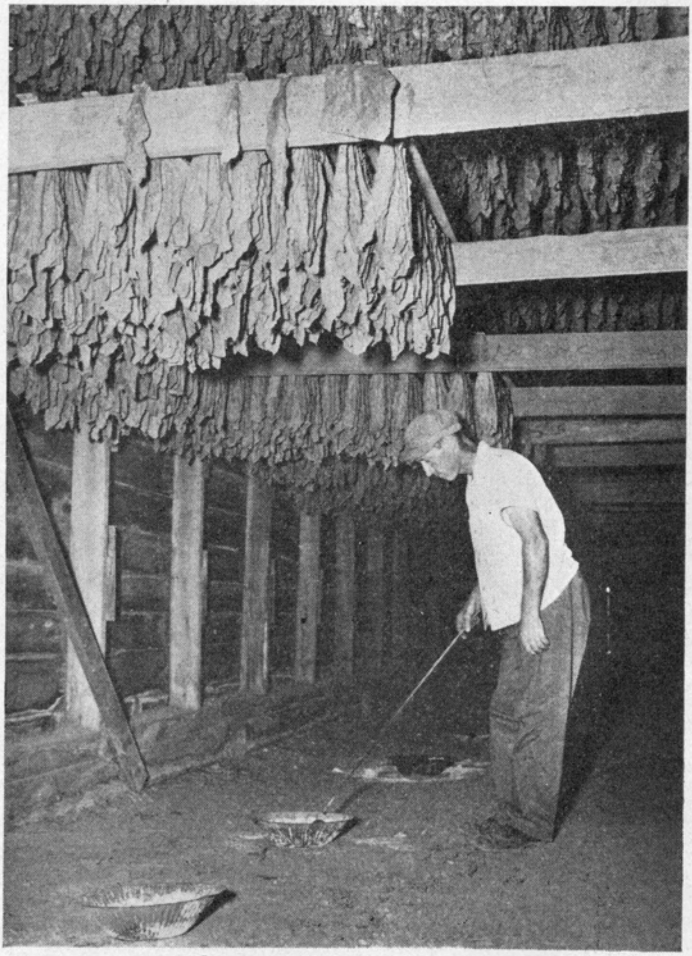
POLE ROT of TOBACCO

P. J. ANDERSON



Curing with charcoal fires, the best preventive measure against pole rot.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION
NEW HAVEN

BULLETIN 517

MARCH, 1948

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Pole rot is responsible for greater loss to Connecticut tobacco growers than any other disease of this crop. The extent of the loss varies greatly from year to year depending on the weather prevailing during the harvesting and curing season. Negligible during favorable years, it too often becomes catastrophic during bad seasons. It was more damaging in 1947 than any recent year. The loss has been conservatively estimated at 10 per cent of the crop of the Havana Seed and Broadleaf types. Translated into dollars, this would mean about $1,500,000. This does not include losses to Shade tobacco but this type was only lightly damaged because of the universal practice of Shade growers in "firing" the sheds early so that there is little danger of pole rot.

The moist curing weather during September and crowding too much tobacco in the sheds were largely responsible for these heavy losses. Many of the growers of binders used charcoal fires but for the most part they did not fire at all or did not fire long enough or at the right time.

Pole rot has been under investigation at the Windsor Tobacco Laboratory for many years as opportunities were presented for such studies. Results of these investigations have been published from time to time.[1] These bulletins have dealt principally with the organisms that cause pole rot. The important subject of control measures has not been adequately covered in the previous publications. The purpose of the present bulletin is to make available in one publication the pertinent information we have on the cause and development of pole rot and particularly on methods of prevention.

POPULAR NAMES OF THE DISEASE

Under the name "pole rot" we include all types of rot that damage tobacco while it is hanging on the poles in the curing sheds. Various other names are in common use here and in other tobacco sections to designate the same disease or certain types of it. Sweat, pole sweat, pole burn, shed burn, house burn, stalk rot, slimy stalk, hollow stalk, rattle-box, stem rot, vein rot and freckle rot are some of them. The term pole rot does not include the rots and disorders which occur in the bundle after removal from the poles or in the packing case, such as bundle rot, must, black rot or canker. These latter are caused by different organisms and have no relation to pole rot.

SYMPTOMS

Most growers are familiar with the final symptoms or effects of pole rot but are less likely to observe or recognize them in the early stages while it is still possible to apply remedial measures. When the midveins are so decayed that the leaves fall off the stalks in the shed, or the web of the leaf separates from the midrib, or the leaf is "tender" and soggy and pulls apart when opened in the sorting shop, the grower recognizes pole rot, but he neglects to look for the early stages that lead to such disaster.

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[1] Conn. Agr. Exp. Sta. Buls. 382: 600-607; 391: 112-117; 469: 120-123; 493: 23-27.

For convenience of discussion, we distinguish four types of pole rot, recognizing, however, that the types may intergrade one into the other and do not represent four distinct diseases. These are (1) stalk rot, (2) vein rot, (3) web rot, and (4) freckle rot.

Stalk Rot

In point of time, this is usually the earliest type to appear. In fact, it is not unusual to find the symptoms of stalk rot before tobacco is harvested. It is common on the stalks of Shade tobacco but, since these stalks are not taken into the shed, it does not cause further trouble unless it has passed into the leaves. This is the same disease that the Shade growers call "dead-blossom" leaf spot or "blow rot". Although it is observed more often on the leaves, it frequently affects the stalks, where it produces a definite canker (Figure 1). The canker nearly always originates at the base of a leaf and spreads in an oval up and down the stalk. In its youngest stages the dead tissue of the canker is olive-colored and watery but soon turns brown and is sunken. Later it bleaches out to gray or straw color. After it has girdled the stalk, the leaves above the canker turn yellow and die.

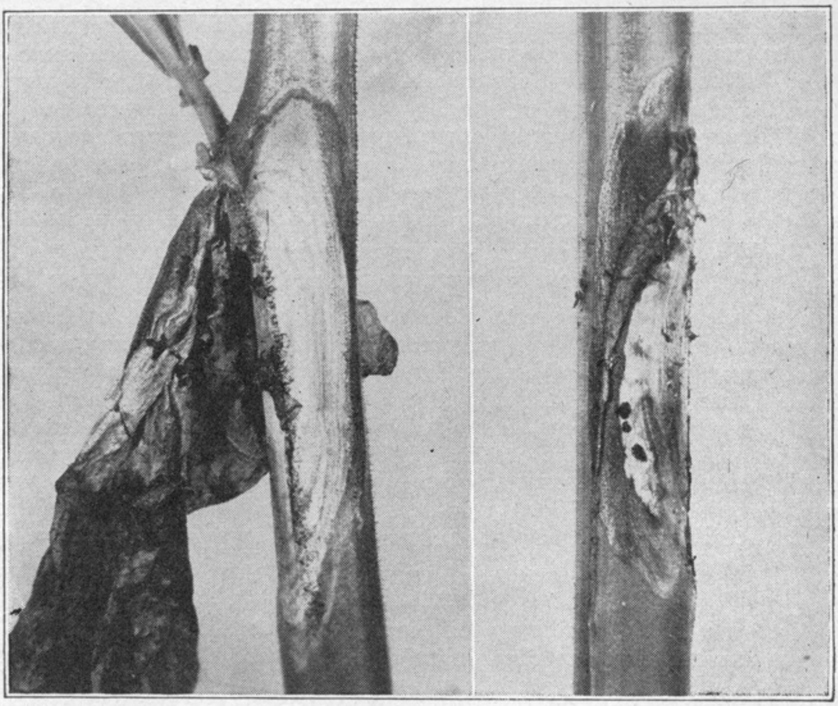

Figure 1
Stalk canker on Shade tobacco (Sclerotinia).

In stalk-cut tobacco, the type of canker we have just described on Shade is not seen so often but may sometimes be found, especially in wet years. On Broadleaf and Havana Seed, the initial stages of rot are more often found on the scars where the suckers or the tops have been broken out. Starting from the lacerated tissues in such scars, the rot spreads on the surface of the stalk or down through the pith which turns brown and may leave a portion of the stalk hollow. (This should not be confused, however, with the common bacterial "hollow-stalk" in stalk-cut tobacco.) Except in continuous wet weather the rot around such wounds does not spread far and is not very conspicuous but assumes considerable importance in the later development of pole rot.

Most of the stalk rot that develops in the shed starts from the lesions just described and works down the stalk. There are two well-known types of stalk rot in the shed. In the first type, which the grower calls "hollow-stalk", the entire pith rots and then shrivels and dries, leaving the stalk entirely hollow and very light in weight. Inside the cavity of the stalk, little hard black pellets (sclerotia) rattle around, when the stalk is shaken. Growers sometimes call it "rattle box". The leaves on such stalks are prematurely cured, off-color, thin and papery and of inferior quality generally. Another type of stalk rot is popularly called "slimy stalk" or "slippery stalk". All the surface layer becomes soft, wet and slimy and, when handled, it slips off the woody cylinder of the stalk. Then the surface, or large areas of it, becomes covered with a dense gray velvety felt, like a mouse-skin, from which clouds of dust arise with the slightest breath of air. Any leaves which are in direct contact with such stalks quickly rot.

Vein Rot

This type of pole rot is more often called "stem rot" by tobacco handlers because, in tobacco parlance, the large midvein of the leaf is called the "stem". This usage of the term "stem" is incorrect since, botanically, the stem refers to the stalk of a plant. Another reason for preferring the term "vein rot" is that this same type of rot often affects the larger lateral veins of the leaves with exactly the same symptoms. Use of the term "vein rot" avoids confusion.

Vein rot often starts where there is stalk rot, when the rot runs from the infected stalk out into the midribs and then may go into the laterals. But such is not always the origin. The veins may be rotted without involving the stalk at all. Sometimes vein rot is associated with web rot (described below) with both parts of the leaf affected alike. In Shade tobacco, vein rot (like web rot) originates usually from infected dead blossoms which adhere to the leaves. We may have vein rot in the absence of web rot, because the veins remain green and sappy, susceptible to rot, long after the web has dried out.

All the tissues of the vein become completely disintegrated except the fibres which separate readily and resemble the ravelled threads of a cord. Affected veins are prominent because they turn white or straw colored and are in sharp contrast to the darker web tissue. In the shed, the midribs sometimes become so rotted that the leaves fall off the stalks of their own weight or are easily shaken off in handling.

The tobacco handler is most familiar with vein rot as it appears on the sorting bench. When he opens the leaf in sorting, the web pulls away from the affected midrib (Figure 2). Such leaves are of no commercial value.

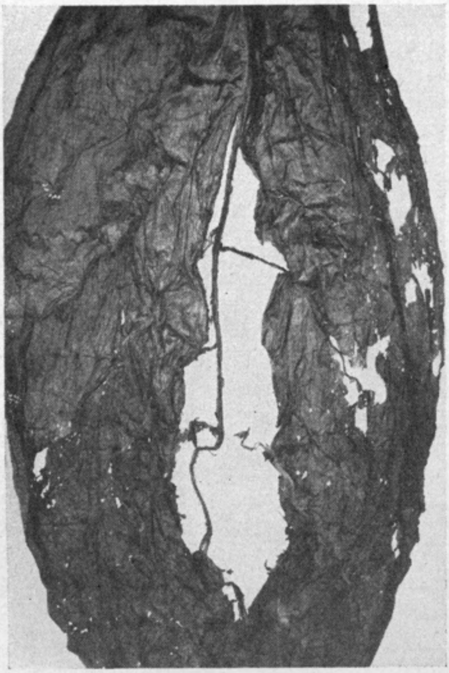

Figure 2
Vein rot. The web of the leaf pulls away from the rotten veins.

Web Rot

The web is the leaf tissue that fills the spaces between the prominent veins of the blade. Web rot is by far the most destructive of the four types of pole rot. Any part of the leaf that is touched at all by web rot is worthless. The prospective buyer cuts the price drastically if he sees only a few leaves in the bundle thus affected because he suspects that, when he sorts, a large proportion of them will be rotted too much to use for cigar binders or wrappers. Like the types previously described, web rot may sometimes be seen starting in the field before the tobacco is harvested. This is rather rare in stalk-cut tobacco but it is sometimes found when there are continuous rains after tobacco has been topped. The affected parts of the leaf turn brown and remain soft and watery as long as the rainy weather continues, but become dry and brittle when the weather clears.

In Shade tobacco, however, it is not uncommon during the latter half of the harvesting season. It is the familiar "dead blossom" leaf spot (Figure 3) that spreads from the dead corollas of the blossoms that have lodged on the upper surfaces of the leaves. Such spots may, under favorable conditions, involve large areas of the leaves, but in dry weather may remain small and inconspicuous. When affected leaves are taken into the curing sheds, the small spots spread rapidly on the same leaf or may quickly spread through the other leaves that are in contact with them until a whole lath of leaves may be ruined.

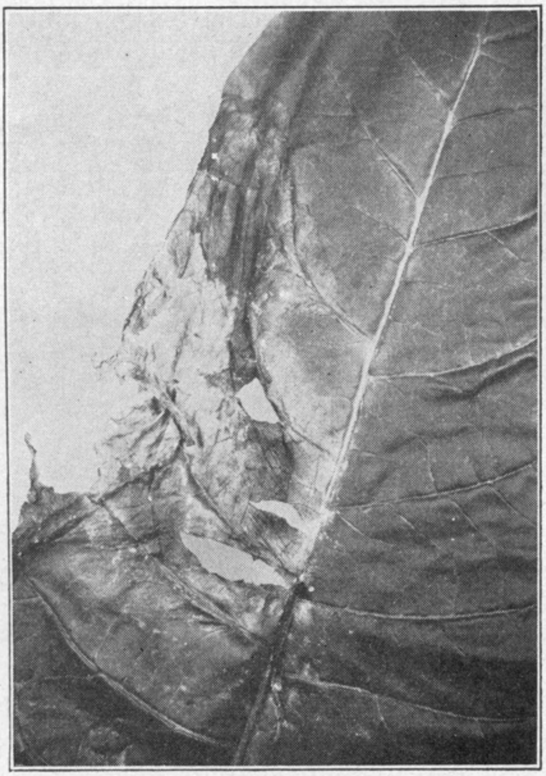

Figure 3
Dead blossom leaf spot in the field.
Web rot on a green leaf.

In the stalk-cut sheds the affected leaves, while still in the green or the early sappy yellow stage, take on a darker hue and feel swollen and clammy at first. Drops of moisture may stand out on the surface (hence the popular name, "sweat"), although this is not a universal symptom. In the initial stages the midribs of the leaves are prone to "strut," *i.e.* they stand out stiff at right angles to the stalk, instead of drooping. Soon the affected leaf blades become so soft and "tender" or slimy that the leaf has no tenacity and tears apart in handling. Badly affected tobacco in this stage gives off a peculiar odor which is recognized by an experienced tobacco man even before he enters the shed. It is the disagreeable odor of decaying green vegetable matter but with a character specific for tobacco. Another characteristic of this type of rot is the extreme rapidity with which it develops in humid weather. Only a few days of such weather are needed to start rot in all parts of the shed. It does not seem to start at one place and gradually spread to another part but appears simultaneously in all sections of a shed.

When the tobacco is dried out by the return of clear weather or by firing, the rotted parts of the leaves become stiff and brittle. If handled at all in this stage, the affected leaves shatter into fragments. "Pole rot" leaves do not come into "case" readily during "damps" and may still be rigid when other leaves are in good condition for handling. If the tobacco is put into the bundle at this stage, these leaves come into the sorting shop in a badly shattered condition (Figure 4). Even if the leaves are left in the shed until they finally become soft enough for handling, they are "tender," tear apart easily and must be discarded because they do not have tenacity or elasticity enough for use as cigar wrappers or binders.

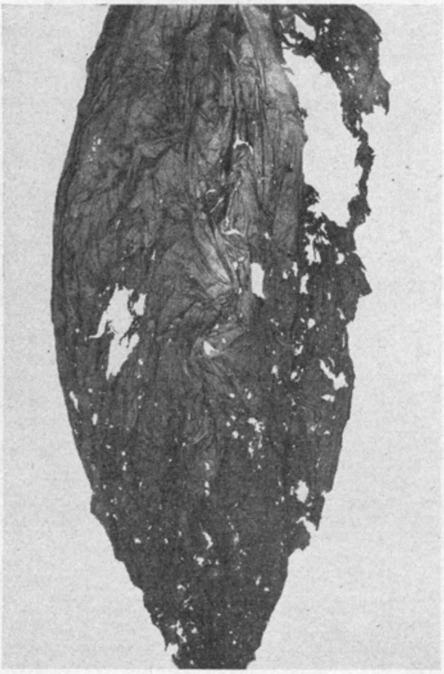

Figure 4
Web rot on cured leaf. Fragments of the leaf drop out when it is handled.

Entire leaves may be involved in the rot but more frequently some parts of the leaf are still sound. The affected areas do not make definite spots with distinct margins but usually involve large patches of no fixed shape or position on the leaf (Figure 5). The surface of such areas is dull and lacks the luster or finish of a normal leaf. Rotted portions are usually darker and not infrequently retain more green color than the normal leaf. This may be the grass green[1] color of "hayed down" leaf or it may show various hues of olive green.

[1] Green web-rot. Conn. Agr. Exp. Sta. Bul. 469: 122. 1943.

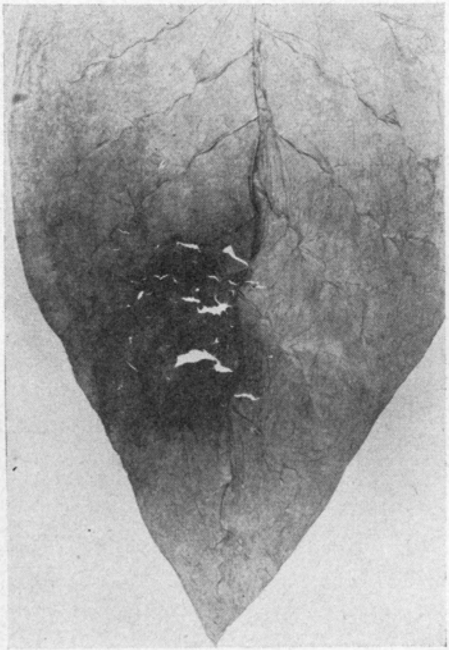

Figure 5
Web rot on cured leaf showing the darkened patch of indefinite outline.

Freckle Rot [1]

This type of rot is quite different from the three types described above and, from the standpoint of crop loss, is of less importance than the other three. It is characterized by the appearance on the blade of the leaf of numerous small dark spots from pinhead size to a quarter of an inch in diameter. In size, shape, distribution and often in color they resemble the freckles on a red-headed urchin's face (Figure 6). This suggested the name. Sometimes they are mistaken for stains from splashing raindrops. On light colored leaves the spots are deep reddish brown, while on dark leaves they are almost black. When the leaf is held up to a strong light, the spots are translucent. These spots do not coalesce to form extensive rotted areas such as occur in web rot. The web does not become as "tender" as with web rot unless accompanied by one of the other types.

CAUSAL AGENTS

Pole rot is always worst when wet, humid weather prevails during the curing season. This is the basis for a common but erroneous idea that pole rot is caused by moisture. Excessive moisture does not *cause* pole rot. It does, however, *create conditions* in the curing shed that are favorable to the action of the organisms that do cause rot.

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[1] See Conn. Agr. Exp. Sta. Bul. 386: 600-607, 1936, for a more complete discussion.

Figure 6
Freckle rot on a cured leaf.

All the types of rot described above are induced by invasion of the leaf tissue by certain parasitic fungi. In order to derive the food on which they live from tobacco leaves, they first break down the cellular structure of leaves by secretion of toxins which dissolve the material that cements the cells together. Thus, with nothing left to hold the cells together, the leaf has no tenacity and tears apart in handling.

A considerable number of species of fungi and bacteria may be found on and in the rotted parts of the leaf. Most of these organisms, however, are saprophytes which have no part in causing the disease but are living on the dead tissue after the true parasites have done their work. Such common saprophytes are species of Penicillium, Aspergillus, Fusarium, Cladosporium, Alternaria, Macrosporium and several others that we have isolated less often. When spores or cultures of these are placed on sound tobacco leaves, even under moist conditions, they have no ability to rot the leaves. Hence, they may be eliminated as possible primary agents of pole rot.

Among all the species of fungi that we have isolated from pole rot leaves, only three have shown, on inoculation of normal leaves, that they are capable of producing the types of rot described above. These three are *Alternaria tenuis* Nees, *Sclerotinia sclerotiorum* (Lib) Massee and *Botrytis cinerea* Pers. Under favorable atmospheric conditions, Sclerotinia and Botrytis are virulently parasitic on the green parts of the plant in the field or in the curing shed. These two appear to be responsible for most, if not all, of the serious outbreaks in Connecticut that we have investigated. Alternaria, on the contrary, is at best only a weak parasite and has been demonstrated to be the causal agent of the freckle rot type and a slow rot of the midribs that is of much less importance.[1] It is quite possible that further investigations may show there are also other organisms that are capable of inducing pole rot in Connecticut or in other tobacco sections. Up to the present, however, we have never been able to demonstrate the pathogenicity of any organism other than these three.

It is beyond the scope of this summary discussion to describe the morphology, cultural characters, isolation, proof of pathogenicity, and other pathological or mycological features of these species. All of this information is available to the interested reader in our previous publications cited above. There are, however, some phases of the seasonal life history of the fungi, their methods of dissemination and influence of environmental factors that need to be considered to get a complete picture of this trouble and to understand the reasons for the control measures suggested.

Alternaria tenuis

Alternaria tenuis as a semi-parasite or in the saprophytic stage is commonly found on a variety of tobacco leaf spots, such as "brown spot", "white speck", "rust" following mosaic, *etc*. The large black spores are produced in abundance, are easily scattered by wind, water, handling operations and other means. By the time the leaves reach the curing shed, every leaf probably has a population of hundreds or thousands of Alternaria spores on it. They germinate easily when there is sufficient moisture and more spores are produced on the stalks and midribs, in turn to be blown about the shed. It is only because the parasitic capacity of this species is quite low and the growth of the mycelium inside the leaf tissues is slow, that the damage caused is never so severe nor spectacular as that caused by the other two species. The little "freckle" spots caused by Alternaria are limited in size and have no tendency to coalesce or to spread indefinitely to kill large areas of the leaf. Moreover, the veins attacked by Alternaria do not collapse quickly into a watery, mushy rot (as is the case with the other two pathogens), but remain fairly firm and tenacious. Therefore, losses caused by Alternaria are much less than those due to the other two species.

Sclerotinia sclerotiorum

Sclerotinia sclerotiorum has a seasonal life cycle that peculiarly adapts it to the role it plays in causing pole rot. A brief review of its development will explain this. Most growers are familiar with the little hard black pellets (sclerotia) which rattle around in the cavity of dried stalks where the pith has rotted out. These hard sclerotia, less than a quarter of an inch across, may also be observed attached to the surface of the stalk in the shed, as well as in the field on stalk cankers (Figure 1), which occur on Shade tobacco especially. They are found in less abundance on the mid-

[1] Conn. Agr. Exp. Sta. Bul. 386: 602. 1936. Wis. Agr. Exp. Sta. Res. Bul. 110: 40-45. 1931.

ribs and occasionally on the blades of the leaves. These black sclerotia are the resting or overwintering stage of Sclerotinia, and, in this respect, they play the role of seeds of green plants. When the tobacco stalks are thrown out on the fields and worked into the soil, the stalks rot and disappear. However, the fungous sclerotia do not rot; they remain intact in the soil all winter and at least a part of the following spring and summer. Buried in the upper layer of the soil they then "sprout". A slender stalk grows up from the sclerotium. When it reaches the light above ground, it spreads out into a cup-shaped or goblet-shaped brown structure called an apothecium. This structure is never more than a quarter to a half inch in diameter and is so inconspicuous that it is seldom observed. In the upper (inner) surface of this cup, minute spores are borne in countless numbers. These spores (ascospores) are forcibly "puffed" into the air and are wafted about like dust particles, often travelling long distances before they settle down. Since the apothecia do not develop all at one time but continue to sprout up all through the season, there is a population of spores blowing about through the air and settling down on the tobacco plants throughout the summer.

If there is water on the surface where the ascospores alight, they germinate within a few hours. However, germination of the spores on the tobacco plant does not necessarily mean that infection will take place. These germinating spores appear to have no capacity to infect a sound tobacco leaf or stalk and so they die without doing any harm. There are, however, two ports of entry for Sclerotinia into the tobacco plants: (1) the blossoms and (2) watery bruised tissues.

The blossoms seem to provide the ideal infection court. The corolla (colored trumpet-shaped part of the flower), and the enclosed pistil and stamens offer no resistance to the germ tube of Sclerotinia spores. If the weather is favorable for sporulation and drops of water remain a few hours on the corollas, a large percentage of the flowers becomes infected. When the diseased corollas wither and drop, many of them adhere to the upper surfaces of the leaves. This occurs especially in wet weather but, even during moderately dry weather, the gum on all parts of the tobacco plant causes many of the blossoms to adhere to the leaves. The dead flower part is now a mass of well-nourished fungous growth which is able to overcome the resistance of the green leaf, continue its parasitic advance into the leaf cells, spread rapidly and produce the "dead-blossom" leaf spot (Figure 3) that we have previously mentioned. By this indirect route through the blossoms, the parasite secures a foothold which it could not accomplish directly. When the infected leaves are transferred to the sheds, the rot continues to spread through them and to other leaves that are directly in contact.

Although blossom infection could easily account for the origin of pole rot in Shade tobacco, it does not explain pole rot in stalk-cut tobacco. The flowers are removed from these types before they have an opportunity to become infected, although sometimes the suckers or tops are left too long and blossom infection occurs. Generally, field infection in stalk-cut tobacco occurs through the lacerated tissues where tops or suckers are removed or accidents have broken or crushed leaves or stalks. Unless the damaged parts dry out immediately, the watery bruised tissues furnish a favorable infection court for the spores.[1]

Sclerotinia rot in the curing shed can spread *only* to other leaves that are *directly in contact* with an infected leaf or stalk. It produces no spores in the shed which could be blown about to spread the disease to leaves even at a distance of a few inches. This insures the safety of all *sound* leaves that are not in contact, but there is another danger that threatens leaves that have been bruised or broken during the process of harvesting. Large numbers of spores are likely to be carried into the shed on the surfaces of leaves or may be wafted by air currents through the ventilators. These spores in contact with the bruised parts of the leaf can start infection, unless the leaves are quickly dried. This danger exists only as long as the leaves are green or in the early "sappy" yellow stage. In artificial inoculation tests with spores or cultures, the writer has not been able to infect leaves which have changed to the late yellow or brown stage, even under the most favorable moisture conditions.

Botrytis cinerea

Botrytis cinerea is a common parasite and saprophyte growing on a large number of cultivated and weed plants. It sporulates quickly and abundantly. The spores are very light and are blown about through the air. Therefore, there is always a good supply on the leaves and stalks.

In its pathogenic characteristics, it shows a remarkable parallelism to the Sclerotinia just discussed. In fact, they are so similar that one might be tempted to consider them as two stages of the same fungus, if it had not been demonstrated so often that they are two distinct organisms. In their ability to infect blossoms and wounds, the inability of their spores to infect sound leaves, production of dead blossom spots, production of vein rot, stalk rot and web rot, their marvellously rapid spread in the leaf, the rot symptoms in all stages, and their dependence on high moisture conditions, there is little difference between the two species. All that has been said above about the Sclerotinia rot in these features applies equally to Botrytis rot. Unless one sees the sclerotia or spores on the surface or has made cultures, he cannot say which of the two is responsible for the rot. There are, however, a few differences which have a bearing on the spread of the disease and methods of control.

The writer has never been able to produce stalk cankers by inoculation of living plants with Botrytis, in which respect it differs from Sclerotinia. In the shed, however, it grows rapidly on the outer layer of the stalk but has not been observed in the pith cavities.

A more important difference, however, is in the capacity of Botrytis to produce enormous quantities of spores on the tobacco in the sheds. The dust clouds that arise from the stalks covered with the gray fungous felt mentioned above are countless numbers of Botrytis spores which are carried all over the shed and are capable of starting new infections on wet bruised leaves, if moisture conditions are favorable. Unlike Sclerotinia, it is not necessary that the leaves be in direct contact. The spores

[1] Conn. Agr. Exp. Sta. Bul. 493: 24. 1946.

are also borne on the midribs, but only rarely have been seen on the blades of the leaves.

It is interesting that only very rarely does one find both of these species on the same leaf or stalk. Moreover, during some years, an outbreak seems to be due almost entirely to Botrytis, while in other seasons it is predominantly Sclerotinia. Probably the weather conditions that prevail during the harvesting and curing season determine which shall predominate.

CONTROL

It is obvious from the preceding description of the symptoms and pathogens of pole rot that we are dealing here with a parasitic fungous disease even though the greatest damage occurs after the plants are removed from the field and are in a dying condition. One would naturally expect, therefore, that control would be attained by some of the methods practiced in controlling other fungous diseases. Most of such control methods, however, are not practicable against pole rot.

It is not possible to eliminate these fungi from a neighborhood or even from a field because both of them grow on a large number of other common plants in and around the tobacco fields where it would not be practicable to destroy them nor greatly reduce their abundance. Air currents carry the spores such long distances and in such great numbers that there will always be a supply of spores on the leaves.

The most popular method of combating fungous diseases is to spray or dust the plants with fungicides which either kill the spores or prevent the entrance of the germ tubes into the interior tissues of the plants. No kind of a sprayer or duster, however, that operates on the ground could be drawn through a field of mature tobacco without damaging more leaves than it saved by preventing pole rot. Airplane application would, of course, overcome this objection but, even if the fungicide could be thoroughly distributed in mature tobacco, there would still be the problem of finding a suitable fungicide. Such a material would have, not only to kill the spores, but leave no visible deposit on the leaves nor objectionable taste or aroma when the tobacco is smoked. Also, it should remain effective through the curing season in the shed. As yet, such a fungicide has not been found. A more promising approach would be to search for some fungicide that could be used as a fumigant in the curing shed. Such a fumigant must not only be fungicidal but also must not kill the cells of the leaves before the catabolic changes involved in curing have gone to completion. Such a fumigant has not been found but its discovery lies well within the range of probability. This method would hardly be expected to stop rot which has already started when the leaves are brought into the shed but it should prevent new infections.

All measures now practiced by growers are based on the principle of rendering the conditions which surround tobacco plants hanging in the shed unfavorable to infection and growth of the fungi. Moisture control is the key to prevention of pole rot by this method. Such methods are indicated because of the following characteristics of the causal fungi:

1. Spores can germinate only in the presence of water.
2. Water must be present continuously over a considerable period

to allow time for germination and entrance of the germ tubes into the tissues of the leaf.

3. If bruised tissue is desiccated quickly, it is not susceptible to infection.

4. The spread of the rot into the healthy web of the leaf stops as soon as the water content of the tissue is sufficiently reduced.

5. Sclerotinia rot can pass only to leaves that are directly in contact with diseased tissues over a considerable period (this is not true of Botrytis rot, however).

The problem, then, is to find the most effective and easy way to rid the tobacco of excess moisture and keep the leaf surfaces free of water, especially in the early stages of curing. To accomplish this is one of the objects of the common practice of warming the tobacco by the use of charcoal fires on the floor of the sheds, a procedure long called "firing the sheds". This is the universal and routine practice of all growers of Shade tobacco, but only a low percentage of growers of Havana Seed and Broadleaf types "fire" their sheds. Shade tobacco is just as susceptible to pole rot as the other two types. The fact that Shade growers have comparatively little pole rot while growers of the other types suffer staggering losses every epidemic year is a clear demonstration of the efficacy of firing to control pole rot.

Proper firing can improve the quality of tobacco even in the absence of pole rot. A brief consideration of the reasons for the curing operation will explain this. If tobacco leaves are dried out within a few hours by heat or toxic chemicals ("hayed down"), they remain green in color and, when ignited, the smoke is bitter and rank smelling. They have no capacity to hold fire but burn like paper. If, however, the leaves are permitted to dry gradually through several weeks instead of a few hours, they become brown, have good fire holding capacity, and a pleasant taste and aroma when smoked. To accomplish these differences is the object of curing, as contrasted with drying. These beneficial changes are the expression of a complicated series of chemical reactions that occur inside the leaves kept under these conditions. It is beyond the scope of this circular to discuss these reactions except to note that the speed with which they take place is materially influenced by temperature. At a relatively high temperature, 85 to 95° F., they progress more rapidly and more completely than at a low temperature, *e.g.,* 50 to 60° F. Thus, if the temperature of the shed is raised by charcoal fires or by other means, the cure is accomplished more effectively and in a shorter space of time. Moreover, the tobacco is exposed to danger of pole rot for a shorter period.

Danger of Over-Firing

It is quite possible to eliminate pole rot *completely* by firing for a long period at a high temperature. The grower who is over-anxious to guard against pole rot may easily go too far in his zeal and "hay down" his tobacco. The quality of the tobacco may be seriously impaired in taste and aroma even when it does not appear to be "hayed down". Over-firing should be avoided just as much as not firing at all.

Evaporating all surface moisture from the leaves and reducing the water content of the tissues of the leaves as fast as possible without stopping the desirable chemical reactions, is the ideal curing procedure. Heating with charcoal fires favors this ideal in two ways: (1) when air is heated, its evaporating capacity increases very rapidly, (2) fires on the floor of the shed start air currents circulating through the hanging tobacco.

Role of Air Currents

Water may be evaporated as effectively by air currents as by raising the temperature unless the humidity outside the sheds is approximately as high as that inside. Air currents dry tobacco leaves on the same principle that a wind dries a washing on a backyard clothes line. Moreover, the currents start a gentle movement of the leaves so that they are not in continuous contact with each other and thus do not favor the progress of rot from leaf to leaf or stalk to leaf. Experiments have shown that proper distribution and volume of air currents can be obtained by mechanical fans to assist in offsetting high humidities. The fans alone are sufficient for good cure in favorable weather, but in very humid weather, or seasons when the temperature is too low for good curing, it is desirable to have fires also.

Firing Procedure

It is not possible to set down fixed rules for fire curing tobacco under all conditions. Duration of firing, optimum temperatures, *etc.,* depend so much on the weather and condition of the tobacco that only general rules can be laid down as a guide. Experience and understanding of the qualities of leaf desired and of the conditions that favor pole rot are of greater value than adherence to a fixed set of rules. With this reservation, the following rules of procedure are offered.

When to Fire and How Long

Most growers of Shade tobacco start firing just as soon as a shed is filled. Only a few of the Havana Seed and Broadleaf growers practice this initial firing, commonly called "firing to wilt". Growers who do not fire at all, or only occasionally, operate on the theory that since pole rot losses do not occur every year, the cost of firing regularly every year amounts in the aggregate to more than the occasional financial loss in bad years. This is a question for each individual to decide for himself, but if he plans to fire at all, the initial "firing to wilt", is the most important firing. In the first place it wilts the tobacco so that the leaves no longer form a continuous solid blockading curtain across the shed. Once wilted, each plant is separated from the next so that the air may circulate freely between them and there is less chance for the rot to pass by contact from plant to plant. Secondly, "firing to wilt" dries out the bruised areas on stems and leaves caused by harvesting operations which form the infection courts for rot fungi. If such areas are dried quickly, they no longer serve as breeding places for fungi. In the third place, this firing hastens the cure and, therefore, the tobacco is exposed to pole rot for a shorter period of time. The initial firing should be continued for two or three days, or until the leaves hang limp from the stalks. If it is found that the leaves, while still green, are becoming dry and stiff, the fires should be stopped.

After the initial firing, later firings may not be necessary. In good curing weather, the cured parts of the leaves become damp and soft at night and then dry and stiff during the day. If, however, the weather is such that they fail to dry for two successive days, then it is time to fire again. This is especially needed if parts of the leaves or the midribs are still green or sappy. If the midribs are already cured, firing is not necessary. In these later firings, the fires should be continued until all brown parts of the leaves are dry and hard. Firing for too short a period should be avoided since this only drives the moisture from one part of the shed to another section. Change of temperature alone does not hinder growth of the fungi, in fact, it only makes them grow faster. They are retarded only by lack of moisture. Second or subsequent firings should usually be continued for at least two days unless dry windy weather intervenes.

Number and Location of Fires

A large number of small fires in a shed is better than a small number of large fires. More than about four to a bent (16 feet square) is not economical, however, because of the amount of labor involved in tending too many small ones. They should be equally distributed on the floor, if the hanging of the tobacco allows this. Where the tobacco hangs close to the ground and only one run has been left for fires, however, equal distribution in the bent is not possible. It is not necessary to locate fires close to the outside walls.

Pits, Pans or Stoves

It makes little difference in the effectiveness of the cure whether the fires are built in pits in the ground, in open pans (see cover), or in simple stoves or salamanders. Each has its advocates but the preference is based largely on arguments for convenience or safety rather than the effectiveness of the cure. Various kinds of metal shields or spreaders are used over the fires and have merit in preventing "haying down" of the leaves directly above the fires. If the lowest leaves are not too close to the ground, however, the spreaders are not necessary.

Temperature

Tobacco cures best at temperatures of 85 to 95° F. Only during a period of very wet and very warm weather will it be necessary to go higher. In unseasonably cool weather, it may not be advisable to raise the temperature so much because the humidity will be too low and water will be lost too rapidly. A general rule is to raise the temperature about 10 to 15° above the outside air. A rise in temperature, of itself, does not hinder the growth of the rot fungi. These organisms grow normally at all ordinary temperatures maintained in the curing shed. The benefit of raising the temperature (as far as rot is concerned) depends only on its effect in lowering humidity. A rise of 20° F. doubles the capacity of the air to absorb moisture.

Humidity

For best cure, the relative humidity should be about 10 points (expressed in percentage) below the temperature (expressed in degrees Farenheit). For example, if the temperature is 85° F. the relative humidity of the air should be 75 per cent. It is realized that it is not always possible to attain this relationship but this is the ideal to guide the operator who should approach it as closely as he can. Actually, if pole rot control were the only goal sought, a lower humidity would be better, but for a combination of rot control and attainment of good quality in tobacco, controlled experiments have shown that the one above is the best relationship. Lowering the humidity of the air hastens evaporation of moisture from the leaves and therefore makes them less susceptible to rot.

Manipulation of Ventilators

The amount of moisture in the shed, and often the severity of rot, can be reduced considerably by proper manipulation of side and top ventilators and doors. When they are open, they allow the breezes to pass through the tobacco to remove excess moisture. Their capacity to keep moist air out of the shed, however, is quite limited, contrary to popular belief, because shed construction is usually too loose to prevent the infiltration of any kind of air from the outside for any length of time. During the early stages of curing, when not firing, all ventilators should be wide open to allow the maximum quantity of water to pass off from the green leaves. The only occasions for closing the ventilators at this stage are in too *windy* weather, to *prevent wind whip,* and *during rains,* to *prevent rain splashing.* During later stages, when the cure is nearing completion, it is usually better to close the ventilators at night and open them during the day except during rains. However, during windy days, ventilators on the windward side should be closed to prevent damage of the dried leaves by whipping. After the midribs are dried out, the shed may be kept closed all the time except when a long damp spell threatens to cause mold on the leaves. In this case the tobacco should be ventilated until the leaves get dry and hard.

More tobacco is ruined by too little ventilation than by too much. Many successful growers keep the ventilators wide open during the entire curing season except for periods of high winds or blowing rains.

The side ventilators are closed during firing but the roof ventilators should always be open. Some consider it a good practice to open the side ventilators occasionally for short periods during the firing.

Spacing and Arrangement of Tobacco in the Shed

If a grower has adequate shed room, he can almost eliminate the risk of pole rot damage by proper spacing and hanging. Unfortunately, too many growers raise more tobacco than they have room for in their sheds and therefore crowd it too much. This accounts for a large part of the severe damage of the 1947 season. Expanding acreage and very high costs of shed construction present a dilemma to the grower and he is tempted to crowd rather than to build.

Rot is usually most severe in the tobacco nearest the floor. To prevent this, tobacco on the first tier should be hung so that the tips of the leaves are five or six feet off the ground. In many sheds this means leaving out the first tier entirely. In addition to keeping the tobacco away from the hazardous zone, this arrangement allows for more freedom in distributing and tending the fires and for better circulation of air. If it is necessary to hang the lowest tier near the ground, it is customary to leave out one run the length of the shed through each side for fires. This should never be the outside run but preferably about the third run in from the sides. If more than two runs to a shed could be omitted, the heat would be better distributed. This can be accomplished also by short lateral runs coming off from the main runs.

The number of stalks on each lath should not be more than six for Havana Seed or five for Broadleaf. The lath should be spaced as far apart on the poles as is possible with the shed room available. Large tobacco should be spaced farther than small tobacco. Usually the lath are hung closer in the peak than at the bottom of the shed. Under no conditions should they be less than six or seven inches apart, and eight or ten inches is better. They can be spaced more closely if the owner plans on regular firing.

Relation of Maturity of Tobacco to Pole Rot

Tobacco that is quite "ripe" when harvested is in less danger of pole rot damage than tobacco harvested green. Ripe tobacco passes through the curing stages more rapidly and soon reaches a state in which it is no longer subject to infection. If all stalk-cut tobacco were left in the field three weeks after topping, it would aid materially in preventing pole rot.

Wilting Before Hanging

Tobacco that is thoroughly wilted after cutting, and while still on the field, is less subject to pole rot. Wilted tobacco can be handled with less breakage and, therefore, there will not be so many infection courts for the fungi. Moreover, initial wilting starts the cure at once and thus reduces the duration of the danger period.

Hanging Wet Tobacco

Growers try to avoid harvesting tobacco when the leaves are wet with rain or dew but sometimes unexpected rains or other unavoidable circumstances make it necessary to hang wet tobacco. This furnishes ideal conditions for rot since the leaves dry very slowly when crowded into a shed and there is abundant time for the fungi to work. Immediate and heavy firing is the best insurance unless drying winds come immediately and the ventilators and doors are kept wide open.

Discard Infected Leaves

Shade growers can avoid shed damage by discarding all leaves which have even small "dead blossom" leaf spots on them. These can be seen easily and thrown out when the leaves are being sewed on the lath in the shed. Such spots are not often seen on the leaves of stalk-cut tobacco and it would rarely be practicable to rogue them out.

Some strains of Shade tobacco, such as Connecticut 15, develop flowers late in the season and in smaller numbers. Consequently these leaf spots are not so common on them and there is less opportunity for rot to spread in the shed.