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# TOBACCO SUBSTATION AT WINDSOR

## REPORT FOR 1945

P. J. ANDERSON AND T. R. SWANBACK

Connecticut
Agricultural Experiment Station
New Haven

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## REPORT FOR 1945

P. J. Anderson and T. R. Swanback

This twenty-fourth annual report describes the work of the Tobacco Substation for the year, 1945.

The year was an excellent one for Connecticut tobacco growers. Prices were good, there were few insect or disease outbreaks, and little loss from hail storms, fires, drought or flood.

The rainfall was well above average, up to the middle of August (Table 1). A season of high rainfall and little sunshine always results in lower yields, even though the tobacco may appear just as large while growing; the reduced weight being due to thinner leaves. This year was no exception and yields were somewhat below average.

Pertinent data showing the trends in acreage, production and consumption of Connecticut Valley tobacco are shown in Tables 2 and 3. In these tables, the four war years are compared with a ten-year period just previous to the war. The total land in tobacco in 1945 has increased by 2,180 acres over the pre-war average but most of this (1,930 acres) has been an increase in Shade acreage. Broadleaf has increased 510 acres while Havana Seed has been reduced by 260 acres. The large increase in Shade acreage is due to the shutting off of imported cigar wrapper, particularly from Sumatra. Acreage of the open field binder types has been kept down by lack of shed room and the high price of labor and lumber for building new curing sheds. Moreover, many sheds and fields which formerly were devoted to Broadleaf or Havana Seed were leased or purchased by the Shade growers. The small number of new sheds constructed during the war are mostly on Shade plantations. There were no empty sheds in 1945. The level of production during the war has thus been controlled by available shed room more than by available land or other factors.

Meanwhile, what has been happening to the stocks of tobacco on hand? Table 3 shows the stocks of Shade tobacco in the hands of dealers and manufacturers have increased a little, but not in proportion to the acreage increase. The picture for the stocks of binder types is quite different. The Broadleaf stock pile (July 1, 1945) dropped by about ten million pounds and Havana Seed showed approximately the same decline. If we assume that the pre-war stock piles were normal, this means that they are now short by about the size of one year's production.

Table 1. Distribution of Rainfall in Inches at the Tobacco Substation, Windsor, 1945

| | | By 10-day periods | By months | Average for preceding 23 years |
|---|---|---|---|---|
| May | 1-10 | 1.93 | 6.11 | 3.33 |
| | 11-20 | 3.53 | | |
| | 21-31 | .65 | | |
| June | 1-10 | .69 | 4.58 | 3.87 |
| | 11-20 | 2.59 | | |
| | 21-30 | 1.30 | | |
| July | 1-10 | 1.30 | 4.77 | 3.49 |
| | 11-20 | 3.15 | | |
| | 21-31 | .32 | | |
| August | 1-10 | 1.40 | 3.75 | 3.81 |
| | 11-20 | .... | | |
| | 21-31 | 2.35 | | |
| Total (4 months) | | | 19.21 | 14.50 |

Table 2. Tobacco Statistics for all Connecticut Valley. War Years Compared with Pre-war Average

| Type | Acres Harvested | | | | | Production (1,000 pounds) | |
|---|---|---|---|---|---|---|---|
| | Average 1932-41 | 1942 | 1943 | 1944 | 1945 | Average 1932-41 | (Estimated) 1945 |
| Broadleaf ........ | 7,690 | 6,800 | 6,600 | 7,800 | 8,200 | 11,937 | 13,444 |
| Havana Seed ..... | 6,860 | 7,600 | 6,500 | 6,800 | 6,600 | 10,941 | 10,648 |
| Shade ........... | 6,170 | 6,100 | 6,300 | 7,300 | 8,100 | 5,941 | 7,357 |
| Total ........ | 20,720 | 20,500 | 19,400 | 21,900 | 22,900 | 28,819 | 31,449 |

Table 3. Stocks of Tobacco and Cigar Consumption

| Year | Total stocks on July 1, unstemmed basis (1,000 pounds) | | | Large cigar consumption (Tax paid withdrawals) |
|---|---|---|---|---|
| | Broadleaf | Havana Seed | Shade | |
| Average 1933-41 ...... | 33,893 | 30,220 | 8,111 | 5,320,252,000 |
| 1942 ........ | 28,504 | 31,311 | 7,523 | 6,206,539,000 |
| 1943 ........ | 23,845 | 30,205 | 7,357 | 5,228,312,000 |
| 1944 ........ | 22,805 | 27,001 | 7,731 | 4,786,126,000 |
| 1945 ........ | 23,999 | 20,840 | 8,879 | 4,576,904,000[1] |

[1] For eleven months.

The data on number of cigars consumed do not show the correct picture after 1942 because we have no complete record of the number of cigars that were sent abroad to the armed services. They paid no internal revenue and our consumption data are based solely on revenue stamps. The rate of disappearance of stocks, and other supporting information, indicate that cigar consumption is about as high now as it was in 1942.

The experimental work at the Tobacco Substation has been considerably reduced in the last two years by vacancies in the staff. The position of Physiologist and Chemist of the Station was filled recently by the appointment of Mr. A. Boyd Pack, formerly of the Massachusetts Experiment Station.

Calls for direct service to the growers, such as soil testing, seed cleaning, germination tests, etc. have continued to increase. More than 5,000 soil samples were brought to the Station for testing during the year. Most of these were tobacco soils, but all other types of crops were represented.

The Substation has enjoyed the splendid cooperation of growers of all types of tobacco, as well as that of dealers and manufacturers. Their assistance in cooperative tests, which frequently involved extra labor, trouble and expense for them, has aided materially in expanding the scope and value of the work that our present staff can undertake.

The following pages contain progress reports on some, but not all of the active projects.

## BORON IN TOBACCO FERTILIZATION

### T. R. Swanback

Boron is a plant food which is as necessary in the normal nutrition of plants as are the nitrogen, phosphorus and potassium of the fertilizer formulas. The function of boron in plants is not fully understood, but its vital importance in furthering cell growth, is shown by the fact that the apex (terminal bud) fails to develop in the absence of boron.[1]

Tobacco's need for boron was established in 1927.[2] From the fact that only one pound of boron per acre is needed for normal plant growth, it might be assumed that sufficient amounts of this element would be present in the soil or possibly be furnished (incidentally) in manures and fertilizers. Active boron, however, is not plentiful in Connecticut soils and deficiencies have been observed on crops other than tobacco. The system of tobacco fertilization in this Valley probably will do no more than maintain the boron level in the land, as was pointed out in a previous publication.[3] Therefore, if the original boron level of the soil is too low, the regular method of fertilization should not alter the boron status to any great extent.

Boron works in close relationship with calcium,[3] in such a way that the more calcium taken up by the plant, the more boron is required for proper plant development. Therefore, proper balance between these two elements in the soil is important. It was indicated in previous tests[3] that a relatively narrow ratio of calcium to boron is

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[1] Conn. Agr. Exp. Sta. Bul. 410:394-395. 1938.

[2] Swanback, T. Robert. The effect of boric acid on the growth of tobacco plants in nutrient solutions. Plant Physiol. 2:475-486. 1927.

[3] Swanback, T. Robert. Possible role of boron in tobacco fertilization. Soil Science (Submitted for publication in April issue of 1946).

most suitable for proper plant development. Ten to 20 pounds of borax per acre, in row applications, produced up to 12 per cent increase in crop values. To be sure, tobacco soils in the Connecticut Valley, in general, are low in calcium content. Therefore, responses to borax applications would fall in a range of relatively narrow calcium-boron ratios.

### Recent Boron Experiments

For the purpose of obtaining further data on the use of boron in tobacco fertilization, additional tests were carried out in 1945. A field was selected which would be considered a tobacco soil type but on which tobacco had not been grown for at least 20 years. Weeds and small shrubs covered the land when it was sampled (in April). Soil reaction varied from pH 5.25 to 5.60. The soil contained only traces of available nitrogen, very low content of potassium and calcium, medium high of magnesium, and high to very high of active aluminum, according to the Universal Soil Test method. Replaceable calcium amounted to about 320 p.p.m. while available boron was down to a mere trace (.03 to .04 p.p.m. B). This parcel of land must be considered as definitely in a "run-down" condition for growing any commercial crop and, least of all, tobacco. Therefore, the land required a basal treatment in order to bring up the fertility level, before regular tobacco fertilizer (3,300 pounds 6–3–6 per acre) was applied. A mixture of 400 pounds hydrated calcic lime, 400 pounds land plaster, 200 pounds sulfate of potash and 200 pounds triple superphosphate to the acre was broadcast and plowed under. The regular fertilizer mixture was applied three weeks later (on June 6) and harrowed in. The field was then divided into 20 plots, each sufficient for four rows of tobacco, 45 feet in length. Five treatments, in quadruplicates, were included:

1. Check, no borax applied.
2. Ten pounds of borax per acre applied on each side of the tobacco row.
3. Twenty pounds of borax per acre applied on each side of the tobacco row.
4. Fifteen pounds of borax per acre broadcast.
5. Twenty pounds of borax per acre broadcast.

The borax was mixed with a quantity of dry sand for easier distribution and was applied at the time of planting. The field was planted to Havana Seed tobacco. Hoeing and cultivation that followed were considered sufficient for incorporating the borax into the soil. The tobacco on this field grew slowly at the beginning but later developed into a luxuriant growth.

The yield figures bear this out, since the average yield from this area was more than one ton per acre (see Table 5). The yields were not affected by borax applications, since there were no (statistically) significant differences between results from check plots[1] and the various borax applications, or within the latter ones.

The grading, however, was improved in most instances where borax was applied, although statistical differences were obtained only when more than 10 pounds per acre were applied.

TABLE 4. SORTING RECORDS OF BORON PLOTS. CROP OF 1945.

| Treatment | | Acre yield | | Percentage of grades | | | | | | | Grade Index | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plot | Ave. | L | M | LS | SS | LD | DS | F | Plot | Ave. |
| Check | A | 2250 | 2110 | 5 | 7 | 47 | 7 | 30 | 1 | 3 | .490 | .483 |
| | B | 2063 | | 3 | 4 | 44 | 8 | 35 | 1 | 5 | .454 | |
| | C | 2063 | | 8 | 4 | 40 | 12 | 27 | 5 | 4 | .475 | |
| | D | 2063 | | 11 | 9 | 40 | 8 | 26 | 2 | 4 | .514 | |
| 10 lbs. Borax in the row | A | 2063 | 2079 | 20 | 8 | 28 | 12 | 28 | | 4 | .540 | .513 |
| | B | 2011 | | 10 | 8 | 43 | 5 | 28 | 2 | 4 | .513 | |
| | C | 2156 | | 5 | 8 | 37 | 7 | 36 | 3 | 4 | .459 | |
| | D | 2085 | | 17 | 11 | 33 | 7 | 26 | | 6 | .539 | |
| 20 lbs. Borax in the row | A | 2109 | 2084 | 15 | 10 | 33 | 8 | 29 | 1 | 4 | .525 | .532 |
| | B | 2109 | | 11 | 7 | 42 | 5 | 30 | 1 | 4 | .517 | |
| | C | 2063 | | 15 | 12 | 32 | 8 | 29 | 2 | 2 | .531 | |
| | D | 2054 | | 19 | 11 | 33 | 7 | 24 | 1 | 5 | .554 | |
| 15 lbs. Borax broadcast | A | 2250 | 2098 | 13 | 6 | 34 | 8 | 32 | 2 | 5 | .499 | .535 |
| | B | 2063 | | 21 | 11 | 32 | 8 | 23 | 1 | 4 | .567 | |
| | C | 2016 | | 14 | 6 | 33 | 9 | 30 | 4 | 4 | .503 | |
| | D | 2063 | | 23 | 12 | 27 | 9 | 25 | 1 | 3 | .571 | |
| 20 lbs. Borax broadcast | A | 2063 | 2118 | 19 | 9 | 30 | 10 | 27 | 2 | 3 | .542 | .543 |
| | B | 2237[1] | | | | | | | | | .567[1] | |
| | C | 2203 | | 14 | 6 | 35 | 8 | 32 | | 5 | .511 | |
| | D | 1969 | | 18 | 10 | 35 | 5 | 26 | 1 | 5 | .550 | |

[1] Missing values replaced by statistical calculation.

In examining the sorting record (Table 4), we find that the improvement in grade indexes is due to increases in percentages of light and medium wrappers (L, M), particularly, the former. Thus, it appears that one of the functions of boron in tobacco nutrition is to aid in the completion of the metabolic processes of the plant. In other words, boron helps to accomplish that which is of interest to every cigar leaf grower—better quality tobacco.

In view of the fact that about one half part per million of boron is needed for normal growth, it is somewhat perplexing if we recall the relatively satisfactory results from the check plots, since the original soil contained only a little more than a trace of boron. It is likely, however, that the vegetation, covering the land before plowing, and the fertilizer added to the land, together with the interaction of certain fertilizer materials,[2] might have furnished sufficient active boron for a normal growth. Moreover, it is suggested that weeds sup-

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[1] The exceptionally high yield value of check plot A might be explained from the fact that an area in this plot was covered with ashes from a brush fire. Although most of these were removed, a residual effect was apparently unavoidable. Statistical correction for values of this plot would be, yield, 2,055 pounds, and grade index, .465.

[2] Swanback, T. Robert. Possible role of boron in tobacco fertilization. Soil Science (Submitted for publication in April issue of 1946).

ply a fair amount of boron which in turn may be one of the reasons for the often observed favorable effect of weeds preceding tobacco.

The problem of adding borax to tobacco land must be handled with caution. An overdose of the material is definitely injurious to plant growth. In the experiments reported above, the soil was enriched from about one half to a little more than one part per million. Since 15 pounds of borax broadcast (together with regular fertilizer), furnishing about one part per million of boron (B), produced optimum response, it would be safe to apply this amount when there is an apparent need for boron. It must be emphasized that this is a *one-time application*, which should not be repeated without a soil test for boron content. A continuous use of not more than five pounds of borax per ton of fertilizer would be a safe procedure. It is difficult, however, for the home mixer to obtain an even distribution of this small amount in the usually bulky tobacco goods. One method would be to mix the borax first with a suitable quantity of the organics or a less bulky ingredient (not liming materials) and then proceed as usual with the mixing.

## PRESERVATION OF SHADE TENT POLES

Henry W. Hicock and P. J. Anderson

During the first 25 years of the Shade tobacco industry, chestnut poles were used exclusively to support the tents. These were ideal poles because they were durable—with a life of at least 10 years when set in the soil—strong, straight, light, and retentive of staples without splitting at the top. Moreover, they were cheap and abundant in suitable sizes in all of our local forests. But even in the first quarter century, the fungous blight was rapidly killing off the chestnut trees, and the native source had almost completely dried up in the early 'thirties.

After the chestnut disappeared as a commercial species, some other supply of tent poles had to be found. No other common native species of wood meets the requirements of durability, strength, straightness and retention of staples. If we are to continue to grow Shade tobacco, some other source of poles must be found. Three possibilities present themselves:

1. To bring into the Valley untreated durable species from other regions.
2. To treat with preservatives some of our non-durable species which are abundant and which meet the other requirements.
3. To use woods commercially pressure-treated.

All of these sources have been or are being explored by the growers and by the Experiment Station. The purpose of the present article is to summarize results to date from the Station experiments and the experience of growers.

### Untreated Species

*White Cedar* has been used by a number of growers but in general has not been found satisfactory. The wood is not only very weak but is quite soft and staples pull out easily. The posts have a thick sapwood which rots quickly.

*Red Cedar* has been used more than white cedar in the last few years and has met with more favor than white cedar. A small quantity of red cedar posts can be obtained within short trucking distance from the Shade section but the main supply must be imported here from longer distances. In purchasing red cedar posts, it should be kept in mind that the only useful part of the tree is the dark-colored heartwood. The white sapwood rots completely in less than five years. Growers who have bought posts of minimum diameter outside measurement are apt to be disappointed in the strength of a much smaller heartwood. Moreover, some of the posts have been rough and knotty and the projecting stubs tear cloth and interfere with cultural operations. Good straight smooth cedar posts with plenty of heartwood are quite expensive but otherwise seem to be satisfactory.

*Black Locust* posts are extremely durable but become so hard when seasoned that staples bend before they can be driven into the wood. Moreover, there is only a small quantity of black locust growing in Connecticut and the supply from other sections is limited and expensive.

*Oak* posts have not been found suitable, although fairly durable and very strong. They are heavy to handle and do not staple well.

### Treated Posts

The choice between home treating native woods found on most farms and purchasing commercially treated poles lies with the growers. If the kind of wood and the type of treatment are properly selected, either will give results commensurate with the money or labor expended. Commercially treated woods will require higher initial outlay but will probably last longer than locally treated poles. The Station's tests, covering a period of 18 years, indicate that the latter may be expected to give very good results. Moreover, the treatment of local woods permits the use of labor during slack periods.

Posts rot because fungi invade them and eat out the strengthening substance in the wood, thus reducing it to soft punk which has no resistance to strain or shock. Durable woods, such as chestnut, resist the digestive action of these fungi, and the life of a post depends on the degree of resistance its composition offers to these invaders. Fungi require moisture and air for their growth. Hence, posts rot first near the soil level where moisture conditions are most suitable for them. From here the fungi may later spread throughout the posts. Deep cracks in the post also furnish a suitable moist environment for them. If wood is impregnated with substances which are poisonous to invading fungi, it can be made to last as long or even longer than chestnut or other durable woods. All wood-preservative treatments are based on this one simple principle. There are many chemicals that are poisonous to fungi but the problem is complicated by the difficulty of introducing the chemicals and properly distributing and retaining them in the wood. Heartwoods are especially resistant to impregnation. Some species absorb chemicals readily while others absorb so little that it is not practicable to use them. Moreover, some chemicals are too soluble or lose their toxicity so quickly that they do not afford a long enough protection. Other chemicals or treatments are entirely effective but are too expensive to be economical. The treatments and preservatives described below are those considered most feasible for the Shade growers.

To be of any value, a preservative must penetrate the wood to a considerable depth. Superficial treatments by brushing, dipping or spraying do not accomplish this and are of little value in treating tobacco tent poles.

Impregnation may be accomplished at atmospheric pressure and at pressures above atmospheric on seasoned wood using either oily or water soluble preservatives, and by sap stream methods on unseasoned wood using water soluble preservatives only.

Poles treated by all these methods have been or are being tested by the Station. The results to date are presented below.

### Seasoned Wood Treated at Atmospheric Pressure

*Open Tank Method: Coal Tar Creosote.* Beginning in 1927, extensive tests have been conducted with creosote at the Tobacco Station and at other locations in the State. In the first tests, pitch pine, white pine, popple, gray birch and red maple were treated. Later tests included most of the common species of trees in Connecticut. Since posts rot most at the ground level, especial attention was given to butt treatment, i.e., impregnating the poles from the butt end up to a foot above the level of the soil. They were treated by the open tank method which consists of standing the poles for two to four hours in a barrel of creosote heated to 220° F. and then cooling them for two hours or more in creosote at about 100° F. This simple and comparatively inexpensive treatment may be made with a minimum of equipment on any farm. In these tests, the treated butts were found to be serviceable for at least 15 years while all untreated butts had rotted and become unserviceable at the end of five years.

Although the butts of these posts remained intact for 15 years or longer, the tops of most of them had begun to show so much rot after five years, that this method—of butt treatment alone—does not seem economically advisable for our common non-durable species.

These results naturally suggested the possible benefits of impregnating the full length of the pole. This possibility was first explored by giving the tops of the butt-treated poles a light treatment of creosote by brushing it on or by a short dip in cold creosote. Although this added somewhat to the life of the tops, the benefits were not sufficient to make it worthwhile.

If the entire length of the poles is given the hot creosote treatment by the open tank method, the life of the poles would be as long as that of the butts. Two objections arise, however, to this procedure. It would necessitate more equipment, labor and creosote. The more important objection is the possibly injurious effect of creosote fumes on the tobacco plants in hot weather. Fumes of creosote as, for example, from creosoted hotbed boards, are highly toxic to tobacco leaves. It must be admitted, however, that no actual tests have been made in the tobacco tents. No injury was observed when only the butts were creosoted.

### Seasoned Wood Treated Above Atmospheric Pressure

*Pressure Treatment with Creosote (Commercial).* Posts treated under pressure without final vacuum, were also included in our tests started in 1927. After 18 years, they show no sign of decay but, for years after they are put in the ground, the creosote on these posts oozes out to the surface in drops on hot days. The drawing of a final vacuum after pressure treatment results in a dryer post than where treatment is done by the open tank method or by pressure without final vacuum. Fifty posts so treated are being set in a tent in 1946 to determine the effect of creosote fumes on tobacco.

*Pressure Treatment with Zinc Meta-arsenite (Z.M.A.)* By this process, the posts are impregnated with zinc meta-arsenite. The process is accomplished under pressure and is not suitable for treatment on the farm. Treated posts must be purchased from lumber companies or wood-preserving corporations. Ten squared hardwood posts, so treated, were set in a tent in the spring of 1933 and have remained in the ground since that date. After 12 years, they are all serviceable and show only a little softening of the surface wood near the ground level.

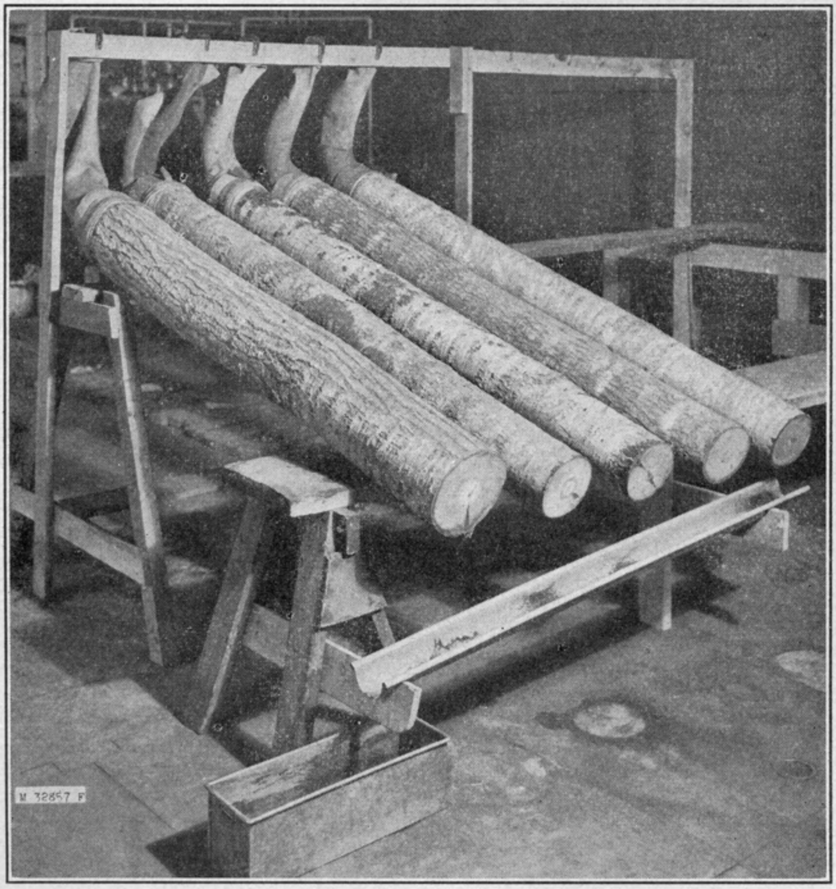
*Pressure Treatment with Other Preservatives.* During 1946, tests will be started on poles treated with Wolman Salts and chromated copper sulphate. One Shade company has been experimenting with posts treated with chromated copper sulphate and reports no deterioration whatever after five years.

In summary of commercial treatments at higher than atmospheric pressure: Any standard treatment performed by a reliable company should prove satisfactory as far as increased durability is concerned. Creosote is the best preservative but poles treated with it should not be extensively used until its effect on tobacco can be ascertained. Almost any wood commercially treated will have sufficient strength but certain of the harder woods should be eliminated because of difficulty in stapling—for instance, oak and beech.

### Sap-stream Methods

In the sap-stream method of post or pole treatment, the water in the normal sap-conducting tissue of the wood (sapwood) is displaced by a solution of some water soluble salt, toxic to fungi. Treatment is always performed on freshly cut wood and peeling is unnecessary. As the post is seasoned, the water is lost and the salt remains behind in the cells of the sapwood. Copper sulphate, sodium fluoride and zinc chloride are the salts most commonly used. Of these, zinc chloride appears to be the most satisfactory. There are several methods of application but only two will be discussed here. Only species with thick sapwood such as maple, birch and pine are suitable for treatment.

*The Tire Tube Method* (*Gravity*). In this method, a two to three-foot section of a tire tube is used as a receptacle for the solution to be



*Courtesy of U. S. Forest Service*

FIGURE 1. Method of applying preservatives to fence posts by means of tire tubes.

introduced into the freshly sawed end of the pole. A few inches of the end of the tire tube is drawn over the end of the post. It is usually necessary first to smooth the bark at the end of the post with a draw shave to remove any deep depressions that would allow the liquid to leak. The connection may be made tighter by means of rubber bands (two-inch sections of tire tubes), cords or wire clinched around the stretched end of the tube. The posts are supported on any improvised rack or a couple of trestles in an inclined position (Figure 1) so that the lower end is at least 18 inches below the tube end. The required amount of solution is poured into the rubber tube and the open end is attached to some overhead support to keep it in an upright position.

The treatment is complete when all the liquid has been drained from the tube by gravity. The water that is normally in the wood is forced out and drips from the lower end of the post along with a little of the solution.

The tire tube method may be used at any time of the year when the temperature is above freezing but the preservative will be absorbed most quickly in warm weather. The time needed will vary with the species, season, length of stick, etc. but will usually be completed in four to 24 hours. Posts may be set immediately after treatment but seasoning first for a few weeks is recommended.

Solutions of various concentrations may be used. Most of the tests at the Experiment Station have been made with a 7.5 per cent solution[1] which seems to be quite satisfactory. The goal is to distribute one pound of dry zinc chloride to each cubic foot of wood. For finding the cubic feet of wood in a given stick and the amount of 7.5 per cent solution which will be necessary to impregnate it, the reader may consult the table below.

Current prices for granular zinc chloride in 500 to 900 pound drums vary from 5.75 to 9 cents a pound. At this price the cost of material for an average post 12 feet long would be about 20 cents.

*Pressure Method.* Recently, a patented pressure head apparatus by which the posts can be impregnated in just a few minutes has been put on the market. Tests at the Experiment Station show this apparatus to be satisfactory and it might be more economical where a large number of posts are required by a grower or a group of growers.

The zinc chloride impregnation method has been extensively tested by the Forest Products Laboratory of the Forest Service of the United States Department of Agriculture with satisfactory results. The limits of serviceability of posts treated with zinc chloride have not yet been determined. The first posts treated by the Connecticut Agricultural Experiment Station—maples, birches and pines—were set in the ground six years ago and up to the present they show no sign of rot or deterioration.

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[1] To make a 7.5 solution, add 7.5 pounds of granular zinc chloride to 92.5 pounds (approximately 11 gallons) of water.

TABLE 5. QUARTS OF 7.5 SOLUTION OF ZINC CHLORIDE SOLUTION REQUIRED TO TREAT POSTS OF DIFFERENT DIAMETER AND VOLUME OF ROUND POSTS IN CUBIC FEET

| Average Diameter (Inside Bark) | Length of Post (in Feet) | | | | | |
|---|---|---|---|---|---|---|
| | 10′ | | 11′ | | 12′ | |
| Inches | Cu. Ft. | Quarts of Solution | Cu. Ft. | Quarts of Solution | Cu. Ft. | Quarts of Solution |
| 3″ | .49 | 3.2 | .54 | 3.5 | .59 | 3.8 |
| 3.5″ | .67 | 4.5 | .74 | 4.7 | .80 | 5.1 |
| 4″ | .87 | 5.8 | .96 | 6.2 | 1.04 | 6.7 |
| 4.5″ | 1.1 | 7.1 | 1.21 | 7.7 | 1.32 | 8.3 |
| 5″ | 1.36 | 8.6 | 1.5 | 9.6 | 1.63 | 10.6 |
| 5.5″ | 1.65 | 10.5 | 1.82 | 11.5 | 1.98 | 12.8 |
| 6″ | 1.96 | 12.5 | 2.16 | 13.4 | 2.35 | 14.8 |
| 6.5″ | 2.3 | 14.7 | 2.53 | 16.3 | 2.76 | 17.7 |
| 7″ | 2.67 | 17.3 | 2.94 | 18.7 | 3.20 | 20.5 |
| 7.5″ | 3.07 | 19.7 | 3.38 | 21.6 | 3.68 | 23.5 |
| 8″ | 3.49 | 22.4 | 3.84 | 24.5 | 4.19 | 26.9 |
| 8.5″ | 3.94 | 25.4 | 4.33 | 27.7 | 4.73 | 30.2 |
| 9″ | 4.42 | 28.2 | 4.86 | 31.2 | 5.30 | 33.9 |

*Other Methods of Treatment.* Several other methods of treatment, besides those discussed above, have been tested here but have been omitted from this article either because they were found to be less satisfactory or because the tests were not conclusive. There are many other chemicals besides the few mentioned here that have been used successfully by forest research laboratories[1] and wood treating companies.

## THE INFLUENCE OF COVER CROPS ON WIREWORM INJURY TO TOBACCO

DOUGLAS E. GREENWOOD

A great many tobacco growers have learned, through experience, that wireworm injury to newly set tobacco plants is reduced to a minimum when rye is used as a winter cover crop. The results of some field work done in 1945 are presented here to explain the factors involved in the success of such a practice.

Before going into detailed discussion, it seems worthwhile to review briefly the feeding habits of wireworms insofar as they relate to the tobacco industry. Wireworms overwinter at variable depths in the soil, usually below five inches, and return to the top few inches of soil as soon as the frost is out of the ground. They are capable of feeding when the soil temperature rises to 50° F. or higher. There are several distinct feeding periods throughout the growing season but that which occurs in the spring is the most destructive (when based on the amount of feeding any one wireworm is capable of doing) and the most prolonged, lasting for several weeks and continuing through planting time. It is evident, therefore, that tobacco plants

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[1] Wilford, B. H. Chemical impregnation of trees and poles for wood preservation. U. S. Dept. Agr. Circ. 717. 1944.

are set at the worst possible time, in relation to the feeding of these insects, unless provision is made for food to be present well in advance of the normal planting season.

The presence of a good rye cover crop in early spring, in fields infested with wireworms, can do two things. First, the roots and fleshy underground portions of the stems serve as food as soon as the wireworms enter the spring feeding phase. Second, by virtue of the fact that the wireworms will continue to feed in the rye for a week or two after it is plowed under, they will remain fairly well scattered throughout the soil. In the absence of a cover crop, or in the presence of a poor one, the larvae have no such ideal source of food and, therefore, must wait until the tobacco plants are set. No starvation takes place in this short interval since wireworms are capable of withstanding long periods without food of any kind. Thus, aside from its value as a source of organic matter for the soil, a good rye cover crop not only feeds the wireworms in advance of the tobacco crop but eliminates any congregating in the rows after the plants are set. The spring feeding period occurs on the cover crop and does not continue on the tobacco crop that follows. To the best of our knowledge, only the underground portions of the rye plants serve as food.

In the spring of 1944, a serious case of wireworm injury to tobacco transplants came to our attention. Upon investigation, it was learned that a very sparse stand of rye had been plowed under and the tobacco had been restocked twice with no letup in wireworm feeding. Field diggings showed a very heavy population of two-year-old worms so that the infestation could be expected to remain for at least one and, possibly, two years more. Arrangements were made with the grower to provide for a very dense stand of rye on this field in the spring of 1945. Early in the 1945 season, diggings were made in this rye and it was established with certainty that the wireworms were still present and actively feeding. Had nothing been done to this field or had a poor stand of rye been present, the wireworms would have caused serious injury. The rye stand, however, was excellent and sufficient time had elapsed before tobacco planting to allow the larvae to complete their spring feeding period. Only an occasional tobacco plant had to be replaced.

As a check on rye as a suitable food early in the season, an adjoining field, just as badly infested with wireworms, was planted to oats in the fall of 1944. Wireworm injury was very serious on this field in 1945 and it had to be restocked several times. This difference can be attributed to the fact that the oat cover crop is winter-killed and does not serve as food when the wireworms first come up to feed in the spring. In this case, the first suitable food available to the wireworms was the tobacco plants and the injury was extremely serious.

To demonstrate the influence of suitable food early in the season on the response to food at a later date, data are presented for two adjoining potato fields. The two fields were separated only by a dirt road and diggings in both fields, before plowing, showed heavy wireworm populations. One field had a very heavy rye cover crop, on which the wireworms had been feeding for several weeks; the other had no cover crop. After the potato seed pieces had been planted for one week, 60 were dug at random in each field and the number of wireworms present was recorded. In the field which had no cover crop, 297 wireworms were found in the 60 pieces; in the field which had a heavy rye cover crop, only five wireworms were recovered in the 60 pieces. This tremendous difference in response to food may be attributed to the fact that in one case the wireworms had finished their early season feeding on the rye, whereas in the other case no food, to any degree, had been present until the seed pieces were plantd, in which case the worms congregated in them.

The success of the practice does not, in any way, come about because of the reduced numbers of wireworms. It works successfully because the wireworms have, for the most part, finished their early season feeding phase, the only phase which is of concern to tobacco growers, and do not feed further on the tobacco plants when they are set out. This procedure must be carried out each year and the stand of rye must be adequate. Cover crops which are sparse will probably be no more effective than no cover crop at all.

## TOBACCO DISEASES IN 1945

P. J. Anderson

This was an average year in the amount of losses from diseases. A few diseases were worse than usual while other common ones were hardly seen at all. No systematic survey was conducted in the fields during the summer but the staff had occasion to look over hundreds of acres of growing tobacco in all parts of the Valley throughout the season. This, in conjunction with constant reports from growers, keeps us always in touch with the disease situation. Observations and reports recorded and summarized each season have been found to be very useful in supplying information on the trend of any particular disease over a series of years, such, for example, as the history of the behavior of wildfire, discussed below.

*Fertilizer root-burn of germinating seedlings.* Excess of plant nutrients in the seed beds often kills the young plants just after germination. We have examined many beds where so many of the young plants died before they were able to establish themselves that the stand of plants became too scanty to make good seedlings for transplanting and often the beds were complete failures. The trouble comes so early and when the plants are so tiny that it is not easy to diagnose and is often attributed to poor seed, cold weather, or a variety of other causes. The symptoms are always the same. A close examination with a lens and a soil test are necessary to make a positive determination but there are certain symptoms that are so constant that a grower who has familiarized himself with them will be able to recognize the trouble, at least with a fair degree of certainty.

When the little plants first come up the stand appears quite normal and satisfactory, but in a few days they begin to disappear mysteriously and then every day the owner notices that the stand is getting thinner. A few plants establish themselves and continue to grow but most of them never get beyond the two-leaf (cotyledon) stage. Close examination shows many little two-leaf plants among the larger ones but they lie loose on the surface and have no roots to hold them upright. Soon they disappear but for some days others appear to take their place. These also fail to take root and disappear in a few days. Large areas of the bed may be completely bare but more often there are a few scattered plants that survive and produce a thin stand. The leaves do not fade to yellow but remain dark green until they shrivel and disappear.

Examination under a low power lens—or even with the naked eye—shows that the affected seedlings have no white living roots such as we see on a healthy plant. In fact, on many of them there is no root at all, but merely a brown stub. If any of the root is left it is dark brown, dead and without any branches or root hairs. The root and stalk are rarely straight. They are variously bent and twisted as indicated in Figure 2 and sometimes may even form a complete loop.

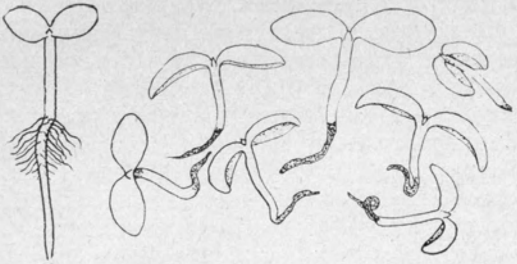

FIGURE 2. Root-burn. Single normal plant on the left. Twisted brown dead roots of those on right due to excess ammonia in the soil.

When examined under a dissecting microscope, the brown root tissue is found to be dead and shrivelled but is tough, not soft and disintegrated, as would be the case if affected by damping-off or rootrot. Microscopic examination under high magnification fails to show that there are fungi or bacteria in these dead roots.

Soil tests on such beds show a high concentration of ammonia and frequently other nutrient elements. The ammonia is probably the principal offender. A typical case in 1945 tested 500 pounds ammonia nitrogen to the acre. In this case, the owner had not used commercial fertilizer when the beds were sowed but had built up his soil with annual heavy applications of manure. The soil was steam-sterilized before seeding in the spring. Steaming greatly increases the available ammonia in a heavily manured soil and kills many of the nitrifying bacteria so that the ammonia is not oxidized before seeding.[1]

At our suggestion the grower mentioned above, in order to neutralize the ammonia, soaked the beds with a solution of calcium chloride prepared by dissolving two pounds of calcium chloride in a barrel of water. He reported later that this produced a marked improvement.

To avoid fertilizer burn, two preventive measures are suggested. (1) Don't fertilize too heavily and (2) don't sow the beds too soon after steaming a heavily fertilized or manured soil. Fall steaming would be better in such cases.

In connection with the above mentioned beds, an interesting observation was made in 1945 on susceptibility of different varieties to such injury. In this block of about a hundred beds, twelve of them were sown with a strain of Shade tobacco known as Connecticut 15. These showed no damage at all from root burning while all the beds sown with the grower's regular Shade strain showed injury to varying degrees. The same regular strain seed sown on another farm showed no injury.

*Yellow patch in seed beds.* This is a name in common use in many tobacco growing sections to designate the appearance of yellow patches of plants in the seed beds. In these areas, which may be from a few inches to several feet in diameter, plants fade to a yellow color and stop growing and are, therefore, much smaller and paler than the surrounding areas of the beds. The cause is not always the same. During this spring we found the injury was apparently due to any of the following causes. (1) Water drips from the mullions of the sash. In many beds the yellow patches were very definitely associated with these drip spots. Excessive water leaches out the plant food and the plants turn yellow for lack of nitrogen. Such spots can be cured by application of nitrogen in the water, as we have frequently demonstrated. Sometimes, however, this excessive water favors fungus infection in the roots and this runs into the next type. (2) Pythium infection of the roots. In a large number of cases an examination of the roots shows them to be rotted with a soft-light-colored rot and the disintegrated tissues filled with mycelium and, in advanced stages, with the spores of *Pythium debaryanum*. This type has been described in one of our previous reports.[2] Sometimes the spots are obviously connected with excessive water but in many cases this is not at all apparent. There is also always the question of whether the fungus is the primary cause of the disease or whether it is secondary to

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[1] *Simple test for excess ammonia.* Put two or three pinches of the soil in palm of hand; add a pinch of hydrated lime. Press hand with palm of other hand and rub vigorously to generate a little heat. If you can smell ammonia when this is brought up to the nose, the soil has too much ammonia. Borderline cases may not react to this test.

[2] Anderson, P. J. Pythium damping-off and root rot in the seed beds. Conn. Agr. Exp. Sta. Bul. 359:338. Rept. of Tobacco Substation for 1933.

injury from some other cause. The fungus Rhizoctonia has been sometimes found in these roots but not so often as Pythium and we have been inclined to regard it as secondary. We have not found any cure for this kind of a spot but have recommended application of nitrate of soda to strengthen the plants. Frequently, these spots disappear with the advent of hot weather. (3) Fertilizer injury. We have usually found this is due to excess of ammonia. It is possible, however, that other unbalanced conditions of the fertilizer may cause trouble. This type of ammonia injury appears later than that described above in that it does not kill the plants in the two-leaf stage but affects them later. The roots will be found to be dead and brown. Often this is not marked by yellow fading; the leaves may be even darker than the others and the plants wilt when the sun becomes hot. Sometimes only the outer pair of leaves turns yellow. This ammonia type of yellow patch is apparently the same as that described by Mandelson[1] as due to excessive use of organic nitrogenous fertilizers.

*Bed rots* were not common in 1945. The few observed were of the type we have previously described as due to *Pythium aphanidermatum.*

*Wildfire.* See special article on page 20.

*Mosaic* or calico was more prevalent in the fields than in any recent year. All types of tobacco were affected and there was active spread throughout the year. Gray top and rust caused considerable damage in Broadleaf fields.

*Sore shin* was particularly prevalent in the north part of the Valley. It was worst in low wet areas of the fields on heavy soils. In one field, 10 per cent of the plants of Havana Seed were affected. Many of them were broken off at the line of the canker by high winds. The Havana Seed type seems to be much more susceptible to this trouble than the other types.

*Dead blossom leaf spot* became quite prevalent in the Shade fields about August 25, shortly after a three-day rain. This was accompanied by many stalk cankers (caused by Sclerotinia) in the same fields. The same type of leaf spot was also observed in smaller amounts on fields of Havana Seed and Broadleaf which were harvested late and where the suckers were allowed to mature a crop of blossoms.

*Hollow stalk* (bacterial) was found in very few fields and was not of any consequence.

*Downy mildew* (blue mold) was reported first on May 18 in Suffield and was very severe in the first beds seen, leading us to expect large losses this year. Actually, this fear was not justified by the later progress of the disease. The larger growers who sprayed their

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[1] Mandelson, L. F. Yellow patch of tobacco seedings. Queensland Agr. Jour. Sept. 1939.

beds systematically with Fermate experienced very little trouble. Very few beds were lost by any of the growers and there was never a shortage of plants in the Valley due to losses from mildew. Field damage was negligible.

*Blackfire* (angular leaf spot) was not found.

*Black root rot* was severe in a few Shade fields on heavy cold soil which became water-logged by the excessive rains of the first part of the summer. Little damage from root rot was observed on other types of tobacco.

*Brown root rot* caused considerable loss on fields where the expanding acreage of the Valley induced growers to set tobacco on fields that had been previously in sod.

*Pole rot.* See separate discussion on page 23.

## WILDFIRE RETURNS TO THE VALLEY

In mid-summer, scattered outbreaks of the bacterial disease, wildfire, were observed in the fields of growing tobacco. The number reported increased from that time up through harvest. In Glastonbury, it assumed epidemic proportions and was found in a more or less large percentage of the Broadleaf fields. But in most parts of the Valley, it occurred only in an occasional field and was usually not of serious consequence. Only one case was reported on Shade tobacco, several on Havana Seed and the greatest number on Broadleaf.

Twenty-five years ago wildfire was the number one worry of our tobacco industry. It was so prevalent and caused such heavy losses that some feared that it spelled the doom of tobacco growing in New England. In fact, the Tobacco Substation at Windsor was started largely for the purpose of investigating ways of combatting wildfire. Almost all the early research and first bulletins issued by this Station dealt with wildfire. Successful means of controlling it—largely through the seed bed—were developed. After the middle 'twenties, it slowly subsided and we saw less and less of it each year. According to the records we have kept every year, from 1929 through 1944, wildfire was either not reported at all or there were just a few minor outbreaks of no consequence, with the exception of one year. In 1938—a disastrous year of continuous and heavy rains and a hurricane—wildfire became serious in some sections, especially in the northern end of Suffield. This was discussed in our annual report for that year and growers were warned to be on their guard since this might be the forerunner of another series of wildfire years. The fear proved groundless, however, and wildfire did not appear again except for a very few mild cases until 1945. This was an unusually wet year. Now we are confronted with the puzzle: Was 1945 just another 1938 to be followed by another disappearing act—or is this the beginning of another series of epidemic years?

No adequate explanation of this erratic behavior of wildfire is apparent to the writer. It cannot be said that the disease was eliminated by the control measures applied by growers. Disease organisms are not that easily eliminated. Moreover, growers have paid very little attention to control measures in the last 15 years. The fact that it was so severe only in two wet years, 1938 and 1945, emphasizes its dependence on excessive rains. But that does not explain its continuous severity for a period of seven or eight years when it first came to the Valley, because all of those years were not above average in rainfall. The theory that the wildfire organism gradually lost its virulence (pathogenicity) after its first spurt in the early 'twenties seems fantastic and not in accord with the usual history of plant pathogens. The same attenuation or waning of wildfire after the initial few years has been repeated in most of the tobacco areas of the eastern United States. On the other hand, there are a few areas where wildfire has continued to be a major problem every year.

After its wane in the late 'twenties, all research on wildfire at this Tobacco Substation was discontinued. Investigations continued at other Experiment Stations, however, have produced some results and theories that might have some bearing on our wildfire situation here.

*Water soaking of leaves.* The fact that wildfire spreads in the field rapidly and destructively after heavy rains or hailstorms has been observed and recorded by almost every investigator of the disease. During such storms, the leaves are apt to be blown over so that the rain beats on the lower surface and large dark colored irregular water-soaked areas may be seen for many hours or a day or two after the rain has stopped. Growers are quite familiar with these spots on the overturned leaves which we have described in previous reports as "rain-bruise", caused by flooding the intercellular spaces inside the leaf with water (driving out the air). Clayton[1] has shown that in this internal flood water the bacteria multiply and spread through the tissue with extraordinary rapidity which would not be possible in normal leaf tissue. He believes that the severe field epidemics may be explained largely through such rain soaking.

*No specific parasite.* Reid and his associates[2] in Pennsylvania are of the opinion that the wildfire organism, *Bacterum tabacum*, is not a distinct species of plant pathogenic bacteria, but is merely a physiological adaptation of a saprophytic species (*Pseudomonas fluorescens*) which is common in all soils. They believe the leaf spots are due to improper nutrition of the plant and do not depend on the presence of a specific parasite. Other students of wildfire do not concur in this explanation.

*Overwintering on roots.* Valleau et al.[3] in Kentucky, have recently shown that the wildfire bacteria may live on roots not only of

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[1] Clayton, E. E. Water soaking of leaves in relation to development of the wildfire disease in tobacco. Jour. Agr. Res. 52:239-269. 1936.

[2] Reid, J. J. et al. Bacterial leaf spots in Pennsylvania. Penn. Agr. Exp. Sta. Bul. 422. 1942.

[3] Valleau, W. D., E. M. Johnson and Stephen Diachun. Root infection of crop plants and weeds by tobacco leaf-spot bacteria. Phytopath. 34:163-174. 1944.

tobacco, but also of a considerable number of crop plants, grasses and weeds. Here, they multiply and overwinter and may be splashed by rains or otherwise carried up to the leaves of tobacco the next summer either in the seed bed or in the field. On the basis of their findings, since the presence of disease in the leaves is not necessary for perpetuation of the species, we could assume that these bactria are at hand most of the time and in most, if not all, of our fields. The outbreak of an epidemic of wildfire, then, would be merely a matter of a period of favorable weather for infection such as rainy seasons or storms and particularly water soaking of the leaves.

The hypothesis of Valleau and his associates offers the most nearly adequate explanation we have seen for the erratic history of wildfire in the Connecticut Valley. Under this hypothesis, however, it is not easy to explain the all-important role of the seed bed, if the pathogen is ubiquitous in the fields. If this is the true explanation, then there is no possible way to predict what the severity of the disease will be in 1946 or any subsequent year, unless we can predict what the weather will be.

*Control.* The investigations discussed above have improved our knowledge of the nature and progress of the disease but they have not changed or improved our methods of combatting wildfire. Control experiments during these years have for the most part merely confirmed the soundness of the methods we developed 25 years ago. No practical method of controlling wildfire in the field has even been suggested—other than starting with disease-free plants. Admitting that infection may *sometimes* start first in the field, all our experience and observations during these years still lead us to believe that the vast majority of cases start in the seed bed. All our efforts at control, therefore, should be directed toward prevention of wildfire in the beds.

And here, weekly and thorough spraying of the plants with Bordeaux mixture is still considered by all investigators to be the most effective method. Valleau puts particular emphasis on a very early application of Bordeaux, just after the plants have come up. This coats the surface of the soil and would prevent bacteria in the soil from reaching the leaves above ground.

The spray program is somewhat complicated by the fact that it is necessary to spray the beds later with Fermate for the control of mildew. The same fungicide cannot be used for both. The two fungicides cannot be mixed together in the same barrel because there is an unfavorable reaction between them. Bordeaux mixture does not control mildew and it has not been demonstrated that Fermate will control wildfire. Paradichlorobenzene, which is also used for the control of mildew, is not effective against wildfire. If both fungicides are to be used, the best plan would seem to be to make the regular weekly applications of Bordeaux; then, beginning about the first week in May to make the Fermate applications in the intervals between the

Bordeaux sprays. If wildfire is found in a bed, it is best not to set out any plants from that bed. The burning out of disease spots in a bed with formaldehyde is frequently not effective because there are likely to be other spots in the same bed that cannot be detected in the early stages.

## STUDIES ON POLE ROT IV. SCLEROTINA ROT

P. J. Anderson

Rated on the basis of financial loss, pole rot is the most destructive disease of New England tobacco. Heating the curing sheds with charcoal fires is the only remedial measure that has been practiced. The fact that we still suffer enormous losses indicates that this remedy has not been sufficiently or properly practiced or that it must be modified or supplemented by other measures. Intelligent control investigations have always been hampered by lack of information about the organisms that cause pole rot and the conditions under which they work. Tobacco scientists do not even agree on the primary question of what organisms are involved. Since this information is basic to any control measures, the writer began an investigation of these organisms 10 years ago. Three articles on the subject have been published in previous reports.[1] In the third report, the writer discussed in detail a type of pole rot (pole sweat) caused by one or both of two fungi, *Sclerotinia sclerotiorum* and *Botrytis cinerea.* Observations over many years have led him to believe that in the Connecticut Valley these two fungi are the primary cause of most, if not all, of the serious outbreaks of pole rot and losses that occur during curing. Losses in 1945 were not of epidemic proportions such as we frequently experience, but many cases of less importance were observed, and many affected stalks from curing sheds were brought to the laboratory by growers for identification.

It was of some interest that, in 1945, almost all of these were infected by Sclerotinia—only a few having Botrytis spores on them. Some of the growers stated, moreover, that they had observed this rot starting on the stalks in the field before harvest, shortly after a rainy week that occurred during the harvesting period. The worst case was on tobacco from a field that had been primed the previous year. During that year the blossoms had been allowed to grow in profusion (not topped) and most of the top leaves were affected with dead blossom leaf spot, a disease that is also caused by Sclerotinia and Botrytis. All of these observations suggested the thought that the Sclerotinia type of pole rot may originate in the field, rather than in the shed, as commonly believed. Therefore, some further studies were undertaken to explore this possibility.

Certain phases of the life history of Sclerotinia must first be reviewed before we can get the whole picture. The first point is that Sclerotinia does not produce spores in the shed and, therefore, it has no chance to be distributed by wind or other agents to the other plants

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[1] Conn. Agr. Exp. Sta. Bul. 386:600-607. 1935; Bul. 391:112-117. 1936; and Bul. 469:120-123. 1942.

hanging in the shed, except by the relatively slow passage to other leaves directly in contact with a diseased leaf or stalk. Such slow transmission could not account for the severe outbreaks where tobacco in all parts of the shed becomes affected at one time. Obviously, the fungus or its spores must have been present on the tobacco when it was brought into the shed, or else spores may have been blown into the sheds from outside through the ventilators or cracks between the boards. (The case with Botrytis, which produces enormous numbers of spores in the shed, is quite different.)

The field origin of Sclerotinia and Botrytis pole rot in Shade tobacco is definitely established (see third reference above). The fungi first infect the blossoms and when the dead corollas fall and adhere to the leaves below, the fungous threads attack the leaves and kill the tissues beneath. When these leaves are packed close together in the curing shed, the fungus spreads rapidly through them. Not all rot in Shade sheds originates in this manner but apparently the greatest part of it does. The importance of the blossoms which furnish the ideal court of infection is not to be underrated. Inoculation experiments both with ascospores of Sclerotinia and with conidiospores of Botrytis have shown how easy it is to inoculate the blossoms and how quickly the fungi grow into the leaves from the fallen blossoms. However, if these spores fall directly on the leaves or stalks, instead of the flowers, no infection occurs. The green parts of the plant have a protective resistance which the flower does not possess.

Since, however, in the normal culture of Havana Seed and Broadleaf tobacco (binder types) the flowers are removed by topping and suckering, the question arises as to how infection could occur in these types. In passing, it might be mentioned, that sometimes the growers of these types get behind in their work of suckering and allow the blossoms to mature. Then the blossoms become infected and the writer has often found dead blossom spots on the leaves. This could well account for some of the disease in these types but is not the most common source of trouble because rot is often quite severe on farms where no flowers are allowed to mature.

*Inoculation experiments with ascospores on injured green plants.* Observations on the early stages of infection in the curing shed show that, in the majority of cases, the rot starts near the top of the stalk in the stubs left by topping and suckering. This suggested the possibility that the ascospores might be able to infect injured tissues, even though they are powerless to invade normal healthy parts.

In order to explore this possibility, artificial inoculation experiments were undertaken in the laboratory and greenhouse. A supply of ascospores was obtained by planting sclerotia in moist sand. Mature apothecia began to appear in about five weeks and when the apothecia were crushed in water and passed through a cheese cloth to remove the remains of the apothecia, the water was found to contain ascospores in abundance. Drops of this water were then applied to the injured and healthy surfaces. Injuries were made on leaves, midribs and stalks, by (1) crushing between the fingers, (2) by making rough breaks and (3) by making clean cuts. The leaves and stalks were kept in a moist atmosphere. No rot occurred on parts that had not been injured. But on the injured tissues a brown soft rot appeared within three days, first on the crushed areas on the leaves, then on the broken stalks and midribs, last of all on the clean cut wounds. The rot spread rapidly until entire leaves and entire plants kept in moist chambers were reduced to rotton pulp. Sclerotia appeared later on the stalks and midribs but not on the leaf blades. The experiment was repeated with growing plants in the greenhouse and with similar results except that the percentage of infection was not as high. The results clearly showed the capacity of ascospores to infect injured parts of the green plant either while standing in the field or after they have been cut and hung in the shed.

These experiments also showed the necessity of a moist atmosphere for the development of pole rot. When the plants were kept in a dry atmosphere after inoculation, no rot occurred. Moreover, even after the rot had begun to spread in the leaf blade, it stopped when the leaf was transferred to a dry atmosphere. This absolute dependence of the fungi on excessive moisture goes far to explain the erratic occurrence of pole rot and, moreover, presents the key to control of the trouble.

Granted that these injuries in the field are the incubating points for rot that develops later in the curing sheds, there still remains to be explained how the spores reach the broken stubs and bruises at just the right time to infect them. The spores are developed only in the little goblet-shaped apothecia that grow up from the sclerotia—small hard black pellets that develop on and in the affected stalks—the only organs of the fungus that are familiar to the growers. But these sclerotia do not grow apothecia in the shed. They must first get into the soil where they overwinter and develop the apothecia the next summer. This return to the field is accomplished when the stalks are spread on the land after the cured leaves have been removed. This suggests the possibility that we might reduce infection by burning the stalks instead of returning them to the land. This probably would not be so effective as it might seem, because the same fungus also lives on a large number of other plants, weeds, etc., so that there is probably always a source of spores in the neighborhood of tobacco fields. The writer has proved that the fungus from a diseased hollyhock will infect tobacco, and probably the same fungus from other hosts will do the same, although this has never been actually proved.

After the sclerotia have overwintered in the ground they begin to produce apothecia but all the apothecia do not come up at once. New apothecia grow up all through the summer or some may not come up until the following season. Any time that the ground is moist they may appear. When they are mature the spores are "puffed" in clouds into the air where they float around like dust particles and may be carried for miles by air currents. Most of them fall harmlessly on leaves and other objects where they die in time but, if they find a favorable environment such as a freshly broken stub or leaf of a tobacco plant, they start to grow. Economic loss is apparently limited more by good weather than by scarcity of spores.

It should not be inferred from the preceding discussion that *all* infection actually starts in the field. When the tobacco is cut and taken into the shed, there must be great numbers of spores adhering to the surface of the plants—spores which are still viable. Moreover, many leaves are broken and bruised by handling during harvesting. When a great mass of green tobacco is crowded into a shed, the atmosphere remains damp through evaporation of water from the leaves for many days. Under these favorable conditions, the spores on the leaves germinate and infect the fresh breaks or bruises. It is also conceivable that spores from the outside may be blown through the open ventilating doors and start infection in broken leaves.

*Prevention.* We have now filled in many of the gaps in our knowledge of this destructive parasite and its relation to our worst disease of tobacco and we have a fairly clear picture of its life cycle and relation to environment. This information has some bearing on control measures which should be effective against Sclerotinia rot:

1. *Elimination of the blossoms.* The grower of the open field types could keep the plants free from blossoms by early topping and removal of suckers. This might involve a little extra labor in suckering more frequently but would be compensated, at least in part, by increased weight of leaves. Suckers allowed to grow too long reduce crop weight. Absence of blossoms would eliminate one of the most favorable sources of infection. This measure is not advisable for the Shade grower but he could reduce chances of shed rot by discarding leaves which show blossom spots during the harvesting operations.

2. *Avoid working in wet tobacco.* Infection of injuries caused by topping and suckering occurs only during periods of continued rainy weather when the bruised surfaces have little opportunity to dry quickly. If it is practicable to do so, topping and suckering should be confined to days when the plants will quickly dry off. It is realized that this is not always possible in the economy of the farm work.

When leaves are wet, they should not be hung in the shed because water on the leaves furnishes the ideal condition for germination of the spores which are on the leaves as they come from the field. Stalk-cut tobacco should be wilted as much as possible before taking to the shed.

3. *Avoid harvesting immature tobacco.* The more mature tobacco is before it is harvested, the more rapidly it will cure. In this way it will be exposed to rot for a shorter period.

4. *Fire the sheds as soon as they are filled.* The object of charcoal fires is (1) to dry the surfaces of the leaves and stalks and thus

prevent the germination of spores that are on them, (2) to dry up injuries and bruises as quickly as possible, (3) to stop the spread of lesions in the leaf, and (4) to hasten the cure and thus reduce the time of exposure to rot. It is a common misconception that pole rot affects the leaves first when they have faded to yellow or brown. With respect to Sclerotinia and Botrytis rot, this is not true. They are essentially parasites of green leaves and the damage is inflicted before they lose the green color, although it is true that the *effects* are usually observed on the cured leaves. This explains the importance of firing the sheds while the leaves are still green. Also, it explains why a farmer so often fails to stop the rot if he waits until he sees the trouble on the half-cured leaves.

It is not likely that any amount of firing will stop the growth of the fungus in the stalks or in the large green midribs if these were already well started in the field. But it should prevent spread to other plants, as well as prevent the germination of adhering spores as previously mentioned.

## CONNECTICUT FIFTEEN, A ROOT ROT-RESISTANT TYPE OF SHADE TOBACCO

P. J. Anderson and Allen Green

Beginning in 1940, the Connecticut Valley Shade Growers' Association sponsored a project in cooperation with the Experiment Station for the purpose of improving the Valley Shade type by breeding and selection. This project has been actively pursued every year since that time and several promising strains have been standardized. One of the best of the new strains is known as Connecticut 15. Connecticut 15 is superior to the ordinary Shade strain in many respects. It has been selected until now it is very uniform in all its characteristics. It is taller than the ordinary, producing 20 to 25 marketable leaves, as compared with 15 to 18 of the common type. It tops out later and is not so inclined to branch into long suckers at the top. The leaves are of a more desirable, rounder shape and this shape persists to the very top leaf, while in the common type the leaves become narrow and pointed as they approach the top of the plant. The cured leaves are of a lighter shade and more uniform color, less inclined to exhibit yellow spots, tips and margins. The vein is less prominent than in the common type. This means that a larger percentage of the leaves are sorted into the higher priced grades.

In the tests that have been carried on, the various strains were grown in rows side by side in commercial fields under identical treatment. The cured tobacco was sorted in a commercial warehouse by the regular sorters under the careful inspection of Mr. Allen Green. Each grade and length was weighed and the price per pound for the whole lot computed on percentage weight of grades and the established OPA minimum price for each grade. Average of the last two years showed an increase of 34 per cent in value per pound. Growers who have tried Connecticut 15 on a small scale report similar results in grading and increase in yield up to 50 per cent over the common strains.

The burn and ash characteristics are no different from the common Shade strain. Since these characters are determined more by soil, fertilizer and the season, it is not surprising that we find no differences. With respect to the taste of the cigar, however, there is considerable difference of opinion among those who are rated as experts or connoisseurs of this immeasurable attribute of cigars. Some state that the taste is definitely inferior to that of common Shade. Others find no difference in taste.

Although the primary object of this cooperative project was declared in 1940 to be to improve the quality and yield of Shade tobacco, a secondary object was to develop resistance to diseases and insects. In pursuing the primary object, the secondary phase of resistance has received little attention except for recording constant observations on the natural incidence of the usual diseases and pests. No hybridization of these strains with others known to be resistant to any insect or disease has been undertaken.

Quite by accident, however, it was discovered in 1944 that Connecticut 15 is highly resistant to black root rot, a disease that was very prevalent in many Shade fields that season. By mistake, a few plants of Connecticut 15 were set in a field of common Shade that was badly affected with the root rot that year. The contrast in growth was so marked that the Connecticut 15 plants could be picked out as soon as one entered the tent. They grew to a normal size while, on the same part of the field, the ordinary Shade produced few leaves that were large enough to pay for harvesting. In order to give this a more thorough test in 1945, a seven acre field which is known to be quite subject to black root rot was set to Connecticut 15, except for one row through the middle of the whole field which was set to the common variety grown on that plantation. The results were just as striking as in the previous year. When the plants were ready to bud, the Connecticut 15 had grown up to the tent cloth, while common Shade was only three to four feet high and the leaves were too small to pay for priming. Leaves on Connecticut 15 were large and normal for the variety. The roots on common Shade were found to be scanty and badly affected with rot. Roots on Connecticut 15 were strong, white, wide spreading and almost normal but there were scattered lesions of root rot. The new strain is thus not immune to attack, but is so little affected that the plants make an almost normal growth.

No differences with respect to resistance to mildew or other diseases have been observed (but see page 18). Less blossom spot has been found on Connecticut 15 but this is probably due to its late flowering habit. Some growers have reported less flea beetle injury on Connecticut 15 but we do not have sufficient experimental data on this point.

## CHLORPICRIN FOR STERILIZATION OF TOBACCO SEED BEDS

T. R. Swanback and P. J. Anderson

Steam sterilization of tobacco seed beds has long been in use in the Valley. It is an effective method of destroying fungi and insects as well as weeds and weed seeds. The method, however, is time-consuming and relatively expensive. In addition, it becomes more difficult to replace the major equipment, usually an old fire engine or a second-hand boiler. For these and perhaps other reasons many tobacco beds are not sterilized at all.

In recent years experiments and trials on a commercial scale have shown that chlorpicrin may be used for soil fumigation. It appears to be an economical, rapid and effective method of disinfecting seed beds for control of important soil-borne fungus diseases and for elimination of weeds.

Chlorpicrin (manufactured and sold under the name of "Larvacide" by Innis & Speiden) has been tested in treatment of seed beds at this Station since 1941. Moreover we have had opportunity to follow carefully comparative results obtained by growers on a large scale where steam and chlorpicrin were tried side by side. Results so far show that:

1. Weeds are controlled almost as well as with steam. These tests did not provide an opportunity to observe the effect of chlorpicrin on soil-borne fungous diseases but it is likely that any treatment which will kill weed seeds will also kill fungous spores.

2. The fumigation must be done in the fall with a soil temperature above 55° F. for a proper distribution of the gas in the soil.

3. Cleaning up weeds around the beds helps to prevent re-infestation after the beds are fumigated.

A motor-driven continuous-flow applicator (see Figure 3) of chlorpicrin now has been developed (by Innis & Speiden) whereby the work of fumigation is speeded up so that about an acre of seed beds can be treated in one day. This is a great saving in time in comparison with steaming. The method has been used by many plantation owners for a number of years and it should prove very convenient for the small growers as well. We believe that if this gas treatment is properly made and acccording to directions outlined below, the results with respect to weed and disease control and seedling production are comparable to those from steaming.

*Soil Preparation.* 1. Beds should be properly fertilized. It is, however, of importance not to use an excess of nitrogen, because in that case any type of sterilization may produce an excess of ammonia that will injure the roots of the young seedlings (see page 16). 2. The beds should be spaded or cultivated to a depth of eight inches and whatever manure or fertilizer is used should be worked in at this time. Then the beds are raked level and the surface should be free from lumps or clods of soil. 3. The soil should be thoroughly moistened about a week or ten days ahead of the gas treatment. Weed seeds, in particular, will then absorb moisture which facilitates penetration of the gas.

*Chlorpicrin Application.* The soil at time of application of gas should be just moist enough to retain its shape when compacted in the hand. The gas is applied with the continuous-flow applicator, usually operated by a local contractor. For most soil types in this area, a dosage of 16 to 20 pounds chlorpicrin (Larvacide) per 1,000 square feet at a depth of three to four inches is recommended.

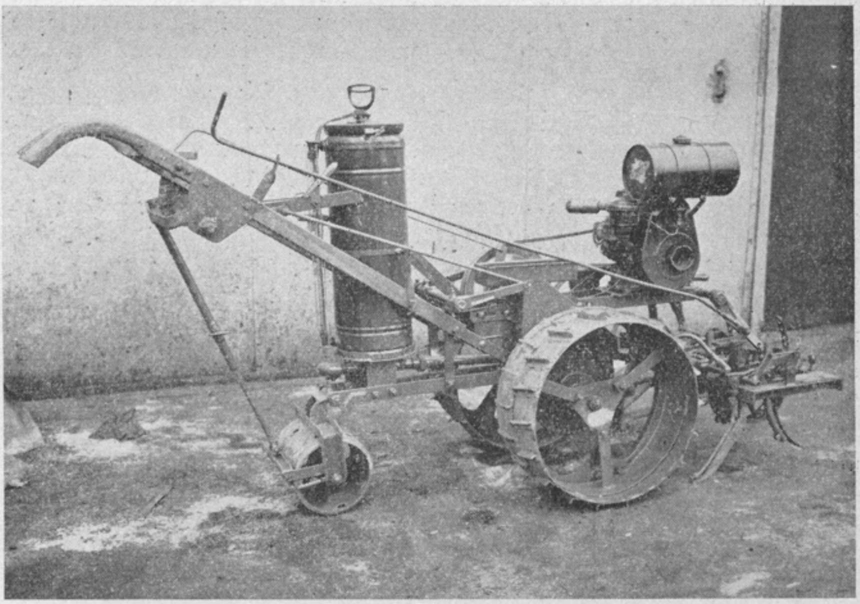

FIGURE 3. Continuous-flow applicator of chlorpicrin.

*Treatment Following Application.* As soon as possible after the fumigation, the beds should be raked level and the surface sprinkled with water until it has penetrated to a depth of one half to one inch. The beds should then be covered with three thicknesses of old shade cloth and watered until the cloth is wet. The cloth should be kept moist for the next three days in order to keep a film of moisture on the soil surface. This confines the gas in the soil.

Another very effective method for confining the gas is to cover the surface with weed-free well shredded black or brown peat to a depth of about one and one-half inches. This material should be damp before spreading and then wetted down. Usually this cover needs no further watering.

*Cost of Treatment.* The cost of material (with rental of machine and operator) is about one and one-half cents to two cents per square foot. The larger the area treated, the lower the cost per unit of beds.