ORCHARD PRACTICE FOR THE CONTROL OF BLISTER CANKER OF APPLE TREES

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INTRODUCTION

Years of effort on the part of Illinois orchardists to eliminate blister canker have resulted in no material decrease in the number of infested trees. As a matter of fact, the loss has increased annually, and many growers have given up all attempts to control the disease. In a large measure, their failure has been due to a lack of knowledge concerning the characteristics of the disease and the life history of the fungus causing it. This has meant that when control measures have been applied, they many times have been started too late to be of much benefit.

The first steps in control should be taken before the orchard is planted, or if it has been planted, before the disease appears. This circular, describing the orchard practice necessary for the control of blister canker, therefore, is intended more for the orchardist who has not yet found the blister canker in his orchard, than for the one who has a badly infested orchard. If this is understood and the directions herein given are followed, it is reasonable to expect that the young orchards of the future will be free from this serious disease, and the old orchards not too badly infested will continue to yield good returns for many years.1 As the basis for successfully controlling a plant disease is a thorough understanding of the habits of the agent causing the disease, this circular includes a description in some detail of the appearance of the disease in its various stages and a life history of the causative fungus.

THE SYMPTOMS OF BLISTER CANKER

What Is a Canker?

“Canker” is a term applied to a diseased area, or “sore,” on the trunks, roots, limbs, or twigs of a plant when such an area has a more or less definite outline and characteristic appearance, and is

1 The recommendations embodied in this circular are the result of field observations, investigations, and experiments of the writer during the past five years. Investigations of the disease confirmed in most details the results obtained by Cooper in Nebraska (Neb. Sta. Research Bul. 12, 1917), and by Gloyer in New York (N. Y. (Geneva) Agr. Exp. Sta. Bul. 485, 1921). While their results have been used freely in the preparation of this circular, the writer makes recommendation only of those practices which have been tried in the field, or which are the logical practice based on known facts in regard to the behavior of the parasite.
bordered by healthy tissue. The bark of the infected area may be entirely dead, as in the case of the blister canker, or alive and roughened, as in the case of apple blotch. The surface of the canker may be rough and cracked, or smooth; it may be sunken, or raised, or level with the surrounding bark; the edge may be sharply defined, or may merge into the surrounding tissue. The diseased tissues may be separated from the healthy by a crack. The color and texture of the diseased area and the presence of the characteristic fruiting bodies of the fungus causing the disease are characters which distinguish various kinds of cankers.

How to Identify Blister Canker

It is essential to know the "ear marks" of blister canker in order to be certain that it is blister canker and not a canker of another sort which is causing the injury. Blister cankers should be looked for on the larger limbs and trunks of the trees, especially about large wounds. Old blister cankers are easily distinguished by the presence of the characteristic fruiting bodies which are called "nail heads" on account of their resemblance to the thick head of the old-fashioned iron nail (Fig. 1). When the bark is worn away they stand out from the wood about one-quarter of an inch and are ordinarily from one-fourth to three-eighths inch in diameter. The "nail heads" are usually crowded together on the older part of the cankered area. They contain what are known as the winter spores of the fungus.

On new cankers and in the younger part of old cankers the fruiting bodies crowd up under the bark, and cause small, blister-like protuberances. Later these blisters split open in a star-like manner (Fig. 2). The ruptured segments curl backwards, exposing a dust-colored mass, which consists of the summer spores of the fungus.

If the top layer of the bark is cut away where either of these types of fruiting bodies occur, black rings, the diameters of the "nail heads"
or blisters, may be observed (Fig. 3). When the fruit bodies are not very evident from an exterior examination, these rings furnish a safe method of distinguishing this canker. A curious characteristic mottling is also apparent on the inner bark. This mottling is quite different from the streaked appearance sometimes evident when black rot or other cankers are exposed in the same manner. With some varieties of apple, such as Willow Twig, the mottled bark is not always in evidence.

As the canker may become quite large before the fruiting bodies appear, it is necessary to have some way of distinguishing the disease in its earlier stages. Fortunately, this characteristic mottled inner bark is apparent before any blisters or nail heads are in evidence. It is the earliest definite indication of the nature of the trouble and may be taken as a sure mark of blister canker.

Abnormal and unusual types of cankers are often found in an orchard, and while the above description applies to most blister cankers, a sure diagnosis sometimes requires examination by a skilled investigator.

**NATURE AND LIFE HISTORY OF BLISTER CANKER FUNGUS**

The organism causing blister canker is a fungus—the group of plants to which molds, mushrooms, and mildews belong. Scabs and rots are also caused by this group of plants. The fungus plant consists of numerous minute, thread-like structures which penetrate the tissues of the plant attacked and derive nourishment therefrom. The fungi develop seed-like bodies, as do higher plants. These spores, as they are called, are microscopic in size and of very simple structure. They are developed in or on the fruit bodies. The fruit bodies vary greatly in structure among the different kinds of fungi. In the case of blister canker they consist of portions of the "nail heads" and the blisters referred to above (Figs. 1 and 2).
If one of the small "nail heads" is removed and cut vertically thru the center, a black line will be observed across the upper surface (Fig. 4). If this is magnified, it will be seen to contain little flask-shaped pockets (Fig. 5). In these pockets are borne numerous club-shaped bodies which stand upright and fill the interior of the pocket. Inside each club-shaped body are eight round ascospores (Fig. 6), also known as the winter spores.

When the bark about the "nail heads" becomes moist, the spores are either shot forcibly into the air or are crowded out on the surface where they form a thick, gelatinous layer. They may then be washed down the trees or carried by various agents to neighboring trees. The fact that infested trees usually occur in groups in an orchard indicates that the spores are not ordinarily carried by the wind, as in the case of such fungi as apple rust. On the other hand, the distribution of the disease in orchards miles apart indicates that there are carrying agents such as birds or insects. Workmen commonly distribute the spores in an orchard by means of tools used in pruning.

If the spores alight on an unwounded surface they will not grow into the healthy tissues. They will rarely infect when they alight on a small wound. But when they encounter a large, exposed wound,
they are fairly certain to infect. Such wounds are often cracked and the spores sift down into these cracks, where they find the moisture necessary for their germination. Wounds produced by the sawing off of large limbs, and especially those made by the breaking of fruit-laden branches, furnish ideal infection-courts for these spores.

The spores germinate by the development of a small germ tube, which penetrates the wood, or which branches, the individual branches boring their way into the wood tissues. This is the fungus plant, which grows downward into the healthy tissues of the limb, deriving its nourishment from the surrounding tissue as it advances. The growth at first is confined largely to the wood. In fact, the trees may be infected for some months before there is external evidence of the disease. There is no evidence of infection about the edge of the wound where the spores entered. In this respect the fungus of the blister canker differs from most canker-producing fungi and bacteria. In the case of black rot, the fungus is confined to the bark and its attack is at once evident thru the formation of cankered areas. The same is true of the bacteria of fire blight.

The fungus of blister canker grows down into the heartwood from the point of infection and then may spread up or down the limb. It usually causes definite brown streaks in the wood, which may be followed by cutting cross-sections of the limb (Fig. 10). Later, the fungus invades the wood of neighboring limbs, and if unchecked, becomes fairly well distributed thruout the entire woody portion of the tree, even into the roots.

In the meantime, evidences of the disease appear about the wound where the fungus gained entrance. The bark dies, becomes roughened and, if the outer layer is cut away, shows the typical mottled character. Within a year the typical blisters of the canker are evident on this diseased bark. These blisters rupture, as shown in Fig. 2, disclosing dust-like masses of spores (the conidia, known also as the summer spores) (Fig. 7). These are freely exposed and may be carried by currents of air, by insects and by rain. However, it has been the
experience of all investigators who have studied this disease that summer spores play a relatively unimportant part in distributing the disease, since they do not ordinarily infect even when placed under

Fig. 6.—A single ascus with its eight ascospores. These club-shaped spore holders are borne in large numbers in the chambers shown in Fig. 5

favorable conditions. They are far less resistant to heat and drying than are the winter spores, which are chiefly responsible for the distribution of this disease. Some infections, however, are no doubt due to the summer spores, and these should not be neglected.

Following the production of the summer spores, chambers (perithecia) develop in which the winter spores are borne, and the nail heads then become evident. The mature nail heads containing the active winter spores do not develop in a single year but may take two or more years to reach maturity. Cankers produced by a number of artificial inoculations made by the writer in September, 1917, did not show mature spores until 1921.

Other cankers may appear above or below the point of original infection, especially if limbs have been removed. These develop from the interior of the branch rather than from new infections, and may be called "secondary cankers." The fact that secondary cankers may appear on an apparently sound limb gives rise to the erroneous idea that the fungus can gain an entrance thru the unbroken bark surface.

**SUSCEPTIBILITY OF VARIETIES**

Blister canker is known to occur on nearly all the varieties of apple grown on a commercial scale in Illinois. A few varieties, however, show a high percentage of infection, and one variety in particular, Ben Davis, stands so high above all others in degree of susceptibility, that, under Illinois conditions, its elimination would mean almost complete elimination of losses from that disease (Fig. 8). In a forty-acre, twenty-five-year-old orchard in central Illinois
planted to York Imperial and Ben Davis, a survey of the orchard revealed 32 percent blister-canker Ben Davis trees and not one diseased York Imperial. Another orchard planted to Grimes, Jonathan, and Ben Davis showed 18 percent of the Ben Davis trees cankered, with less than 1 percent of the Grimes and Jonathan diseased. Yellow Transparent and Chenango are two varieties quite susceptible to blister canker under Illinois conditions, but they can be safely planted if proper orchard practices are followed.
PREVENTIVE MEASURES

The control of blister canker consists in rigidly following a definite program, which in a new orchard, in the majority of cases, will prevent the disease from getting a start, and in old orchards will confine the canker largely to the trees already infected. There is no safe remedy or "cure" for blister canker after it has become established in a tree, except in rare instances where newly infected limbs may be cut out.

When to Begin Control Measures

The first step in control should be taken before the orchard is planted. This precaution consists in avoiding varieties known to be especially susceptible to blister canker. Illinois orchardists should avoid planting Ben Davis, a highly susceptible variety. Many varieties of apple are superior to Ben Davis, or equal to it, and Illinois orchards are already over-planted to this variety.

Care of a Young Orchard

Infections from the spores of the blister canker fungus are rare in a young orchard, that is, one under six years of age. However, the orchard practice during the first ten years of the life of the orchard determines, in a large measure, the amount of infection which will occur later. Infection does not ordinarily take place in small wounds on rapidly growing, healthy trees. Therefore the tree should be shaped in its early life, when the limbs which are not wanted may be removed without danger of infection. It is not essential to sterilize the tools or wounds in ordinary pruning practice in orchards under ten years of age, so far as blister canker is concerned. However, pruning tools which have been used in an old orchard should always be sterilized before being taken into a young orchard. When a young orchard in the neighborhood of a cankered older orchard is pruned, the wounds should always be treated as described later, especially the wounds exposing wood over four years of age. In all cases, the limbs that are removed should be cut flush with the surface of the tree so as not to leave a stub.

Care of Uninfected, Bearing Orchards

Since large wounds of any origin are the points where infection takes place, any orchard practice which tends to produce large, uncovered wounds is to be condemned. In some cases, however, thru early neglect of the orchard, or thru accident, large wounds are produced. Such wounds should be properly treated at the earliest possible moment. If it becomes necessary to cut off large limbs, the workman should be instructed as to the proper method of removal. If limbs
are broken thru over-bearing, they should be cut back to the proper length. Limbs are frequently broken at the point of origin on a larger limb, thus leaving a "pocket." These pockets are very commonly courts of infection because the moisture which collects in them provides a good condition for the accumulation and germination of the spores. Such wounds should be opened by cutting a groove at the base.

The wounds should be dressed promptly and carefully. Fresh cuts need not be sterilized but should be covered immediately with a coat of shellac, which, after drying a few minutes, should be covered with a coating of ordinary gas tar. These dressings should be examined during the course of the year, and if any cracks have appeared, the surface should be recoated.

If a tree has become sunscalded, or if areas of bark have been killed by other agents, the dead bark should be removed and shellac applied immediately, followed by the tar dressing. Lower limbs that are too shaded, and consequently weak, should be removed rather than allowed to die.

Tools used in pruning operations should be sterilized before passing from one tree to another unless the orchardist is certain that there is no blister canker in the orchard. (See page 15 for method of sterilizing tools.) Even then it is wise to use precaution in handling the tools, owing to the fact that blister canker may be present in a tree several years before it becomes evident externally.

CONTROL OF BLISTER CANKER IN INFECTED ORCHARDS

Orchards having as high as 20 percent cankered trees may be saved to produce profitable crops for many years. The labor involved the first year is great, but subsequent treatments are not much more complicated or expensive than is ordinary pruning. A single large apple tree often yields a return of $40 to $50 in a single season, and even when a return of $10 is secured, a single crop will pay the expense involved in saving the trees.

Preliminary Survey of Orchard

Effective control can be secured only when every infected tree in the orchard has been located. Therefore a careful, systematic examination of every tree is necessary. This should be done by one who is thoroly familiar with all the symptoms of the disease. Unless the grower feels confident of his ability to locate the infected trees, it will more than pay him to employ such an expert. The survey is best made in the winter when all the foliage is off, so that the entire surface of the limbs may be examined. When examining large trees one should

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1 Shellac may be obtained at any local drug store or from any dealer in paints; gas tar may be obtained from any plant manufacturing artificial gas.
walk entirely around the tree, and if an unobstructed view of all the limbs cannot be obtained it will be necessary to climb the tree. The dark, roughened surface of old cankers may be readily located, but young cankers may be very easily overlooked. Special attention should be given to areas about large wounds, stubs, and split crotches. When a diseased tree is located the person making the survey should mark the location of the tree on a previously prepared plan of the orchard and should also paint a broad band around the trunk of the tree to serve as an identification mark.

A large, sharp knife should be carried, and when the true nature of a diseased area is questioned, a cut should be made across the surface to determine the presence or absence of the characteristic mottled inner bark.

It has been stated that the fungus in infected trees may invade many limbs which show no external signs of canker. In pruning operations it is not at all unusual for workmen to cut into such limbs altho they may avoid the cankered limbs. Under no circumstances, therefore, should the workmen who do the ordinary pruning operations in an orchard be allowed to prune a tree which has canker. Marking these trees and warning the workmen to leave them alone prevents the possibility of spreading the disease on the tools. Experiments of the writer have proved that the fungus may be carried in a living condition in the sawdust between the teeth of a pruning saw.

It is a well known fact that many trees have blister canker for years without showing any external evidence of the disease, or at least such as would be noticed by the unskilled observer. Such trees may sometimes be detected by the character of the heartwood when weakened limbs are removed. If dark brown, irregular areas are observed in the heartwood, such as those represented in Fig. 9, a, the chances are that the disease is present and such trees should be painted and classed as cankered. This difficulty in detecting diseased trees is an additional reason for the practice of sterilizing the tools before passing from one tree to another in ordinary pruning operations, especially in old orchards.

Cutting Out the Cankers

After a careful survey of the orchard has been made, the next operation is to get rid of all infectious material and at the same time to treat the diseased trees in such a way as to reduce the injury to a minimum. The removal of the cankers does not eliminate the disease. Rather, the object of all this labor is to remove the superficial cankers, whereby all possibility of the natural spread of the disease is deferred until another crop of spores is produced. Since it takes at least a year for the production of a new crop of spores, the chances of new trees becoming infected are thus almost eliminated.
Fig. 9.—Cross- and Longi-Sections of a Limb Having No Canker but Taken from a Diseased Tree
The tools necessary for cutting out the cankers are:

1. A good pruning saw which will cut large limbs.
2. A farriers knife with hook at the end straightened to a right angle, or broken off near the base and sharpened (Fig. 10). (Any other strong sharp knife will serve but the curved blade of this knife reduces the chances of skinned knuckles.)
3. A broad, sharp chisel (1 1/2 inch blade is a convenient size).
4. A can of shellac and one of tar.
5. Two paint brushes.
6. A bottle or can of corrosive sublimate or copper sulfate.
7. A sponge.

The winter months are best for cutting out cankers, since the limbs are bare at that time and workmen are more easily obtained. The

![Figure 10](image)

**Fig. 10.—Two Tools Useful in Cutting Out Cankers, A Farriers Knife and a Chisel**

wounds start to callus early in the spring so that the operations should be completed by the middle of March. A man skilled in cutting out cankers should be employed if possible and a helper furnished him. If the diseased trees have been designated with bands of paint as described above, four rows may be treated at one time, each man being responsible for two rows.

The method of procedure depends upon the nature of the canker in the diseased tree. If the limb is girdled and dead it should be cut out, the cut being made at some convenient point below the lower limits of the cankered area. This operation does not eliminate the disease

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**Explanation of Fig. 9**

The closest evident canker was on a branch two feet above the base of this limb. Dark areas indicate infected wood. (a) One foot above base of limb; (b) Two and one-half feet above base of limb; (c) Four feet above base of limb; (d) The limb branched ten inches below this point; the disease extended into each of the branches. The single black dot in the smallest section is a "streak" infection; (e) At the left is shown a longi-section of the "streak" in the smallest branch, taken immediately above the section shown in d. The other sections were about ten inches above those of d; (f) The end of the infection. This was over six feet from the base of the limb.
ordinarily, since the wood is always infected some distance below the canker. If there is only one canker in the tree or if it is possible to cut some distance below the surface canker without seriously exposing the remaining limbs to sunsealcl, it may be possible to eliminate the disease from the tree. A cut across the diseased limb just below the canker will reveal dark, irregular heartwood. A cut a foot or so below this will usually show a diminution in the size of the darkened area, or only isolated dark spots (Fig. 9, e and f). The cuts should be continued until the spots disappear entirely. These dark spots are cross-sections of infested streaks which extend down in the wood for several feet below the canker. Near the end of the infection the streaks are about the size of a period on this page and may be easily overlooked. If the streaks extend below any large branches which would not otherwise need to be sacrificed, the elimination of the disease from the tree should be abandoned.

In case the limb has not been killed, even tho it is two-thirds encircled by cankers, the best policy is to leave it on the tree since it will serve to protect other limbs from sunsealcl. Moreover, nothing is gained by cutting off the limb. It has been observed that a heavily pruned tree seems to develop more superficial cankers than one less severely pruned, which may be suffering equally from the disease.

All cankers found should be cut out and dressed in the manner here described. It is well to follow these directions exactly as small variations may make marked differences in the result.

1. Remove all the dead bark, "nail heads," etc., over the cankered area so that a smooth wood surface is exposed as far as the living, healthy bark. This may be done with the farriers knife if the bark is not thick
and dry. The loosened bark may be allowed to fall to the ground for, altho it contains infectious material, the chances of infecting other trees are remote. Attempts made by the writer to collect and burn this bark showed that the task was too great to justify the practice, considering the chances of infection. However, if this precaution is to be taken, a large piece of burlap in the form of a hammock suspended below the limb will catch most of the waste, altho when the work is done rapidly, the pieces fly some distance.

2. After removing the dead bark, take the knife and make a clean cut about one-half inch or less into the healthy bark, extending around the edge of the cleaned canker. If the farriers knife is used the shank should be held toward the center of the canker (Fig. 11). This raises the bark along the inner edge and makes it easier to remove. Before this strip is removed, however, the person doing the dressing should be at hand with the shellac.

3. Insert a chisel or knife under the strip and carefully remove it. A clean, even, vertical edge should be left about the entire wound with the bark healthy to the surface (Fig. 12).

4. Apply the shellac to the entire surface, at once. Allow it to dry a few minutes, and then apply the tar.

5. All tools used in the operation should be sterilized by sponging with mercuric chloride or copper-sulfate solution,¹ before passing to another tree.

¹ The solution best adapted to use for sterilizing tools in orchards is mercuric chloride (corrosive sublimate), diluted 1 to 1,000 parts of water. This chemical may be purchased in tablet form from any drug store; one tablet to be dissolved in a pint of water. This substance corrodes metals, so tools should not be left standing in it. It is also very poisonous, and should not be left where children or stock can get into it. Copper sulfate (bluestone) is also recommended as most orchardists have this on hand for making Bordeaux mixture. A saturated solution may be used for sterilizing. Tools should not be left standing in this solution.
6. All limbs cut off should be collected, removed within a few days, and burned.

It is a help to the man who treats the cankers the following year to have designated on the trunk of the tree, above the painted line, the number of cankers which have been treated in the tree.

RECOMMENDATIONS FOR CONTINUED TREATMENT OF INFECTED ORCHARDS

Should the fight against blister canker be discontinued with the above treatment, all the labor involved would be lost. It would be like cutting off the tops of weeds, thus allowing them to sprout again to produce a larger crop of seed than they would have otherwise. Blister canker continues to develop and the year following the treatment some of the cankers will be found to be surrounded by dead bark with fruiting bodies beginning to develop. In other cases, fortunately, the treatment seems to check the spread of the canker, a good callus is formed about the edge of the wound, and several years may elapse before the canker again appears. A careful operation in which a healthy edge has been left round the wound after the fruiting bodies and the dead bark have been removed, is a contributing factor in the quick and complete recovery of the wound and reduces the chances of borers and woolly aphids working in the edge of the canker.

During the summer following the treatment of the cankers, the edges of the treated areas should be scrutinized in order to ascertain whether the canker is advancing. If it has advanced but there is no evidence of the summer stage of the fruit bodies, with their characteristic star-shaped openings, it is safe to leave the treatment until winter. If the canker has advanced rapidly, however, and the fruit bodies are forming, it is a good plan to cut out the diseased area immediately. This can be done hastily with a few strokes of the knife. No dressing need be applied at this time.

The winter following the first canker removal is the proper time to go over the orchard again to examine all the trees, both healthy and diseased. The healthy trees should be examined for the possible appearance of new cankers, while the diseased trees should be treated in the same manner as in the previous operation. This operation is much simplified by the facts that, first, the canker rarely extends more than a few inches during the year; secondly, the bark has been but recently killed and consequently is soft and easily removed; and finally, many of the cankers will show no advance.

Each winter a similar survey should be made. As the infected trees become so badly mutilated as to be unsightly and unprofitable, they should be removed and burned. New trees may be planted in their places without danger of infection.