

*Controlling Diseases*  
of  
**TOBACCO**



**CONNECTICUT AGRICULTURAL  
EXPERIMENT STATION  
NEW HAVEN**

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## CONTENTS

	PAGE
INTRODUCTION .....	5
EARLY DAMPING-OFF OF SEEDLINGS .....	5
MILDEW OR BLUE MOULD .....	7
BED ROTS .....	12
WILDFIRE .....	14
BLACKFIRE OR ANGULAR LEAFSPOT .....	17
BROWN ROOTROT OR NEMATODE INFESTATION .....	18
BLACK ROOTROT .....	21
STALK-ROT OF TRANSPLANTS .....	23
SORE SHIN .....	24
HOLLOW STALK .....	26
FUSARIUM WILT .....	28
MOSAIC OR CALICO .....	30
RINGSPOT .....	35
FRENCHING .....	37
MALNUTRITION DISORDERS .....	38
Magnesia Hunger or Sand Drown .....	40
Calcium Deficiency .....	40
Nitrogen Starvation .....	40
Ammonia Injury in Seedbeds .....	41
Phosphorus Deficiency .....	42
Potash Deficiency .....	42
Manganese Poisoning .....	43
DEAD-BLOSSOM LEAFSPOT .....	43
POLE ROT .....	45
APPENDIX. KEEPING THE SEED BED HEALTHY .....	51
Proper Fertilization .....	51
Sterilizing the Soil .....	51
Spraying for Wildfire .....	54
Spraying for Mildew .....	54
Treatment for Aphis and Flea Beetle .....	55
Destroying Beds at Close of Season .....	55

# CONTROLLING TOBACCO DISEASES

P. J. Anderson

In a previous bulletin, "Diseases and Decays of Connecticut Tobacco",<sup>1</sup> all the diseases known to damage Connecticut tobacco were discussed with full descriptions of the symptoms, of the causal parasites, influence of environmental conditions, historical background and other pertinent information, along with methods of control. Since the publication of Bulletin 432, considerable additional information has been accumulated here and in other states, particularly with respect to methods of control. Easier and better means of combating or preventing some of the diseases have been found than those described in the previous bulletin. The object of the present bulletin is to make this new information available to tobacco growers. For a more complete discussion of the nature and cause of the diseases, the grower is referred to the previous bulletin which is still available.

The emphasis in the present bulletin is on control methods. Most of the material dealing with causal organisms and the other phases mentioned above has been omitted from this revision. Symptoms are discussed only sufficiently to insure correct diagnosis. Scientific names of causal organisms are given in footnotes but they are not described. Effects of environmental conditions are discussed only as they relate to control. The illustrations are included to assist the reader to recognize the diseases more quickly.

With the aid of this bulletin, it is our hope that the grower will be able to identify any disease that afflicts his crop and apply the best remedies that have been developed at the Tobacco Laboratory and elsewhere.

A few minor diseases causing only negligible damage, which were included for completeness in Bulletin 432, have been omitted from this bulletin. Decays and storage troubles are also omitted here.

The arrangement of the diseases is roughly chronological, starting with those that first appear in the seed bed and ending with the curing shed troubles.

In the Appendix is outlined a complete sanitation program for seed beds.

## EARLY DAMPING-OFF OF SEEDLINGS

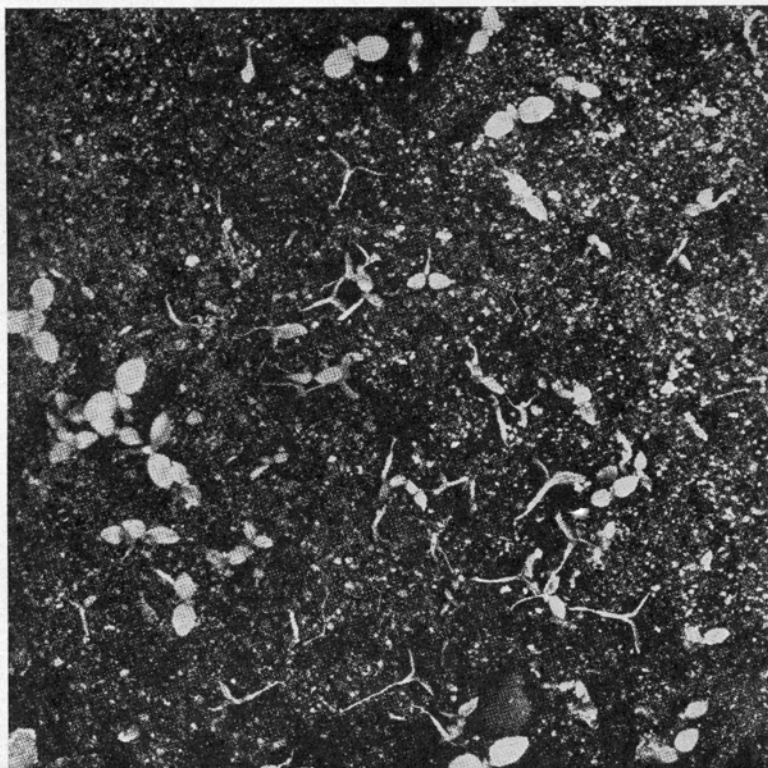
This is the first disease of the season, occurring every year. It is usually not sufficiently severe to cause loss of beds but frequently causes such a thinning of the stand that the grower does not have plants enough to set his intended acreage.

### Symptoms

This is a disease of the tiny seedlings in the two-leaf (cotyledon) stage and should not be confused with the later bed rots described on p. 12.

<sup>1</sup> Conn. Agr. Exp. Sta. Bul. 432. 1940.

The grower first notices that, although the beds looked thick enough when the seeds first started, they become thinner every day. On close examination, he finds that many of the seedlings have fallen over to the ground and the stems are shrivelled to strings (Figure 1). The dead plants soon wilt or rot completely and disappear with the first watering.



**Figure 1**

**Damping-off of young seedlings. Note shrivelled stems of prostrate plants.**

This type of damping-off is caused by the attack of a soil inhabiting parasitic fungus<sup>1</sup> which may be found in most fertile soils and causes a similar damping-off of young seedlings of a large number of vegetables, flowers and other plants.

### **Control<sup>2</sup>**

It is easy to kill the causal fungus by the usual sterilization of the soil by steam or chlorpicrin. Unfortunately, however, this is not effective in stopping the disease because the soil becomes reinfested too quickly. Con-

<sup>1</sup> *Pythium debaryanum*.

<sup>2</sup> See Conn. Agr. Exp. Sta. Bul. 487, p. 293, for a more detailed discussion of control.

control measures applied after the disease is noticed in the bed are usually too late.

The most effective method of control is to treat the soil with formaldehyde just previous to sowing the seed. This must be done carefully because an overdose may kill the plants. Directions are as follows:

1. Stir one pint of formaldehyde into about one gallon of water in a sprinkling can.
2. Have soil pulverized and ready for sowing.
3. While raking over the soil the last time just before sowing, sprinkle the above amount of solution evenly over an area of four or five sash (72 to 90 square feet). Mix thoroughly into the top three inches of soil with the rake.
4. Level the surface and sow the dry seed as usual.

The formaldehyde fumes remain in the soil long enough to kill or prevent growth of the fungus during the period when the seedlings are becoming established, but are not concentrated enough to injure the tobacco plants.

Coating the seed with fungicidal dusts gives some control but sometimes is not effective. In a series of trials at the Tobacco Laboratory, the three that gave best results were Arasan, Cuproside and Fermate, in the order named.

Spraying with copper fungicides as described under "Downy Mildew" is beneficial but is usually too late to be dependable.

Fumigation of the beds with paradichlorobenzene every second night after the seeds start to germinate gave excellent control in experiments at the Tobacco Laboratory.

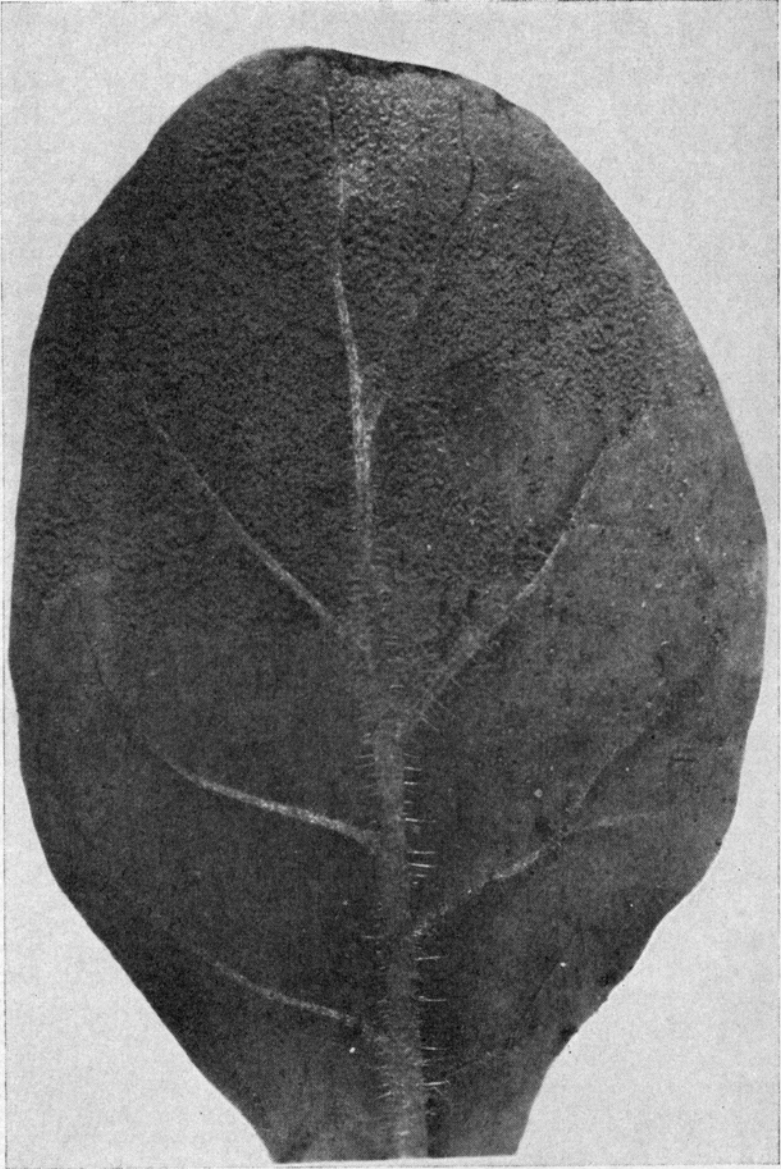
## MILDEW OR BLUE MOULD

This is the most troublesome disease of seed beds and rightly has first consideration in any seed bed spray program. If it gets into the beds when the plants are quite small, it kills many of them and may even destroy the whole bed. If the plants are large, it kills parts or all of the leaves but the plants survive and put out new foliage. This, however, may cause serious delay in getting the plants set in the field.

### Symptoms

Mildew first causes yellow blotches on the upper surfaces of the leaves which then become distorted. The sure diagnostic symptom, however, is the mould-like growth of fungus<sup>1</sup> which soon appears on the lower surface of the leaves (Figure 2). This growth may have a violet color when fresh, hence the popular name "blue" mould, but it soon assumes some shade of gray or brown. If the bed atmosphere is moist, the leaves develop a wet rot; under drier conditions, they shrivel and lie like twisted strings on the soil (Figure 3).

<sup>1</sup> *Peronospora tabacini*.



**Figure 2**

**Downy mildew. This leaf from the seed bed shows the fungus covering a part of lower surface. (Somewhat enlarged).**

Mildew usually first appears in Connecticut about May 15 but during early springs it may attack before that date. It spreads rapidly by means of spores which are blown about in the air and, when it is found in one bed, it almost always shows up quickly in other beds in the neighborhood.

### Control

Any one of several fungicides may be used to control mildew :

*Fermate spray.* Fermate is more often used for this purpose in Connecticut than any other chemical. It is easily applied, cheap, generally available and gives excellent control, if properly applied. It is mixed in water at the rate of one pound (about four pints) in 50 gallons when the plants are small and increased to two pounds as the plants become larger or if mildew has become general in the neighborhood.

Fermate is a light fluffy powder not easily mixed with water. Mixing is much easier if the required amount of powder is first shaken vigorously with a small amount of water in a closed container such as a large mason jar and then added to the larger amount of water in the spray tank.

Its action is preventive rather than curative and, therefore, it should be on the leaves before infection is expected. The beds are sprayed regularly twice a week beginning about the first week in May and continuing until setting in the field is completed.

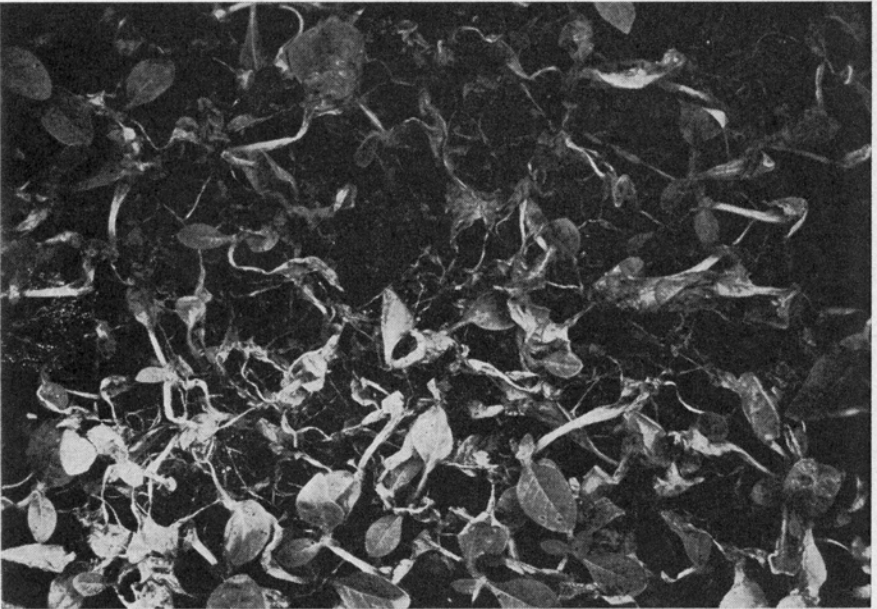
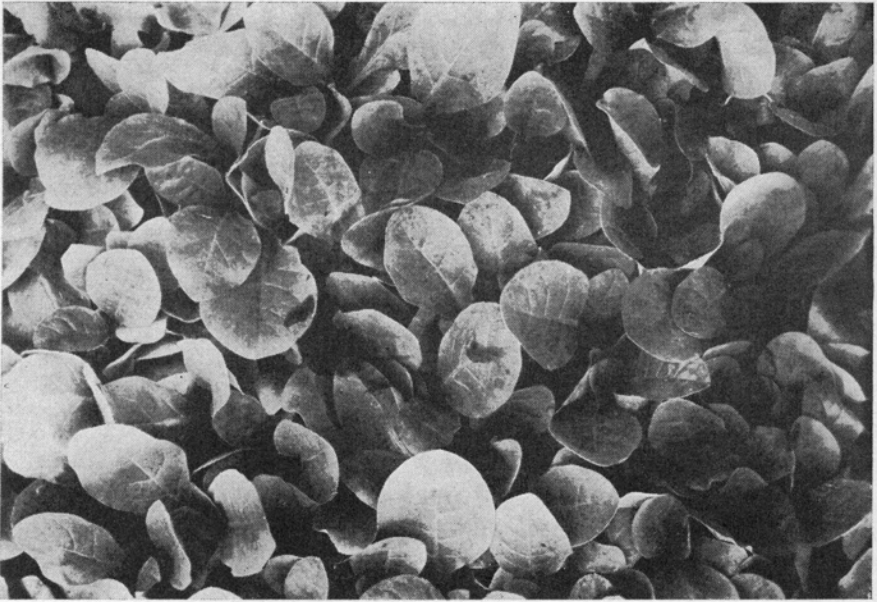
Any type of spray pump, which gives a moderately high pressure and fine distribution of the spray, may be used. A good coverage is indicated when every leaf shows black droplets of Fermate. It requires three to five gallons of spray to cover 100 square yards of bed, depending on the type of sprayer used and size of plants. Applications should not be delayed for inclement weather unless rain is actually falling at the time and would wash off the spray. It is not necessary to leave the beds uncovered until the spray has dried on. The beds should not be watered, however, until the spray has dried.

There is little danger of spray injury from Fermate, although heavy application under certain weather conditions may cause the bud leaves to become strap-shape. The plants quickly outgrow this and there is no permanent damage.

*Karbam* is another proprietary fungicide which contains the same effective compound (ferric dimethyl dithiocarbamate) as Fermate. It controls mildew as well as Fermate. In tests here and in other states it has caused some leaf burn. It mixes with water more easily than Fermate and is used at the same dilution.

*Dithane Z-78.* In several years of tests at the Experiment Station Farm, this has given as complete control of mildew as has Fermate. The directions for preparation and application are the same as given above for Fermate. It has not caused any leaf burn. Although it has not been used here as extensively as Fermate, it appears to be just as effective and safe.

*Parzate* contains the same effective ingredient as Dithane Z-78 and controls mildew to the same degree.



**Figure 3**  
**Downy mildew. Looking down on a diseased**  
**(below) and a healthy part (above)**  
**of the same bed.**



*Dusts.* Each of the four fungicides noted above may also be obtained in a dry mixture suitable for application as a dust (Fermate and Karbam 15 per cent, Dithane and Parzate 10 per cent). Experiments at Windsor showed that Fermate dust was as effective as spray. With equal distribution, there appears to be no reason why any of the fungicides should not be applied in dust form. The choice of methods depends on which the grower considers more convenient and the equipment he has available.

*Fumigation with paradichlorobenzene* (PDB or Dichlorocide). Fumigation of the beds with crystals of PDB was the method commonly used before the Fermate spray method was developed. The action of PDB differs from that of the fungicides discussed above in that it kills the fungus after the plants are already diseased while Fermate and the others are preventive. The PDB method is, therefore, preferable if mildew is already present in the bed. Wise growers keep a supply at hand as a second line of defense. If, for any reason, mildew has not been stopped by the spray program and the disease appears in the beds, then they use PDB. Some growers still depend on the PDB method alone but most of them consider the spray method less troublesome.

The fungicidal (or fungistatic) action of PDB is dependent on the concentration of fumigating gas in the seed bed air produced by vaporization of the crystals. Adequate concentration can be built up only in tight beds where the air does not leak out too rapidly. Thus, the key to success is to keep the sash and side boards free of cracks or holes which would allow the gas to escape.

The crystals are exposed in the beds during the night when the sash are closed and are removed in the morning before the sun warms the bed air to a degree which causes too rapid vaporization. On cloudy days, however, PDB may be left in the beds all day. The crystals are placed in screen wire baskets supported above the plants. A common practice is to attach these flat shallow baskets to the side boards alternately on the top and bottom. Baskets should not be more than six feet apart and the rate of application not less than one-quarter ounce to the square yard of bed.

If mildew is already present in the beds, the treatment should be repeated for several nights in succession, or until no fresh growth of mildew can be found. If, however, mildew has not yet been found in the beds, treatment on alternate nights is sufficient.

There is danger of injury to plants if the beds are kept closed during sunny warm days without removing the crystals. The initial injury appears as fading of the green leaves to yellow, and stunting, or slow growth of plants.

During cold nights when the temperature is below 45° F., the crystals do not vaporize fast enough to produce a lethal concentration of the gas and the treatment is not effective. Under these conditions it is best not to remove the crystals too early in the morning but to wait until the bed temperature gets up to 80° F.

*Fumigation with benzol.* The practice of this method is essentially the same as for PDB except that liquid benzol is vaporized from shallow pans,

such as eight-inch pie tins. When the weather is cool or during cold nights, it is more effective than PDB, because benzol vaporizes more readily at lower temperatures. The pans are supported on wire standards above the plants, one to every two sash. The benzol is poured about one-quarter inch deep in the pans. Although more effective than PDB, the benzol method has certain disadvantages. Tipping of the pans or falling of water drops from the sash splashes the liquid onto the leaves. Every drop kills a spot on the leaves and entire patches of plants may be killed. Another disadvantage is the extreme flammability of benzol, which involves danger of fires where it is stored.

*Field control.* During some years, mildew may cause damage to growing plants in the field, especially Shade fields. Usually this is not serious enough to warrant control measures but occasionally there have been extensive losses. A test by one of the Shade growers demonstrated that mildew in the field could be controlled by Fermate applied by field spray machinery (potato equipment) at the same dilution and frequency of application as recommended above for the seed beds.

Field infection is most commonly caused by the blowing of spores from infected beds where the spray program has been discontinued. Much of it can be prevented by destroying all plants in the beds just as soon as the fields are all set out. If it is necessary to keep some beds for restocking, they should be sprayed regularly twice a week as prescribed above.

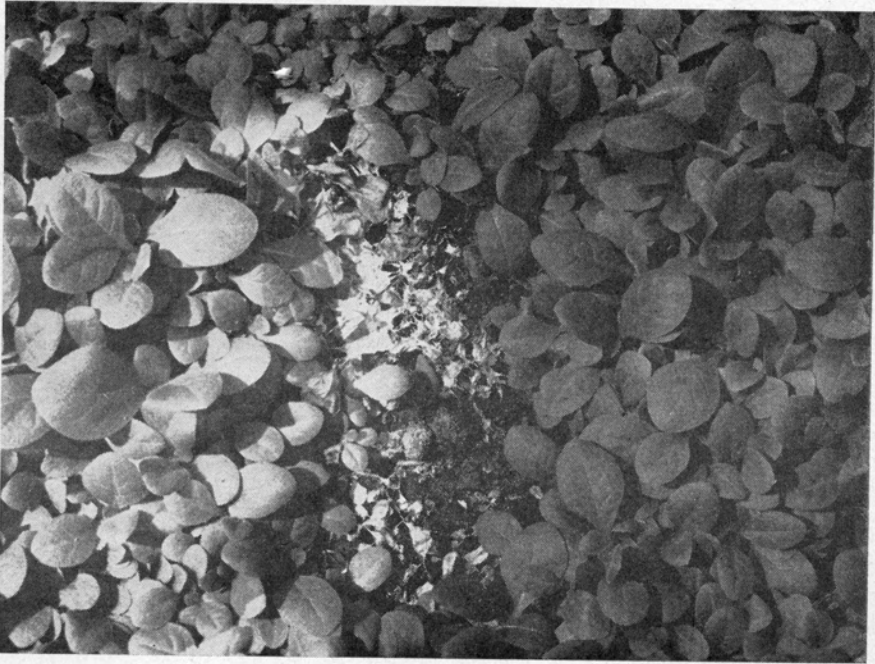
## BED ROTS

Bed rot attacks plants in the later seed bed stages, from the time they are half-grown until they are pulled, with greater frequency as the plants grow and become more crowded. Beds that are too thick, too little ventilated or overwatered are most often affected, but the disease is not confined to such beds.

### Symptoms

There are really four different kinds of bed rots that occur here, each caused by a different species of parasites<sup>1</sup> and having slightly different symptoms. The general effects on the plant, however, are about the same and since all seem to respond to the same treatment, they will be considered collectively here. Patches of plants, from a few inches to several feet in diameter, wilt and then collapse in a wet rot (Figure 4). Close examination of the plants on the periphery of a patch usually shows a wet brown rot on the stalk at the surface of the ground. Beginning here, it travels up the stalk and into the leaves (Figure 5). When the plants are dense, however, the rot may run from plant to plant through the leaves. Fungous growth may or may not be found on plants and soil, depending on the species of the parasite and moisture conditions. Finally, the whole mass of plants sinks to the ground and dries out as a parchment-like brown or bleached mat over the soil. Under wet conditions the spot spreads centrifugally and kills

<sup>1</sup> *Rhizoctonia Solani*, *Pythium aphanidermatum*, *Botrytis cinerea* and *Bacillus aroideae*.



**Figure 4**

**Bed rot due to *Pythium*. It causes patches of plants to rot and fall to the ground.**

all the plants as it goes. With a return of dry conditions it stops and there may be no further trouble. Around the edge of the patch some plants are usually left which do not die but survive with brown lesions on the stalks. Such plants often die when set in the field and are the start of stalk diseases, such as wet stem rot and sore shin, mentioned later in this bulletin.

### **Control**

The first line of defense against bed rot is the sterilization of the soil by steaming or by chlorpicrin. This kills the parasites which are in the soil at the time but does not prevent re-infestation.

Another preventive measure is to avoid overcrowding, overwatering and too little ventilation.

Regular spraying of the beds with Fermate, as for mildew, gives almost complete control. Bed rot rarely occurs in beds that have been so treated.

Spraying with Bordeaux or the copper sprays used for wildfire control also reduce bed rot but are not so effective as Fermate.

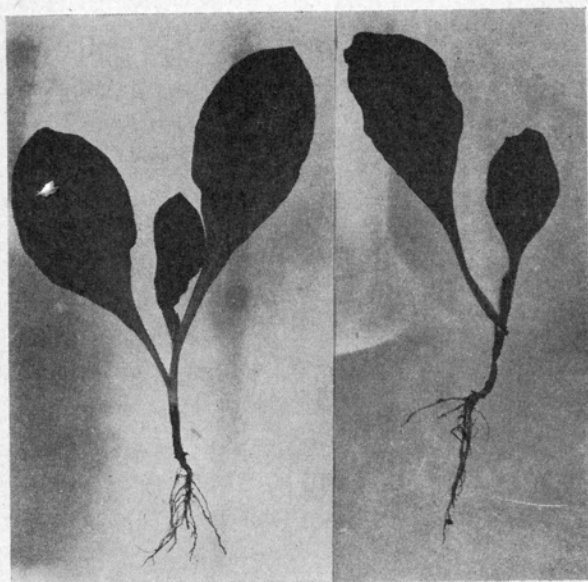


Figure 5

Bed rot. Note the black and rotted bases of stalks.

### WILDFIRE

The severity of wildfire, caused by bacteria,<sup>1</sup> varies greatly from year to year. Years of severe infestation seem to go in cycles. In the early 'twenties it was the most destructive disease of tobacco in Connecticut. In the 'thirties it almost disappeared from our fields. Since 1945, it has again been building up each year but has not yet reached the destructive proportions of the 'twenties.

#### Symptoms

Wildfire is a major disease both in the seed bed and in the field. It causes dead spots in the leaves which make them unsuitable for wrappers or binders. The symptom by which it can be readily distinguished from all other leaf spot diseases is the "halo" spot (Figure 6). This is a perfectly round spot with a dead brown center surrounded by a wide yellow band (the halo) with a smooth regular margin. As the spots in the field become older, especially in dry weather, the entire spot becomes brown and dead and may crack or drop out (cover picture).

In the seed bed, wildfire starts in patches and, when severe, may kill all the young plants in these areas. The most harmful aspect of seed bed infestation, however, is not that it kills the plants but that infected plants

<sup>1</sup> *Phytophthora tabaci*.



**Figure 6**  
**Wildfire, showing the halo spot typical**  
**of this disease.**

transplanted to the field are the principal source of field infection. Almost invariably, wildfire in the field can be traced back to disease in the bed.

Control of wildfire, therefore, depends largely on keeping the seed beds free of the disease.

### **Control**

Early spraying of the beds with a copper fungicide is the most important measure in preventing wildfire. Homemade Bordeaux mixture is satisfactory but many growers do not like to bother with preparing it and would rather purchase a fungicide which requires only mixing in water to be ready for application. A number of such materials with a higher copper content (30 to 50 per cent) are now marketed by several chemical companies under different trade names.<sup>1</sup> These are satisfactory and, at least in small amounts, are more convenient to use than Bordeaux. Rates of dilution with water are given in the directions on the package. Copper A Compound, for example, is stirred at the rate of one pound in 10 gallons of water. One gallon of this mixture is sufficient to spray 15 to 25 sash, depending on the type of sprayer used.

The first application should be made just as soon as the plants are up and established, while they are still mostly in the two-leaf stage. If, on drying, every leaf is blue, the rate of application is sufficient. A copper covering on the soil surface is important because it stops the bacteria from passing from the soil into the lower leaves. Later applications should be

<sup>1</sup> Such as Copper A, COCS, Basi-Cop, Tennessee Tribasic, etc.

made at weekly intervals. These copper sprays are not compatible with Fermate and, therefore, should not be mixed or applied on the same day but should alternate with the sprays for controlling mildew.

After spraying with copper compounds, the leaves should be allowed to dry before replacing the sash; otherwise, there is danger of leaf burn.

If wildfire was prevalent on the farm during the preceding year, precautions should be taken against transferring any infected material from the sheds to the beds. If wildfire was in the beds, it is well to drench the sash and boards with formaldehyde diluted at the rate of one part in 25 parts of water.

Frequently, wildfire appears only in isolated spots or areas in the beds. Whenever such an infection is found, all the plants in the area, as well as those bordering on it for a foot or more, should be destroyed by drenching them with formaldehyde diluted at the rate of about one part in 25 parts of water. Glass should be removed from the bed during and for at least 24 hours after this operation, to prevent the fumes from spreading and injuring other plants.

If the infected spots are numerous or if the disease is distributed generally throughout the bed, it is best to destroy the bed entirely by drenching with a one to 50 solution of formaldehyde on a hot day and leaving the glass tightly closed.

Wildfire is contagious. Tools used in infected beds should be dipped in formaldehyde before being brought into contact with healthy plants. If it is at all practicable, no plants should be pulled from beds in which wildfire is present.

Control measures taken after the disease is in the field are not dependable for the most part. If only a few diseased plants are found when they are quite young, they may be removed and carried from the field. If the infection is more general, this method is questionable because healthy plants, set where the diseased ones have been pulled, commonly become infected from bacteria left in the soil. Picking of diseased leaves has generally not been successful in stopping wildfire when weather conditions favor its spread. Thorough spraying of the young plants in the field may reduce spread somewhat but this is not practicable or effective when the plants are large. Plowing under a diseased stand and setting the field with healthy plants will eliminate wildfire only when subsequent weather conditions are unfavorable to its spread. When there is any wildfire in the field, cultural operations should be carefully avoided while the leaves are wet.

*Resistant strains.* The growing of strains of tobacco that are immune or at least highly resistant to wildfire will probably soon be the happy solution of the wildfire problem, making the remedial measures described above unnecessary. Such strains, however, must have all the desirable qualities of types now grown. Excellent progress has already been made and we can confidently anticipate that, within the next few years, such strains will be ready for distribution to growers. Immune or highly resistant strains have already been developed by researchers in several tobacco experiment stations and it now appears to be only a matter of eliminating some "off" characteristics and standardizing to uniformity.

**BLACKFIRE OR ANGULAR LEAFSPOT**

Blackfire, a bacteria leafspot,<sup>1</sup> is not as common in Connecticut as it is in other tobacco sections, but is occasionally found both in the seed bed and in the field. In its distribution and course of development, it is similar to wildfire but the appearance of the spots on the leaves is quite distinctive.



**Figure 7**  
**Blackfire, showing the angular spots**  
**on the matured leaf.**

**Symptoms**

The spots are angular or irregular and there is no definite broad round yellow halo around them (Figure 7). In the initial stages the small spots are black and water-soaked, but as they dry out they take on various shades of brown and gray. If numerous, the spots may coalesce and form irregu-

<sup>1</sup> *Phytomonas angulata*.

lar dead areas that distort the leaves. When the spots become dry and brittle, the tissue frequently breaks out, leaving ragged holes in the leaves. In the seed beds blackfire is found in patches that spread centrifugally from a center.

In the field the individual spots are larger, up to one-half inch across. They have the same irregular shape and lack the halo, although there may be some yellowing around the margin of the brown dead tissue. The yellow part, however, does not have a smooth regular rim but is narrow and fades away indefinitely into the green. Field infection is usually confined to the lower leaves.

### **Control**

The preventive measures in the seed bed, which are described above for wildfire, will also control blackfire. We have never seen a case here in the field that was sufficiently damaging to warrant any control operations.

## **BROWN ROOTROT OR NEMATODE INFESTATION**

Brown rootrot is a major disease of long standing in Connecticut and causes some loss every season. During some years as, for example, in 1948, it becomes our most damaging field disease. It long baffled plant pathologists, largely because they were never able to find the causal agent and, therefore, did not know how to fight it.

### **Symptoms**

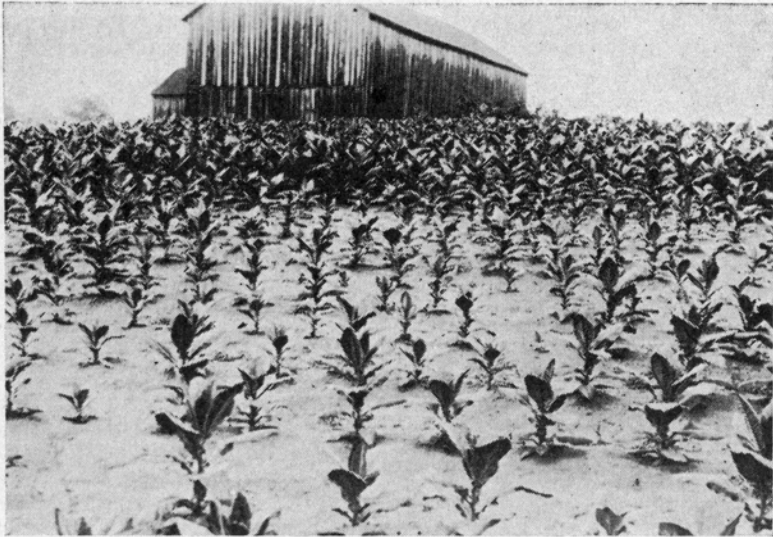
The above-ground symptoms are the same as those of black rootrot, stunting, slow growth and wilting, and it is not possible to distinguish between the two maladies without an examination of the roots (Figure 8). The root system of a plant infected with brown rootrot is not white and wide-spreading like that of a normal plant. It consists mostly of a bushy tuft of short, brown, dead, fibrous roots at the base of the stalk with possibly a few normal roots near the surface of the soil. This reduced root system naturally cannot supply the necessary water and food for the leaves; hence, the wilting and stunting. None of the dead roots are coal black as in black rootrot, but the brown color shows they have ceased to function.

### **Cause**

Within the last few years most pathologists have come to believe that brown rootrot is caused primarily by soil-inhabiting parasitic nematodes, tiny microscopic eel-worms which may be either inside the root tissue or on the surface of the roots. They either kill the tiny roots by feeding on them or make lesions in the roots which provide entryways for fungi or bacteria to complete the disintegration.

Nematodes of the meadow nematode (*Pratylenchus*) type are commonly found associated with the disease. Absolute proof that these are the primary cause of the type of brown rootrot we have in Connecticut has not





**Figure 8**  
**Brown rootrot area in a field of**  
**Havana Seed.**

been produced, largely because no way has been found to grow these species in pure culture and reproduce brown rootrot with them under aseptic conditions. Nevertheless, all the peculiarities of the behavior of brown rootrot can be explained by the nematode hypothesis. Moreover, the disease can be eliminated by fumigating the soil with a chemical which is known to kill the nematodes.

The relation of brown rootrot to certain crops that precede tobacco has been observed by all investigators of the disease. It is always worse after timothy, corn, or forage crops and least serious after a preceding crop of tobacco. This has led to the belief that tobacco is not a favorite host but that nematodes prefer and build up on such plants as timothy and corn so that the soil is more thoroughly infested when tobacco is planted after these crops. Yet the disease is not entirely dependent on these other hosts because it sometimes persists several years in successive tobacco crops on the same field.

### **Control**

If practicable, the growing of tobacco following hay, corn or forage crops should be avoided.

Fumigation of the soil with nematocides has given remarkably successful control. This method is still quite new and several questions must be answered before it can be recommended unqualifiedly. The two fumigating chemicals that have given good control here are ethylene dibromide and

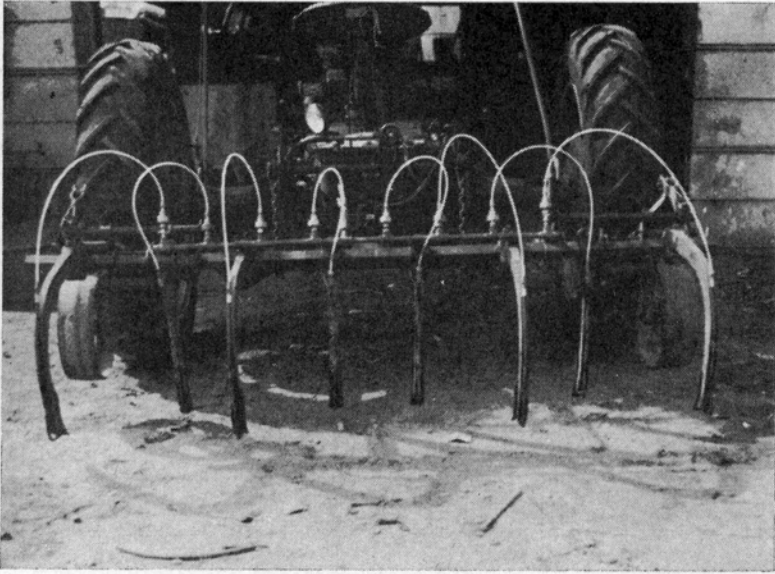
a mixture of dichloropropene and dichloropropane. Iscobrome D contains 10 per cent and Dowfume W-40 contains 20 per cent by volume of ethylene dibromide. Dichloropropene-dichloropropane mixture is sold as "D-D" and "Dowfume N". In our tests, Iscobrome was applied at the rate of 30 gallons to the acre, Dowfume W-40 at the rate of 15 gallons and D-D at the rate of 30 gallons. Other commercial mixtures containing these same fumigants may be just as effective. Further experimentation may also result in good control at other rates of application. In Florida, 20 gallons of D-D has been found to be enough.

Soil should be damp enough for seed germination but not muddy at the time of application. The temperature of the soil should not be below 50° F. (40° for D-D at six inches below surface). Application may be made either in late fall or early spring. The fumigant should be deposited at a depth of six to eight inches. Points or lines of application should not be more than 10 to 12 inches apart. Immediately after application, the soil should be rolled or dragged to seal in the fumigant. Plants should not be set in the field for at least two weeks after the fumigant is applied to the soil. Soil should be prepared for planting, harrowed and levelled before using a shank type applicator. Plow application should be preceded by harrowing to cut up trash and cover crop. If there is time, it is better to harrow the cover crop well in advance to allow roots which harbor the nematodes to decay.

For distributing the chemical in the soil, a mechanical applicator is necessary. A considerable number of machines for this purpose are already on the market and they are being constantly improved and modified. In general, they are of three types:

1. Hand applicators, suitable only for small areas like seed beds. These are built on the principle of a large hypodermic needle, three feet or more long, the point of which is pushed into the soil and a measured charge ejected by a manually operated plunger.
2. The tooth or shank type either built directly on the tractor or on a trailer machine. This has a motor-driven or tractor-driven (from power take-off) pump which forces a stream down through narrow tubes, attached to the back side of narrow cultivator-like teeth (Figure 9). This gives a continuous flow, depositing the liquid in parallel lines, not more than one foot apart, as the tractor moves across the field. The soil coverage is made more complete by a smoothing drag or board behind the machine.
3. The plow sole type is attached directly to the plow and has a motor driven pump or gravity flow system which drives the liquid through pipes onto the plow sole just as it is being covered by the soil from the next furrow. This convenient type eliminates an extra operation for distributing the fumigant.

Up to the present we have not observed any deleterious effect of fumigants on the qualities of the finished tobacco but this point should be still further investigated. Another question concerns possible effects of fumigation on the microbiological balance in the soil. Observations and tests show that fumigation puts more nitrogen at the disposal of the plant at



**Figure 9**  
**Shank type of applicator attached to tractor.**

midseason. Will this involve a modification of the rates of fertilizer application? These are some of the many questions which must be answered before we dare make wholesale applications. Until we have more information, growers are cautioned to treat only small acreages confined to the most badly affected parts of fields.

### **BLACK ROOTROT**

Black rootrot, caused by a soil-inhabiting fungus<sup>1</sup> was the most damaging disease of tobacco in Connecticut fields a generation ago. Today it has ceased to be a major trouble because rather simple means of preventing it have been found and are generally practiced.

#### **Symptoms**

The first symptom of the disease is growth stoppage. The plants are stunted, with narrow, thick, tough leaves that are either a starved yellow color or, where the nitrogen supply is high, a very dark green. On hot days the leaves wilt or "flag" more quickly than on healthy tobacco. The dwarfed plants "top out" prematurely. Only rarely is a field equally affected in all parts. Usually there are patches, from a square rod to several acres in extent, where the tobacco is short, while in other parts of the field, growth is normal. In the diseased patches the plants are frequently very uneven in development.

<sup>1</sup> *Thielaviopsis basicola*.

From the above-ground symptoms, however, it is not possible, even for an expert, to be sure that this is black rootrot. Other troubles such as brown rootrot, lack of fertilizer, or water-logged soil may produce the same appearance. One must dig the plants and wash the soil from the roots to see the lesions which are unmistakable signs of black rootrot. Normal young roots are white, but on diseased plants many are black (brown at first) either throughout their length or only in segments, with other segments appearing normal. The tissue of the smaller roots is rotted through, but on the large roots there occur enlarged, rough, scurfy lesions which may or may not kill the interior tissues. The character which distinguishes this disease from all other tobacco ailments is the coal black color of parts of the roots. The reduced root system is unable to secure sufficient water and soil nutrients for normal growth of the above-ground parts of the plant. Hence, the dwarfed growth and flagging on hot days.

### Prevention

There are two simple and effective methods of eliminating or greatly reducing losses from black rootrot: (1) regulation of soil reaction and (2) planting resistant strains.

*Soil reaction.* Connecticut Valley tobacco soils are for the most part rather acid, 5.2 pH or lower. It was only after this natural acidity had been neutralized by large applications of lime, wood ashes or alkaline fertilizers that rootrot became serious a generation ago. When such treatments are omitted for several years, the soil gradually returns to its original reaction. Avoidance of too much alkaline material on the land thus offers a logical means of control. It has been found that black rootrot is rarely serious on soils testing below 5.6 pH. Only those testing below 5.0 pH should be limed, and then sparingly, not over 500 pounds to the acre at any one time except in extreme cases. Stable manure, wood ashes or alkaline fertilizers should be avoided on soils testing near or above the danger point, 5.6. If a soil test has shown that the field is too alkaline, it can be made more acid through heavy application of ammonium sulfate. This should be applied in the fall or late summer after the crop is removed, since spring treatment is detrimental to the quality of tobacco. Not more than 500 pounds to the acre should be applied.

*Planting resistant strains.* Highly resistant strains of Havana Seed tobacco have been developed and are now being generally planted in the Connecticut Valley. Probably 75 per cent of the Havana Seed acreage is now planted to one of these types. Havana Seed No. 221, K1 and K2 are three of these types that are not only resistant but will out-yield and out-grade the older susceptible strains of Havana Seed.

For Shade tobacco, Connecticut 15, Connecticut G4 and the 4R strain are all highly resistant. The first two give an increased yield of about 50 per cent more than the old strains, due to the greater numbers of uniform leaves on the stalk. These strains are being grown more extensively every year. The 4R strain is exactly like the ordinary strain of Shade tobacco except for its resistance.

No resistant strains of Broadleaf type have been developed but fortunately this type as a whole is naturally less susceptible to black rootrot.

A secondary advantage of growing resistant strains is that the fields may be limed without risk of reduction in yield. The quality of Connecticut tobacco would be improved if we could safely use more lime on our fields.

*In the seed bed.* Black rootrot may also be very damaging in the seed beds since growth of the causal fungus is favored by the low soil temperature of early spring. Patches of the plants stop growing and the whole bed has an uneven appearance. Wilting, unnatural leaf color and the root symptoms are the same as described above for field infestation.

Soil sterilization by steam or by chlorpicrin is a simple and effective preventive. This usually involves no extra work nor expense since most beds are now so treated to kill weed seeds. See Appendix, p. 52 for methods of sterilizing the soil.

### STALK-ROT OF TRANSPLANTS

Some years there are heavy losses of plants shortly after they are set in the field from a soft rot of the stalks.

#### Symptoms

This is a watery, black (or at least very dark), mushy rot that completely disintegrates all the tissues of the stalk (Figure 10). It starts just at, or below, the ground level, but under favorable conditions quickly works upward, even into the bases of the leaves, and causes the plant to fall over and completely collapse. The stalk is so rotted that it no longer holds together when the plant is pulled up. This trouble has been prevalent only during seasons of frequent rainfall when the soil remains wet and soggy for several days at a time.

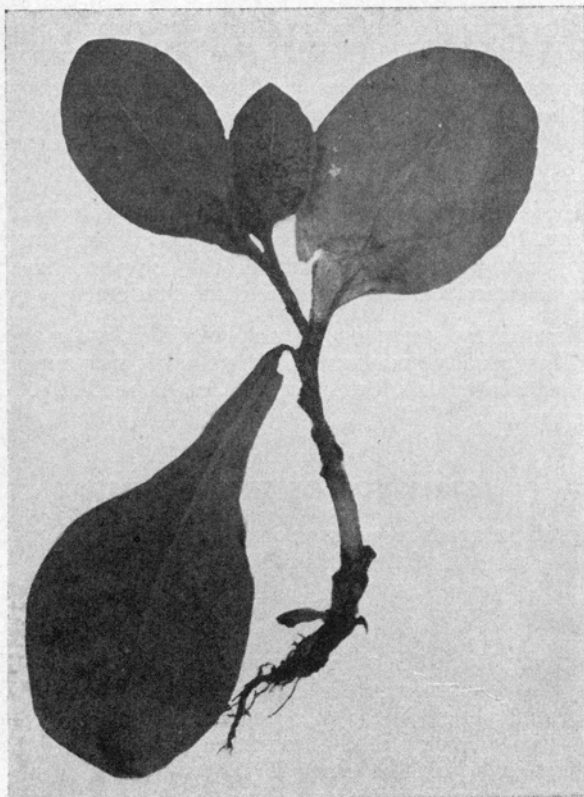
The rot is caused by the same species of fungi<sup>1</sup> that cause damping-off and bed rot in the seed beds. This leads us to believe that the trouble starts while the plants are still in the seed beds. However, these same species of fungi also live in the field soil and may infect sometimes from that source.

#### Control

Since the disease is most serious in wet years, control measures should be taken when there are frequent rains during the season. Since there is a possibility that at least some of the infection starts in the beds, one obvious control measure would be to keep the beds as free as possible from disease by sterilizing the soil, by aeration, by keeping the stand thin, by avoiding too moist conditions and by keeping the plants sprayed as directed under "Mildew" and "Bed Rot".

Succulent, tender, fast-growing plants appear to be more subject to attack than those which are hardened. Plants of the first pulling from the beds are more susceptible than the later pullings. The use of well hardened and

<sup>1</sup> We have usually found *Pythium debaryanum* and *P. aphanidermatum* but there may be others.



**Figure 10**  
**Stalk-rot in the field. Note dead black**  
**stem and bases of leaves.**

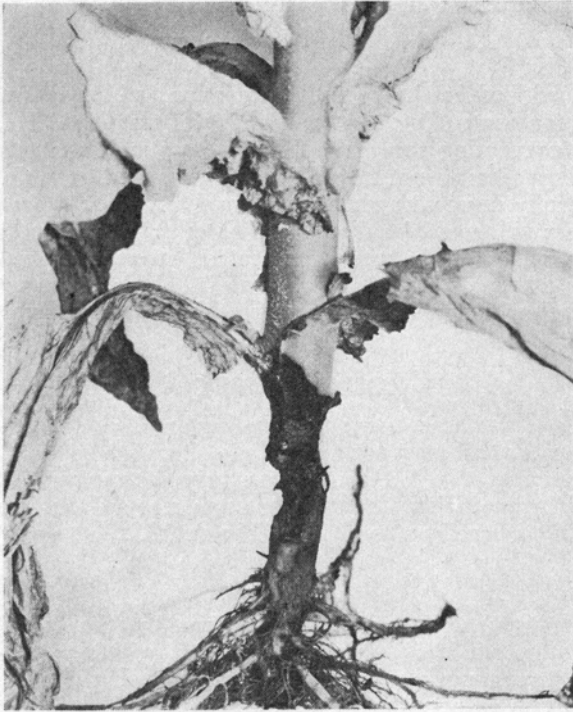
disease-free plants should do much to keep this stalk-rot under control. It might prove profitable to discard the first pulling and use only plants from the later pullings. Forcing the plants too much in the seed beds should be avoided since it makes them tender and more susceptible to fungous attack.

### **SORE SHIN**

Sore shin, which is also called stem canker, stem rot, collar rot or black leg, is of common occurrence in Connecticut tobacco fields. It is rarely of major importance because the number of affected plants is usually small, and the total loss is not heavy. Occasionally, however, under favorable conditions, it may take a serious toll and even necessitate replanting of entire fields.

**Symptoms**

The characteristic symptom most commonly observed is a brown or black, sunken, rotten canker at the base of the stalk when the plants in the field are half grown or larger (Figure 11). The canker may be only on one side or may entirely girdle the stalk at, or just below, the surface of the soil. In other cases, it may extend several inches up the side of the stalk, sometimes involving the lower leaves, which drop off after the bases of the



**Figure 11**

**Sore shin. Note black canker at base.**

midribs become rotten. The canker reduces transfer of water and nutrients through the stalk so that the whole plant becomes sickly, yellow and smaller than neighboring healthy plants. During strong winds many of these plants are broken off at the canker and fall over.

Various fungi and bacteria, believed to be the causal agents, have been found in the diseased tissues by different investigators. The one most commonly found in this State by the writer is *Rhizoctonia*, which has been mentioned previously as causing bed rot.

It has been observed frequently that the most severe cases of sore shin are in fields set from beds known to be affected with bed rot. Sore shin,

therefore, may be regarded for the most part as a later development of this disease. It is not at all improbable, however, that some infection of previously healthy plants may occur directly in fields. Injuries to the stalk by tools or insects probably facilitate field infection.

Heavy, wet soils and periods of continuous rainfall favor development of sore shin. Under dry conditions the canker stops spreading, and dry, inactive scars, which are apparently harmless, may be observed on the stalk. With the return of moist conditions, however, activity of the parasite is renewed and the canker continues to spread.

### Control

Since the seed bed is the focus of infection, all measures previously recommended for controlling bed rot should be practiced. This offers the best means of preventing sore shin. If it is practicable, plants from beds that have bed rot should not be used. If this is not possible, the plants should be carefully inspected when pulled and all which show the smallest brown stem lesions should be discarded. Even with such precautions, all diseased plants will probably not be eliminated. Frequent restocking shortly after setting is advisable but late restocking is hardly worth while. Heavy, wet soils and fields known to produce sore shin should be avoided.

### HOLLOW STALK

Hollow stalk is a disease of long standing in Connecticut. It belongs strictly to wet years and may not appear anywhere in dry seasons. During the very wet summer of 1938, the disease ruined as many as 10 per cent of the plants in some fields. It is almost never found on Shade tobacco. A diseased plant is usually a total loss (Figure 12).

### Symptoms

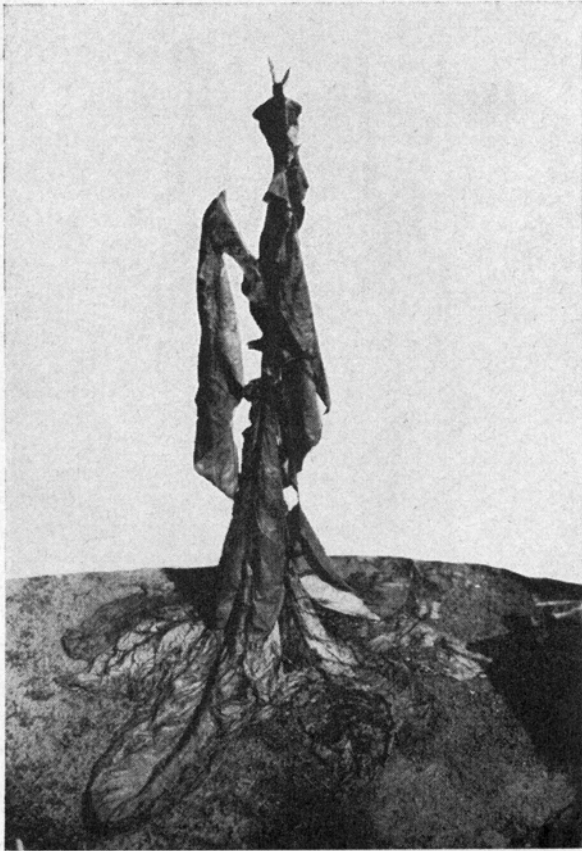
In general, hollow stalk appears first at about the time of topping. The characteristic symptom is the decay of the pith, which in wet weather is reduced quickly to a dark colored, watery jelly (Figure 13). With the recurrence of dry weather, the rotten pith dries and shrivels, leaving the stalk hollow; hence, the popular name of the disease. The progress of the rot does not stop at the pith. From there, it passes by natural channels into the bases of the leaves, causing them to droop and hang down (Figure 12), or to fall off, leaving the stalk bare. Even if the stalks are harvested in the early stages, the leaves do not cure well in the shed.

The rot usually starts in the pith where the top has been broken out. During very wet years or in exceptionally damp locations, it may start in the leaves and rot out the midribs or produce large holes in fleshy leaves.

The rot is caused by invasion of the pith by parasitic bacteria.<sup>1</sup> Finding the succulent pith a favorable food, they multiply and spread with incredible rapidity, causing complete collapse of the interior of the stalks and the bases of the leaves within a few days. They are spread from plant to plant on the hands of workmen and gain access to the pith

<sup>1</sup> *Bacillus aroideae*.





**Figure 12**

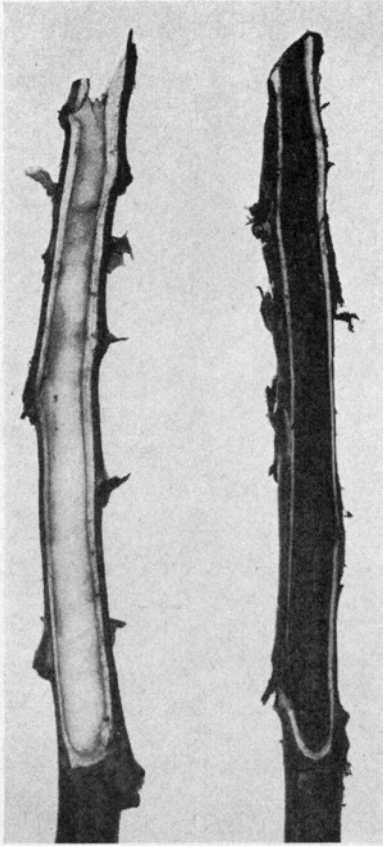
**Hollow stalk. Bacterial decay runs from the pith into the bases of the leaves, causing them to collapse.**

through the fresh wounds caused by breaking out tops or suckers. Broken midribs or other injuries give them access to the leaves.

Moisture is the important element in incidence of hollow stalk. It is most prevalent when there is continuous rainy weather during the topping season. Wet, soggy soils are also said to foster it. Hot, humid weather is favorable to it in that this makes the pith more succulent and wounds do not dry out as quickly.

### **Control**

There is no known remedy for hollow stalk. The spread in the field may be reduced, however, by restricting the operations in an affected field to periods when the leaves are dry. Also, workmen should avoid touching or working with affected plants while topping or suckering.



**Figure 13**  
**Hollow stalk. Blackened pith (right) compared**  
**with healthy white pith (left).**

### **FUSARIUM WILT**

This stalk disease of field tobacco was first found in Connecticut in 1943, is rarely seen, and usually is confined to a few plants in a field. In one Broadleaf field, however, the writer found 10 per cent of the plants ruined in 1948. Infected plants are a complete loss because, even if some of the leaves remain alive until harvest, they are of very inferior quality when cured.

#### **Symptoms**

The first symptom of wilt is fading and drooping of the leaves along one side of the plant (Figure 14). The affected leaves die gradually and turn brown while the leaves on the opposite side of the stalk remain green. The



**Figure 14**

**Fusarium wilt on Broadleaf. Only one side of the plant is affected at this stage.**

top of the stalk develops a curvature toward the diseased side; hence, the disease is sometimes called "crook-neck". The stalk of the plant remains green up to a very late stage. When the outer green cortex on the affected side is peeled off, however, the underlying woody part is found to be dark brown or black, although that on the healthy side of the stalk remains white. The dark discoloration on the affected parts not only runs up to the top of the stalk but out into the midveins of the leaves as dark streaks.

The dark color of the woody cylinder of the plant and the dark streaks in the midveins are the sure signs by which *Fusarium* wilt can be distinguished from any other tobacco disease that occurs in Connecticut. In late stages, the outside of the affected bark also turns black and in very severe cases the entire plant dies.

Wilt is caused by the penetration of a parasitic fungus<sup>1</sup> which enters the roots from the soil and grows up to the top of the plant through the water carrying ducts (xylem).

Hot weather favors the disease, which accounts for the fact that it first appears in fields here in July and August. This also accounts for its greater destructiveness in southern tobacco states and makes it more unlikely that it will ever be a major disease in Connecticut.

### Control

No method of control is known. Varieties that are resistant have been developed in southern states where it is more important. If it should ever assume dangerous proportions here, this line of attack would be most hopeful but, at present, control operations do not seem necessary.

## MOSAIC OR CALICO

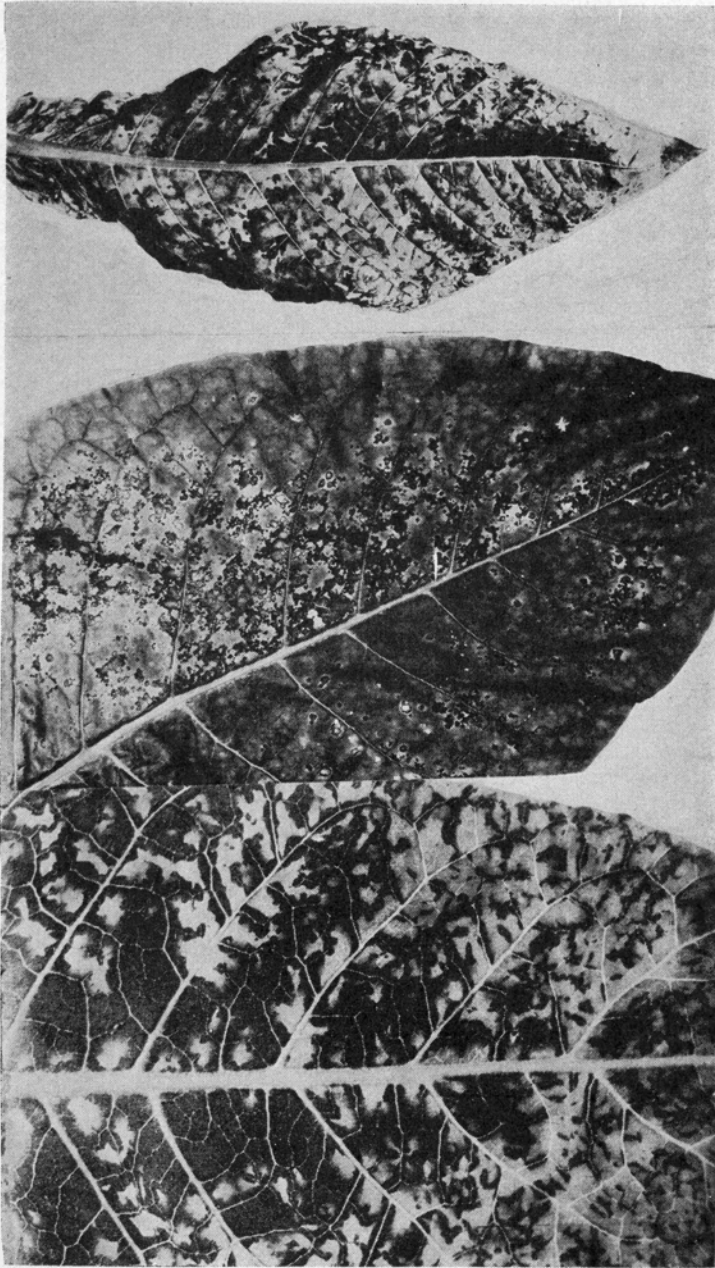
Mosaic is one of the oldest of our tobacco diseases and has been in Connecticut as long as any living tobacco grower can remember. Other names by which the growers know it are "mongrel", "brindle", "gray top" and "rust", descriptive of specific symptoms. In most fields it is not a major disease, affecting only a few plants, but in some fields and during some seasons it causes serious losses, particularly to the quality of the crop.

### Symptoms

Every experienced tobacco grower recognizes an ordinary calico plant in his field. The mottled appearance of the leaves, with splotched areas of greenish yellow between other areas of normal green, is familiar to all (Figure 15, top). Symptoms show all graduations of intensity. Sometimes the differences in shade of color are barely noticeable; at the other extreme, the light chlorotic areas of the leaf may be bright yellow to almost white, therefore standing out very sharply in contrast. Also, the pattern or mosaic, formed by the irregular alternating chlorotic and normal parts, is so extremely varied as to defy description. In some types, however, the darker areas have a tendency to follow the veins (Figure 15, bottom).

Attempts have been made to distinguish and name several types of mosaic according to differences in leaf symptoms, such as pattern or color of the chlorotic areas. There are, however, so many intergradations between field types that, except for the mosaic specialist, such a classification adds nothing to clarity of understanding. In severe cases young leaves may become distorted or "puffed" and are inclined to be abnormally narrow.

<sup>1</sup> *Fusarium oxysporum* var. *nicotianae*. See Conn. Agr. Exp. Sta. Bul. 478, p. 111, for a more complete description of the disease.



**Figure 15**

**Tobacco leaves showing patterns of mosaic: Top, the most common pattern of mottling; center, red rust, a symptom of calico marked by irregular, dead, brown patches; bottom, the pattern in which the dark areas follow the veins.**

Plants affected early become dwarfed, do not make a normal growth and are practically worthless when mature. Late infestations, with only a few of the top leaves showing the symptoms, frequently not severe, are commonly known as "gray top" by growers.

There are other symptoms, however, which growers do not always realize are manifestations of the same disease. This is particularly true of the necrotic or dead spots of various shapes and colors that develop in the leaf tissue. These are of two general types and have been called white rust and red rust. The white rust, also called fleck, is marked by numerous small white spots peppered over the leaf. In the red rust type the spots are larger, more irregular and of a reddish brown color (Figure 15, center). This may be so severe as to cause death of the whole leaf. The red rust type, if more diffused, is sometimes called mosaic burn and usually appears on the upper leaves of the plant. Burning of the top leaves usually results from the spread of mosaic while topping. Since such leaves often show no mosaic mottling, the grower is not aware of the connection.

The extent of damage to a plant depends largely on the stage of the plant's development at the time it became infected with the disease. A plant infected in the seed bed probably never attains sufficiently normal growth for its leaves to be suitable for cigar wrappers or binders. On the other hand, if infection occurs at the time of topping, the damage may be practically negligible, though, even at this late stage, considerable "burn" of the top leaves may result.

### **The Causal Agent**

Ever since tobacco mosaic was described 60 years ago, a considerable variety of theories on its cause have been advanced and supporting evidence published to back each theory. Only in the last few years has the true cause been demonstrated and all the other alleged causes relegated to interesting past history. Mosaic is now known to be caused by a virus, appearing in the plant sap as minute rod-like particles of a protein nature, which have the remarkable characteristic of being able to multiply indefinitely in the living cells of all parts of the tobacco plant.

When introduced into a tobacco plant, the virus spreads rapidly to the roots and to the newly developing leaves, but extremely slowly to leaves already fully grown. The symptoms described above will appear on the leaves that were growing rapidly (rust) and on leaves that were very small (mottle) when infection occurred. All new growth will likewise be mottled.

### **Spread and Overwintering**

Mosaic is extremely infectious and will spread from the most minute quantity of the virus transferred to the cell of a growing plant. From this point, it quickly spreads in the sap to the roots and to the growing point of the plant. Once a plant is infected, it never recovers, since it has no way of eliminating the virus. When, in handling infected plants, the juice gets on the hands of the workman, he need only touch or rub his fingers over the leaf of a healthy plant to infect it. Any virus introduced into seed

beds would be thoroughly disseminated by weeding or pulling the plants for setting. When the infected plants are established in the field, the virus may be spread around on hands, clothing, tools, etc. during any cultural operations.

Although the methods of dissemination in beds and fields are well known, the means by which mosaic first gets its start each spring are not so obvious. Its method of overwintering, however, gives some clue. In cured or dried leaves the virus will remain infective almost indefinitely. Its longevity is probably the most important fact to be kept in mind in connection with the prevention of mosaic. It will even survive in manufactured tobacco, such as cigars, cigarettes and chewing tobacco, although in smaller amounts than in the barn-cured tobacco. The chewing and smoking of tobacco by workmen while handling the plants in the beds is often a source of early infection.

Badly infected beds have been observed in Connecticut where growers have used tobacco refuse, raked from the floor of curing sheds, as fertilizer. In some sections of the country perennial weeds belonging to the tobacco family are sometimes infected, and the virus is transferred to tobacco plants while weeding. This does not appear to be a common source of infection here, however.

Unsterilized stalks and "stems" may carry mosaic to fields in which they are spread unless they are thoroughly plowed under and allowed to rot before the crop is planted. No doubt, the greater percentage of virus becomes inactivated in the soil, especially in the upper layer which is stirred and well aerated before setting. Virus, like other protein substances, is decomposed by the action of soil organisms and, thereafter, cannot cause infection. The residues of tobacco plants quickly decompose when incorporated in the soil, especially if the soil is moist and well aerated. There is some evidence that under certain conditions the virus may live over winter in patches in the fields. Investigators have shown that the type of the soil may have an influence on the ability of the virus to survive. This may explain the report by many growers that certain spots in their fields are prone to show mosaic more or less every year. The soil in these areas may be more suitable for keeping the virus in an active condition. This is not, however, the main source of infection in our fields.

### **Control**

No spray or dust is effective in controlling mosaic. Control measures must start with an understanding of the nature of the disease and, particularly, its method of dissemination as described above. Methods should aim, first, at preventing the introduction of the disease into the bed or field in the spring and, secondly, at removing infected plants which may spread it from plant to plant in the field.

The following preventive measures have been found useful and are offered as suggestions to growers whose crops are troubled with mosaic.

1. Tobacco refuse from curing sheds, sorting rooms or other sources should be kept entirely away from the seed beds. Sometimes tools or bed

sashes, which have been stored in sheds without being carefully cleaned, may carry bits of diseased leaves to the beds.

2. If the stalks of a preceding crop are to be used on tobacco land for fertilizer, they should be plowed under the surface as thoroughly and early as possible to give them every opportunity to decay. If stalks are from a mosaic crop, or if results from this practice in previous years have been bad, it is better to use them on land intended for other crops.

3. Men who are weeding, pulling or setting, or handling the crop in any way, should be discouraged from using tobacco. This applies to the use of the leaf in any form, but particularly in chewing and pipe tobacco.

4. Plants should never be set from a bed known to contain the disease. Mosaic plants are difficult to detect in the seed bed. If only a few are found, it is quite certain that there are many other diseased ones which have not been "spotted". Rather than risk spreading the disease to the field, it is better to sacrifice the whole bed. Second and third pullings from a bed are much more likely to have mosaic than the first ones, because of spread while pulling.

5. Just after the plants start in the field, "rogue" out any diseased ones. About once a week, while the plants are small,<sup>1</sup> a workman should systematically inspect each row, pull up every calico plant and put it in a basket. This should be done before cultivating or performing other operations which might spread the disease. The person who rogues should avoid touching any healthy plant, otherwise he may spread more disease than he removes. The basket of diseased plants should be dumped far from any growing tobacco. The workman should thoroughly wash his hands before handling healthy plants again.

We regard this "rogueing" as a very essential measure of control. Both the Experiment Station Farm and commercial growers have used it with success for many years. If it is carefully done, no other control measure should be necessary during the remainder of the season. Rogueing is practicable only where the percentage of infected plants is small, but this is the condition in at least 95 per cent of Connecticut fields. Where the percentage is very high, it is better to plow under the crop and replant from healthy beds.

6. If rogueing has not been successful, avoid spreading the virus from diseased to healthy plants during field operations, even at the time of topping and suckering. If there are several men working, one of them may handle all the diseased plants ahead of the others and not touch the healthy ones. This measure is of less importance than the preceding since the direct damage at this stage is not great, but it has some bearing on the practice mentioned in the next paragraph.

7. Every precaution should be taken to keep the entire tobacco farm free from mosaic. By carrying out sanitation practices the grower reduces chances of infection from refuse, which holds no danger if leaves and stalks

<sup>1</sup> If plants are large, there is too much danger of spread by carrying them through the field.



are disease-free. Moreover, a soil which does not harbor mosaic cannot spread infection. Some Connecticut tobacco farms have had practically no mosaic for years because the owners will not tolerate any sources of infection.

*Mosaic Resistant Varieties.* The perfect method of controlling any disease is to find or develop a strain or variety of the crop which is naturally immune or so highly resistant to the disease that need of further control measures is permanently eliminated. A resistant strain of tobacco must also have satisfactory commercial qualifications. The incorporation of good characters in a resistant strain may be the most difficult part of a breeding program.

Satisfactory resistant strains have already been developed in several types of tobacco in different states. None of the resistant strains, which we have developed in our Connecticut types, are yet ready for distribution but, from present indications, this will soon be the final solution of the mosaic problem.

## RINGSPOT

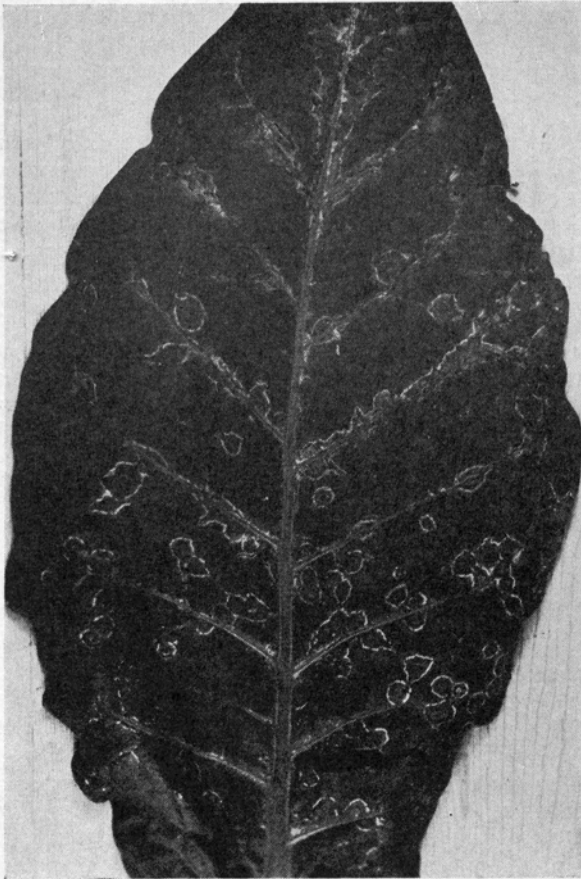
Ringspot is a minor disease of tobacco leaves that occurs sparingly in Connecticut every year. It has not received much attention here because the damage, in the aggregate, is small, and the symptoms are usually so inconspicuous that they may easily be overlooked.

### Symptoms

The characteristic symptom of ringspot is the occurrence on the upper side of the leaves of irregular white, or light brown, lines about the width of a pencil mark. These are more or less continuous but broken lines are not uncommon. They make a variable pattern. Between the veins they generally form definite closed circles, or rings, which give the disease its name (Figure 16). The tissue enclosed by the circular lines retains, at least at first, its normal green color. In later stages, it may fade to yellow and finally die. Circles within circles are also common. Other lines usually run parallel to the lateral veins, quite close on either side and tend to run out to points where secondary branches of these veins start. Sometimes the lines are broken into short segments scattered without any definite pattern over the leaf surface.

Some plants show the symptoms on all leaves from top to bottom. More generally, some of the foliage is affected while the rest appears entirely normal. At times only a part of a leaf is affected. The lines may be so distinct that they can be seen from a considerable distance, or so indistinct that they would be overlooked unless one made a close examination.

The symptoms are usually first observed when the plants are nearly or quite mature. Severely affected leaves are rendered quite useless. Loss from mild attacks is probably slight or negligible. Stunting of the plants, as found in other tobacco sections, has not been observed here.



**Figure 16**

**Ringspot. Continuous lines follow the veins  
or form rings between them.**

### **Cause**

Ringspot is not caused by any parasitic organism or by insects. Neither is there any convincing evidence that it has any relation to the nutrition of the plant. Like the mosaic disease, it appears to be caused by a virus, but the two diseases have no other relation to each other. The virus is in the sap of the plant and the disease can be transmitted by transferring the juice of an infected plant to a healthy one. Thus, it is an infectious disease. Infected juice on the hands of workmen or on tools may spread it from plant to plant in the field. It does not spread as readily as mosaic, however. If the infective capacity were not so low, the number of infected plants would be much larger. The virus of ringspot, unlike that of mosaic, is quickly destroyed when the leaves are dried in curing. Hence, there is no

danger of carrying it to the new crop from the cured leaves of the previous season.

Since no tobacco plants remain alive over winter in this climate, and all the virus must die out every winter, there is the question of how the disease gets into the fields each year. Ringspot also affects a large number of other species of plants, some of which are common weeds or garden plants. Since some live over the winter, there is the possibility that they may serve as agents for keeping the virus alive until the next season. It is also known to pass from one generation to the next through the seed.

### **Control**

Ringspot is not of sufficient importance here to warrant special control operations. If it should become serious at any time, roguing out the diseased plants would seem to be the logical control. Other precautionary measures against spreading it, as outlined under mosaic, should be practiced.

## **FRENCHING**

Frenching is a rare disease of long standing in Connecticut. Although a severely affected plant is a total loss, the disease does not usually cause serious trouble. Only a small percentage of plants in the field is likely to be affected and these are confined to certain definite areas. If frenching occurs during succeeding years, the location in the field is likely to be the same. Often it disappears entirely after one season. It occasionally appears in the seed beds.

### **Symptoms**

The earliest symptoms is chlorosis, or fading of the bud to pale yellow. The most characteristic symptom comes somewhat later. The leaves become thick, brittle, narrow and strap- or sword-shaped, with wavy, scalloped or crinkled margins (Figure 17). They may or may not be mottled in a manner resembling mosaic. The leaf margins have a tendency to curl downward. In severe cases all the leaves on a plant are affected; in less severe cases, the lower leaves are normal, or nearly so, showing that the attack occurred after the plants were partly grown. The stem does not elongate naturally and the number of leaves is multiplied so that the whole plant appears as a bush of dagger-like leaves in unusually large number set very close together (Figure 17). This appearance may be intensified by abnormal branching of the stalk.

### **Cause**

The cause of frenching has not been definitely proved. It is not associated with any fungus, bacterium, insect or other foreign organism. It cannot be transmitted from a diseased to a healthy plant (non-infectious). It is probably a trouble caused by malnutrition. Opinions expressed by several investigators, that it is caused by shortage of nitrogen, potash or phosphorus, by excessive fertilization, or by a soil toxin, however, are not supported by adequate experimental evidence. There is considerable obser-



**Figure 17**  
**Frenching or strap leaf.**

vational and some experimental evidence to indicate that it is associated with poor aeration or excessive moisture in the soil. Such conditions may be due to poor drainage or heavy soils that pack easily. It occurs only on land having neutral to basic reaction. Usually these soils have been limed. We have never found it on soils that tested below pH 6.0. This soil alkalinity seems to interfere with the availability of some essential element or the ability of the leaf cells to utilize it.

### **Control**

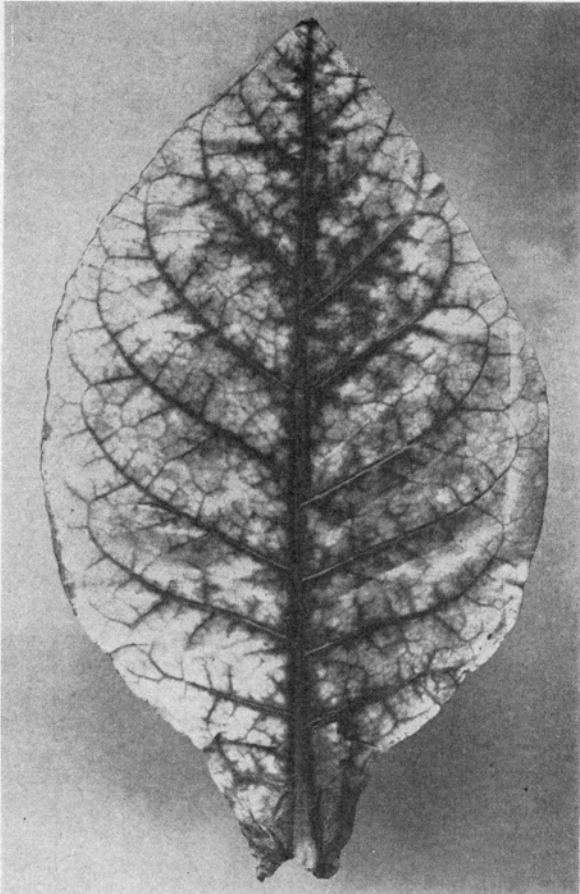
No method of control is known. Growing of tobacco on fields where the disease is wont to occur should be avoided. The soil reaction should be kept below 6.0 pH. If it does not become more prevalent in Connecticut than it is at present, control operations are hardly warranted.

### **MALNUTRITION DISORDERS**

There are nine food elements which the tobacco plant absorbs from the soil: nitrogen, potash, phosphorus, magnesium, calcium, iron, sulfur, manganese and boron. If there is an inadequate supply of any one of these, the plant becomes abnormal (diseased). The disease symptoms produced by a shortage of any one of these differ from those of the others, with the possible exception of sulfur. Symptoms resulting from deficiency of iron,

sulfur and boron never appear in the field because these elements are never sufficiently scarce in Connecticut soils to induce visible symptoms. Abnormal conditions may also be brought about by absorption of an excess amount of some of the food elements. Moreover, there are elements, which are not nutrients, but which may be taken into the plant from the soil under certain conditions in sufficient quantity to produce abnormal symptoms.

All these disturbances are called malnutrition diseases. Some of the common ones are described below. Frenching possibly should also be included in this group.



**Figure 18**

**Magnesium hunger or "sand drown".  
Green network of veins against the  
white web of the leaf.**

### **Magnesia Hunger or Sand Drown**

Magnesia leaches from very sandy soils, especially during seasons of excessive rainfall. When the soil supply becomes so low that the roots cannot absorb enough to meet the physiological requirements of the plant (.4 per cent MgO), the leaves develop chlorotic symptoms known popularly as "sand drown". The color fades out between the veins to light yellow or almost white, contrasting strongly with the dark green pattern of the vein system (Figure 18). The leaves do not become hobbly or recurved downward at the margins, as is the case in potash hunger, but remain smooth and feel thick and stiff between the fingers. The lower leaves are affected first but later the symptoms may travel up the plant, even to the top leaves in extreme cases. In very advanced stages, the yellow areas between the veins may die and turn brown. The most serious damage, however, comes from the checked growth of the plants and the lifeless character of the cured leaves.

If "sand drown" is observed early in the season, it may be remedied by applying 75 pounds of magnesia, preferably in magnesium sulfate, to the acre and working it into the soil. Magnesia hunger is rarely found if sufficient magnesia has been included in the fertilizer (See Conn. Agr. Exp. Sta. Bul. 503: 21-22 for fertilizer requirements).

### **Calcium Deficiency**

Calcium oxide makes up 4.5 to 8 per cent of the dry weight of the tobacco plant and performs very necessary functions in metabolism. Most of our soils contain a large supply of calcium naturally and more is added in lime or land plaster, as well as in bone phosphates and some of the other fertilizer materials.<sup>1</sup> Consequently, it is only rarely that shortage of calcium is acute enough to cause calcium starvation symptoms in the plant. Calcium leaches very easily from the soil, however, and in extremely wet years starvation symptoms do occur.

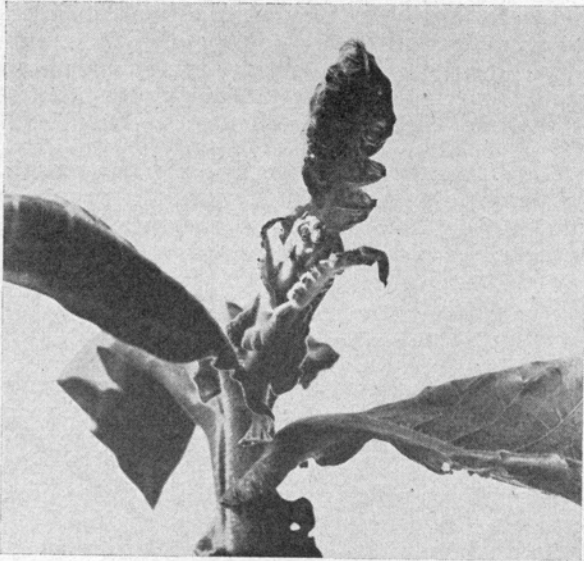
The symptoms appear in the unfolding bud (Figure 19) or youngest leaves of the plant. The terminal leaves are distorted, dwarfed or fail to develop at all. The tips of the youngest leaves turn brown or black. The partly developed, deformed leaves have ragged and incised margins.

The obvious remedy is to apply to the soil enough lime or land plaster to increase the supply of calcium. At least 500 pounds to the acre of lime or land plaster should be added if starvation symptoms are found in a field. As a basis for the treatment, however, the soil should first be tested for degree of acidity and quantity of calcium. Inclusion of an adequate supply of calcium in the original fertilizer is usually sufficient to avoid this trouble.

### **Nitrogen Starvation**

Nitrogen starvation causes the entire plant to turn pale and in severe cases to remain smaller and produce narrower leaves than normally. This trouble is well known by tobacco growers and is remedied by nitrate applications in the bed or by side dressing in the field.

<sup>1</sup> See Conn. Agr. Exp. Sta. Bul. 503, p. 19, for calcium requirement of the tobacco fertilizer.



**Figure 19**

**Calcium deficiency symptoms on field grown plant. Note distorted bud leaves.**

### **Ammonia Injury in Seed Beds ("Yellow Patch")**

Sometimes excess ammonia in the soil kills or stunts young plants in the early seed bed stages and may ruin entire beds. This malnutrition disorder is difficult to diagnose, requiring soil analysis and microscopic root examination before absolute confirmation. Sometimes the seed does not germinate at all but usually the seedlings come up and struggle along for a while before disappearing. As most commonly found, the disease occurs in patches of a few inches to a foot or more in diameter where the plants die off before they are a quarter of an inch high. First they turn yellow and then fall over and disappear, leaving ragged bare spots scattered over the beds. Even those that do not die are likely to be stunted and of slow growth. Microscopic examination of the affected plants show that the stems are sound and normal but the roots are brown and dead without any fungous mycelium or signs of disintegration. These symptoms distinguish this trouble from the various forms of rootrot and damping-off with which it can easily be confused.

Ammonia injury occurs most often on bed soils which have been steamed in the spring. A soil test shows huge quantities of ammonia liberated from such organic materials as fish meal, cottonseed meal and manure during the process of steaming. Cold wet springs, which are not favorable for nitrification, also seem to cause accumulation of ammonia in the soil. This ammonia is very toxic to the young roots.

The control lies primarily in avoiding the application of nitrogenous materials, such as those listed above, just previous to steaming. Also, it is well to delay seeding as long as possible after steaming in order to permit the ammonia to be converted to nitrate. Steaming the beds in late autumn instead of in the spring will also often eliminate the trouble.

When it is found that the plants are dying from ammonia injury, the trouble may be alleviated by soaking the soil with calcium chloride solution made by adding two or three pounds of calcium chloride to a barrel of water. Apply one gallon of solution to a sash.

### **Phosphorus Deficiency**

Phosphorus deficiency is evidenced by slow, "pinched" or stunted growth, and narrow, dark leaves. The narrowing is particularly evident at the heel of the leaves, giving them a somewhat spatulate shape. They do not become pale or yellow but, when viewed at an oblique angle, have a bronze cast. On old tobacco fields this trouble is not so often seen but is wont to occur in new fields during the first year or two of tobacco culture. When symptoms of phosphorus deficiency are found while the plants are young, the trouble can be overcome by side dressings of "ammo-phos" (200 pounds to the acre) applied as a side dressing and thoroughly worked into the soil. (See Conn. Agr. Exp. Sta. Bul. 503 and Tob. Exp. Sta. Bul. 7 for phosphorus fertilization of tobacco.)

### **Potash Deficiency**

This is not a very common trouble but a few cases are brought to our attention almost every year. Shortage of potash in the soil produces characteristic symptoms on the leaves of the plants. The most severe cases that the writer has seen in this State were in seed beds, but mild cases have been found in the field also. Under the Connecticut Valley practice of heavy potash fertilization, however, they are not common in the field.

In the earliest stages, the potassium-starved leaves are mottled with yellow near the margins and tips, resembling somewhat the early stages of ripening. Soon the surface of the leaf becomes rough and puckered ("hobbly"). Meanwhile, the centers of the mottled areas have died and the margins and tips of the leaves are speckled with numerous small white spots. As conditions grow worse, margins of the leaves turn downward, giving them a rim-bound appearance. In severe cases the dead portions may coalesce and fall out or break and make the leaf appear ragged. On large leaves in the field, when potassium deficiency is not severe, we have found the only symptoms to be a yellowing and sharp downward recurving of the leaf tips.

Unlike magnesia hunger, the symptoms of potash hunger do not always appear first on the lower leaves. These may be quite normal and the worst symptoms occur on the middle leaves. In severe cases plants are dwarfed. Plants with low potash supply are the first to wilt during dry



weather or on hot days. The cured leaves do not come into "case" in the shed so quickly as those which have more potash. They are dry, harsh, non-elastic and have poor fire-holding capacity.

When this disorder occurs in the beds, the plants should be thoroughly sprinkled with a solution of nitrate of potash made by adding two pounds of this material to a barrel of water. After the solution has been applied, it should be washed from the leaves with clear water. Even when the plants are severely affected in the beds, they may be set in the field safely since they recover rapidly there. The remedy in the field consists in supplying any of the potash materials commonly used in the fertilizer mixture. The trouble in the field, however, is rarely observed until it is too late to undertake remedial measures for the current year.

### **Manganese Poisoning**

All tobacco leaves normally contain a small amount of manganese, usually less than .25 per cent of manganese oxide ( $Mn_2O_4$ ). The more acid the soil, the higher the percentage of manganese in solution in the soil water and, consequently, in the plant. At a somewhat increased concentration it becomes toxic to the plant and produces symptoms of poisoning. Affected leaves grow pale and may be distorted. The yellow color develops between the minute ramifications of the veins. In later stages the leaf is dotted with small, irregular, brown dead spots. The plants remain stunted throughout the affected part of the field. Cured leaves are yellow, non-elastic and of inferior quality.

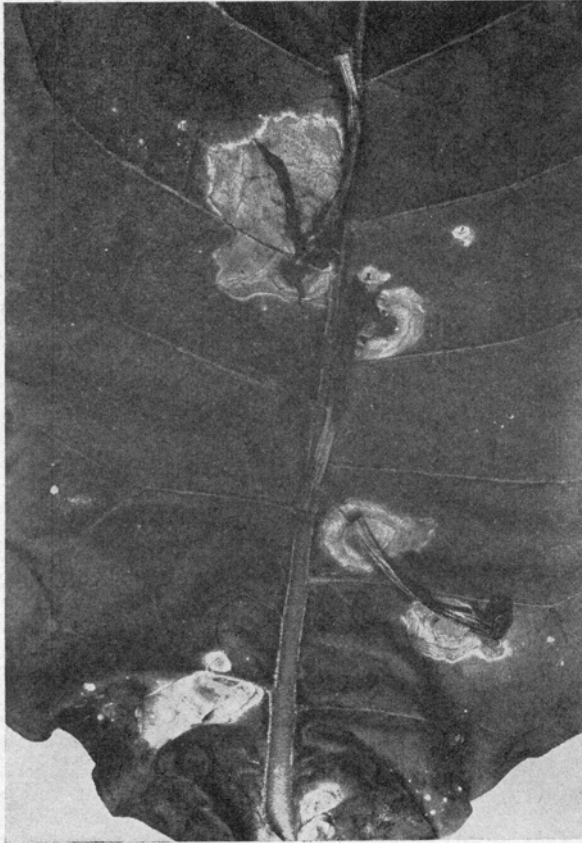
The remedy is to apply lime to correct the extreme acidity of the soil. The disease has been observed only on fields testing below 4.5 pH. Sufficient lime should be applied to bring this reaction up to 5.0 pH or somewhat above.

### **DEAD-BLOSSOM LEAFSPOT**

This is a disease that frequently causes considerable loss to Shade fields but is rarely seen in the open field except on primed tobacco where the sucker blossoms are allowed to mature. It causes losses in two ways: (1) the large dead spots on the leaves make them useless for cigar wrappers, (2) blossom rot leaves carried into the sheds are the principal source of pole rot (see "Pole Rot" on page 45).

### **Symptoms**

After the blossoms mature, the corollas, or pink trumpet-like parts, drop off. Many of them do not fall to the ground but stay on the leaves where they are held by the sticky nature of the surface hairs. As they dry out or rot, especially in wet weather, large dead spots develop under and around the fallen corollas (Figure 20). The spot starts first as a small darkened area just under the dead corolla but spreads rapidly and is soon an inch or more in diameter, becoming brown and dry or bleached to gray in the sunshine. The corolla may become black with fungous spores and remains



**Figure 20**

**Dead-blossom leafspot. Note the adherent partly decayed blossoms and dead leaf areas about them.**

tightly attached to the leaf. In wet weather the spot may spread until it involves half or more of the leaf. Frequently, it rots the midrib so that the leaf hangs limp and yellow. If it runs down the rib to the stalk, it often causes brown cankers several inches long on the stalk. When the canker spreads around the stalk, all the leaves above the canker become yellow and soon die.

### **Cause**

This leafspot and decay is caused by two species of parasitic fungi.<sup>1</sup> The symptoms are about the same, regardless of which of the two parasites is present. The fungous spores at this season of the year are blown about in

<sup>1</sup> *Sclerotinia sclerotiorum* and *Botrytis cinerea*. These are the same species of fungi that cause pole rot.

the air in countless numbers and fall on all parts of the tobacco plants. On the surfaces of healthy leaves and stalks they soon die even though they may germinate in wet weather. They are not able to infect the leaves or stalks. But on the corollas the story is quite different since these organs seem to furnish the natural medium for their growth. The germ tubes enter and spread with amazing rapidity in the flower tissues. The corollas that fall on the leaves are masses of fungous growth with a stepped-up vigor that enables the fungous threads to penetrate the leaf tissues and spread swiftly. When the rot starts to spread in the leaf, nothing stops it except the coming of dry weather. Then it stops abruptly and there is a sharp definite margin to the spot. It often resumes its spread when wet weather comes again. Sometimes the spots or cankers start where the leaf or stalk is broken or bruised but the vast majority of the spots start from the fallen blossoms.

### Control

No practical method of stopping the development of the spots in the field has been found. If the blossoms could be kept off there would be no trouble, but topping and suckering are not considered good practice for other reasons. Those who raise tall, late flowering strains like Connecticut 15 have very little trouble because most of the valuable leaves are harvested before the blossoms begin to drop.

### POLE ROT<sup>1</sup>

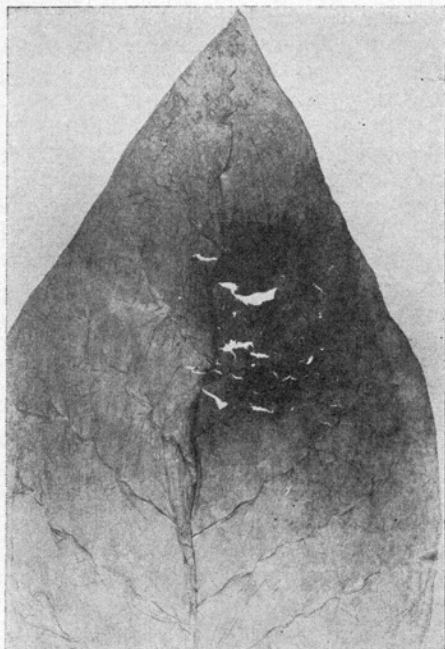
Disease, spoilage, or decay of tobacco while it is curing on the poles in the sheds is called pole rot. Other common names are sweat, pole sweat, shed burn, stalk rot, stem rot, slimy stalk, hollow stalk and rattle box. During bad years losses of more than a million dollars for the tobacco region are not uncommon. During exceptionally good curing years, losses may be almost negligible but we never have a crop cured without some loss.

### Symptoms

The leaves or large patches on them in the green or early yellow stage first swell and become discolored and clammy to the touch. Drops of water may stand out on them. This soon develops into a darker soft rot (Figure 21) and the leaves have no strength but pull apart when handled. They give off an odor of decaying vegetable matter. The midribs swell and, as they weaken in advanced stages, the leaves drop easily off the stalks. When the leaves are dried they do not come into case easily and the affected parts are brittle and shatter with handling (Figure 22) during a damp, when healthy leaves are soft and pliable. On the sorting bench, the leaf blades pull away from the midribs when the leaf is opened (Figure 23). The midribs themselves disintegrate leaving intact only the vascular strands, like ravelled cords.

On the stalks, there are different symptoms. The stalks may become slimy and wet and the outer part may slip easily off the woody cylinder

<sup>1</sup> For a more complete discussion, see Conn. Agr. Exp. Sta. Bul. 517, "Pole Rot of Tobacco", 1948.



**Figure 21**

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

("slimy stalk"). Such stalks frequently become covered with a mouse-gray, felt-like mold which sends off dusty clouds of spores when the stalk is handled. Other stalks become hollow and, when they are dry, little hard black pellets are found inside which rattle around like a rattle box if the stalk is shaken. The leaves on such stalks are prematurely cured, off-color, thin and papery and of inferior quality generally.

In another type of rot (freckle rot) the leaves become peppered with small darker spots of the size and distribution of freckles on the face. This type is not so damaging and seldom causes complete breakdown of the tissues.

### **Cause**

Pole rot in all its forms is caused by the attack of parasitic fungi.<sup>1</sup> Wet weather and moisture in the sheds are not the primary causal agents of rot. They merely *create a condition* in the sheds which is necessary for the

<sup>1</sup> *Sclerotinia sclerotiorum*, *Botrytis cinerea* and *Alternaria tenuis* are the three species which we have found causing rot in Connecticut but other species may at times be responsible. Most of our destructive rot is caused by the first two mentioned. *Alternaria* causes only the freckle rot type.



**Figure 22**

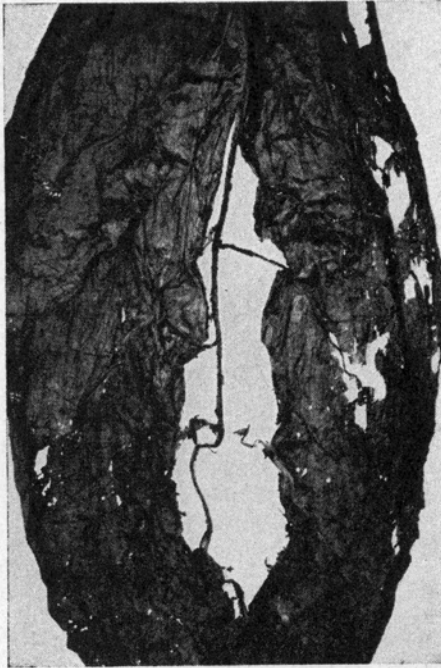
**Web rot on cured leaf. Fragments of the leaf drop out when it is handled.**

attack and growth of the parasitic fungi. These fungi frequently attack the plants while they are still in the field making incipient cankers in injured tissues around wounds caused by topping, suckering and accidental bruises. In Shade tobacco they cause the previously described dead-blossom leafspot and the introduction of such infested leaves is commonly the start of rot in Shade sheds.

Tobacco leaves in the field always have great numbers of spores of these fungi on the surface. The numerous breaks and bruises incident to harvesting furnish ideal infection courts for these spores. One of the main advantages of "green firing" mentioned below is to dry out these wounds before rot can get started. Too, these spores are blown about in the air and enter the shed through cracks and ventilators. If they find the surfaces of the plants moist, they germinate and start new infection.

### **Control**

No method of destroying the spores or causal fungi in the sheds nor preventing the spores from entering the sheds has been found. Since they will always be there, the obvious method of preventing rot is to create conditions in the shed which will stop their growth. Fortunately, these fungi



**Figure 23**

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

have one weak point where they can be attacked: they are very dependent on moisture. There must be much moisture in the air or on the surface of the leaves to allow their spores to germinate. Too, as soon as the water content inside the leaves is sufficiently reduced, growth and spread of the parasite stops.

The whole purpose of fire curing is to reduce the moisture inside the sheds as completely and quickly as is consistent with development of good quality in the cured leaves. (A too rapid loss of water produces a green "hayed down" leaf, lacking quality, and must be avoided.) Raising the shed temperature above that of the outside air and maintaining air currents are the two means of removing moisture. This is the only workable method of combating pole rot that has been developed.

Concise directions for fire curing are given below.

1. In hanging the tobacco, either leave out the lower tier or leave lanes the length of the sheds on both sides. Short side lanes at right angles in each bent will also allow better distribution of fires.

2. Distribute four fires in each 16 foot square bent in holes or in firing pans or simple stoves.
3. Dig holes twelve inches wide and eight inches deep in the floor.
4. Fill with a shovelful of charcoal (briquets or lump charcoal), pour one-fourth cup of kerosene over the charcoal and ignite with a flame on the end of a lath.
5. Replenish charcoal every half hour or so to keep the fires going.
6. Locate thermometers in the second tier along the middle of the shed as far as possible from the fires. Also place a thermometer outside of the shed in the shade.
7. Maintain the temperature inside at 10 to 15° F. above outside.
8. First firing (called "green" firing) should start just as soon as the shed is filled and should continue 48 to 72 hours or until all the leaves hang limp from the stalks, and the plants stand apart so that you can look up to the rafters between the plants (or between lath of primed tobacco).
9. Later firings will be necessary only during wet weather or prolonged periods of high humidity. In good curing weather the cured parts of leaves become soft at night but dry and brittle during the day. If the humidity in the air remains high so that the leaves do not dry out for two days in succession, it is time to start the fires again and continue until all cured parts of the leaves are dry and brittle.

*Ventilation.* Except during the period of firing, all ventilators should be wide open during the early part of the curing season to allow for maximum air movement to remove moisture from the sheds. During this early period they may be left open night and day, except during storms, when they must be closed to guard against rain splashing or wind whip.

After a considerable portion of the leaf area has dried, it is better to open the ventilators during the day but close them at night to minimize the effect of night damps on the still sappy parts of the leaves. With strong winds, the ventilators only on the side away from the wind should be opened during the day. This is to avoid breakage of the dry leaves by wind whip.

After the completion of the cure, the ventilators and doors should be kept closed all the time except when long continued rainy periods start secondary mould. Then they should be opened to allow the breezes to remove the stale air and dry the leaves again.

Electric fans have been used with good success by some to create air currents and remove water from the sheds during curing.

*Effect of maturity.* If tobacco is quite ripe when harvested, it has a better chance of escaping rot than green tobacco. It is less sappy, cures more rapidly and, hence, is exposed to danger for a shorter period.

*Wilting before hanging.* If tobacco is well wilted in the field before it goes to the curing sheds, it is less subject to rot. This wilted tobacco can

be handled with less breakage, which means fewer infection courts for rot fungi. Too, if it is well wilted in the field, it has already started to cure and will be in danger for a shorter period in the shed.

*Spacing.* Crowding too much tobacco into the shed should be avoided. If a grower had sufficient shed room he could almost escape rot by wide spacing, but few growers have that much shed room at their disposal. With a given shed capacity the best rule is to space as widely as possible.

No more than five Broadleaf plants or six Havana Seed plants should be strung on a lath. Since there is more danger of rot on the lower tiers, it is customary to space the lath closer in the peak and farther apart progressively downward. In no case should they be less than six or seven inches apart while eight to ten is better. If a grower plans on regular firing, he may space more closely.

*Covers for fires.* In order to spread the heat and so that the tobacco directly over the fires will not get scorched, some kind of a metal cover is useful. A simple cover may be made as follows:

Take a piece of No. 22 gauge galvanized sheet iron 32 by 30 inches. Bend seven inches of each end downward at right angles for legs: this leaves a cover 18 by 30 inches with solid sides and open ends seven inches high. Place directly over fire holes.



## Appendix

### KEEPING THE SEED BED HEALTHY

There are two reasons why the seed beds should be kept as free as possible from diseases and insects: (1) to obtain an adequate supply of plants at the time they are needed, and (2) to avoid carrying diseases and insects into the fields. Many of our field troubles can be traced back to the seed beds. Not only is the seed bed the ideal spot to spread any disease or insect, since the plants are crowded together, but it is also the best place to combat them with the least outlay of time and effort.

Because of this strategic importance of keeping the seed beds free of trouble, we have attempted to outline below an inclusive program of operations and precautions, which would go far towards minimizing this source of danger until the plants are ready to set in the field.

#### Proper Fertilization

Many seed bed troubles start from over-fertilizing or fertilizing at the wrong time (as, for example, "Ammonia Injury" described on p. 41). If manure is used, it should be applied the previous summer. If a regular tobacco mixture or cottonseed meal is used, it should be applied the previous fall and not in excess of one-half to three-quarters of a pound to a square yard. If soil tests show that some particular element is in short supply, this should also be remedied in the fall. Commercial shredded humus or black swamp soil is excellent to mix with the bed soil for a conditioner, but it contains very little nutrient substance and does not take the place of fertilizer.

No fertilizer should be applied at the time of sowing the beds. If, after the plants are growing, they show symptoms of nitrogen or potash starvation, the beds should receive an application of nitrate of soda or nitrate of potash. Two or three pounds of nitrate of soda is dissolved in a barrel of water and sprinkled on the bed at the rate of one gallon to the sash. Nitrate of potash is used in place of nitrate of soda if the difficulty is potash starvation. The solution should be washed off the leaves with clear water after treatment. Top dressings may also be made with fish meal, "Vigoro", "Swiftsure" or other mixtures which contain quickly available nutrients. These top dressings should be made only when shortages are very pronounced because overfed plants are sappy and tender, more subject to disease and do not survive as well when planted.

#### Sterilizing the Soil

Since many of the pathogenic organisms and noxious insects are soil-borne, their injuries can be eliminated or reduced by killing them in the soil before the bed is seeded (soil sterilization). This same operation also kills weed seeds and, thus, eliminates the need of hand weeding.

Two methods of sterilizing tobacco beds are in general use: (1) steaming, (2) treating with chlorpicrin.

### Steam Sterilizing the Soil

Steaming the soil not only kills germs, insects and weed seeds, but also makes the plant nutrients in the soil more available and produces a more vigorous growth.

Soil may be sterilized either in late autumn or in spring. The advantage of fall sterilization is that it distributes the labor better by avoiding the spring rush, and also eliminates the danger of ammonia injury. Spring sterilization may delay considerably the time of seeding, especially during late springs. The disadvantage of fall sterilization is that the soil may become reinfested with weed seeds, insect pests and fungi to some extent

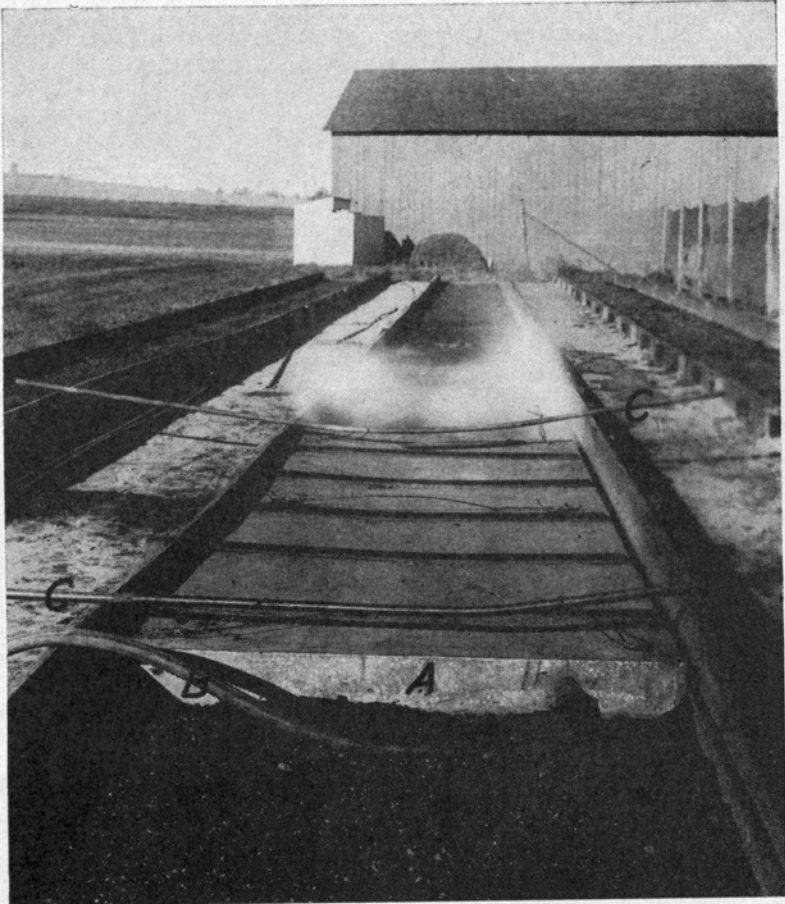


Figure 24

Steam sterilizing beds. (A) pan; (B) steam supply line; (C) cross bar for lifting pan; (D) sides of seedbeds. Steam beyond pan is rising from soil from which the pan has just been removed.

during the winter. On this account, the operation should be delayed until as late in the season as possible.

Injury to the germinating seed sometimes results when the bed is seeded immediately after steaming. For this reason, it is best to wait a few days before the sowing; a lapse of 10 days is better, if it does not delay the time of seeding too seriously.

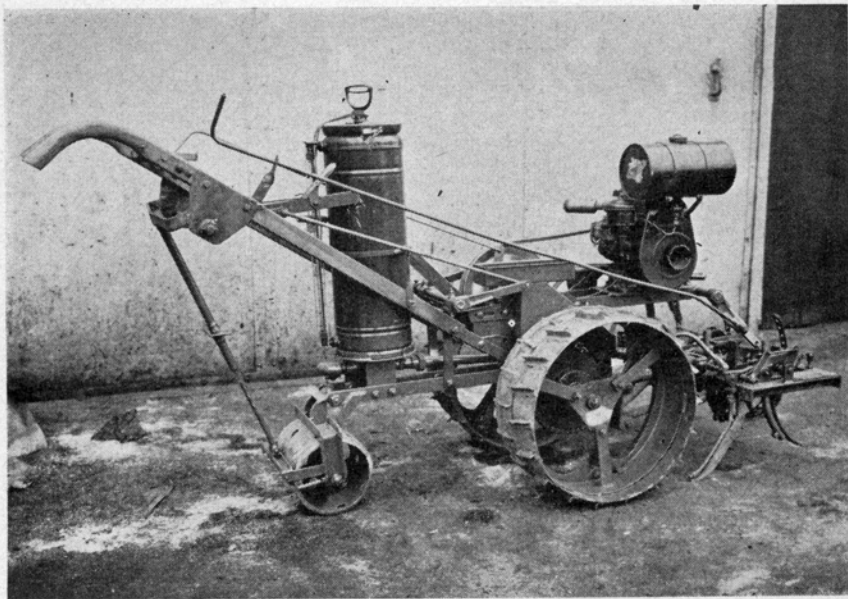
Of the various ways for steaming soils, the only one used in Connecticut is the "inverted pan" method. A galvanized iron pan, reinforced with angle irons, about 10 inches deep, 12 to 16 feet long and just wide enough to fit inside the bed, is inverted over the soil and the sharp edges pressed a few inches into the loose earth (Figure 24). Steam under high pressure from a steam boiler is forced through a pipe into the end of the pan and penetrates into and sterilizes the soil. The method is too well known to require further description except for the following precautions:

The soil should be well worked up and loose before steaming. Any manure or humus to be added should be applied in advance. Commercial fertilizers may be added before or afterward. A moderately dry soil is more easily sterilized than one that is water-logged, because steam penetrates mud very slowly. Twenty to 30 minutes with a pressure of 75 to 125 pounds is usually sufficient. If, after removing the pan, the soil is so hot that you cannot hold your hand in it at a depth of five to six inches, the steaming is sufficient. Otherwise, the length of steaming should be prolonged. The soil should not be worked deeply after steaming because there is danger of turning up some of the unsterilized earth.

### **Chemical Sterilization**

Of the various chemicals that have been tried, the only one we have yet found to be satisfactory is chlorpicrin (sold as "Larvacide"). It does not give quite as good weed control as steaming but in all other respects has been satisfactory. The principal advantage of the chemical method is that the soil can be sterilized in one-tenth of the time it takes to steam sterilize it. Thus, there is a big saving in labor. Moreover, the cost of the apparatus is not as great as the cost of a steam boiler and steam pans and it can be handled and housed in less space. In small beds chlorpicrin can be applied with a small hand applicator such as that described on p. 20, spacing the injections about 10 inches apart (spot application). It requires 16 to 20 pounds of chlorpicrin to 1,000 square feet of bed. The volume of each injection can be regulated by a "stop" on the plunger bar and should be calibrated before starting application. For larger beds it is more economical to use a motor driven continuous-flow applicator, such as that shown in Figure 25. Chlorpicrin should be applied three to four inches below soil surface.

The beds should be sterilized in the fall because the soil is too cold in the early spring and there is not time for the gas to get out of the soil between application and seeding, thus endangering the young seedlings. The soil should be fertilized and pulverized before treatment. It should be thoroughly watered a week or two previously in order to start germination of



**Figure 25**  
**Continuous-flow applicator for chlorpicrin.**

weed seeds, thus making them more easily killed. The soil should be moist but not muddy at time of treatment.

As soon as possible after fumigation, the soil should be raked level and watered so that it is wet to a depth of one inch. This is to seal the top and hold the gas in the soil. The seal can be improved by spreading several thicknesses of Shade cloth over the surface before watering. Another very effective method is to cover the surface with a  $1\frac{1}{2}$  inch layer of shredded, weed-free black humus and water it thoroughly.

### **Spraying for Wildfire**

The wildfire spray program (as given on p. 15) should be started just as soon as the seedlings have pushed the first roots down into the soil and while they are still mostly in the two-leaf stage. This copper spray material will also aid in controlling early damping-off but is not as dependable for this purpose as the formaldehyde method described on p. 7.

### **Spraying for Mildew**

The mildew spray program (as detailed on p. 9) should be started about the first week in May and repeated twice a week until all the fields are set and the grower is ready to destroy the plants in the beds. If wildfire

is prevalent in the neighborhood at the time that the mildew spray is started, applications for the two diseases can be alternated. The mildew spray will also control bed rots.

### **Treatment for Aphis and Flea Beetle**

The seed bed is often the start for both of these species of insects in the field. All beds should be dusted with 1 per cent parathion at least twice before the plants are set in the field, one application a week before pulling starts, the other treatment a week or two previous to that. Parathion 15 per cent wettable powder at the rate of one-half to one pound in 100 gallons of water may be used as a spray, if preferred. This may be included in the Fermate spray.

### **Destroying Beds at Close of Season**

Plants allowed to grow in the beds long after the transplanting is finished are usually neglected and are excellent breeding places for disease organisms and insects. Many field infestations are directly traceable to such neglected beds. Just as soon as there is no further use for transplants, it is best to destroy such breeding places. They may be pulled or hoed out and removed. A better, safer way is to drench them with formaldehyde diluted at the rate of one gallon in a barrel of water. The beds are then covered tightly with the glass sash until the fumes of formaldehyde have killed all the plants.