decay in a confined space.

A Danish investigator, Jensen, has stated that the spores (conidia) do not penetrate the soil more than 10 centimetres (4 in.), apparently referring to that which is compact and quite devoid of fissures. He, therefore, recommends earthing up the tubers well to protect them from spores, late shed by the affected-foliage. It has, however, been found in practice that this diminishes the yield.

With regard to the susceptibility of different varieties of potatoes it is found that generally speaking there is little difference, and that those that are credited with being immune from attack do not long maintain this character. It has, however, been found—at the Potato-culture Experiment Station in Germany—there is a relation between starch content and the incidence of disease, those containing most starch experiencing less damage.

PREVENTIVE MEASURES.

1. To any section of the State or district thereof in which potato culture is pursued, and in which the disease does not already occur, no potatoes should be conveyed that have emanated from any other place in which it does, much less should potatoes—presumably tainted, as ones having such an origin would be—be used for seed purposes. "It is madness to use, as seed, tubers which have been procured from a district known to have severely suffered from the disease in the last season." (E. J. Butler, Cryptogamist Botanist to the Government of India.)

2. Should the portion of the State be one in which the disease has occurred, the same obligation with regard to the origin of seed should be observed as far as is practicable, and if this cannot be done the seed, after first being found to be free from disease (*vid.* 3 and 4), should be subjected for two hours to a temperature of 40 degrees C. (104 degrees Fahr.), acting on the advice of Delacroix, in favouring this method of Jensen, and who states, that the buds are not injured by the treatment.

3. In the latter event also preference should be given to potatoes that require to be cut, rather than to small tubers to which this process would not be applied, and all those that exhibit any decay whatever, either active or otherwise, should be discarded. Then they should be examined in the

light of the description of symptoms already set forth (page 2), both before and after they have been cut into sets, and any found to manifest evidence of disease-presence be discarded. Scraping with the fingernail and so disclosing the discoloured inner surface will often lead to the detection of Phytophthora if present, when otherwise it would be overlooked. Should none of these be noticeable, but should the ring—the light line shown on section running a short distance within the margin—be brown—even pale-brown—instead of white, a symptom of Brown Rot or of Dry Rot, the potato should equally be discarded.

4. Should in the course of the inspection of the seed, disease-affected potatoes be detected, it may be safely presumed that many more occur in which the most careful scrutiny will fail to bring infection to light; and it may be deemed a ground for rejecting the whole.

5. Disease in the tuber being constituted by the presence of "spawn" or "fungus threads" buried within the tissue of the tubers, it is obvious that no chemical wash to which these may be subjected will destroy it, although it may possibly succumb to Jensen's method of heating. [*Vid.* 2.]

6. Should from any circumstance (*vid.* "Establishment and Dissemination," page 4) the disease become manifest in any new district, all delay should be avoided and the "tops" at once destroyed. This is best accomplished by spraying them with a 5 per cent. solution of sulphate of iron, sulphuric acid being added at the rate of ·88 fl. oz. per gallon (equal 1 per cent.) should the sulphate of iron be oxidised to any extent. The potatoes—if any—should then be at once dug and disinfected in the usual way with formalin and, if at all visibly disease-affected, burnt.

7. In replanting in a district in which the disease has already occurred in the past season, as great an interval of time as possible should be observed between the removal of the preceding crop and this act. All should, as far as practicable, plant about the same time. It would be preferable, however, to cease potato-growing locally for a season, and then commence afresh, using clean seed potatoes.

8. The plot of land in which a diseased crop has occurred in the immediately past season should not be used for the succeeding potato field. If, however, this be unavoidable, care should be taken that no refuse connected with the previous crop be present, and, wherever practicable, a dressing of lime should be applied.

9. In all other countries in which the *Phytophthora infestans* occurs it became perennial after its first introduction, and to avoid the damage due to its onslaught the plants have to be sprayed with a special preparation. Notwithstanding the disease—as has been already seen—may not appear, or if so be little prevalent, during any particular season, still this spraying is persisted in as a protective measure against its visitation, it not being possible to foretell whether it will put in any appearance or not; and, when procedure is delayed until the earliest symptoms of its presence are revealed, so rapidly may it be propagated that the time for dealing with it will have already gone by in most cases, for the treatment has little or no influence on infection that has already taken place.

To demonstrate that year in and year out this spraying produces results that are profitable to the potato-grower, experiments have been prosecuted throughout a course of years—ten or more continuously—in England, the United States, Germany, and elsewhere.

As has been seen, infection is brought about by the seed or spore of the *Phytophthora infestans* germinating upon the potato leaf, and the particular spray-material resorted to has reference to the fact that certain mineral salts prevent, if present, this germination. Thus Dr. Wuthrich

has found that, in the case of blue stone (copper sulphate), 1 part in 10,000 of water stops swarm-spore formation, and 1 part in 1,000 similarly stops their sprouting.

10. Copper sulphate (blue stone) is therefore used as the essential of the spray-fluid—Bordeaux mixture—that is employed.

As this "has proved extremely successful" in New Zealand, where much destruction has been wrought by *Phytophthora infestans,* one is justified in quoting from the report of its eminent biologist—T. W. Kirk—the words that he uses in describing its manufacture:—

"Bordeaux Mixture.—Sulphate of copper, 4 lb.; fresh lime, 4 lb.; water, 40 gallons. Dissolve the copper in, say, 5 gallons of water in a wooden vessel: the best way is to tie it in a loosely woven bag, and suspend the bag from a stick across the tub, or, if in a hurry, use hot water. Slake the lime in another vessel, and add it to the copper solution; stir well till thoroughly mixed, then add sufficient water to bring the whole up to 40 gallons. Now strain out any dirt. The addition of 3 lb. of treacle (molasses) makes the mixture more adhesive, and should be used if damp weather is feared." [*Note.*—In practice it is found convenient to have two 40-gallon casks, one of which is cut across the middle to make two vessels—one for the lime water, and the other for the blue-stone solution—and to mix these two fluids together in the cask that is intact, straining everything through a piece of bagging attached to a frame on its entering therein. The Bordeaux mixture should also be tested in order that when prepared no unaltered blue stone remains in it to injure foliage. It is "tested" by dropping into it a few drops of a solution of yellow prussiate of potash (potassium ferro-cyanide 10 per cent.). If more lime is required the "test" solution turns reddish-brown as soon as it comes in contact with the mixture. In such case more milk of lime is strained in until the brown colour ceases to appear. Then a little more milk of lime is added to ensure an adequate amount being present.—H. T.] "Apply (Mr. Kirk continues) with a proper spray pump with a cyclone or Bordeaux nozzle, first when the potatoes are between 6 in. and 9 in. high, and twice later at intervals of about ten days. Two sprayings are often sufficient, the second being given when the plants are in flower; but in bad seasons three are desirable. The under surface of the leaves should be specially sprayed, for it is there that the fungus is chiefly developed." [*Note.*—The germination of the *Phytophthora infestans* zoo-spore or spore takes place on the upper surface, and penetration of the leaf by the germ-tube is effected there also.—H. T.] "Repeat if necessary. . . . If there be reason to suspect the presence of insects, 4 oz. of Paris green may be made into a paste and stirred into the mixture. In the case of the second and third sprayings, and of crops already grown, where the foliage is toughened, the 6, 4, 40 formula (*i.e.,* 6 lb. blue stone, 4 lb. lime, and 40 gallons water) may be used with advantage. Should rain fall within three or four hours after spraying, it will, of course, be necessary to repeat the dressing as soon as possible. . . . It is very important to spray all potato crops which do not appear to have yet contracted the disease. Such spraying should be looked upon as an insurance policy. *Caution.*—See *that the blue stone is pure, and the lime quick lime, spray at once"* [on making the Bordeaux mixture.—H. T.], "*using not less than 75 gallons of mixture per acre. . . . If good fresh lime cannot be got, use 5 lb. of washing soda instead of 4 lb. of lime.*" [This makes what is styled soda Bordeaux or Burgundy mixture. It—it may be remarked—loses its power of adherence in twenty-four to forty-eight hours after it has been made, especially should the temperature be high (Gastine). It should, therefore, never be used unless freshly prepared.—H. T.]

11. To Prevent Infection of Tubers.—When a plot of potatoes is attacked, Delacroix, already referred to, recommends that shortly before harvesting the crop the tops be cut, heaped up, and burnt. For, he adds, at the end of two or three days the conidia (spores) will be all dead, and cannot reach the tubers. Instead of cutting them, and in so doing necessarily disturbing the spores all round, the writer recommends killing them and the parasite at the same time with sulphate of iron. (*Vid.* 6.)

The question as to whether it will be expedient to leave the tubers in the soil after the tops have already succumbed to the disease, pending the destruction of the spores by the dry atmosphere, will depend on circumstances. Should rain come on, or the soil be already moist, the tubers will in this event, where they have been suffered to remain, succumb to the disease, infection being brought about not only by spores and zoo-spores derived from the plant above ground, but by spawn-threads passing from tuber to tuber through the soil separating them.

The earthing-up process has already been referred to as a measure directed towards the preservation of the tubers in the ground from disease already affecting the tops.

12. To prevent the spread of the disease amongst the tubers that have been dug out:—It is usual to proclaim against the common procedure of covering potatoes as a protection from the sun with potato-haulms when disease has visited the crop. Certain experiments that have been carried out in Germany, however, suggest—what would appear improbable—that tuber infection is very little effected by this action.

"Great care (writes T. W. Kirk) should be exercised, when picking the potatoes, to place on one side and burn all those that show the slightest sign of the disease, for if diseased tubers are stored with healthy ones they will become rotten and useless."

When a potato has once become discoloured only through the action of the disease, no conditions usually realised in potato-storing will prevent its decay. Nor will dipping it in formalin solution or sprinkling it with lime hinder this—rather the reverse.

13. In order to ensure the fullest benefit from the spraying operation it is essential that it cover the entire leaf-surface, and that it remain adherent to it. Whenever the Bordeaux mixture be present thereon, the fact will be denoted by the occurrence of a bluish-green film. A single fungus spore being competent to produce a leaf-spot, and this in the course of a few days to give rise to myriads of other spores, and such leaf-spot being liable to develop on any part of the foliage—the younger and more tender leaves especially—not only will renewed spraying be required after rainfall generally, but also for application to those leaves that have arisen in course of ordinary growth since the last spraying operation was completed. Except with a lavish expenditure of material, and then only with little perfection, can the application be made without the use of a properly manufactured spray pump.

Many kinds of these appliances have been devised for this work; but under Queensland conditions, where small areas only are devoted to potato-growing, the Knapsack spray pump will be found in every way suitable. Under different circumstances other pumps of larger capacity and force may be more economically employed, attached to vehicles drawn through the fields by horse power, and having each several delivery tubes and nozzles, the pumping as well as the control of these being effected by ordinary labour, or the motive power to work the pump being derived from the wheels by special gearing, and the nozzles adjusted to the height and distance apart of the rows of potato plants. It has, however, been found in practice that the ordinary Knapsack pump does the best work.

The larger machines, of which there are several models, may be used by handy men contracting to undertake the work of spraying for more than one farmer.

14. The Bordeaux mixture (and the same remark applies to the soda Bordeaux), if properly made, is not injurious to the potato plant in any way. Not only so, it is claimed for it that it improves the tuber itself, endowing it with a larger amount of starch than is possessed by unsprayed potatoes, even when these are not visited by *Phytophthora infestans*. Thus it has been asserted of its application that the cost of this is met by the improvement of crop. At any rate, where the disease is endemic the outlay for spraying must be regarded as a necessary addition to the cost of cultural operations that has to be incurred.

15. Spray pumps are obtainable from Messrs. Smellie and Co., Edward street, Brisbane; and from Messrs. Perry Bros., Queen street, Brisbane. They should be made of copper, and the valves—that are liable to perish when of rubber—should be metal valves, unless—if not of metal—several spare ones can be supplied. The former firm stock an excellent Knapsack spray pump named "Gould" that costs £4: the latter, the well-known "Figaro" that costs £2 15s. and does not possess the metal valves of the former; other pumps can be supplied by either of them. Sulphate of copper (bluestone) is procurable from Messrs. Taylor and Colledge, Charlotte street, Brisbane; Elliott Bros., Eagle street, Brisbane; and Thomason, Chater, Limited, William street, Brisbane. The price varies from 30s. to 32s. per cwt. In ordering this chemical it should be stipulated that it be iron-free and wholly soluble in ammonia. Sulphuric acid supplied by the first two of the foregoing firms costs from 2½d. to 3d. per lb.

16. In conclusion, farmers will do well on observing disease in their potato crops to notify the Department of Agriculture at once, and accompany by specimens whatever intimation they may make, to illustrate their statements. In this first instance of an outbreak of *Phytophthora infestans* disease in Queensland, scores of farmers have suffered loss through its visitation. Only two of them and one farmers' association, however, deemed it worth their while to bring the occurrence under notice; and then not until their crop was entirely ruined. Under these circumstances, its permanent presence in the State may be predicted with some confidence.

Note.—Horse-power Sprayers, and Potato Sprayers worked from a cart, are stocked by Langwill Bros. and Davies, 1 Queen street, Melbourne.

OTHER POTATO DISEASES.

Other affections may be confounded with *Phytophthora infestans,* and in certain instances Nos. 1 and 5 may coexist with it, *e.g.*—

1. Black Spot of Foliage (*Alternaria solani,* and *Macrosporium solani*). Markings darker coloured, better defined with raised waved lines. May destroy entire foliage of a crop. Tubers not directly affected.

2. Brown Rot, Tryon's Potato Disease, Bacteriosis. Sudden wilting of foliage. Brown discolouration along line of vessels (the "ring") on section of tuber with issue of droplets of gum. Ultimate speedy decay.

3. Dry Rot (*Fusarium spp.*). Foliage wilting and discolouration of "ring" as initial symptom also. No decay of tuber, or, if so, rarely.

4. Brown patches isolated within tubers (physiological).

5. Rhizoctonia disease. Stems with small tubers, young shoots from tubers "ring-barked": Skin of potato brown, cracked, and dead. Small black raised bodies on surface on wetting it. Tubers mummified and cracking on storing.

12-7-09. H. T.