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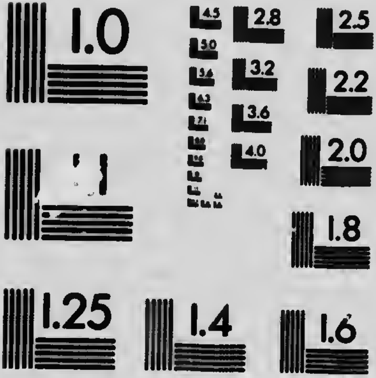

BULLETIN 136 Aug. '04 Au

Ontario Agricultural College and Experime

SOME BACTERIAL DISEASES OF PLANTS PREVALENT IN ONTARIO.

12 Illustrations (Figs. 3-12 original F. C. H.)

FIRE BLIGHT.

"That species of blight which is sometimes called the 'fire blight, frequently destroys trees in the fullest apparent vigor and health, in

Fig. 1.—A pear orchard badly infected with Fire Blight.

a few hours turning the leaves suddenly brown, as if they had passed through a hot flame and causing a morbid matter to exude from the pores of the bark of a black *ferruginous* appearance; this happens throughout the whole course of the warm season—more frequently in weather both hot and moist." So wrote William Coxe in a book on the "Cultivation of Fruit Trees," published in 1817, which is said to be the oldest American book on fruit culture.

Nearly forty years before this we have a record of the disease mentioned in a letter written by one William Denning, who first saw the disease in the Highlands of the Hudson, in 1770. He described the disease fairly well, and thought it was due to a borer in the trunk of the tree.

From 1817 to almost the present time, we find in horticultural literature many theories as to the cause of the blight. It would be tedious to give an account of all the different theories put forward by various writers during this period. The most diverse views were entertained as to the cause of the disease, and it was a constant topic for discussion in the horticultural journals and societies. These discussions were so wearisome and so barren of results that the Western New York Society resolved that the subject should not be discussed at their meetings unless some one had something entirely new concerning the disease to communicate.

Amongst the different theories put forward to explain the cause of pear blight, we may mention the following:

1. Insects.
2. Rays of the sun passing through vapors.
3. Poor or deleterious soil.
4. Violent changes of the temperature of the air or the moisture in the soil.
5. Sudden change from sod to high tillage resulting in surfeit or overplus of sap.
6. The effects of age; old varieties being most subject to it.
7. Autumn freezing of unripe wood, which engendered a poison which destroyed the shoots and branches in the following season.
8. Electricity, or atmospheric influence.
9. Freezing of the sap, or freezing of the bark.
10. The heat of the sun assisted by rain-drops acting as lenses causing the scalding of the sap and bursting of the cells.
11. Fermentation of the sap.
12. The absence of certain mineral matters in the soil.
13. An epidemic transmitted from place to place by the air.
14. Fungi.

Each of the above theories was sustained by various writers, and it may be of interest to note that Henry Ward Beecher was an advocate of the theory that the cause of blight was due to the autumn freezing of unripe wood.

A. J. Downing, the distinguished author of "Fruits and Fruit Trees of America," applied the name "Frozen-sap blight" to the disease. His theory was that the disease was due to the freezing and thawing of sap. The sap thus lost its vitality, became dark and discolored and poisonous to the plant.

Thomas Meehan, editor of the "Gardeners' Monthly," supported the idea that fungi were the cause of the disease; but no tests were applied to prove that the inoculation of these fungi into healthy trees would cause the disease. It was not until the year 1878, when W. T. Burrill, Professor of Botany in the University of Illinois, announced to the Horticultural Society of that State the discovery of bacteria, apparently connected with the disease. Burrill also proved that the disease was infectious, and could be communicated to healthy limbs by inoculation, using the gummy exudation from an affected tree as a virus. Not only was he able to produce the disease in pears, but also in apples and quinces. Dr. J. C. Arthur, Botanist of the New York Experimental Station, subsequently confirmed Prof. Burrill's results, and thoroughly established the fact that a certain species of micro-organism, named by the discoverer *Bacterium amylovorum* or the starch destroying bacterium, was the sole cause of the disease.

Geographical Distribution. This disease is peculiar to North America. So far it has never been recognized in Europe. Professor Budd, of Iowa, who is familiar with the disease as it occurs in North America, has inspected the orchards of Europe and states that no [illegible] of fire blight of pear or apple trees can be seen in Europe. It is [illegible] unknown in New Zealand and Australia. In North America, the blight extends from New York to California and from the northern counties of Ontario to Texas.

Dr. Beadle, in a sketch of the history of the disease in Ontario, states that, "In the early days of fruit-growing in the Niagara district we had no pear tree blight nor apple tree blight. With the advent of what people termed grafted fruit there came, after a few years, 'blight' on the pear tree." "By the year 1840 it had spread considerably." N. J. Clinton, of Essex County; S. Hunter, of Oxford; E. D. Smith, of Wentworth; Stone and Wellington, of Welland; R. Hamilton, of Argenteuil, reported its presence in their respective counties about 35 years ago. The colder parts of the Province have suffered as severely from the disease as the more favoured districts. The orchard of the Dominion Experimental Farm, at Ottawa, has been attacked, and the 140 Russian variety of apples cultivated there have suffered severely. In warmer districts, however, the disease has been much more severe. Whole orchards have been completely destroyed in the State of Texas, and certain pear-growing districts in that State have been practically ruined by this parasite.

Losses. No statistics are available to give us an idea as to the amount of loss to fruit growers from pear blight, but a few references to losses by this destructive disease will help to give us an appreciation of the subject. Coxe, in 1817, reported that he had lost upwards of fifty trees in twenty years. In the years 1826, 1832, and 1844 there was an increased prevalence of the disease, and few pear orchards escaped without partial or total loss of many trees and some orchards were quite destroyed. Downing called it the "monstrous malady of the pear." Lyons stated, as the opinion of many cultivators in the State of Michigan, that "The pear tree cannot be grown with financial success on account of the blight." Hallam, in 1882, reported that, "In Southern Illinois, pears have failed—utterly failed—so that none are now cultivated for market. The blight has destroyed the trees branch and root;" while A. Noice of the same State, doubted "if one-tenth of the pear trees that are planted lived ten years on account of this destructive agent." E. H. S. Dart stated that the severities of winter were not so much to be dreaded as the ravages of blight. He had in 1874 one to two thousand trees affected. Dr. P. A. Jewell, in 1876, lost 10,000 Tetofsky apple trees by it. Bailey, of Cornell declared that fire blight was undoubtedly the most serious disease with which the quince grower had to contend. It is the same disease which is so destructive to pear orchards in certain years and to certain varieties of apples, particularly the crabs. Selby, of Ohio, reported that the disease ranks among the most destructive known to the orchardist in his State. Chester, of Delaware, announced that pear blight was of unusual severity during the season of 1901 and caused much alarm because of its rapid spread through the orchards of the State. In 1895 its ravages were most severe on apple trees in the vicinity of Hamilton and Burlington Bay. J. Craig gathered information as to the character of injury of the disease from fruit growers throughout this Province and a number of these state that the injury was very severe.

These citations are enough to show that the disease is of special economic importance and greatly dreaded by many fruit growers.

Symptoms. The first indication of fire blight is seen either in the browning and subsequent blackening of the leaves or of the young twigs or of the tender shoots. When the twigs or shoots are the principal parts affected the disease is spoken of as twig blight. Pears show the presence of the disease more frequently by the blighting and blackening of the leafy tufts of the spurs, and show it especially by th darkening of the blossom clusters on the larger clusters, while, later, the branches themselves become blackened The progress of the disease is always downward—an inch or more each day, depending upon the season, until the larger branches are infected. In the more susceptible varieties it spreads more quickly, involving the whole tree; but in the more resistant varieties the progress of the disease is not so fast. When the disease is active the bark of the diseased branches cracks, and a thick, blackish, gummy fluid exudes, and later the infected bark becomes hardened, dry and shrunken. The disease occasionally appears on the larger branches and trunks of fruit trees when these have been bruised or otherwise injured, when its appearance is similiar to the injury known as "sun-burn" or "sun-scald." This disease of the trunks or larger branches is sometimes spoken of as "body blight" or "rough bark." The inner bark and cambium layer of the limbs and trunk are the most important parts of the tree killed by the blight. Instances are known of its attacking the fruit, producing watery ulcers accompanied by brown discoloration and decay. The disease may be known by its peculia dor, said by some writers to resemble putrefaction.

. a the disease is in progress, the discolored blighted portion blends gradually into the color of the normal bark, but when the disease has stopped there is a sharp line of demarcation between the diseased and healthy portions. (Waite).

Microscopic Appearance of the Diseased Tissues. The most conspicuous change in the tissues affected with the blight is the disappearance of the stored starch, and on account of this peculiarity the organism has been named the "starch destroying bacillus" (*Bacterium ɩ nylovorum*). The germ penetrates from one cell to another and produces a gummy or mucilaginous matter which is found on the exterior of the affected parts. The microbe is found, as a rule, only in the inner bark and the actively growing tissues (called the cambium, which produces wood on the inner side and bark on the outer side). The organism is unable to grow when the tissues are lignified or woody.

Life History of the Pear Blight Germ. The organism which produces the disease is a small motile bacillus, which increases with great rapidity in the succulent parts of affected trees. (Fig. 4). The microbe is of microscopic size, so small that 25,000 placed end to end would only measure an inch. They are able to live and multiply in the nectar of the blossoms, from whence they are carried to other flowers by bees and insects which visit the blossoms for honey and pollen. From this locality the germs extend into the tissues and then downward into the branches by way of the inner bark, girdling the limbs and causing a large amount of damage. The blight germ also gains entrance to the plant through the tips of growing shoots, thus producing twig blight. The organism is not killed by the winter frosts, but lives in the bark in a dormant condition until spring. As soon as the plant tissues become gorged with sap in the spring the microbes, which have remained alive all through the winter, start to grow and extend into the new bark. This new blight which develops in the spring can be recognized by its moist and fresh appearance from the blighted, dead and dried bark of the previous summer. A large amount of gum is exuded from the affected bark, and runs down the tree and attracts to it bees and other insects, which carry the microbes to the early blossoms, and from these first flowers it is carried to others, and thus the disease extends.

The germ has never been discovered in the soil, although careful search has been made; hence the importance of recognizing the winter form of the disease, for if these affected portions of the tree are cut out and destroyed, the pear blight question is solved, for without the microbes there can be no disease.

Conditions Affecting the Spread of the Disease. Fire blight differs in severity in different localities, and there are a number of conditions which affect the character and progress of the disease.

Every tree of the pome family is subject to the blight, but pears and quinces are more susceptible than plums and apples. The mountain ash, service berry and hawthorn are frequently diseased, but not to such an extent as the first named trees. There is a difference in the susceptibility of varieties. Thus, among pears, Clapp's Favorite, Flemish Beauty, and Bartlett are more liable to the disease than Keiffer and Duchess, and amongst apples, the Crab varieties are the least resistant.

Fig. 2a.—Showing the result of inoculating a terminal shoot with a pure culture of the Fire Blight organism by puncture at the point *a*.

Fig. 2b.—Showing the blighting of a terminal shoot by inoculation of the terminal bud with a pure culture of the Fire Blight organism. (After Chester).

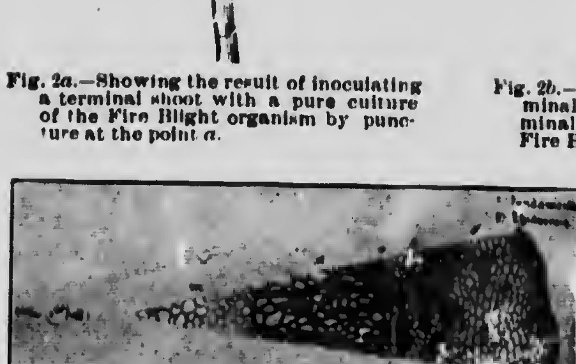

Fig. 3.—Cross section of a one and two year old stem. Fire blight bacteria grow in the cambium (c) and inner bark (F). E—epidermis. Co—Corky layer, B—Bast fibres, P—Parenchyma, C—Cambium. X—Xylem or woody tissue. M—Medulla or pith.

Fig. 4.—Fire Blight bacteria (B. amylovorum.) x2000.

Climatic conditions influence the disease; warm, moist weather with much rain favour it, whilst bright, dry, sunny weather tends to check it.

High cultivation, rich soil, heavy manuring, free use of fertilizers, heavy pruning, or any other treatment which has a tendency to induce new and succulent growth, favors the disease, as the bacteria grow with far greater rapidity and penetrate more quickly from cell to cell when the tissues are gorged with sap. Insects are more partial to young succulent shoots and leaves, and the bites and punctures of such insects whose mouth parts may be contaminated with pear blight germs often serve to infect the tree.

It is thus manifest that healthy, thrifty, vigorous, well fed and well cultivated trees are more liable to the disease than others, and hence the severity of an attack of fire blight may be lessened by conditions which are under the control of the grower.

Treatment. The treatment of fire blight is of two kinds—that which is designed to put the tree in a condition to withstand the attack of the blight microbe, and those methods which aim at the extermination of the causal bacterium. Unfortunately all methods which are used for hindering the attack of the microbe consist of restraining the full development of the tree, and hence any such system of procedure should not be followed unless an orchard is very badly attacked.

High cultivation with pruning and the other conditions already mentioned as predisposing trees to blight should be avoided, but the trees should be allowed to ripen the wood, and in order to do this the fruit grower must use any method which will check the amount of moisture in the soil—for instance, by the growth of a clover crop.

The fire blight organism cannot be exterminated by spraying, as the microbe lives in the tissues beneath the outer bark, and it is impossible to reach it with any spraying solution, for, unless the bacteria come into contact with the germicide, spraying is ineffectual.

There is, therefore, but one remedy, to cut out and burn the affected parts of the tree. It is very necessary when cutting out a diseased branch or twig to cut well below the discolored portion, as the bacteria are in most cases far below the discolored portion, the discoloration not being produced immediately upon the appearance of a few bacteria, so that if only the discolored portion were cut off numbers of bacteria would still be left in the stump, and these would continue to multiply, and the disease would soon be evident again.

Cutting of affected parts may be done at any time in the winter and spring, but it is not advisable to cut in the growing season, as fresh cases may be constantly occurring, and these, owing to lack of sufficient development, would not be seen.

The best time for cutting out affected branches is towards the fall, or when the trees have stopped forming new wood, when most of the blight has developed, and when the contrast between the discolored leaves and branches and healthy tissues is easily seen

Trees should be carefully inspected for blight during the winter, and in spring before the blossoms come out, in order to destroy any affected parts that may have been missed at previous inspection.

All trees of the pome family in the vicinity should be examined as well, as these, if blighted, may serve to reinfect an orchard which has been carefully treated.

In cases where the bark of the trunk is affected, it can be cut out and the wound covered with a lead and oil paint. The cut surface of the branches over one-half inch in diameter should also be painted.

A BACTERIAL DISEASE OF BEANS.

Lima beans are not grown commercially in Ontario. Wax beans are grown in gardens and for canning. Field beans are grown extensively in the lake counties of Essex, Kent and Elgin, Blenheim and Ridgetown being centres of the bean industry.

A bacterial disease of beans is causing loss and injury in nearby bean-growing sections of the United States, from New Jersey to Michigan, and it is probable that it occurs in this Province. We have made some study of the disease under field conditions in Michigan and in our laboratory at the College.

The disease usually begins at the margin of the leaf, or where the leaf has been injured or torn by insects, wind, or hail. Here a yellow spot appears, and the green of the leaf is destroyed. The spot increases rather slowly, and the diseased tissues become brown, especially the minute veins, which become almost black.

This diseased part of the blade turns dry and brittle in the sun, and soft in the rain, and it may be broken away, leaving ragged holes and torn margins. The whole leaf may die and fall to the ground or remain withered on the stem. The disease enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to the young pods. In severe cases the pod may wilt and die, and, on opening it, the half-grown seeds will be found shrivelled and discolored. Most of the affected pods, however, reach full size, and the beans may be apparently sound or only slightly discolored at the seed scar, or they may be much discolored. The whole plant does not usually die outright, but lingers through the season

If we tear out a bit of tissue from a diseased spot in the leaf, crush it on clean glass, and examine it under the microscope, we shall find bacteria in very great numbers; they are so numerous that the diseased tissue seems to be a mass of bacteria, and all apparently of one kind—small, short rods, single, or joined end to end in twos. This germ, and the disease caused by it, were first described by Erwin Smith, and the name given to it is *Pseudomonas phaseoli*.

Fig. 5.—The bean plant inoculated with the bacillus which causes the disease. Showing the wilted leaves.

With proper care, we may tear open a stem, take a bit of diseased tissue, crush it in melted gelatin; and pour the whole into glass dishes. Here, the gelatin becomes solid, holding each germ apart from others, where it grows and multiplies, and in four days small, round, yellow spots or colonies appear. On examination these colonies are found to consist of bacteria like those in the diseased plant. We can now transplant a colony to various media and observe its growth in pure culture. By such methods, we have repeatedly got pure cultures from leaf, stem, pod and seed. The bacteria have been obtained alive from the seed coats of beans kept in the dry pods or in sterile test tubes over winter, and the same seeds have then germinated and grown.

During the past winter, we have inoculated more than twenty bean plants growing in pots in the laboratory. The surface to be inoculated was touched with a hot platinum needle and then punctured with a sharp, sterile platinum needle. The needle was then touched into a pure culture of bacteria from the diseased beans and thrust again into the puncture. The puncture was closed and sealed with a loop of sterile, melted paraffin. Other punctures were made and covered in the same way but no bacteria were introduced. Every inoculated plant sickened and the same symptoms developed as were observed in the diseased plants in the field. Numerous check plants remained healthy. Plants inoculated in the stem showed symptoms after two or three weeks. At first, there is a yellow discoloration, spreading slowly from the point of inoculation. As the disease progresses, it enters the leaf by way of the leaf stalk and kills it. Finally, the whole plant may be killed or it may linger alive for months.

Fig. 6.—The bean plant inoculated with the bacillus which causes the disease. Showing the wilted leaves.

The leaf may be inoculated by puncturing the veins, but a better way is to inoculate in the petiolules, or short stalks of the individual leaflets. The disease most affects the woody bundles of leaf and stem, and all the woody bundles of the leaflet converge in the petiolule. A puncture in the petiolule causes no lasting injury but soon heals if no bacteria are introduced.

The needle, which should be fine and sharp, is thrust into the petiolule from its upper end downward. Each of the three petiolules is thus punctured and the culture is then introduced into one or more of the punctures and all are closed with sterile, melted paraffin.

Some time will pass before any symptoms appear. In about three weeks, the inoculated leaflet droops on its stalk and wilts in the sunshine, but apparently recovers at night. There is a yellowing at the base of the blade; this spreads rapidly, following the veins. The affected tissues wilt, and the veins become dark brown. Within five days from the appearance of the first symptoms, the leaflet is dead and dry.

During this time, the leaflets of the same leaf which were punctured but not inoculated remain healthy, and it is nine or ten days, on the average, before the disease reaches them. In a few days more, these leaflets also are dead. The disease now travels down the main leaf stalk and enters the stem, where it progresses slowly from node to node, killing the leaves and finally it may kill the whole plant.

All inoculated plants developed the characteristic symptoms of the disease, and all were, at some period, examined for bacteria. The characteristic bacteria were found in every instance, and in all parts examined which showed the symptoms. Numerous check plants, kept under the same conditions, but not inoculated, showed no symptoms of the disease, but remained healthy and, on examination, no bacteria could be found in their tissues. Plate cultures from the diseased tissues of inoculated plants developed uniform pure cultures of the germ inoculated into them. Sections of the inoculated plants showed characteristic bacteria present within the cells and especially numerous within the woody bundles; the vessels being choked with them and the cell walls frequently dissolved.

Prevention.

No remedy is known for the disease after the symptoms once appear in the plant. Measures may be suggested, however, to prevent its introduction and spread. Seed containing the bacteria must not be planted. Such seed may be much discolored, may show slight evidence of infection, and for this reason seeds from fields where the bean plants have shown symptoms of the disease should not be planted, even though such seed has been carefully picked over and all discolored beans removed from it. This precaution in the selection of healthy seeds applies with special force to the planting of new fields where beans have not been grown. It is hoped that a method of treating the seed may be worked out, by which the bacteria may be surely killed without injury to the seed. This germ, *Pseudomonas phaseoli*, forms no spores and is readily killed in water heated to only 122° F., for ten minutes, a temperature which dry bean seed can endure for some time without injury. It is readily killed, also, by a solution of mercuric chloride, one part to 1,000 of water.

A field where beans have sickened with this disease is unfit for growing beans for at least one season, as the germs live over at least one winter in the stems and leaves left on the ground. How long such a field may remain infected is unknown, for we do not yet know whether the germs can live and increase in the soil where no beans are growing, although this is probable.

Bean straw from infected fields may be burned. If it is fed to animals or used as bedding, the manure should be returned to the field on which the beans grew, and not spread on fields as yet free from the disease.

This Department will continue its work with the disease, and we hope to make a survey of the commercial bean-growing areas of the Province about the time of bean harvest this season. We shall be glad, at any rate, to examine diseased bean plants and seeds intended for planting.

SOFT ROT OF WHITE TURNIPS, CAULIFLOWERS, CABBAGES, ETC.

During the last few years we have examined a number of the soft rots, caused by several different kinds of microbes. In one case we made a special study of the causal organism, which proved to be a new species. Considerable study was devoted to a rot of Swedes which has caused much loss to farmers in different districts of the Province. We also found that one of the causes of a soft rot of celery was due to a common soil organism which heretofore had not been found able to produce disease in plants.

The soft rot of white turnips, cauliflowers, etc., has been rather common during the last few years. In 1901 much damage was done to market gardens in the vicinity of Guelph, and wherever white turnips were grown there was considerable rot during the season of 1901.

Cause. This soft rot is caused by a microbe—a bacillus or rod-like organism (scientific name, *Bacillus oleraceae*) which increases very rapidly when once it has gained admission to the plant. It secretes a substance which has the power or property of dissolving the cell wall of the plant. The cells are thus separated from one another, break down, and a soft, pulpy mass is the result. From this action of the microbes, the common name "Soft Rot" has originated.

Symptoms. The character of the rot is similar in all plants that are attacked. In the cauliflower, the head or edible part breaks down into a soft pulpy mass, brown to black in color, usually with an objectionable smell. Cabbages behave in a similar manner. In turnips, the globular root is the portion of the plant that shows the most decay. The rot is brown in color, very soft, and with a dis-

Fig. 7.—*B. oleraceae.* The flagella stained by Van Ermegen's method. The bacteria were taken from an agar culture 18 hours old.

Fig. 8.—A healthy cauliflower plant; inoculated and grown under the same conditions as the inoculated plants.

Fig. 9.—Cauliflower plant inoculated by placing a piece of softened tissue, taken from the interior of an affected inoculated petiole, on the surface of the healthy flower. The flower is reduced to a pulpy, black mass. Five days from time of inoculation.

agreeable odor. The turnip leaves have a wilted appearance, owing to the fact that their supply of nourishment is cut off.

Fig. 10.—A white turnip plant inoculated at the crown from a pure culture of *B. oleraceae* by means of two needle punctures. The photograph shows the plant nine days after inoculation.

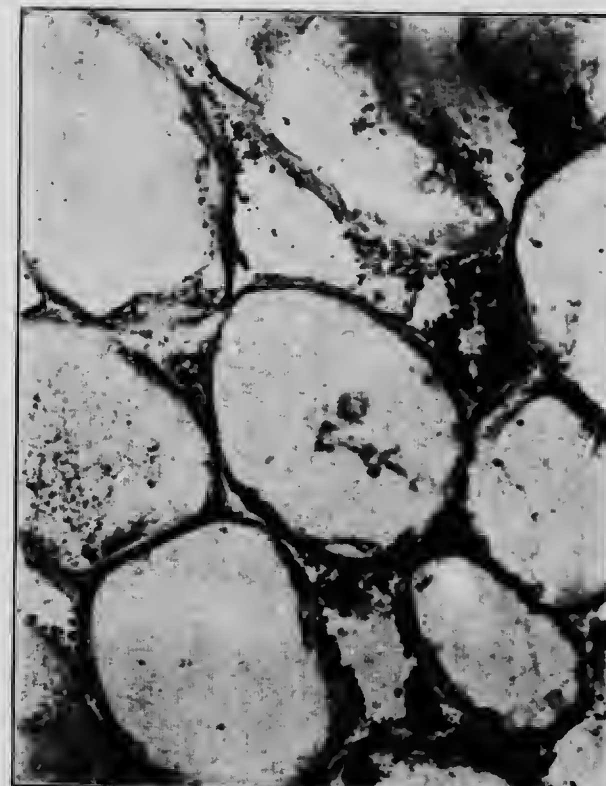

Fig 11.—Cross section of part of the petiole of a diseased cauliflower inoculated with a pure culture of *B. oleraceae*. Note the bacteria in the intercellular spaces and their penetration along the middle lamella.

Conditions Affecting the Spread of the Disease.

1. *Meteorological Conditions.* Warm weather, combined with excessive moisture both of the soil and of the atmosphere, and the fact that transpiration is checked by this condition, undoubtedly play an important part in the spread of the rot amongst cauliflowers and turnips. Those seasons which are warmer and moister than the average predispose plants to rotting.

2. *Rankness of Growth.* The weather conditions above mentioned, and the plentiful use of manure by market gardeners and good cultivation, favor very quick, rank growth. The plants most affected are large and heavy, with many leaves shading the surrounding soil, thus conserving moisture and promoting quick growth.

3. *Abundance of Insect Pests.* The disease is chiefly spread by means of infection by wounds, and under field conditions these are usually produced by insects, especially the cabbage worm and turnip beetle. A careful examination of very many plants show that one or more insects are present on each plant. Slugs also do considerable damage. Ants and other insects swarm around turnips, eat the rotting pulp and no doubt serve to carry the germs to other plants.

4. *Injury from Planting, Cultivation, or Wounds.* Leaves of turnips are frequently bruised or injured during cultivation by either hand or horse hoes. Cauliflowers may be injured during planting out and the infecting organism brought into contact with the broken surface. In cases of very rank growth, heavy wind accompanied by rain may cause leaves to be broken off and thus afford bacteria a chance to penetrate into the plant tissues. Many gardeners trim their cauliflowers on the field, and when these are infected they carry the disease on to another season. The same ground is often used, year after year, for the same crops, a dangerous procedure when disease is present, as it is likely to carry over the trouble to other years.

5. *Susceptibility of Varieties.* Some varieties of turnips rot far more easily than others. Thus, the Yellow Aberdeen Green Top, the Yellow Globe. All Gold, etc., are usually far more rotted than a number of other varieties.

Prevention.

It is impossible to spray with any of the ordinary fungicides for this disease as the organism is in the interior of the plant, and the spray is only effective when it is actually brought into contact with the organism; hence spraying is of no use, and efforts are therefore to be directed towards prevention rather than cure. The following methods will serve to check the disease :

1. The use of rotation by which other crops are grown on infected soil for a number of years.

2. Control of insect pests as these serve to spread the disease.

3. In the case of cauliflowers and white turnips, destined for immediate consumption, early harvesting of the crop is recommended, as the disease is worse when the plants are approaching maturity.

4. In cases where the turnips are stored they should be placed in a well-ventilated and dry cellar in which the temperature can be controlled. The minimum temperature for growth of the germ is about 45° ; hence if the cellar can be cooled to this temperature no rot will take place.

5. The planting of immune varieties. There are a number of varieties which do not seem subject to the rot, thus the Jersey Navet is almost immune and, ander field conditions, the following varieties show less than 5 per cent. of rot : Greystone Improved, Purple Top Mammoth, Early American Purple Top, White Egg, White Lily, Red Top.

SOFT ROT OF SWEDE OR YELLOW TURNIPS.

This disease of Swedes has been observed in the Province for a number of years. In the year 1896, considerable damage was done to the turnip crop before the time of harvesting by soft rot. In many cases the turnips which had been culled out as unfit for storage were left out in the field and were ploughed down in future cultivation, and thus the soil was infected. The turnip crop of 1902 was also infected with rot. Many farmers estimated their loss that season at about one-third of the entire crop. The disease was particularly bad in the London district.

Cause. This rot is also caused by a microbe which has a similar action on the plant to the organism already described as being the cause of the soft rot of white turnips.

Symptoms. Growing Swedes affected with the rot are usually distinguished from the sound turnips by the appearance of the leaves. At first the lower leaves become flabby and have a dull green color which gradually changes to a yellow shade as the leaves dry. The lower leaves appear to be the first affected, and the growth continues in the upper or middle leaves as the lower ones drop off, thus producing what is commonly called "necky turnips." The plant by this time is badly dwarfed and the top nearly dead except for two or three stunted, small leaves in the centre of the top. A softening of the tissue of the turnip now appears around the crown of the plant, which continues to increase until the whole turnip becomes a soft spongy mass with a disagreeable odor. The odor is caused by the decomposition of the tissues and the formation of aromatic compounds.

Conditions Affecting the Spread of the Disease.

The seasons in which this disease was bad were cooler than our usual summer weather,and the amount of rainfall was in excess of the usual amount. In the month of October, 1902, there was a heavy rainfall which probably extended the growing season of the turnip; and the unripe and damp condition of the turnips when harvested, together with the warm weather which followed the storing of the turnips, proved very favorable for the development of the disease.

Fig. 12.—Swede Turnip affected with soft rot.

Other conditions affecting the spread of the disease are the same as those mentioned above.

Prevention.

If roots are properly ripened and cured they are not so liable to the rot when stored as are the roots which are either unripe or improperly cured, or both. When roots are taken from the field in a wet condition and directly stored in the cellar more rot is liable to be found. The temperature after the crop is stored has also a considerable effect upon the growth of the rot if it should happen to be present in the roots and a great deal of rot in stored roots would be avoided if the cellars in which the roots were stored were properly ventilated.

If the cellar adjoins the stable, a great deal of dampness gets into the cellar from the moisture from the cattle stable. This not only adds moisture to the air of the cellar but also raises the temperature.

Affected turnips should not be left out on fields to spread the disease to a following season; but should be gathered and burned, and in the same way the roots in which the rot develops after harvesting should be burned and not thrown upon the manure heap to infect the manure first and then the field to which the manure is applied.

The harvesting of the root crop should be delayed as late as possible in order to allow the crop to become thoroughly ripened. After pulling, the roots should be allowed to dry off before being stored.

A ROT OF STORED CELERY.

Celery may be dug in the fall and stored in a cellar to be used during winter and spring. It is usual to pack it closely, with the roots in soil which is kept moist. With right conditions of moisture and temperature the celery keeps well until spring, but, if the soil is wet, and the temperature varies, and, especially, if the celery freezes and thaws, it will decay.

Decay follows close upon death. The bacteria and moulds are its active agents. They are always present in the soil in which the celery grows, and in the soil in which the roots are packed, and there are no practicable means by which they can be kept away from the plant; neither can they be killed without killing the plant. It remains then to keep the celery alive and in health so that it can resist the invasion of the bacteria. A constant temperature, a little above freezing, keeps the celery alive without growing, and keeps the bacteria in check, for they also become dormant at low temperatures, and increases slowly, or not at all. If the celery freezes it becomes so much dead matter without resistance, fit food for bacteria, and, as soon as the temperature rises, the celery rots.

This was observed in some celery stored in the cellar of the Horticultural department of the Ontario Agricultural College during the winter of 1903-4. The celery tops showed signs of having been frozen, but, as the temperature continued low, it remained sound within, the outer leaves and stalks only showing signs of decay. On staining the decayed tissue, bacteria were found in large numbers, and, on making plates from the inner parts of the decayed stems, many colonies developed. The plates were usually pure cultures, or almost pure cultures, of *Ps. fluorescens*, and two varieties of it were recognized. This is a rod-shaped organism, and is one of the commonest microbes found in water and soil; it is not usually associated with plant diseases. Two varieties of the germ were recognized, one from stems becoming brownish to amber in color in rotting, and the other from stems showing a greenish-blue color in rotting. Both varieties liquefy gelatin with green-yellow fluorescene. Some fresh plants of celery were obtained, and the outer leaves were cut away. The inner leaves were washed under the tap, and covered with mercuric chloride solution, one part to a thousand of water, then rinsed in sterile water and each stem put into a large sterile test tube containing a little sterile water in the bottom. In three weeks, four out of fourteen stems so prepared showed signs of rotting, but some remained sound after a month, and were then inoculated with pure cultures originally isolated from the celery. Some of these stems in test tubes had been standing in the sunshine and had regained their green color. To inoculate them a sterile platinum needle was dipped into the pure culture and thrust into the stem. After one day at room temperature the rot was sometimes evident, and, in about four days, juice from the rotting stem had accumulated in the bottom of the test tube, and the stem was softened throughout so that it could be shaken down into a soft pulp in the bottom of the test tube. Plates from such inoculated and rotted stems developed colonies of *Ps. fluorescens* in pure cultures.

While the weather continued cold the celery in the cellar remained sound, although it developed a sweet taste; but, when warm weather came in early spring, what had not been consumed, rotted.

By such study we learn that bacteria cause decay, and that decay takes place under conditions in some measures known to us and under our control. To keep celery well it should be packed with the roots in clean soil. For this purpose it is best to use the humus, or muck soil, in which the celery is commonly grown. The soil in which the roots are packed should be kept moist, but not wet, with good water. The cellar or storage room should be kept at a uniform low temperature, a little above freezing. Free ventilation should be provided, both as a means of regulating the temperature and for the health of the plants. It should be remembered, also, that celery kept in a close, foul atmosphere becomes tainted.