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BLIGHT AND OTHER PLANT DISEASES.

Approved by the Station Council,
ALSTON ELLIS, President.

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THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO.

BLIGHT AND OTHER PLANT DISEASES.

BY C. S. CRANDALL.

BLIGHT OF APPLE AND PEAR TREES.

Discussion of the disease known as blight is approached with some trepidation, and is only undertaken in response to what seems to be a growing demand from fruit growers for information concerning the disease. It has been present in the state for ten years, but never before have letters of inquiry and appeals for aid been so numerous as during the past summer.

It should be remarked at the outset that I have nothing new to offer regarding the disease or its treatment, but shall simply attempt to bring together the main historical facts, and epitomize the work that has been done by those who have given the disease exhaustive study.

Pear-blight, apple-blight, fire-blight, twig-blight are all names for the same disease; a disease which has proven the most destructive of any of the plant maladies with which the horticulturist has ever had to deal. It is not a new disease; it has been known and dreaded for at least a hundred years. The early horticultural journals abound in articles on the subject, and horticultural societies, ever since their inception, have found it a constant subject for discussion. But writing about it and discussing it failed to eliminate the disease or to make plain its cause. Discussion became so barren of results that the Western New York Society resolved that the subject should not be broached unless some one had something entirely new concerning the disease to communicate.

As with all phenomena arising from causes unknown and therefore mysterious, pear-blight offered abundant opportunity for the theorist. Theory after theory was put forth; some based upon the observations of practical men, and some on pure conceptions of the mind. Every theory as to the cause prescribed a remedy based upon the theory. These remedies were put to trial and reported on; reports varied. Two men would report the use of a remedy under similar circumstances; one with favorable results, the other with adverse results. The next season the same men using the same remedy in the same way would reverse their reports. Success one year would be counterbalanced by failure the next, and the remedy would be laid aside as useless.

Many of the successes with various remedies as reported in the older journals, we can now see were simply successes reasoned from negative results. A man has a tree affected with blight, he cuts off the blighted limbs, applies a wash of copperas over the tree, the blight progresses no further, and he reports a cure effected by washing with copperas. His experiment is worthless; had he allowed the blighted branches to remain on the tree, and applied the copperas, with an arrest of the disease as a result, then his report would have been warranted. But as he reported, might not his accredited cure have been due to the complete removal of the disease with the infested branches which he cut off? And just so with a great number of experiments tried with other remedies. They were of no value because conclusions were hastily drawn from only a part of the attending circumstances.

THEORETICAL CAUSES.

Among the numerous assigned causes of pear-blight I may mention the following. 1–Electricity and atmostpheric influences. 2–A stroke of the sun. 3–Old age, or a long duration of varieties. 4–A sudden freezing of the bark. 5–The freezing of the roots wherby absorption is prevented, and, the supply of moisture being cut off, the evaporation from the branches caused blight. 6–Too high culture. 7–The absence of certain mineral matters in the soil. 8–Insects. 9–Fungi. 10–An epidemic transmitted from place to place by the air.

Each of the above theoretical causes had a following, but most of them were entertained for a brief period only, because observed facts made the theories untenable, and wherever any one of these theories was put to the test of actual experiment it was quickly shown to be fallacious.

DOWNING'S FROZEN–SAP THEORY.

The most widely accepted of the early theories was that advanced by A. J. Downing in the first edition of his "Fruits and Fruit Trees of America" which appeared in 1845. The name "Frozen-sap blight" was there applied to the disease. The theory being that the disease was due to freezing and thawing of the sap which thus lost its vitality, became dark and discolored, and poisonous to the plant. He says a damp warm autumn, followed by a sudden and early winter, always precedes a summer when blight is very prevalent.

In enumerating the symptoms of the disease, Mr. Downing gives just those characteristic features with which every one who has come in contact with the disease is familiar. The thick gummy exudation from diseased tissue, the dark, discolored areas of bark that follow attacks upon the trunk and branches, and the sudden blackening of growing extremities in early summer.

No fault can be found with all that Mr. Downing says of symptoms, and of circumstances attending the disease; but he was wrong in many of the conclusions drawn, and in the wide application he makes of conditions that prevailed only locally. Of remedies Mr. Downing says: "The *most successful remedies* for this disastrous blight, it is very evident, are chiefly preventive ones" .... "As a remedy for blight actually existing in a tree, we know of no other but that of freely cutting out the diseased branches, at the earliest moment after it appears."

In July, 1846, Mr. Downing began the publication of the "Horticulturist," a monthly journal of "Rural Art and Rural Taste," and in the second, or August number of that journal he writes at length of the blight, repeating the theory as advanced in his work of the year previous.

OBJECTIONS TO THE FROZEN-SAP THEORY.

In the December number for the same year, place is given for an article by a correspondent from Terre Haute, Indiana, who signs himself S. B. G. This writer presents a number of observations which appear as valid objections to the frozen-sap theory, some of which I desire to quote. "If this theory be true, why have its effects manifested themselves so recently? Our climate has undergone no change. The vicissitudes of weather have never been less than now. I have resided upon the Wabash more than twenty-three years and have known no difference in this respect. I have known almost whole winters that the plow might have run, while others have been cold. Late spring frosts, and late, warm, humid fall weather, have always marked our fitful climate, yet was the pear blight never heard of until recently."

The prevalence of blight in 1845 was ascribed to a frost occurring on the tenth of May. This writer cites a much more severe frost on the same day of the year 1834, but there was no blight that year.

A further objection refers to the effect of frost upon sap. "The freezing of sap does not change its properties. That the freezing of vegetable matter in a certain state of development produces death, may be admitted."........"It may also be admitted that the freezing in winter may be so severe as to destroy the vital principle as well in vegetable as animal life."........"Death thus produced is not occasioned by deleterious properties imparted to the sap, but by the mechanical force of the frost upon the cellular and woody tissues." ...."All our trees are frozen, except their trunks and large branches, every winter, especially the young and tender wood of the past summer's growth, and if an elaboration of the sap injurious in its consequences were thereby produced, no vegetable matter would survive a single winter. The economy of the vegetable world rests not on so insecure a basis as this would indicate." This writer here speaks of the spread of the disease in the individual plant, and cites a case of the production of the disease in a healthy tree by inoculation from a diseased tree. Further he says: "There is no occasion to theorize upon this subject for the mere sake of theory, and I have none that I regard as certainly true; but I strongly incline to the belief that the pear blight is an *epidemic*, that it prevails like other epidemics, and will pass off like them. The atmosphere is, I believe, generally admitted to be the medium by which they prevail, and are carried from place to place. What that subtle principle may be, which pervades our atmosphere, by which infection is retained and transmitted, so that, like the Asiatic cholera, it makes the whole circuit of our earth, human science has not discovered, and perhaps never will; but that such a principle exists, is sufficiently obivious from its effects."

Looking back in the light of what "human science" in the modern times has discovered, to those days when the germ theory was little more than a suggestion, the statement above quoted is of interest.

CAUSES SOUGHT IN ATMOSPHERIC AND SOIL CONDITIONS.

The writers for the agricultural press of fifty years ago were much inclined to look for causes of the disease in the attendant atmospheric and soil conditions. One writer in 1851 says: * "A fruit tree planted on a well-drained poor

* Patent Office Report. Agriculture. 1851 page 403.

soil will seldom suffer from blight of any kind. Too much trimming, too much moisture, and too rich soils are, in my opinion, some of the causes of blights in apple and pear trees. I believe there are several varieties of blights in apple trees and probably in pear trees also. I think I am in posession of facts and observations which will explode all the blight theories which I have seen published." This gentleman certainly observed some of the conditions which may aggravate blight, but his was as far from the true cause as any of the blight theories he thought himself able to explode.

FUNGI.

The man who introduced the theory of a fungus origin of the disease was for a considerable time quite safe from contradiction. Many fungi are very small; to learn anything of them beyond the fact of their existence requires a microscope. They had then received little attention, little was known of them, and it was impossible to prove or disprove their casual connection with the disease.

An investigator in 1872 ascribes the disease to a local fungus fermentation of the genus Torula and he observes that * "Every condition that will prevent the bark and shoots from ripening will foster under high temperatures, in the presence of organic acid and vegetable nitrogenous matter, one or more species of Torulacei fungi." And he further infers that contamination may come about by the absorption of the fungus germs by the roots, and in this case the fermentation proceeds from the sap-wood to the exterior. Drainage, or the removal of the tree to a more favorable place is recommended. The writer speaks of another form of the disease where the fermentation proceeds from the surface to the interior. This he calls atmospheric blight. Now beyond the fact of the presence of fungi in the diseased tissues this was all theory.

In 1875 Thomas Meehan, editor of the Gardener's Monthly, in speaking of the researches of Dr. Hunt of Philadelphia, says he finds "That a very minute fungus germinates in the outer bark, enters the structure, destroying the cells as it goes, till it reaches the alburnum, and then it penetrates clear to the pith, by the way of the medulary rays, totally destroying the branch from center to circumference;" and he adds, "There is no other conclusion here than that arrived at by Dr. H., that in the true fire blight, fungi are the cause of the disease."

It was an easy matter to find fungi in the dead tissues

* Department of Agriculture Report 1871, page 191.

of trees affected by blight, and their presence there was considered as sufficient evidence that they caused the disease. No crucial test was ever applied to prove that causal action. So in the absence of positive proof, all the claims of discovered cause made, up to this time were valueless.

DISCOVERY OF THE TRUE CAUSE.

The first light shed upon what has since been proved to be the true cause of pear blight was in 1878 when Professor Burrill of Illinois announced to the Illinois State Horticultural Society the discovery of bacteria apparently connected with the disease. The germ theory of disease had been under discussion for several years, and, previous to this time Pasteur had (in 1869-70) demonstrated that a microbe caused the terrible silk-worm disease, and later in 1876 that splenic fever and fowl cholera were also due to the action of specific microbes. Professor Burrill was the first to suggest that these low organisms might be connected with plant diseases. In his announcement in 1878 he made no positive assertion, but simply reported discoveries which were sufficient foundation for a very strong suspicion that these organisms did cause the disease. Continuing his investigations of the subject, in 1880 he had advanced far enough to announce before the American Association for the Advancement of Science that he had discovered the cause of pear blight. That the cause was a specific organism, for which he proposed the name Micrococcus amylovorus. Professor Burrill rested his claim upon the results obtained in a series of experiments. He inoculated healthy pear and apple trees with diseased tissue, and, in a large number of cases, blight followed the inoculation. The process of inoculation was both by the transfer of small pieces of diseased bark, and by pricking with a needle dipped in macerated diseased tissue. His results would seem to warrant his assertion that blight was caused by the organism which the microscope showed was present in large numbers. But in the light of modern methods of experiment, his proof could not be considered as absolute.

Investigators of the etiology of the contagious diseases of animals, agree, that in order to prove positively that any suspected organism is the specific cause of any particular disease, four steps are necessary. These steps which were first recognized, enumerated, and published by Professor Cohn, are as follows:

1. To demonstrate the habitual presence of the organism in cases of the disease in question.

2. To find some medium outside the animal body, in which this organism will live and multiply.

3. To cultivate the organism in this medium for a sufficient number of generations to insure the complete elimination of other organisms that may have been introduced into the first cultivation; in other words, to secure a pure cultivation of the organism.

4. To inoculate a healthy individual from the pure culture of the organism, and produce the original disease.

These steps carefully followed, afford a means of proof that, it seems to me must convince the most skeptical. This method of proof is just as applicable to plant diseases as to animal, and in the case of pear blight it remained for Professor Arthur, then of the New York experiment station at Geneva, to apply it. This he did during the seasons of 1884 and 1885.

WORK OF PROFESSOR ARTHUR.

Professor Arthur used as a culture medium a tea made by steeping corn meal in water and then filtering until a clear infusion was obtained. In this medium he cultivated the organism for a number of generations. Trees inoculated from his last culture, which contained Micrococcus amylovorus, and no other organism, developed the disease. Here was good proof that this specific organism caused pear blight; but there was one question that might be raised. Might not the liquid in which the organism lived be the exciting cause, instead of the organism? To prove this point a culture containing the organism was filtered through porcelain. The clear liquid, which upon examination by the microscope was shown to be free from germs, failed in every case to communicate the disease, but the residue of germs, left after filtering, when used to inoculate healthy trees, readily produced the disease. Thus by the method of experiment has every doubtful point been covered, and the fact established beyond controversy that this particular organism, Micrococcus amylovorus, is the true cause of pear blight, or apple blight.

This demonstration did not at once meet with universal acceptance. Various objections were raised to it. There were many men who refused to accept as the exciting cause something they could not readily see, something which could not readily be made evident to the senses. The observation and study of these low organisms, and of the tissue in which they live must be carried on under high powers of the microscope; they must be magnified at least

1,000 diameters. It is only men trained in the use of the microscope that can carry on observations under these conditions. The growth of an organism in a culture fluid is readily observed by the naked eye, by reason of its action on the fluid, and the results obtained by inoculation are easily seen. These two points must serve to inspire confidence in the statements of the microscopist regarding what takes place beyond the range of natural vision. The specific name, amylovorus, given by Professor Burrill, to this organism, means starch-devouring, and was given because the removal of starch from the cells appears to be the work they perform. In the process, which is a true fermentation, carbon-dioxide is given off, and butyric acid is formed.

EPIDEMIC NATURE OF THE DISEASE.

Like all diseases which have been traced to an origin in low forms of life, pear blight is epidemic in its character. During certain seasons it is very destructive; this extreme virulence may last two, three, or four years, then the disease will decrease, or possibly pass away entirely, to appear again after a long interval.

Charles Downing says, in speaking of his locality: "Pear blight has appeared at intervals of about twenty years, and the duration of each has been from three to five years. I have passed through three of these periods, and with each additional visit the attack is very much lighter; and like many other diseases it may run itself out in time." Mr. Downing's statement was made before the true cause of the disease was known. There does seem to be a periodicity connected with the disease, and while we are likely to have intervals of immunity, I have no faith in its finally running out.

MEANS ON DISSEMINATION.

How does the disease get into the tree, and how is it carried from one tree to another? First as to its dissemination. Whether the germs of the disease are carried in the air or not has not yet been satisfactorily demonstrated, but it is well known that insects carry the disease, and that in them we have the chief means of its dissemination. The gummy exudation already alluded to, which is commonly present in cases of attack upon the trunk or larger branches, is shown by examination to consist of myriads of the living organisms, held together by the viscid secretion which seems so characteristic of their work. This exudation is most abundant in the spring after the tree has started into full activity. It is attractive to insects, and they by their frequent visits disseminates the organisms rapidly at a period when the opportunities for their easy access to healthy plants are best.

HOW THE GERMS GET INTO THE TREE.

Now as to the method of gaining access to the tree. The virus of the disease spread upon healthy bark will not communicate the disease; this has often been proved by experiment. The microbe is incapable of penetrating healthy bark; but prick the bark with a fine needle smeared with the virus and you can produce the disease. The puncture or wound, no matter how small, is large enough to afford access to the germs which at once find themselves under conditions that will promote their growth. Wounds in the bark then, afford one means of access to the disease. Most cases of blight on the body of the tree originate in this way, certainly all those that show only isolated diseased areas, and in many of these cases the fact that the disease has spread from a central point of infection is very apparent. Last season portions of the trunks of several trees, ranging from one and one-half inches to two and one-half inches in diameter were sent us from an orchard near Canon City. Each piece bore from one to four elliptical areas of bark dead from blight, and in each case it was very plain that the disease had spread from a center; the center being a point where a starting shoot had been rubbed off. This would point to a need for some application following the removal of adventitious shoots to prevent the access of the blight organisms.

During the winter season, fully formed bark envelops the whole tree, forming an impervious protective against the disease, so at this season the only means of access would be by wounds. But as the buds push in spring we have presented other vulnerable points. The young shoots are soft and succulent, they have no covering capable of resisting attack, as has been often demonstrated. When the flowers expand we find in the flower cup, parts that are even less protected than are the youngest shoots. The stigma and nectaries offer conditions most favorable to the development of the organism.

Insects are no doubt responsible for the first infection, and in their busy flight from one flower to another during the whole period of flowering they disseminate the disease from one tree to another, and from orchard to orchard. It has always been observed of the disease that the twig-blight form was most common shortly after the blooming period, and the reason seems apparent.

The points of access are then three in number. The flower, the young and growing shoots, and wounds in the bark.

CONDITIONS WHICH AGGRAVATE THE DISEASE.

It remains for us to consider briefly the conditions which may aggravate the disease and what may be done to check or prevent it. It is a matter of common observation that the disease varies greatly in different localities and in different seasons. It may progress slowly or with great rapidity. Knowing as we do now, the cause of the disease, and the conditions under which the organism most rapidly propagates, we can account for this variation by the different conditions prevailing. The old theory that rich soils, and moisture were the cause of the disease was a favorite one, and undoubtedly arose from the observation that on rich soil, and in moist seasons the disease was most virulent and destructive. Rich soils with accompanying moisture is conducive to rank, rapid growth. The tissues formed are gorged with sap, and are very succulent. In this condition of things, we find all that is necessary for a rapid growth of our microbe. On a soil of only moderate fertility the growth is slow, less succulent tissue is produced, and if the supply of moisture is small, we have conditions not advantageous to the organism, and its development is slow. In this matter of growth we find a reason for the various opinions regarding clean culture, or grass in the orchard. One man has no blight and attributes his escape to clean culture. Another has no blight and thinks it is because his orchard is in grass. Both may be right, though the reasons they give for the immunity are wrong. An orchard on rich soil may receive just the necessary check in growth to prevent too great succulency by having grass in the orchard. An orchard on poor soil may need the clean culture to keep it in healthy growth. Anything then, whether in the choice of soil or manner of treatment that gives the trees a slow growth which will thoroughly ripen and harden, will render them less liable to attack from blight. Close planting is objectionable, because the ground being too much shaded, moisture is retained, and moisture favors blight.

In irrigating, care should be taken not to apply an excessive amount of water. I believe the general tendency is toward the use of too much water, and that by this means that succulent growth so readily attacked by blight is induced.

Water should only be applied when needed, and the need is easily discovered by careful examination of trees and soil.

TREATMENT.

From the nature of the disease, it is evident that when it has once gained access to the tree, preventive applications are useless.

The organism is secure in the cell tissue beneath the outer bark; you cannot reach it with any germicide yet known. There is therefore, but one remedy, and that is to cut and burn the infested portion of the tree. If trees are closely watched and diseased portions removed as soon as discovered, the difficulty may be checked without serious injury to the tree, but if allowed to spread until the amputation of large limbs becomes necessary the tree will be deformed if not entirely ruined. In years when the disease is extremely virulent, this work of cutting out is discouraging, and this has led some to object to the practice. Objections have also arisen from those who were unsuccessful because of careless and imperfect work. There is, however, abundant testimony from many sources that it pays to follow the practice closely and persistently. There is no other way of holding the disease in check after it has once started.

In cutting out twig blight it is hardly practicable to protect the cut surfaces; but where branches one-half inch and upward in diameter are removed, and particularly where the bark is cut away from blighted areas on the trunk and larger limbs, the cut surfaces should be at once covered with some protective coat. Lead and oil paint, shellac wash, and various forms of grafting wax, have all been used. I prefer the paint because it is cheaper, and less liable to crack and fall away under the drying action of the sun.

In cutting out blighted portions there is one precaution that should always be observed, and that is the sterilization of the knife after each cut; if this is not done, germs may be left upon the cut surface of the branch and the disease will continue to spread.

The sterilization of the knife may be effected either by passing through a flame or by immersion in carbolic acid or other germicidal solution. In cutting, it should of course, be the aim to cut safely below the diseased part. The limit of the disease is not the well marked line of dead tissue. It is not in the dead tissue that we find active work going on. The very fact that the tissue is dead and discolored is evidence that the organism has sapped it of all nutriment and is through with it. The work of destruction goes on outside this line of dead tissue, and extends a variable distance, from only three or four, to twelve or fifteen inches. So in cutting be sure and make the cut sufficiently low to remove all the infested tissue. If the tree becomes very badly affected before receiving attention, it is best to grub it out and burn the entire tree.

VARIETAL DIFFERENCES.

There appear to be no varieties that are entirely free from attack, but, according to reports, there are wide differences in susceptibility and in resisting power. The testimony concerning pears, gathered from many sources, indicates that Anjou, Angouleme and Seckel resist attack better than do Bartlett, Clapp or Flemish Beauty, and when attacked the disease progresses less rapidly in the first three, than it does in the last three.

Among apples, the varieties of crabs seem everywhere more susceptible than do standard apples, but even here occasional exceptions are met with. A case illustrating this came under my notice at Eaton.

A three-acre garden was surrounded by a row of crabs, Martha and Whitney alternating. The Whitney trees were all either dead or dying of the disease, while not a Martha had been attacked. The difference between the two varieties was here so marked as to suggest security from attack on the part of the Martha, but in other localities the variety has succumbed. Reports concerning the standard varieties of apples vary greatly from different localities. Varieties apparently immune in one locality are badly attacked in another, and I am inclined to the belief that the differences in behavior toward the disease, with both pears and standard apples, are due more to varying local conditions than to varietal differences.

The crabs are so universally attacked that it seems undesirable to plant them at all. In choosing varieties of standard pears and apples, be governed by the best local experience, and by the fruit list as recommended by the Board of Horticulture. Then by rational treatment bring about those conditions of growth that make the trees least liable to attack. If trees are attacked follow the course outlined in the preceeding pages, and by persistence eradicate the disease, or at least hold it in check.

Of remedial preparations offered for sale I have nothing to say. Having stated the cause of the disease, and outlined its manner of work, I leave the probability of cure to the judgment of the intelligent reader.

MECHANICAL INJURIES

TO WHICH

FRUIT TREES ARE SUBJECT.

The disease we have attempted to discuss is only one of the many sources of injury to which our fruit plants are liable. Aside from the numerous insect pests which are demanding constant attention, we have a long list of parasitic fungi, and certain other mechanical injuries whith result from peculiarities of climate. Some of these deserve brief mention here.

The mechanical injuries referred to are commonly spoken of as "frost-crack" and "sun-scald," and both are referred to a combined action of sun and frost. Most of the cases of so-called sun-scald that have come under my observation have proved to be cases of blight upon the trunk or large branches. They are characterized by dark, discolored areas of dead bark, commonly circular or elliptical, but sometimes irregular in form, and most frequently, though not always on the side exposed to the sun. The dead bark as it dries shrinks and adheres closely to the wood.

Frost cracks occur upon the exposed side of the trunk, extending longitudinally. They are produced in winter and early spring under the influence of extreme low temperatures, and may, when growth starts close and entirely heal. The liability of trees to injury of this character depends mainly upon the amount of water contained within the tissues. Trees that grow late, and enter the winter with wood not thoroughly ripened, and hence containing more water, are more susceptible to injury than those that are enabled to ripen and harden the wood. Even well ripened wood contains normally about 40 per cent. of water. Trunks of apple trees cut on the fifteenth day of January 1897 when last weighed, on the eighth of January 1898 showed a loss of water by air drying of 39.36 per cent. and branches from the same trees lost in the same time 42.24 per cent. The weights are not yet quite constant, but the figures may be taken as an approximate showing of the moisture contained in normal tissues in midwinter. But this moisture is not in the easily freezable liquid form; it is distributed as a constituent of cell wall, and in the viscid or solid cell contents, and can only be withdrawn and crystalized under the prolonged action of extreme cold. Suppose a tree thus normally constituted to be subjected, during the winter or early spring, to a period of warm bright weather. The influence of the sun's rays penetrates the tissues, the cell contents become less viscid, water taken in by the roots still further liquifies these cell contents, there is movement within the cells and they become turgid with fluid sap. A sudden change marked by temperatures below zero occurs. There is a gradual shrinking of the tissues until the point of actual freezing, or crystalization is reached, and then comes that familiar and seemingly resistless expansion. If the sap-gorged tissues escaped rupture during the process of shrinking they are sure to yield to the expansive force accompanying congelation.

This form of injury is usually worse on plums, cherries, and peaches, than upon apples and pears. The cracks are less likely to heal; they more often increase in size, and the exudation of gum is followed by rot which leads to the death of the tree.

With all trees this trouble can be in large measure prevented by providing some protection against the sun. This protection is most needed when the trees are young; as they attain size they in a measure protect each other. Various devices have been used, but we find wrapping with burlap the cheapest and most effective. Burlap that has been used for baling was purchased at dry goods stores at two cents per pound. One pound supplies twelve strips four inches wide and three feet long, and one strip is sufficient for a reasonably low-headed tree three to five years in orchard. The burlap being cut, and strings of proper length at hand, one man will wrap the trees at the rate of 60 an hour. The cost is thus nominal and the protection afforded ample.

More serious than the the frost crack is that mechanical injury which is characterized by a separation of the bark from the wood. It has thus far been reported upon apple trees only, and most of the cases of which I have knowledge occurred in the southern portion of the state.

The separation between wood and bark in those cases examined occured near the ground, and was not noticeably confined to any particular side.

In most cases the bark appeared discolored over a portion of the separated area, and more or less ruptured as if from lateral tension in drying. Between the discolored portion and the limits of the affected areas the separated bark often appeared perfectly healthy, and in some cases new growth was protruding into the space between bark and wood. A few cases were found that gave no visible sign of injury beyond a slight change from the normal color of the bark. There was nothing to indicate the size of the affected areas; the bark was smooth and apparently healthy, but when struck emitted the hollow sound that proved a sure test of the extent of the injury. In cases of this kind it would seem that considerable time might elapse between the working of the cause and the discovery of its effect, and I apprehend that the first evidence of injury would be seen in a generally unhealthy appearance of the foliage of the tree. Of course, if the trunk was affected to the extent of girdling it, the tree would soon die. If the affected area was confined to one side the tree might endure for some years, but with vitality diminished in proportion to the extent of the injury.

Where small areas only are affected the tree may by the intrusion of newly formed tissue, completely cover the denuded wood and thus effect a cure. From the location of this trouble beneath the bark, and from the tardy appearance of any evidence of injury, it is clear that a practical demonstration of the cause would be difficult if not impossible. I am not aware that any actual demonstration of the working of the cause has ever been made. Since the trouble became known its origin has been assigned to the action of frost, but there was no tangible basis for the assumption until the matter was taken up and critically studied by Professor Burrill of Illinois. The results of his observations and the theoretical deductions from them were presented in a paper before the American Association for the Advancement of Science at the Ann Arbor meeting in 1885. After explaining frost cracks, and the phenomena attending the crystalization of liquids by frost, he says—"The second form of injury—especially prevalent in apple trees—is believed to be due to the *growth* of ice crystals studding in a close or dense layer, the surface upon which they form. Such miniature forests of crystals can be found in green plants even after slight freezing, as well as in ripened wood in severely low temperatures." The process of crystal growth is further explained as follows: "In the trunks of trees the crystalizations begin in any part where there is proportionally most pure water. The very process of solidification causes, by the law of equal diffusion, a movement of water from adjoining parts, toward the point from which the first liquid (as such) is removed. Hence the ice crystals first formed constantly grow, attracting as it were the water from neighboring parts of the tissue. This growth of the crystals, associated as they occur in close layers, pushes asunder the normally connected tissues." The theory here given being based upon careful observations, and being in perfect accord with physical laws has been accepted as the true explanation of the trouble under discussion. It will be noted that the operation of the theory depends upon the presence of fluid sap, and that the greater the water content of the tree the more liable it is to injury. It follows that the same conditions that protect against other frost injuries will protect against this. Fruit growers should therefore, use every endeavor to thoroughly ripen the wood of the trees before winter sets in and thus reduce the liability to injury from frost to the minimum.

FUNGOUS DISEASES.

Leaf Blight or Rust of the strawberry. This is a cosmopolitan disease due to the parasitic fungus known as Sphærella fragariæ. While our climatic conditions are in general unfavorable for the development of this disease, we do occasionally have periods during which it does injury. Moisture is necessary for the germination of the spores, and the fungus can spread to an injurious extent only during moist and warm weather. The month of June, 1895, was marked by prevailing high temperature and frequent showers, and during that time the disease did considerable damage to strawberry beds about Fort Collins. This past season the disease started under somewhat similar conditions toward the latter part of May, but showers becoming less frequent it did no serious damage.

All growers are familiar with the purple or red spots which mark the presence of this disease. These spots enlarge and become of a brown color; finally, by the growth of the spores beneath, the cuticle is ruptured and they then appear white at the center with a brownish ring outside. Affected leaves soon turn brown throughout and die.

This loss of foliage saps the vitality of the plant, and if the attack comes early in the season it prevents the development of a full crop of fruit. If the attack comes after the fruit has been harvested the plants are weakened so that the crop for the next year will amount to nothing, or at least be shortened, depending upon the severity of the attack. As the mycelial threads of the fungus are within the leaf tissues it is apparent that preventive, rather than curative measures must be resorted to. The fungus survives the winter within the leaf, both by spores and by its mycelium. It follows that the destruction of infested leaves in the fall is important as a means of holding the disease in check. The practice of mowing the old leaves after the fruit has been removed and then burning is not to be recommended because it sometimes results in injury. It is better to rake the leaves off the bed for burning and then by cultivation and the application of ferlilizer induce a vigorous new growth preparatory to fruiting the next season.

The simplest and most effective way of controlling the disease is, however, by spraying with any of the standard fungicides adapted for application to foliage. The following have been successfully used. Hyposulphite of soda, one pound to ten gallons of water, applied every ten days. Modified "Eau celeste" made as follows—Dissolve one pound copper sulphate in two gallons of water; in another vessel dissolve one pound of Sodium carbonate; mix these two solutions and when chemical action has ceased add one and one-half pints of ammonia. Dilute to 25 gallons. Ammoniacal copper carbonate made by dissolving three ounces copper carbonate in one quart of ammonia, and diluting to 25 gallons. Three or four applications of the copper solutions are usually sufficient.

ORANGE RUST OF BLACKBERRIES AND RASPBERRIES.

This disease has been reported from Arvada and other places near Denver, and has been present here in Fort Collins for the past three years. It has not been particularly destructive, but the damage done is sufficient to warrent a word of caution. Eastern growers have in many places suffered severely from the disease, and it would be well to profit by their experience and use every effort to exterminate it. The cause of this disease is a true fungus (Cæoma nitens) which has been known under various names since 1820.

Its presence has been reported from nearly every state east of the mountains: it is common in Canada, and is also known in Europe. Apparently it is confined in its work to plants of the one genus-Rubus, but has been observed on nearly every species of the genus. It works on wild as well as on cultivated plants, and appears to prefer some species to others. As between the dewberry and the blackberry it works most upon the dewberry: and between the black and red raspberries the blacks are more susceptible to attack. The disease also shows choice of varieties: thus the Kittatinny and the Erie blackberries seem much more susceptible to attack than do Snyder and Wilson.

The presence of the disease can be detected quite early in the spring in the tufted slender shoots which are produced, and in the glandular appearance given to some of the new leaves by an early and little understood spore form which the fungus produces. Later, about the first of June the Æcidium or cluster cup spore formation may be looked for. The cluster cups first appear as small raised spots covering the under surface of the leaves: soon the skin is ruptured, the cups containing the spore masses protrude, and then we have that characteristic appearance which suggested the name orange rust.

This, the fruiting stage of the fungus is conspicuous, and cannot fail to attract attention, but it is not all there is to the plant.

The vegetative portion consisting of very minute threads which ramify through the plant, and which must develope before spore formation can take place is not apparent to the naked eye: it gives no sign of its presence except by inducing the tufted growth of slender shoots.

It will readily be seen that this vegetative portion of the fungus is beyond the reach of any curative applications that might be made. It is secure within the tissues of the plant, and since it has been proved that the threads extend into the roots and are perennial, we are led to the conclusion that our only course is to completely destroy the infested plants Spraying has been recommended as a protection against the spreading of the fungus by the spores, but spraying will be unnecessary if the plants are carefully watched and the infested ones removed before the dissemination of spores begins.

ANTHRACNOSE OF THE RASPBERRY AND BLACKBERRY.

In 1896 canes of black-cap raspberry infested with this disease were sent us from near Denver. From the fact that nothing has been heard of the presence of the disease since, we regard this as an isolated case introduced, in all probability, on plants from some eastern nursery. The dryness of our climate is not favorable to the development of this disease and we apprehend no serious trouble from it; but as it is liable to appear at any time on introduced stock, it may be well to dwell briefly upon its characteristics. The cause of the disease is a fungus (Glœosporium venetum) and Professor Burrill of Illinois is credited with publishing the first account of it in 1882 under the name Raspberry Cane Rust. The disease appears to be confined to the blackberry and black-cap raspberry. As with the orange rust the vegetative threads of the fungus ramify within the plant and are perennial. The first evidence of the presence of the fungus is seen in small, purplish, circular or elliptical spot on the canes near the ground. As the canes grow the fungus ascends and the spots appear at intervals even to the tips of the canes. The spores are formed about the centers of these spots and as they push outward the bark is ruptured and curled back. The spots then appear grayish white with a purplish border. Often several spots may coalesce forming irregular patches. While the principal work of the fungus is on the canes, it is not wholly confined there, but may appear on the petioles and veins of the leaves. The nature of this fungus suggests the cutting out and burning of all canes seen to be affected. As a preventive measure it is recommended to spray, as soon as the canes are uncovered in the spring, with a solution of sulphate of iron, two pounds to five gallons of water, to be followed later, if the disease appears, by an application of the Bordeaux mixture.