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WILDFIRE OF TOBACCO IN CONNECTICUT

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CONTENTS

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George P. Clinton and Florence A. McCormick.

Introduction.

State Survey. The question of establishing a sub-station for tobacco experimentation having been presented to the Director of the New Haven Station early in 1920 by County Agent B. G. Southwick of Hartford County, it was decided that before any definite decision was given there should be made some preliminary investigations. These were to include a canvass of the opinions of tobacco growers toward such a proposition and a survey of the tobacco districts, to determine the diseases and injuries with which the growers had to contend. In 1920 this survey was undertaken by the joint financial coöperation of the Experiment Station, the Hartford County Farm Bureau and the Extension Service of the Connecticut Agricultural College. Somewhat similar work was undertaken by the Massachusetts Station in that state. In Connecticut the work resolved itself largely into a disease survey of tobacco seedbeds and fields, for which Mr. Southwick served as a scout, in connection with his interviews with the growers, and the writers as the botanical investigators of the troubles brought to light.

After the preliminary work of seedbed examinations by Mr. Southwick and Dr. Clinton in May and June, it was decided to facilitate the field work by establishing, during July and August, a small laboratory at the Farm Bureau headquarters in Hartford with Dr. McCormick in charge, Dr. Clinton being in Europe. During the entire season of 1921 the work was continued with even more intensity. No field laboratory was maintained this year at Hartford, the work being done at New Haven, but considerable experimental work was carried on at the Station's new tobacco farm at Windsor, the state by that time having authorized by law tobacco investigations for which an appropriation was given. Mr. G. E. Graham, assistant in the botanical department of the Experiment Station, helped with the various experiments there and elsewhere in 1921.

In the disease survey considerable data were obtained, much of which, however, was merely an extension of the knowledge of diseases and injuries that had been previously studied more or less intensively by the Station botanist. It is hoped to present this and further data in future bulletins from this department. One of the striking features of the survey was the discovery of a tobacco disease, new to the state, which has now proved to be quite serious under certain conditions. It is with this trouble, popularly known as wildfire, that this bulletin has to deal.

Nature of the Disease. As a result of one of the field examinations in late June, 1920, Mr. Southwick sent to New Haven plants from Tariffville showing an unusual leaf spot trouble, but no definite information concerning it was obtained at that time because of the poor condition of the material when received. Later at Hartford Dr. McCormick, in examinations of other material brought to the laboratory by a grower from Poquonock, found the diseased spots accompanied by bacteria with which she was able to produce infection on healthy plants.

The subsequent studies of the disease by the writers have been made, 1st, to thoroughly convince themselves of its bacterial nature, since some growers have been very sceptical as to its identity and the damage it might cause, and 2d, to find practical methods for its control, since, in 1920 and even more so in 1921, it proved a serious trouble in certain localities and fields.

General Description. The disease is generally limited to the leaves, and under certain conditions does not prove serious, but with the right weather conditions its possibilities of injury are unusually great. It belongs with the leaf spot troubles of which several have been found in this state. It differs, however, from all the other leaf spots by certain definite characters, usually evident to the ordinary observer. In both the seedbed and field, infected plants develop yellow discolorations in the normally green tissues and these spots are usually rounded and about the size of a finger tip. In their center there is a small point of white to brownish dead tissue that indicates the origin of the spot. In time the dead center encroaches on the yellow discoloration limiting it to a more or less narrow encircling band, the so-called halo. If numerous enough the spots cause death of intervening tissues so that eventually a very large part of the leaf surface is killed in an irregular way as if by sun scorch. The appearance then is much like the so-called rust that follows calico, but usually even at this late stage the yellow halo rings are still evident for definite identification.

Distribution.

In Other Countries. Because the blue mold, a menace to tobacco in certain parts of Asia and Australia, has recently appeared in this country, some persons have thought that wildfire has been imported from similar tobacco districts into the United States. Wolf and Moss (33, p. 25.) in 1919 stated that "it is presumably identical with a disease which has been recently reported from Connecticut and from the Philippine Islands." So far as Connecticut is concerned their statement was correct. The disease mentioned from the Philippine Islands is evidently that briefly described by Reinking (22, p. 130.) also in 1919. It is impossible to tell definitely from Reinking's preliminary description whether or not he is dealing with the wildfire or some of the other bacterial spots now known on tobacco.

Very recently Fromme (7, p. 37.) called attention to a disease in Africa which is described (evidently by the editor Klerck, 19.) in the Journal of the Department of Agriculture, Union of South Africa, in March, 1921, as follows:

"A tobacco disease occurring in the Piet-Retief District and known to farmers as 'Verterende roest,' was brought to our notice by the Chief of the Tobacco and Cotton Division. An officer of this Division was detailed to investigate the matter; the disease starts on the lower leaves which at first appear to be maturing prematurely, and spreads to the upper leaves. The disease was prevalent on the experiment station as well as on neighboring farms, and it was stated that only 10 per cent. of the 1920 crop reached its normal development, the remaining plants being stunted. Considerable losses had also been suffered on other farms which were visited. The 'verterende roest' is due to a bacterium which is being carefully studied in the laboratory, with a view to devising preventive measures which may be tested on a practical scale next season. Specimens of the tobacco affected by a similar trouble have also been received from Rhodesia; these are also under investigation." A month later he further states "The bacterial disease of tobacco previously recorded from the Piet-Retief District is now spreading rapidly at Marikana in the Rustenburg District, and is probably very widespread. So far as this investigation of this disease has gone, it bears a very strong resemblance to the wildfire in tobacco recorded in the United States."

In the same publication, Evans (34) in January, 1922, makes the following definite statement:

"Tobacco Wild Fire (*Bacterium tabacum*), a serious disease, was investigated. It occurs extensively in the Pietersburg and Rustenburg Districts. It was sent to us first from Rhodesia. Preliminary studies from Rhodesian material were made, and it is intended, if possible, to carry out field experiments in connection with preventive measures during the coming season."

The preceding quotation would seem definitely to decide the nature of the South African disease but Klerck (19), in the February issue of the Journal, again put it in the doubtful category by the following remarks:

"Wild-fire and angular spot of tobacco has been causing considerable anxiety amongst tobacco growers, and appears to be spreading rapidly. During the season 1920-21, this disease was only reported from the Government experiment stations at Rustenburg and Piet-Retief, from certain farms in the Piet-Retief District, and one in the Rustenburg District. During the present season specimens have been identified from three more farms within fifty miles of Rustenburg, and also from Groot Marico and Swaziland. A detailed study of this disease and the organisms concerned has been carried out by Mr. W. E. Schlitz, of this Division, and the South African organism compared with cultures obtained from America, and some interesting results have been obtained. The South African organism is identical with *Bacterium angulatum*, the bacterium connected in the states with angular leaf spot. The lesions on tobacco leaves found in the field and those produced by inoculation resemble 'wild-fire' but the organism concerned is not the 'wild-fire' organism, *B. tabacum*, which has not once been isolated. A full account of these investigations will be published at a later date."

It is evident from the testimony, so far as published, that this disease in S. Africa needs even more critical examination as to its relationships and it suggests to us that perhaps wildfire and angular spot in the United States also should be more carefully compared. The following data, however, satisfies the writers as to the identity of the African trouble with the American wildfire.

In January, receiving a letter from Wolf, in which he stated that Miss E. M. Doidge, of Pretoria, South Africa, had written him that wildfire had appeared in that section, we wrote Miss Doidge and received the following letter, dated March 6th:

"In reply to your letter of the 30th January, I may say that nothing further has been published on the occurrence of Wildfire in South Africa, but that there appears to be no doubt as to the identity of the disease which was prevalent in our tobacco fields last season with the American Wildfire. I am sending under separate cover some dried specimens as requested."

An examination of these specimens from Rustenburg (dated Jan. 2, 1922) showed their similarity in appearance to our Connecticut disease. Attempts to inoculate pricked greenhouse plants with water in which the crushed infected tissues had been soaked for several hours, were unusually successful despite the fact that the specimens had been enclosed in an envelope containing naphthaline flakes, apparently for the purpose of disinfecting them.

In the recent visit to the New Haven Station, Dr. Butler, of Kew, England, stated that he had seen a somewhat similar leaf spot of tobacco in India or in the adjacent islands, but had made no special study of it, and was in doubt as to its nature.

In the United States. The discovery of wildfire in this country seems to have been made first in North Carolina, at least Wolf and Foster, (31, p. 361.) in 1917, noted it as a new disease found there in the seedbeds and fields and gave a name to the germ which caused it. Early the next year they (32.) published a scientific description of the germ, *Bacterium tabacum,* and gave a more detailed account of the trouble which they listed as also occurring in Virginia. In September, 1920, Garner (3.) reported it from Maryland, Chapman (3.) from Massachusetts, and Valleau (3.) from Kentucky; while in October, Hesler (13.) recorded it from Tennessee and Johnson (13.) (*in litt.,* temporary escapes at Madison) from Wisconsin. In 1921 it was reported, in June, by Westbrook (29.) from Georgia, and in July, by Orton (20.) from Pennsylvania, and Clayton (4, apparently also reported in 1920,) from Ohio. Besides the above states Ludwig (10.) in August, 1921, reported it questioningly, from South Carolina, and the writers received in the fall a dried specimen from Vermont, sent by Lutman, that proved to be this disease. In a letter recently received from Burger, he states that the disease has now also been identified in Florida. It seems, therefore, to have been found in thirteen or fourteen states east of the Mississippi where tobacco is most commonly grown.

In Connecticut. Wolf and Moss' note that "presumably" wildfire occurred in Connecticut, was based on statements of Johnson, in charge of U. S. Department of Agriculture tobacco experiments in New England, who has since told the writers that he saw the disease during the growing season of 1919 at a certain farm in Suffield. As no previous mention of this was made to Station authorities here, his observations were unknown to them until after the definite identification of the disease a year later.

In the summer of 1918 Beinhart, at that time the U. S. Government tobacco agent in New England, called to the senior writer's attention a leaf spot trouble of tobacco in a tent in which he had experiments at Buckland. This trouble seemed to be different from the ordinary spots seen here, and both thought it might be either a fertilizer or bacterial spot, but no study was made of it, and apparently specimens were not collected, or if collected were lost, so we cannot be sure of its identity. During the last of July, 1919, the senior writer collected an inconspicuous tobacco leaf spot at East Windsor Hill that was not carefully examined at the time. Recent more critical examination of this specimen shows it to be the wildfire, so far as one can be positive from the examination of dried material.

Late in June, 1920, as stated before, County Agent Southwick obtained specimens of an unusual tobacco trouble at Tariffville, which later was found elsewhere. Dr. McCormick, at the Hartford laboratory, upon examination of material from various sources, showed these to be a bacterial trouble, both by the presence of bacteria in the diseased tissues and by the production of similar spots on healthy tobacco leaves from crushed tissue of the diseased leaves. Specimens of the disease were sent by her to Dr. Smith, of the U. S. Department of Agriculture, and he definitely pronounced it wildfire. This then, was the first positive identification of the trouble in the state, so far as the writers are concerned.

Following the newspaper agitation of the subject in 1921, occasional growers have expressed the belief that the disease was not necessarily new but that outbreaks of it had occurred locally years before. This does not seem very plausible, since with all the United States tobacco investigators who have been in the state, and the local ones, who have watched the tobacco troubles rather closely, it is unlikely that it would have entirely escaped detection. If not native this brings up for consideration the manner in which it may have been introduced into Connecticut.

Possible Methods of Introduction.

Theoretically there are a number of different ways in which the germ of wildfire may have been brought into the state. We can discuss them briefly under the following headings.

Mats, etc. Some growers have advanced the theory that the germ was brought in from foreign countries on the matting used to bale imported tobacco, especially Sumatra. This matting is sometimes sold to the growers and used on their beds for shade in sunny and for protection in freezing weather. One grower who used it on the ground just before the plants came up had an idea that he got infection in his seedbed in this manner. He, at least, by this use obtained favorable moisture conditions for the spread of wildfire possibly already there. If the disease is foreign in origin, it is quite reasonable to suppose that mats, etc., from infected districts may have been the means of introducing the germs here. However, there is no direct evidence to this effect.

Fertilizers. Another of the out-of-state materials used on tobacco farms are the fertilizers and of these cotton seed meal, coming from the south, both because of its source and its organic nature, has come under suspicion more generally than the strictly chemical fertilizers. Our attempts to produce the disease on leaves of individual plants in the greenhouse, by sprinkling cotton seed meal from various sources on them, failed in every case. It would seem, therefore, that cotton seed meal was not a very probable means of its introduction.

Tobacco stems, imported from the south as a source of potash fertilizer, have also been under suspicion. Ordinarily the grower does not use them in his seedbeds, though he may sometimes make the seedbed on an old tobacco field or very close to it. Wolf and Foster (32, p. 457.), who investigated tobacco stems as one of the possible sources of infection, failed to get cultures from them, and conclude as follows: "Furthermore, in the preparation of tobacco stems for incorporation with fertilizer material they are subjected to a sufficient degree of heat to insure complete sterilization." Whether the ordinary tobacco stems as shipped direct from the factories after stripping off the leaves, and possibly more or less mixed with unfermented tissues, are a source of infection, has never been proven. Such few attempts at producing the disease from tobacco stems as we attempted were negative. It is conceivable, even if unproven, that they may be an occasional agent of introduction, but now that the disease is already here they do not seem to be such a serious menace as to prohibit their use for general field purposes. For this possible occasional danger, and other reasons, however, it is unwise to ever use tobacco stems on seedbeds.

Seed. We now come to the most probable agent of wildfire introduction into the state. Both Fromme and Wolf are convinced from their studies that it is a seed-borne disease, and that this is a common way in which it is carried over winter, and so naturally tobacco seed would most satisfactorily account for its distribution to new districts, especially from the south, where the disease was first noticed, to our own state where it appeared more recently. For example Wolf and Moss (33, p. 30.) say: "As has already been stated, the pods are subject to attack, thus making it entirely possible for the seed to become contaminated." Fromme (6, p. 29.) makes the following statements along similar lines:

"If seed were selected from plants entirely free from disease there would be no danger of infection from this source. Unfortunately, the diseases are now so general that it is difficult to find disease free fields, and the selection of disease free seed is therefore possible in only an occasional field. Seed treatment is therefore necessary to insure against introduction of the disease into the bed on the seed."

Having shown that the disease is carried by the seed in some cases, the question of its introduction here in this way may now be considered. There is no doubt that growers, Government and Station investigators have at different times grown plants from seed produced outside the state or even outside the country. So far as we can learn the Station has only upon two occasions, many years ago, used seed that was grown elsewhere. On one of these occasions Sumatra seed from Florida was obtained for the first shade tobacco grown here. In recent years we know personally of others who have used tobacco seed here that was grown in states where the wildfire has since been found. It is entirely supposable that the wildfire may have been brought in with this seed and escaped especial notice on the plants grown therefrom.

Just to show that seed grown elsewhere has been used here, we quote from a bulletin by Shamel (23, pp. 6, 11.) published some years ago before wildfire was known.

"In all of the crops grown from freshly imported seed, there appeared a large proportion of abnormally early, small heavy leaved types, commonly called freaks. * * * * These freaks were particularly noticeable in the crops grown from freshly imported Cuban seed. * * * If it is desirable for the grower to test foreign, imported or new seed of any kind, it should be done on a small scale, etc. * * * * A field was set out with plants grown from imported seed, which were attacked by a fungous root disease, and all died with the exception of a few plants."

Seedlings. It is not a common thing for seedling plants to be brought into the state from elsewhere. No doubt it is sometimes done on the border line of this state and Massachusetts in the Connecticut valley, but such cases would hardly account for the introduction of wildfire since it was found here shortly before it was in Massachusetts. Upon one occasion we know of experimental plants used here that were grown either at Washington or Kentucky, but here again we have no evidence that they were infected either before or after they were brought in. Altogether this source does not seem quite as probable a method of introduction as by seed, though within the realm of possibility.

Upon the whole it seems too late now to actually prove the exact way by which the disease first got a foothold here, and certainly no one intentionally brought it in. Introduction through seed, however, seems to have been the most probable method.

Agents of Dispersal.

Almost equally well do certain of the ways already discussed, concerning the means of introduction of the germs into the state, apply to their dispersal over the state when once introduced. State spread, however, often involves only short distances and there are additional factors that need to be considered. The discussion presented here, under similar headings, avoids repetition of preceding statements so far as possible.

Seed. We have taken for granted the conclusion of Fromme and Wolf that the disease is in part seed-borne, and so have made no extensive efforts to isolate the germ from seed. While others have observed the wildfire spots on the seed-pods, we failed to find any so affected in a careful search during the season of 1921. In 1920 Mr. Southwick gave us seed-pods that were supposed to have shown wildfire spots on them, but we failed to obtain any diseased seedlings grown from the same. We do not doubt that seed-pods can become so infected, but from our experience it seems probable that this takes place only in certain favorable seasons and perhaps then not to so great an extent here as in the south. There can be no question that seed may be contaminated in other ways than through infected seed-pods. For example, in the process of blowing or cleaning seed there is a chance that seed free from the germs might become contaminated by dust ladened with the germs. One cannot be too careful, therefore, in obtaining seed originally free from these bacteria to protect it from later exposure to them. Our experience leads us to doubt that seed has been the chief source of yearly infection in Connecticut. Quite a number of farmers have told us that their seed was gathered a few years before the wildfire was known here and that they had no trouble with wildfire in their seedbeds from the same seed until last year or the year before. It would seem in some of these cases, therefore, that the seed was not the source of the infection.

On the other hand there have come to us one or two cases where it seemed probable that the seed was the source of infection. For example, a grower who was known to have had it in his fields in 1920, grew some of the Round Tip tobacco in 1920, and used the seed next year. The wildfire appeared in his seedbed where this was grown, and also in at least three other seedbeds of growers to whom he had given the seed. In two of these places it appeared earlier, if not confined to the seedbeds containing this Round Tip seed. Some of this seed was obtained by us and planted in the greenhouse late in the season and at least one of the young plants showed a wildfire spot on a leaf or two. It would seem that this seed then may have been a source of spreading the disease somewhat, though we failed in our attempts to isolate the germ from it.

Seedlings. There is no doubt that one of the most common methods of spreading the disease has been by the seedling plants set in the fields. A great many growers either do not, for one cause or another, grow all the plants they need, or in some cases depend entirely on outside sources for the same. No doubt for economical reasons this is the best course to pursue for certain small growers. With the advent of the wildfire, however, one needs to be especially careful how he buys his plants. He cannot watch another's seedbed as he can his own, and as wildfire is often masked in the plants, he cannot be sure of what he is getting unless the plants come from a region where wildfire has not yet appeared or he has evidence that the plants were grown under the best possible conditions for its prevention.

We have heard of a number of cases where persons knowingly or unknowingly have purchased plants from seedbeds that contained wildfire infected plants. In some instances this has happened where the purchaser had seedbeds of his own in which wildfire did not occur and thus he brought it into his field from outside sources. Perhaps the best illustration of this was a case in Suffield, where a grower in 1920 furnished plants to a number of growers who had wildfire in their fields that year apparently for the first time. Yet the seedbeds of this man looked unusually well and wildfire was not found in them until the planting season was over.

Tools, Cloth, etc. We do not have any direct evidence of spread of the disease by means of tools, etc., used in a diseased seedbed or field, carrying the germs later to another free from the trouble. We doubt if this frequently happens, yet a reasonable amount of care should be used as regards planters, cultivators, etc., in seeing that they are clean when taken from one field to another. Refuse tobacco should not be used on seedbeds under any condition.

Another factor that needs to be taken into consideration is the use of old tent cloth as a seedbed covering. If this came from an infected field the year previous it has been shown by Fromme and Wolf that it may prove a source of infection. We have no personal evidence along this line but do know that Florida authorities are considering barring the importation of second-hand tent cloth from Connecticut into that state. Wolf and Moss (33, p. 32.) make the following definite statement:

"When seeds of known healthy origin were used in certain of these beds [free from the disease], and the beds were covered with new cloths, the plants remained free from wildfire. When, however, other of the beds were planted with seed from the same source and covered with cloths taken from beds which had been affected with wildfire during the previous year, the disease appeared."

Insects. In the same article from which we have just quoted, the writers (p. 30.) state, that they failed to find wildfire carried by thrips that were abundant on diseased plants but that,

"Flea-beetles, however, are to be regarded as carriers of infection, since the wildfire organism has been isolated from individuals which had been feeding upon diseased plants. Transmission of wildfire by these insects is a fact supported indirectly by the frequency with which the disease appears around the holes which they have eaten through the leaves."

In Connecticut the most suspicious insect carriers that we have noticed are also the tobacco flea-beetles and these chiefly in the seedbeds. We have frequently seen them abundant in certain seedbeds and absent or infrequent in others. Some of these beds were abundantly infected with wildfire and often the halos centered around the small spots which had been eaten by the flea-beetles. In an effort to confirm this evidence Dr. McCormick, with Mr. Zappe of the entomological department, tried to produce wildfire with flea-beetles. These were gathered from infected plants, or fed with them for a short time, and then placed on healthy plants under bell-jars and imprisoned there for some days. In none of the plants experimented with did any wildfire develop. However the experiments were too limited in number to be of great value. We are convinced that they may in some cases become an important factor in the spread of the wildfire within the seedbeds, and possibly carry it outside to adjacent beds. Similar experiments with lice also failed.

Man. Here, perhaps next to seed and seedlings, one finds the most common carrier of the disease. Usually no care is taken when the beds are pulled that the workers do not carry the disease to the other beds which, after handling diseased plants, they might do. Again growers from one locality visit seedbeds in another and more or less miscellaneous handling of the plants occurs. Growers seem to be somewhat alert in this respect now, as many of them have been rather cautious as to indiscriminate inspection of their beds, while some few have posted signs for visitors to keep away from the beds. Perhaps in the exchange of plants from one locality to another infected dirt may be carried in on the shoes or in the uncleaned baskets used to transfer the plants. Care is needed in these respects also.

To illustrate how the disease may be carried into a bed in an inconspicuous way, which after it occurs would be impossible of detection if one did not have the facts, we may cite the following personal experience. In a seedbed at New Haven, planted under conditions where wildfire would not occur, we tried to inoculate some of the plants with a fungous disease, somewhat related to the blue mold, that occurs on certain weeds not uncommon in tobacco beds. The infected leaves were gathered twice in regions of the state where wildfire did not occur and these, under proper moisture conditions, were placed on the tobacco seedlings in marked spots in the bed. Both having failed, they were gathered a third time from a seedbed where wildfire was common. This time the fungus again failed to develop but wildfire appeared on the plants within a few days, at the particular spot where the leaves were placed. Now this weed, Lambs Quarters (*Chaenopodium albidum*), is not infected with wildfire but by contact with infected tobacco plants evidently carried some of the germs mechanically on the leaves to the experimental seedbed and infection resulted from these under the favorable moisture conditions provided.

Wind and Rain. While certain weather conditions have much to do with the development of wildfire in the seedbed, once it gains entrance there, we cannot be so positive about the wind and rain as agents of its introduction into the seedbed. It seems reasonable to suppose that even if one did sterilize his seed, soil, frames, etc., that the germs of adjacent soil might be spattered in by rains or even more probably be blown in with infected dust. This would not mean much if it were not for the fact that it is vitally necessary to keep the disease *entirely out of the seedbed* if one wishes to escape injury in the field. We have more positive observations on these points, however, when it comes to spread in the field, but we shall speak of them later on.

Overwintering of the Germs.

Seeds. Our discussion of infected seeds under the preceding headings will largely cover the possibility of one year old seed overwintering the germ and the re-infection of seedlings the next year. Just how long the germs can remain attached to the dry seeds and still retain their viability is not known. So far no one has shown that the seed itself is invaded by the germs so it is presumed that the overwintering is by germs accidentally attached to the seed coats. It is very doubtful if such germs can retain their vitality as long as the tobacco seed, which often germinates fairly well when eight to ten years old. Rapp (Okla. Agr. Sta. Bull. 131 : 37.) has recently found with the bacterial blight of beans that two and three year old seed gave blight-free plants. This is a case where the beans themselves are sometimes invaded, and so presumably a longer viability of the bacteria would be found here than with the tobacco germ, other things being equal.

Cloth, Sash, etc. We have no data of our own showing that the germ may be carried over the winter on the boards, sash, or cloth used on diseased beds or fields the previous year. Yet there seem to be sufficient data, as far as the cloth is concerned, furnished by Wolf and Fromme from the south. What difference the greater severity of our winters would have regarding overwintering we cannot tell, but if at all it would be unfavorable rather than favorable. Fromme (8, p. 1.) has recently published the following incidents to show infection from the use of old cloth.

"The germs of blackfire (angular spot) and wildfire may be carried on old canvas and cause infection in the plant bed. This was proved by experiments and also by the following cases. R. H. Mantiply of Amherst County used seed that had been treated but did not boil his canvas. Tilden Gooch used the same seed and boiled his canvas. Wildfire and blackfire were found in Mr. Mantiply's bed and not a trace of either could be found in the bed of Mr. Gooch."

The only incident along this line that we can cite for Connecticut is where a grower sterilized both the seed and the soil but not the sash, cloth or boards used on his beds. It was in those beds that the first appearance of wildfire in Connecticut in 1921 was found. Apparently in this case the germs carried over in the materials used in making the seedbeds, or, less probably, were carried in from other unknown sources.

Soil. Soil probably may be the source of infection in some seedbeds and fields, yet data absolutely proving this is difficult to obtain. We have little convincing data along this line, in fact so far as field infection goes, it does not seem to hold a very important part. But an occasional holding over in the field is quite a different matter from that in the seedbed where an infection, no matter how slight or infrequent, can become an important means of further spread. As yet we have made no attempt to isolate the germ from wintered-over soil exposed to infection the previous year, but our attempts to infect tobacco plants in the greenhouse directly with such soil were successful in one out of several different trials. Wolf and Moss, *loc. cit.* pp. 30-1, also, make the following definite statement of a case in North Carolina:

"In the tests on transmission through soil, old plant beds, which had borne diseased plants and which were not 'fired' prior to planting, were used. Seed from a locality where wildfire was absent were sown in these beds, and new cloth was used as covers. The disease developed in some of these beds."

Tobacco Refuse. It seems certain that where a field or seedbed has been badly infected with wildfire and the diseased plants were left there that the germs can, to a certain extent, be carried over in the more or less disintegrated tissues. This might be the way it is carried in the soil where it is supposed to have survived as stated above. Infected tobacco refuse from indoors thrown on the fields or seedbeds in the spring might also supply the infecting germs in some cases. Our few attempts to inoculate greenhouse plants with outdoor overwintered tobacco refuse were successful in one case. Evidence along this line is also indicated in the following extract from Fromme (8, p. 1.):

"The disease may live over in the field and infect the next crop where tobacco follows tobacco. Evidence of this was obtained in several cases but in some other cases it was equally true that the disease had not lived over in the field. It is believed that the time of plowing had a great deal to do with this and that the danger from this can be greatly lessened if the land is plowed in the fall or early spring, *so that the suckers have time to rot in the soil* before the crop is set. There was also more carry-over of the disease in the field during the mild winter of 1920-21 than would be true in ordinary seasons."

Detailed Distribution in the State.

Survey. As previously mentioned, a tobacco disease survey of the state was started in 1920 and continued in 1921. For Hartford County, B. G. Southwick, County Agent, gave valuable help in both seasons. In the spring of 1920 Mr. Southwick and Dr. Clinton spent considerable time on the seedbeds and during the summer Mr. Southwick frequently, and Dr. McCormick occasionally, made field trips. The work was not undertaken especially for wildfire investigation, though the discovery the first year that the disease was widespread in the state was the most important feature of the work, and largely influenced the nature of the work the second year. In 1921 Mr. Southwick, with Dr. Clinton, again gave much of his time during the whole season to the examination of seedbeds and fields. The writers are especially indebted to him for first information about, and aid in visiting, many of the farms containing infected plants in Hartford County.

Little work outside of Hartford County was done in 1920, but in 1921 tobacco seedbeds and fields in Tolland, Middlesex, Litchfield and Fairfield counties were also examined and additional data obtained. County Agents E. E. Tucker, of Tolland, and J. H. Fay, of Middlesex, were also helpful in aiding investigations in their respective counties.

In 1920. In the survey of seedbeds in 1920, which ended about the first of June, no cases of wildfire were found. However later in the season, after it had been found in the fields, Mr. Southwick reported that he examined one or two seedbeds from which infected fields had been set, and found a few infected plants in these. Of course in the early seedbed examinations, as nothing was known then about the presence of wildfire in the state, the disease may have been overlooked. On the other hand, it could not have been at all conspicuous since care was taken to find all troubles of any nature that showed either on the leaves or the roots.

This same year in the fields the disease was first discovered the latter part of June, and during the remainder of the season it was looked for particularly, and was eventually found in twenty-one other fields. The known distribution by the end of the 1920 season is shown in Table I.

TABLE I. KNOWN INFECTIONS PREVIOUS TO 1921.

Infected Fields, 1918.

No.	Place.	Town.	County.
1(?)	Buckland,	Manchester,	Hartford.

Infected Fields, 1919.

No.	Place.	Town.	County.
1(?)	East Windsor Hill,	South Windsor,	Hartford.
1	West Suffield,	Suffield,	Hartford.

Infected Seed Beds, 1920.

No.	Place.	Town.	County.
1(?)	Floydville,	E. Granby,	Hartford.
1	West Suffield,	Suffield,	Hartford.

Infected Fields, 1920.

No.	Place.	Town.	County.
2	East Granby,	E. Granby,	Hartford.
1	Warehouse Point,	E. Windsor,	Hartford.
1	S. Glastonbury,	Glastonbury,	Hartford.
11	Suffield,	Suffield,	Hartford.
6	:Poquonock : :Windsor :	Windsor,	Hartford.
1	Windsor Locks,	Windsor Locks,	Hartford.

In 1921. As this year especial attention was given to the disease, wildfire was found in a great many more seedbeds and fields than in 1920. This was partly due to the extra search for the trouble, and also in part because it was undoubtedly more widespread and serious than the previous year. Of the 122 seedbeds (122 growers) that were examined, it was found in fifty-one, and seventy-one were free from the trouble so far as could be seen at the time of the examination. As most of these beds were examined only once there is more or less doubt whether all of these listed as free remained so during all of the season. In fact we have data showing that, in a few cases, beds pronounced apparently free of wildfire at the time of the examination were either not entirely free, or later developed the trouble, so that it was carried in sufficient amount into the fields to eventually cause serious injury.

In the field inspections 125 fields, belonging to about as many different growers, were examined and in sixty-seven wildfire was more or less prominent as compared with fifty-eight fields that were apparently free of the disease. Of the sixty-seven infected fields we can loosely classify them, according to the amount of wildfire that showed at the time of the last examination, as follows: thirty-four with little injury, that is less than 5% loss; eighteen with a moderate amount; eight with much; and seven with very serious injury, in a few cases reaching almost a total loss. The condensed data of distribution obtained in 1921 is given in Table II.

TABLE II. INFECTED AND FREE SEEDBEDS AND FIELDS, 1921.

Town.	County.	*Seed Beds.* Infected.	Free.	*Fields.* Infected.	Free.
Brookfield,	Fairfield,	0	6	0	4
Sherman,	Fairfield,	0	0	0	9
Barkhamsted,	Litchfield,	1	0	3	1
Kent,	Litchfield,	0	6	0	0
New Hartford,	Litchfield,	0	0	0	1
New Milford,	Litchfield,	0	19	0	15
Avon,	Hartford,	1	0	1	0
Berlin,	Hartford,	0	0	0	1
Bloomfield,	Hartford,	3	0	1	0
Canton,	Hartford,	0	0	0	1
E. Granby,	Hartford,	5	0	7	0
E. Hartford,	Hartford,	2	7	6	2
E. Windsor,	Hartford,	1	3	2	0
Enfield,	Hartford,	2	0	5	1
Glastonbury,	Hartford,	1	2	0	0
Granby,	Hartford,	1	1	5	0
Hartland,	Hartford,	0	0	0	7
Manchester,	Hartford,	2	1	3	0
Simsbury,	Hartford,	3	1	4	0
Suffield,	Hartford,	3	3	5	0
S. Windsor,	Hartford,	3	1	4	0
Windsor,	Hartford,	16	2	8	1
Windsor Locks,	Hartford,	0	0	2	0
Cromwell,	Middlesex,	0	9	0	8
Middletown,	Middlesex,	0	0	0	3
Portland,	Middlesex,	0	7	0	3
Ellington,	Tolland,	4	3	7	0
Somers,	Tolland,	2	0	4	1
Vernon,	Tolland,	1	0	0	0
Totals 29.	5	51	71	67	58

Distribution. Examination of these tables shows that wildfire has now been found in three of the five counties of the state where tobacco is grown commercially, namely in Hartford, Tolland and Litchfield counties, but not, so far as we have data, in Middlesex or Fairfield counties. By far the greatest center of infection lies in Hartford county north of the city of Hartford. The disease has been found in over half of the towns of this county and these include nearly all of the towns where tobacco is grown to any extent. Much less is found in the southern towns than in the northern ones. Hartford county grows more tobacco than all the rest of the New England counties combined. Of the twenty-nine towns in the county four grew no tobacco, nine in less amount than twenty-five acres, while the other sixteen grew it as one of, if not their chief crop.

In Tolland county to the east of Hartford, the tobacco region is largely limited to the towns bordering on Hartford county, and in the three most northern of these wildfire has been found just as abundantly as in the adjacent towns in that county. Tolland next to Hartford grows the most tobacco in this state, but not one-tenth of that grown in Hartford.

Middlesex county to the south of Hartford grows tobacco in three or four towns on its northern border. Fortunately, so far, we have been unable to find wildfire in any of these. As this district is somewhat cut off from the infected region to the north there is some hope that with care the disease may be kept out of it.

Litchfield county to the west of Hartford grows tobacco in two distinct regions. One of these embraces two or more of the towns bordering on Hartford, and wildfire has been found in one of these to a slight extent. To the north of Hartford county come the tobacco counties of Massachusetts and wildfire exists there also. The counties already mentioned in general make up the tobacco region of the Connecticut river valley, the great tobacco district of New England.

The second tobacco region in this state lies in the valley of the Housatonic river in the northern part of Fairfield and the southwestern part of Litchfield county, embraced chiefly in five or six towns. So far a general survey of this region has not revealed the presence of wildfire there. As this district is even more isolated from the infected region than is the tobacco grown in Middlesex county, there is a still better possibility of keeping the disease out of it. This region has a small tobacco acreage, like that in Middlesex, in fact all of the tobacco grown in these three counties is less than that grown in Tolland county.

Disease in the Seedbeds.

Appearance. On May 2, 1921, Mr. Southwick asked Dr. Clinton to examine, at East Windsor Hill, tobacco beds with which the grower was having trouble. The plants at this time were quite small, the largest leaves being about one-half inch long. The trouble showed at the tips, or less frequently at the upper edges of the leaves, the infected tissues rapidly rotting and drying up (Plate XXIX f). With favorable moisture conditions present the rot continued until nothing of the blades remained and the plants then shriveled up, leaving vacant spots in the beds (Plate XXIX e). With less favorable moisture conditions the rotten tissues, of greater or less extent, dried up and fell off, leaving the rest of the mutilated leaf apparently healthy. The general appearance was so much like the result of dampening-off fungi, common in tobacco seedbeds, that we were surprised, upon a preliminary examination at that time, to find no suspicious mycelium present in the tissues. On the other hand in certain intercellular spaces in the rotten tissues evident masses of bacteria were present, so that we concluded, temporarily, that the trouble was of a bacterial nature, possibly the bacterial soft rot. Specimens brought to the laboratory seemed to confirm this view.

About a week after the first examination, Mr. Southwick asked Dr. Clinton to examine another bed at Poquonock having similar trouble. At this time the plants had grown so that some of the leaves were an inch or more in length. While the dampening-off rot was present as before, it was not so conspicuous, and there were beginning to appear yellow bordering areas in advance of these rotted tissues; also isolated yellow "halo" spots within the leaf blades were to be seen. This proved that the trouble was the true wildfire disease. An examination on this date, May 8th, also showed that the first beds seen had now developed these characteristic halo spots.

So far as we are aware this rot stage of wildfire has not been described before, in fact Wolf and the other writers do not give a very detailed description of the disease in the seedbed. We have since seen it in many other seedbeds and in every case the halo or yellow spots developed later. This convinces us that this wet rot is the first stage of the disease in the seedbeds. We have not seen it on the larger plants. It seems probable that with very young plants the first leaves come in contact with the ground and, if the wildfire germs are present, this favors early invasion through the large stomates at the tip or margin of the leaf into the intercellular spaces. This environment, especially with the greater amount of moisture present, facilitates a rapid rotting of the tissues and a greater production of bacteria. We have not as yet studied this stage carefully enough to state positively that these more abundant bacteria are all wildfire germs. The first stage then, according to our belief, develops more as a soft rot trouble and chiefly from the tip or edges of the leaves inward.

The second stage we consider the halo or yellow spot which comes on quickly after the first and on the somewhat larger plants. These spots also may begin at the tip or edge of the leaf, in which case they are semicircular in outline, or they may start more slowly within the tissues as small circular yellow spots that gradually enlarge, eventually becoming about half an inch in diameter. Their abundance on the leaf depends upon the number of infections and the size of the leaf. In leaves of plants of the size for transplanting half a dozen or more may show on a single leaf, and eventually may run together and become somewhat irregular in shape. At the center of each of these circular yellow spots is a small whitish or blackish speck, the point of origin of the disease. In some cases this is insect-injured tissue, usually a small hole eaten out by flea-beetles, but in most cases it is merely the position of the stomates or breathing pores through which the bacteria originally gained entrance between the guard cells into the intercellular space beneath. There they multiplied, killed the tissue in their immediate vicinity and caused a slow death of the surrounding tissue, showing first by the injury to the chlorophyll grains, thus forming the yellow halo spot. Plate XXX a.

The third stage does not usually appear to any extent in the seedbeds. This is where the yellow spots die, turning white or brown, and if placed thickly enough on leaves, cause the intervening healthy tissues also to die. Before the disease reaches this stage the plants have usually been transplanted into the field. Our experience so far has been that the plants left in the infected seedbed do not seem to continue the disease in the progressive way that one would expect from its aggressive first appearance there. This may be because the moisture conditions, after the covers are permanently removed and watering is infrequent, are not so favorable, but it is also probably due in part to the slow growth of the thickly set and competing plants, a condition that seems unfavorable for rapid development of the disease anywhere.

Conditions favoring the Disease. Of course the first essential is that the germ should already be present in the seedbed or be carried there in some manner. We have already discussed the various sources of infection such as soil, equipment, fertilizers, and such active agents of introduction as spattering rain, wind, insects and man. But even if present the active development of the germs depends on other conditions, such as the weather, the method of watering, and the airing of the beds. These latter are quite important factors and will be discussed further, but before doing so it might be well to mention one phase of the fertilizer proposition. A good many growers have the idea that nitrate of soda has some influence on the development of wildfire in seedbeds. The only evidence we have obtained is that with the disease present in the seedbeds the liberal use of this fertilizer incidentally has some part in a more rapid spread of the disease, other things being the same, because of the quick growth of the plants, a condition that favors the spread.

Weather. It was quite evident in the spring of 1921 that there were certain periods in which seedbed infection appeared and progressed more rapidly than at other times. The first favorable period was when the plants were quite young, about the first of May, as has already been pointed out. After this first outbreak, due in part to the greater care given the seedbeds by the growers because of the agitation started against wildfire, the spread did not seem so rapid, and certainly infected plants were not so conspicuous in the beds.

During the first part of the week of May 22-28 there were several days of cold wet weather so that by the end of the week there began a second outbreak that was even more conspicuous than the first because of the large size of the plants at this time and the consequent prominent halo spots that appeared abundantly on the leaves. Even when plants were selected from beds that did not show the disease to the ordinary observer, the grower did not always escape trouble in the field because incipient or masked infections were already there.

Glass versus Cloth. The grower cannot control weather conditions, though he can usually provide somewhat against their ill effect. For example he can help by the type of covering used in the seedbeds. Our inspections in the infected regions indicated that the beds with glass are less likely to develop serious cases of wildfire than the cloth beds. If we take the percent. each of glass and cloth-covered beds that developed wildfire as compared with those free, as shown by our total inspection, we find that the cloth beds really had a much smaller percentage. This means nothing, however, as most of the growers in the districts free from wildfire, especially in the Housatonic valley, happen to use cloth almost entirely, while in the infected regions of the Connecticut valley, glass seems to have the preference. The cloth beds do not keep out the rain and so at times they are much damper than the glass beds. Also they are not aired so well, and on the whole they are colder and shadier and water does not evaporate so quickly from the leaves. It is this water on the leaves, if it stands on them any great length of time, that causes serious development of wildfire. With the glass bed the rain does not get on the plants if care is used, and the sash can be partially raised even in rainy weather so that the plants can be aired and water kept out at the same time. However, if the sash leaks and water becomes abundant in spots, wildfire often gets a start there. Plate XXIX a-b.

Watering and Airing. As a rule watering of the beds should be as light as compatible with good growth and should be made at that time of day when the plants have opportunity to dry off. Perhaps the early morning or late afternoon is the best time, since there is less likelihood of sun scorch at these times. Beds made on wet soils or well protected against wind are difficult to keep dry and free from wildfire. Much of the water that stands on the leaves, however, is water of transpiration given off from the leaves. If the air of the bed is saturated, this water does not evaporate into the air, but accumulates as small drops all over the leaves. Airing the beds prevents this. Airing somewhat at night, when there is no danger of frost, helps to keep water of transpiration off the leaves.

Susceptible Varieties. So far as the seedbed inspection revealed there was no indication whatever that the varieties commonly grown in Connecticut had any degree of immunity. Wildfire was found bad on Broadleaf, Cuban, Havana and Round Tip. There were also beds of each of these that showed large, moderate and little amounts of the disease, and the percent. of beds showing these different amounts was not very different for any of the above varieties. Whether particular resistant strains of the above can be found we do not know, but it seems very doubtful unless the nature of the variety is changed; so control of the disease will not come along this line, at least for some time to come.

Damage. While we have seen wildfire very prominent in certain beds, if it were confined to the seedbeds as certain fungous troubles are, we would not consider it a disease of sufficient importance to cause much anxiety on the part of the grower. Of course in the wet rot stage it does cause the loss of some plants, clearing out small spots in the bed. Older plants, too, are often injured enough to misshape them or cause them to be smaller and less vigorous. The real danger, however, comes from the menace of infected plants when transferred to the field. Even a few infected plants in the bed because of this menace are very undesirable, and of course if abundant are the possible source of complete failure of the crop. The approximate amount of wildfire in the seedbeds examined in 1921 is shown in the following table:

TABLE III. WILDFIRE IN SEEDBEDS IN 1921.

Variety.	No. Bad.	No. Moderate.	No. Little.	No. Free.
Broadleaf,	3	2	9	19*
Cuban,	3	4	8	5
Havana,	4	3	6	46**
Round Tip,	2	3	4	1

* Many of these were in Portland wildfire-free district.
** These were mostly in the Housatonic wildfire-free district.

The seedbed then is the strategic point for control of the disease, and fortunately this is where it can be controlled with the least effort. This leads up to a discussion of the best methods for control.

Control Measures. Seed Treatment. Certain precautionary measures against introduction of the germs and care in ventilating and watering the plants, have been discussed. In the south the investigators place considerable stress on seed treatment. We doubt if this is quite so important a factor in the spread of the trouble in the north. While we have evidence of its being carried by the seed, there seems to be so many other ways by which infection occurs that seed treatment alone would prove of little value. Virginia investigators have been the most active in the seed treatment campaign in the south. In 1921 it is stated by Thomas (26.) that about 2,500 farmers planted treated seed. Fromme (6, p. 30.) first advocated soaking the seed in formalin 1 oz. to 1 pint of water for 15 minutes. Later the same investigator (8, p. 2.) recommended the corrosive sublimate treatment, using 1 part of this poison to 1,000 parts water and soaking the seed also for 15 minutes. Our experience with both of these treatments has been that with certain seed the treatments, especially with the formalin, have been rather severe, killing part of the seed so that we believe that 10 minutes is long enough for the formalin. Where seed was gathered several years ago, before the appearance of wildfire, or where gathered recently from free fields, there is no particular need of treating it. We know of only one Connecticut grower who treated (in part) his seed in 1921, and it was at his place that we first found the wildfire.

Soil, etc., Sterilization. Where infection has occurred in the bed the preceding year, steam sterilization of the soil should be practiced the next, or else the beds moved to new land not in tobacco recently. If we were to judge from our examination of seedbeds alone we would find that sterilized seedbeds gave a far higher percentage of wildfire than the unsterilized beds, but here again it was a question merely of location, since very few of the beds in the Housatonic valley, which is free from wildfire, are sterilized. The beds should receive a good steam sterilization, say for 30 minutes at a pressure above 100 lbs. It is well, where possible, to extend this sterilization to the paths immediately around the beds. Sterilization of the soil and seed is not sufficient, as has been shown in the south, so that this should include the boards, sash and cloth used in the construction of the beds, if these materials have at all been exposed to the germs. This can best be done by sprinkling them all over thoroughly with formalin at the rate of 1 to 30 of water, and piling them up under cover to dry out slowly; or the cloth can be boiled for an hour.

We are quite sure that steam sterilization of the soil alone is not effective against the appearance of wildfire. In the Connecticut river valley steam sterilization of soil is a common practice, yet wildfire was found just as commonly in the infected districts in the steam sterilized beds as in those that were not. This was, at least largely, because the seed, boards, sash and cloth were not sterilized also. We know of no place where all of these precautions were taken.

Spraying. In 1921 wildfire appearing in the seedbeds in so many places, it was necessary to devise other methods of control. There were apparently just two things that could be done under these conditions, namely, spraying the beds and careful watering and ventilation of them. Both of these seemed to give promising results where put in practice. The writers had had no experience in spraying tobacco seedbeds and the opinion of scientists had been that spraying is not generally effective against bacterial diseases. Bordeaux mixture, where no injury results, has on the whole proved the most satisfactory fungicide, so this was selected for experimentation, and as flea-beetles seemed to be concerned with spreading the trouble, lead arsenate was added as an insecticide. We did not know, however, whether injury might result from this spray, but, from the relationship of tobacco to the potato, with which we have had much experience in spraying, concluded to try the above on a badly infected bed at Poquonock. The senior writer sprayed this bed on May 8th, and the grower sprayed it again the next day. This was the first time, to the writers' knowledge, Bordeaux was used as a treatment against wildfire. No harm resulting from these treatments, at the meeting at Windsor of tobacco growers called to discuss wildfire, Dr. Clinton advocated the spraying of tobacco beds with 4-4-50 Bordeaux, with lead arsenate added. Many growers sprayed their beds from one to several times during the rest of the season with either homemade or commercial Bordeaux mixtures.

As a result, from our subsequent experience and that of others, we are convinced that spraying of tobacco beds should be made one of the routine practices of tobacco growing as long as there is danger from wildfire. We have seen no serious injury from spraying with Bordeaux mixture, though in some cases we have sprayed the young plants fourteen different times covering an interval of as many weeks. We have seen a little injury from spraying, of a sun-scorch type, when the plants were uncovered and sprayed in strong sunlight. Similar injury might result from careless watering.

We have evidence that plants thoroughly coated with the spray do not become infected anything like unsprayed plants in the same beds. Spraying to be most effective, however, must start before the appearance of wildfire and be continued until the end of the transplanting season. We would start with the young plants that have just taken root and whose largest leaves are about the size of a thumb nail, and spray every week thereafter. Spraying we believe is the only remedy that prevents spread of the wildfire in a seedbed no matter what the source of its introduction. Homemade Bordeaux being cheaper and apparently somewhat more effective, we prefer it to commercial brands though most growers like to buy a prepared mixture rather than make it themselves. We do not as yet advocate commercial lime-sulphur and have had little experience with the dusts. A fifty gallon barrel of Bordeaux properly applied should be sufficient to go over once a six-foot bed of 400 to 500 feet in length.

One cannot be too careful to see that the plants he is to set out are absolutely free from the trouble. This does not mean that if a grower finds a little of it in his seedbed, he should neglect this bed and purchase plants elsewhere. Unless he has had opportunity to thoroughly acquaint himself with the seedbeds from which he purchases plants and knows that they are free from this disease (or at least better than his own if he cannot obtain plants from wildfire-disease-free beds) he had better stick to his own beds and make efforts to eliminate or at least prevent further spread of the wildfire.

If a grower finds that the best thing for him to do is use his own plants in which wildfire has appeared because of his neglect, he should start at once to attempt to eradicate the disease. We use the word *attempt* since we believe it will be difficult to absolutely eradicate it once it has appeared, although it may be so masked as to seem to disappear entirely. Growers in 1921 attempted this by killing certain beds or parts of beds, (Plate XXIX d) with formalin (one to fifteen parts water) sprinkled over the bad spots. Care in airing has to be used in this case so that the fumes do not extend beyond the sprinkled spot and injure other plants. One sprinkling will not always entirely kill plants of some size. If these spots are few in number it is just as well to pull up all the plants in these spots and those on their border and destroy them. Spraying, as advocated above, should then be begun and especial care given in airing and watering, and the beds be watched for any further infection, always removing any suspicious plants at once.

Disease in the Fields.

General Appearance. The first stage in the field is the halo yellow spot state (Plate XXXI a) already described under the seed-bed infections. On the larger leaves of the field plants, of course, many more of these halo spots eventually appear. Naturally badly infected plants are rarely set out by the growers. Growth of plants is slow at first after transplanting and little spread takes place then. If the weather is also dry no spread occurs, and as the older infected leaves wither up and fall off there comes a time when the disease seems to have largely disappeared. The grower is then apt to conclude that his plants have outgrown the trouble. With later wet or muggy weather of several days duration, however, the wildfire can reappear with startling suddenness. As the plants gain in size it will be found that the wildfire is largely confined to the older and lower leaves. With age and conditions favorable for spreading, the upper leaves also become infected, until at the end of the season the uppermost small leaves of the flowering branches may even show the trouble.

Once the disease gets a good start the old yellow halo spots gradually give place to white or brown spots of varying shades, the chlorophyll having disappeared and the tissues die (Plate XXXI b). This is when the serious injury from the disease really begins. These spots are still roundish and usually show a more or less evident yellow border, the remnant of the halo stage. If the spots are now abundant enough on the leaf the intervening tissue may die and the whole leaf become irregularly spotted and eventually brittle and worthless. The final injury is indicated by the number of leaves thus destroyed and the partial injury to the remaining spotted ones. The greatest injury comes just after the disease spreads over the plants during the period of wet weather and the sun suddenly appears again. The halo spots then turn to brown irregular burn-like areas (Plate XXXI c). This transformation often takes place quickly and so probably is largely a mechanical injury to the badly infected tissues. One grower claimed that most of the injury in his field occurred in a few hours after such a rainy period was followed by bright sunshine.

Conditions favoring Spread. Infected Seedlings. The first, and by far the most important, factor we need to consider in field infections is the seedlings used in setting out. Our experience last year indicated that if the grower can set his field with plants absolutely free of wildfire he has very little to fear from this disease. As a rule the greater amount of infection in the seedbed the greater amount of injury one may expect in his field. This does not always hold, however, and it does not necessarily mean that if one grower has it bad in his seedbed and his neighbor has only a moderate amount, that the former will have the poorer crop. Often the field conditions are factors in the greater or less spread of the disease. It is likewise true that a moderate number of the diseased plants scattered over the field, with very favorable conditions for spread, can by the end of the season injure the crop as completely as would a large number.

It is always best, however, to play safe if one can do so. For example, we know of a grower who had a moderate amount of wildfire develop in his beds. These beds were later sprayed a few times and the disease was kept down so that it no longer appeared conspicuous. The plants as a whole were unusually nice looking and healthy. This grower would not use these plants but went to a district some distance away and bought plants that were known to be free of this disease. The plants otherwise were not as good as those in his own seedbeds. A neighbor knowing that wildfire had occurred in this man's beds, but seeing how well they looked, bought the beds for his own use. He did not use especial effort to throw out the wildfire plants though they at that time were not prominent as such. He did notice after the plants were set out that there were some in the field. However, dry weather followed and the wildfire seemed to be disappearing. Then, suddenly, there came on a more favorable period and the wildfire spread rapidly through that part of the field where diseased plants had been seen, and to a less extent where they were not so conspicuous. He became alarmed and began to prime his plants earlier than he naturally would have done, and in this way avoided a part of the very serious injury that would have resulted had the plants not been primed. The other man grew a crop not injured at all, although his field had a less favorable start than it would have had with his own plants. A little wildfire in one or two spots on just a few plants finally appeared, but whether from the soil or accidentally carried into the field in some manner we could not determine.

It is not an uncommon practice for a grower who runs short of plants to purchase additional ones from another grower without especial attention being paid to them except their general vigorous appearance, which may be very deceptive so far as the presence of wildfire is concerned. Such plants in setting are often scattered more or less throughout the fields with his own plants. In case they happen to come from beds containing wildfire while his own were entirely free, their presence thus scattered through the fields may largely nullify the advantage he had with his own disease-free plants.

If it is necessary to buy plants outside, one should be sure that they are as free from this trouble as his own, and if possible plant them in blocks by themselves to prevent any outside spreading if infected, or to protect them if free, from his own possibly infected plants. We know of growers who were fairly free from wildfire in their own seedbeds but who brought the disease in by purchased plants which they happened to keep together in certain parts of their fields, and as a consequence the disease developed much more prominently there than elsewhere.

Method of Handling Seedlings. Another factor that seems to be very favorable to spreading the disease before planting is the manner in which the seed plants are handled after pulling from the beds. Often the plants are wet down all over and allowed to stand for some time before planting. Where wet closely packed plants, some of which are infected with wildfire, are left in the baskets over night in a damp atmosphere, the disease will spread further according to our experience. If the plants cannot be used soon after pulling, it is just as well to keep water off the leaves, although if necessary the basket may be kept on moist ground with a good air circulation above.

Certain of the crosses experimented with at the Windsor farm in 1921 came from a seedbed in which wildfire was present. This could not be avoided as they were the only plants of the kind to be obtained. Another mistake was made in pulling the plants on a Saturday or Sunday and keeping them in a damp place until Monday. As a result of this treatment wildfire developed in this field even worse than it did in another set with badly diseased plants as a wildfire experiment. At least two growers have told us of a somewhat similar experience where they kept wet plants in baskets in cellars over night. These wet plants were set together in fields otherwise planted with freshly pulled seedlings from the same bed. Wildfire in each field first showed prominently in those particular parts set with the hold-over plants.

Infected Fields. The next point to consider is, will a field set with plants free from the disease later become infected? We believe it can under certain conditions. This will not likely happen, however, in such isolated regions as the Housatonic valley, or the towns of Cromwell, Portland or Middletown of Middlesex county.

It may not even occur in fields in a badly infected region. That it does occur is shown in the example cited under conditions favoring spread. In any case it is not likely to become serious if the field is at all isolated from infected fields. Where an infected crop was grown on the land the previous year, the rotted or rotting leaves, especially of the suckers, may possibly be the source of an infection here and there. The encouraging thing about this is that they apparently are not the source of any serious field infections.

We know a grower who had a little wildfire in his field in 1919 but paid no especial attention to it. In 1920 in the same field he had it so seriously that he made an effort to keep wildfire out of his seedbed in 1921, with the result that the plants set that year were fairly if not entirely free, and so in much better shape than the year before. His crop this year on the same land showed no ill effects from wildfire, although showing some slight signs of it. This would not have been the case if the germ had carried over abundantly in the soil, as the season on the whole was favorable for the development of the trouble.

Soil, Fertilizers, etc. We cannot speak very definitely about different types of soil as regards the development of this disease, since we have seen it on all types, sometimes worse on one and sometimes worse on an entirely different type. In general we are inclined to believe that a soil that dries out quickly would not favor the spread of the trouble as readily as a wet one. Likewise a field on a hillside would not be so bad as one in a lower or less protected position. Yet we have seen fields where the worst infections were on the higher, drier spots. This was when the field as a whole was too wet, however. Perhaps a favorable location for the spread may be held back by the slight infection to start with, or an unfavorable one be aided by an original heavy infection of the plants. In such cases neither will prove as bad as where both factors are favorable for the rapid spread.

So far as fertilizers are concerned we can only say that the use of any fertilizer that favors rapid growth is more likely to help infection, during a period of weather favorable to the spread of the disease, than where the fertilization is such that slower or less satisfactory growth takes place. Our field fertilization experiments were not extensive, but so far as they proved anything they showed that the plants with added fertilizer, especially that with nitrate of soda, giving more rapid growth, were the worst infected.

Speaking along this line before tobacco growers at Suffield in 1921 Garner (11.), of the U. S. Department of Agriculture, said:

"It has been found that, other things being equal, an increase in the nitrogen supply of the plant increases its susceptibility to leaf spot, for nitrogen promotes a rapid, tender, 'watery' type of development. This conclusion is based on extensive observations in the field by means of fertilizer plot tests and other field and laboratory studies. * * * * As a general propostion applying nitrate of soda or other quickly available form of nitrogen to young tobacco seedlings should be avoided as far as possible and if used at all, an excess should be guarded against. On the other hand, a liberal supply of potash in suitable form tends to increase the resistance of the plant against leaf spot by promoting a more substantial hardy type of growth. Potash alone cannot be relied upon as a means of control but at times it is of great value and is to be recommended as a safeguard both in the field and in the seedbed."

Rain and Wind. These factors have to be considered somewhat together since they often act simultaneously; at least wind without rain has no effect unless it is by occasionally carrying the wildfire germs into fields through dust. This last statement is based largely on supposition rather than proof. We do know positively, however, that rainy weather of some duration, with or without wind, is favorable to the rapid development of wildfire. There were only two periods during 1921 that favored spread of wildfire in the fields. The first of these came the week of June 26th to July 2d, the latter half being especially favorable for the spread. Growers first began to notice this increase on July 2d, and by the 4th the injury was very pronounced. Previous to this time the disease had spread little or none even in fields that were set with plants badly infected. This led some growers to believe that there was nothing to fear from this trouble.

The only other time during the year when there was a general spread was about the last of July and the first of August when there was a similar prolonged moist period. This was when the most damage occurred, as the previous period had spread the disease so that it was abundant or wide spread in many fields. However, even with this last serious development there were some rather badly injured fields that had spots in which the plants were not hurt to any great extent.

In the first spread the rain was accompanied by a high wind that in itself caused much damage to the plants, but entirely independent of this was its effect on the spread of the wildfire. This wind came from the west, or more accurately from the northwest. That it had something to do with the spread of the wildfire was shown in fields exposed to its full sweep. Here the wildfire developed at first most prominently on that side of the plants exposed to the wind. This phenomenon had been noticed the previous year. It can be explained by the dashing of the rain drops onto the ground with consequent spattering of the muddy water containing the germs onto the leaves. These germs may have been washed off the plants or may have been carried into the soil by the infected dead leaves that gradually disintegrated there. These suppositions are borne out somewhat by our infection experiments with muddy water from infected soil.

In contrast to this condition there were other fields, more protected from the wind, that showed no special infection of the plants on one side over the other. There were also particularly protected fields or spots where the total spread was not nearly so great. In some of these cases other factors entered. In the Station field, for instance, where the plants were shaded by barns, hedge rows, etc., there never was the spread that there was in the more open places. Protection against the wind and rain accounted for this in part, but it was also due to the slower, smaller growth from shading and poorer fertilizing. We saw another field, protected on two sides by a forest, where the growth and the wildfire infection were both much less than in the more open and exposed part. In a dry season rather unfavorable for wildfire it is quite possible that the reverse of these results might occur since here the shaded parts would have better moisture conditions.

The effect of a rainy or a dry season on wildfire development has been evident in the southern states where this disease first appeared. It has not increased each year but its severity has been entirely regulated by the moisture of the growing season. For example, in most of the southern states last year it was much drier than usual, and the result was that wildfire was inconspicuous. In other wet years wildfire has threatened the industry by its severity. We may expect similar variations in this state; in other words, if one were able to foretell the weather he could predict the severity of wildfire that year.

Distance of Spread. We have no records of the spread of the disease *from a distance* into an isolated field by means of wind or even by insects. In fact infection by these agents would be an extremely difficult matter to absolutely prove, but so far as our observations go, it does not seem that either is a *common* method of field infections. If this does occur the infections are so infrequent as to prove of little consequence. On the other hand we have seen many cases where we are sure that the disease has spread from infected plants in the field to those near by and even from one field to another separated only by a short distance. In such cases the spread seems to go most rapidly with the wind or the wind driven rain. A few examples will illustrate this.

At the Station's Windsor farm several rows of disease-free seedlings from New Haven were set out late. These had badly diseased plants on one side and plants with little disease on the other. While the rain storms of late June and early July were largely away from these plants toward the badly infected, they soon became infected, at first largely on the side toward the badly infected but in time all over. In another place disease-free tobacco plants were beside infected, but so that the wind came from the diseased ones to them, and here the general infection was much more rapid. A more isolated field entirely out of the direction of the wind from the diseased plants, showed only slight infections here and there, but mostly on the end towards the diseased plants. The wildfire, however, was so slow here in getting a start that it never became serious.

A grower near Windsor Locks set out a couple of rows containing infected plants on one side of his field in which there was no disease. It spread slowly to the next row or two but not further in, at least not before the middle of the season when last seen by us. Another grower near Broadbrook had in July a badly infected field with the last one or two rows from another source fairly free. Just beyond these and a narrow grass roadway was another field almost entirely free, the wildfire having spread only to a few plants in the first row or two next the diseased field. We know of another field at East Granby badly injured, while the adjacent field of another farmer separated by a rod or two of grass remained practically uninjured during the whole season, the most infections being next the badly infected field. In another badly infected field at Hockanum wildfire spread only slightly to the corner of a field overlapping but separated by a grass roadway.

These and other instances, together with the probable fact that the germs do not carry over to any great extent in the fields, lead us to conclude that if the grower keeps the trouble out of his seedbed he need not fear serious injury in his field.

Varieties Injured. While we have proved that the different varieties grown in the seedbeds showed no difference in susceptibility to this disease, the fact remains that in the field they are not all injured to the same degree, even when the percent. of infected plants set out was the same. This does not mean that in the field certain varieties acquire immunity but rather that the type of growth and the manner of handling the plants seem to influence the spread of the disease as the plants grow to maturity. In general we can classify Broadleaf and Havana as being more subject to injury, and Round Tip and Cuban as being less.

There is little doubt that Broadleaf on the whole will suffer more from this disease than Havana, though fields of the latter are also frequently severely injured. The large drooping Broadleaf leaves coming in greater contact with the ground, seem to offer the best conditions for infection of any of the varieties. The fact that Havana has the leaves more erect and so not so frequently in touch with the ground, especially the higher ones, seems to help lessen infection somewhat. Where Havana plants are primed the infection is somewhat checked by removal of the infected leaves before the end of the growing season. Some growers take advantage of this and by early priming try to keep partially ahead of the spread, or at least pick the leaves if possible before serious injury occurs. This is never done with Broadleaf so all the leaves are exposed throughout the season.

Round Tip as compared with Havana suffered less, partly because the leaves of this variety are always primed. Other factors tending to lessen its infection are the shorter and broader leaves, separated more widely on the stem with the last ones borne much higher from the ground and the more vigorous root system that keeps the plants from lopping over in heavy winds. We have not had opportunity to examine a sufficient number of Round Tip fields to state that these advantages always hold. We got some rather badly infected plants in certain of our field experiments where there was no priming made.

Undoubtedly the Cuban tobacco grown in the tents suffered the least of any of the varieties and we have no records of any very serious losses with this variety. Not only does it have all of the advantages mentioned for the Round Tip (except the strong root system) but it also has the further one of partial protection of the tent against the whipping rain storms that seem to bring the most infections. Even in cases where we know considerable infection on the young plants was carried into the tents the resulting injury was not nearly as serious as similar infections produced out in the open on Broadleaf and Havana. However, it can be said that on the whole the grower of tent tobacco took more precautions to prevent this trouble, both in the seedbeds and the fields, than did the growers of Havana and Broadleaf.

Damage. According to the variety and the degree of freedom from the disease we could find all the way from no loss up to a total loss. In a number of fields we estimated the damage around 60 to 70%. When a field is injured to this extent it is very doubtful if it pays to harvest the crop, because the subsequent cost of harvesting, curing, etc., will sometimes be greater than the return from such a crop.

The damage caused in all of the 125 fields inspected, estimated at the time of the last inspection, is shown by varieties in the following table. Of course these fields were inspected at different dates and some only once, so the final damage may have been greater than given here. Apparently no further injury results after the crop is harvested, as there is no evidence that the wildfire spreads on the leaves after hanging in the barns.

Variety.	Very bad, over 50%.	Bad, 25-50%.	Moderate, 5-10%.	Little, Less than 5%.	Free.
Broadleaf,	5	5	8	12	8
Cuban,	0	0	2	9	0
Havana,	2	3	6	10	50*
Round Tip.	0	0	2	3	0

* Chiefly in the wildfire-free Housatonic valley.

The damage by wildfire to Connecticut tobacco is more serious, even with the same percent. of injury, than it is in most other states for the simple reason that all the tobacco grown here is for wrappers. The same injury to a leaf used as a wrapper means much more than it does to a leaf used for a binder, filler, or for other purposes. The injured tissues have that lifeless quality which is so objectionable because of brittleness but whether or not the burn is affected we cannot state. In the field the infected tissues do not often fall out to any extent but are more subject to injury in the handling during curing, fermentation, etc. The color is also affected. These factors would not be so objectionable in tobacco used for other purposes. If the spots are small and infrequent perhaps no great objection would be raised as spots of various kinds in the past have sometimes been sought for rather than avoided. Another consideration besides the use to which the tobacco is put, in estimating the financial loss, is the value of the product. Wrapper tobacco is sold for a higher price than any other tobacco, and in the tent-grown reaches its highest value in this country. Therefore a 50% injury to a dollar-a-pound tobacco means a loss of fifty cents as compared with a loss of five cents on a ten cent tobacco similarly injured. In view of these facts it is much more essential that the disease be controlled here than it would be in some of the southern states.

Control Measures. What are the control measures that can be taken when the grower finds that he has the wildfire in his field? In the first place these must be confined largely to the early stage, as not much can be done with the older fields. There are only two measures of any value of which we know and these are: 1st, Destruction of infected plants, and 2d, Removal of the infected leaves. A third measure that has been suggested is spraying or dusting the plants with a fungicide. We have tried spraying in a preliminary way, but feel that even if this may be helpful in retarding the spread, as it did in our experiments, it is generally not a practical method of control because of the cost and the unknown effect of the spray on the quality of the mature leaf. The other two methods may be discussed further under their separate headings.

Destruction of Infected Plants. This may involve only a few plants or the plowing up of the whole field. Let us consider the former first. After setting out their fields in 1921 a good many growers found that the disease was showing on the small plants. Some few then went over their fields and removed these diseased plants and reset with healthy ones. Where the diseased plants are not very abundant we believe that this is a good practice. The time to do this is within two or three weeks after the plants are set out and are just beginning to grow. The plants pulled up we believe should be placed in baskets and carried off the field. As the plants are small at this time this will not involve much extra labor. Handling of the healthy plants should be avoided, and the field reset as soon as possible with healthy plants. We doubt if this method is practical after the plants have grown to any considerable extent, because of the greater amount of work involved, and the resulting unevenness of the field if reset.

We have no positive data as to the value of this treatment but only the knowledge that theoretically we have removed so many plants that would have served as centers of spread under favorable conditions. Not all of the infected plants will have been removed, even with a second careful inspection of the field, as the disease will be so masked on some of the leaves as to escape detection. If, however, a large percentage has been removed, this should help delay the spread and under some conditions certainly would serve to protect the field against the more serious injury that would have resulted with a greater infection to start with.

Where there was considerable infection in a field some of the growers plowed up the whole field and reset with other plants. This is a practice that can be followed only when the plants are small and one is sure that the new plants put out are freer of the disease than those plowed up. The question arises whether or not these plants plowed in may not serve as source of infection for the new plants. We believe that this infection is at least possible under some conditions, but whether or not it is ever a serious menace we have no data as yet to make a positive statement. We do know of at least one field where the infected plants were plowed under, which after replanting remained fairly free from the disease until danger of serious infection, at least, was past. We heard of another field seriously injured in 1920 that was plowed up when the plants were of some size and reset, and in this case also the disease did not make any headway later. The late replanting gave a fair growth but quality was lacking in the crop. This is a thing that must be taken into consideration in plowing up infected fields, namely, it must be done in time so that the replanted crop can thoroughly mature. The season of 1921 was more favorable than most seasons in this respect since the frosts held off unusually late, allowing late planted fields to mature.

It is not always easy to decide whether or not to plow up a field. We know, for example, of a grower of tent tobacco who had a considerable amount of wildfire in the plants when set out. The plants were of some size when, because of the abundance of wildfire, he was advised to plow up the field. Because of the difficulty of plowing them under, he let them grow finally, and got a crop fairly free from injury. He might not have been so lucky if this crop had been Broadleaf, for no doubt the tent and priming helped to keep down the disease in this case. Each grower will have to settle his own policy after careful inspection of his field as no hard and fast rule can be laid down to govern all cases.

Removal of Infected Leaves. If the infected crop has begun to grow and it is too late or inadvisable to plow it up, there is still a possibility of partial control by picking off all lower leaves showing any signs of infection. In fact, if the plants have only a few infected leaves it is better to pick off all the leaves below these as well, whether or not they show halo spots. On such leaves the infection may be present and still not be very evident because of their yellowed and often withered condition. They are of no commercial value anyway. On young plants the removal of these leaves, if there are still several healthy green ones remaining, does little injury to the growth. After the plants have made some growth it may be found that the first removal was not sufficient and a second or even a third be required. In the latter case if many large leaves are removed the plants are later hindered in their growth. In other words, the removal of leaves once or twice before or shortly after the plants have started to grow seems practical, but if required again, where the final leaves of commercial value have to be removed, it is of very doubtful value. The removal therefore should be with fairly small plants and include leaves of no commercial value and should take place before there has been much chance for field infection from the infections actually brought from the seedbed. Leaves removed should, for greater security, be carried off the field.

We know of one or two growers who practiced this removal and felt that it had resulted in a more limited field infection. These were cases of Cuban tent-grown tobacco and it looks as if the best results would be obtained with this variety. These lower leaves are of no value and often are picked off and thrown on the ground so that only a little more care and effort is required to do a good job. The advantage would be to get rid of a considerable number of infections and also to remove those lower leaves that come in contact with the ground from which secondary infection might start. The usual priming that follows in these fields then should help to keep in check further serious injury.

With primed Havana similar treatment might be helpful to a less degree but with unprimed Havana and Broadleaf the value is uncertain. In these cases it would naturally be limited to the very early stages of growth. Once it becomes necessary to pull off the large or commercial leaves, it is doubtful if one can check the disease enough to pay for the extra expense of removal, loss of leaves removed and injury to the growth of the plant that results. We know of a few cases of infected Broadleaf of some size where removal under these conditions did not seem to be of any value.

Our own experiments at Windsor were rather unfavorable to removal of leaves as a means of retarding the spread of the disease. The leaves here were removed from some of the rows once and from others twice, with check rows with leaves unremoved. Eventually the disease spread about as badly to those rows with leaves removed once or twice as to those with leaves unremoved, and the second late removal checked somewhat the rapidly growing plants. In this experiment, however, there was no protection against re-infection of the plants after their infected leaves were removed, since they were always side by side or nearly so with rows from which no leaves were removed. Because of this it is quite possible that much of the value of removal was lost compared with an entire field in which total removal is practiced.

Seedbed and Field Experiments.

These are miscellaneous experiments tried during 1921 in an effort to learn something about the development, spread and control of wildfire. It is partly from these and the laboratory studies that our preceding statements have been made. Quite a number of the field experiments were not followed closely after it became evident that wildfire was general in the plants experimented with, as little further information was to be gained. Upon the whole we did not aim to collect figures to illustrate the results, but rather depended on general examinations.

Spraying and Dusting Seedbeds. It must be borne in mind that the treatment of seedbeds was begun in most cases after the wildfire appeared in them. In a few cases wildfire did not develop much further, or at all, either in the sprayed or unsprayed parts, so here conclusions could be drawn only of the general effect of the fungicides on the young plants. In most cases Bordeaux mixture was used, and this was usually the homemade 4-4-50 strength, and almost always had lead arsenate in it. In one or two cases Bowker's Pyrox or other commercial Bordeaux mixtures were used, and in one place Bordeaux dust was compared with Bordeaux mixture. Altogether spraying tests were made in nine different beds in the following places: three at Rainbow; one at Poquonock; three at East Hartford; one at East Windsor Hill; one at New Haven.

Seedbeds 1-2, Rainbow. Each seedbed had the same treatment and other conditions were the same: Havana, glass, soil sterilized, flea-beetles rather abundant; used lead arsenate in each spraying; sprayed five times, May 9, May 20, May 27, June 3, June 20; wildfire scattered irregularly in spots in beds before treatments began. Plot 1, Check, no treatment (except received spraying first time), 35 feet of each bed. Plot 2, Homemade Bordeaux, 4-4-50, on twenty-five feet of each bed. *Results:* Final examinations showed that wildfire did not develop further in the sprayed plots, and while its spread in the checks was not so rapid as earlier, the difference between them was marked by the characteristic halo spots on unsprayed plants close up to the line separating the two plots. Likewise the flea-beetle injury was much more evident on the unsprayed plants. The grower did not use these beds (he also destroyed with formalin four other more badly infected beds, see Plate XXIX d) but bought disease-free plants elsewhere; he had no trouble in his fields. Another farmer bought the experimental beds but we did not examine his field except very early in the season when very little wildfire showed.

Seedbed 3, Rainbow. Same place and variety as beds 1-2, but with soil unsterilized, cloth covers and planted very late, after appearance of wildfire in the other beds. Spraying was started on the very young plants soon after coming up (largest leaves size of finger-nail) and before any wildfire showed. Care was used in watering, and airing was always good. Sprays, all containing lead arsenate, applied seven times, as follows: May 27, June 3, June 10, June 20, June 28, July 6, July 14. Plot 1, Check, no treatment, first 20 feet of bed. Plot 2, General Chemical Co. Bordeaux, 3½ lbs. to 50 gals. water, next 20 feet of bed. Plot 3, Bordeaux mixture, homemade, 4-4-50, 20 feet of bed. Plot 4, Bowker's Pyrox, 10 lbs. to 50 gals. water, last 20 feet of bed. *Results:* June 20th wildfire appeared in the Check plot in a single spot, and eventually showed abundantly in several spots, one or two entirely isolated from first. Weather was not very favorable, except once for spread, so disease finally became more or less masked. Eventually it also appeared in a very small spot in Plot 2, but did not seem to spread. This plot was nearest to the check, and seemed least protected by spray as the sediment was not so evident on leaves after spraying. No wildfire was seen at any time in the other two sprayed plots.

Seedbed 4, Poquonock. Havana, soil sterilized, beds with glass but uncovered most if not all of the time. Wildfire showed a little in spots over bed before treatment began. Spray, containing lead arsenate, was applied five times, May 11, May 15, May, 20, May 27, June 3. Plot 1, Check, no treatment (except received spray the first time) first 12 feet in bed. Plot 2, Bordeaux mixture, homemade, 4-4-50, on rest of bed, 50 feet. *Results:* This and the other beds of the grower were among the first to show wildfire, but because of care in airing and one or two general sprayings, the disease never became very prominent after its first appearance. In our experimental plots there was no further development in the sprayed one, and apparently but little more in the check. However, plants used from the other beds developed a conspicuous wildfire outbreak in the field in early July.

Seedbed 5, East Hartford. Broadleaf, soil sterilized, glass alternating with cloth sash. Wildfire appeared shortly before first spraying, spotting bed more in some plots than in others. Used lead arsenate in all sprays which were applied four times, May 18, May 24, June 1, June 8. Plot 1, Check, no treatment, 8 feet at end of bed. Plot 2, Bordeaux mixture, homemade, 4-4-50, next 40 feet. Plot 3, Bordeaux mixture, homemade, 2-2-50, 32 feet of bed. Plot 4, Bowker's Pyrox, 10 lbs. to 50 gals. water, last 48 feet of bed. *Results:* Before treatment most wildfire showed in the Bordeaux plots, but did not increase afterward and really became less conspicuous; also no further development occurred in the Pyrox plot. The check plot had least of any to start with, and because of good airing and watering, it did not increase very much. Care was used in selecting plants from this and bed 6 for field planting, and wildfire was never conspicuous there.

Seedbed 6, East Hartford. Same grower and conditions as bed 5, but only three sprayings given, the first being omitted. Experimental plots 1-4 with same treatment as in bed 5. Wildfire more prominent in this bed when treatments began, especially in the sprayed plots. *Results:* Wildfire checked in all the sprayed plots, as there was no further development there, but in the check plot it developed further in spots. A little burn, of the sun-scorch type, resulted after the second spraying of June 1st, probably because made in too strong sunlight on recently uncovered plants.

Seedbed 7, East Hartford. Same grower as of beds 5-6 but bed late planted and in more shaded, damper spot, covered with cloth only. Four treatments on same dates as bed 5. Plot 1, Check. Plot 2, 2-2-50 Bordeaux. Plot 3, 4-4-50 Bordeaux. *Results:* Very good place for development of wildfire but germs apparently absent as no wildfire was seen either before or after the experiment in any of the plots. No spray injury.

Seedbed 8, East Windsor Hill. Broadleaf, beds not sterilized, glass. No lead arsenate used in any of the three sprayings (as flea-beetles not evident) made on May 18, May 24, and June 1. Wildfire evident in about two-thirds of bed before spraying began. Plot 1, Check, no treatment, 8 feet of bed. Plot 2, Bordeaux, homemade, 4-4-50, remaining 40 feet. *Results:* Wildfire was checked entirely in sprayed part of bed and became less conspicuous in time. In the check it developed so that it was more prominent even though masked and hidden by the crowded plants at the end of the experiment. Other beds were sprayed at least once by the grower, kept well aired, and he took his plants only from the least infected parts of the beds. However he got a fair sprinkling of infected plants in the field, and eventually suffered about 15% loss from wildfire. If he had not used this care in the beds and in selecting his plants, his loss, without doubt, would have been much greater.

Seedbed 9, New Haven. Havana, soil unsterilized, cloth cover. This was planned to test value of dusting as compared with spraying, using both Bordeaux and Lime Sulphur dust as well as Bordeaux mixture and commercial L. & S. solution. Some of the plots whose seed was soaked with water containing wildfire germs did not come up so only Bordeaux mixture and Bordeaux dust were used. The experiment was started in the fall and five treatments were given in the seedbed, on Oct. 4, Oct. 10, Oct. 19, Oct. 26, and Nov. 6. After the last treatment, however, a few plants from each plot were transferred to small flats in the greenhouse and treatments continued there during the next nine weeks. Plot 1, Check, no treatment, seed sterilized with formalin. Plot 2, seed and soil sprayed with wildfire germs before planting; dusted well each time with Glidden's Bordeaux dust. Plot 3, seed and soil sprayed with wildfire germs before planting; sprayed well each time with homemade, 4-4-50 Bordeaux. *Results:* No wildfire developed on any of the plants in the seedbeds or in the greenhouse. No evident injury resulted from spraying with Bordeaux mixture fourteen times. Soon after dusting began it was seen that these plants were yellowing and injured somewhat; they were more or less stunted by subsequent treatments and never grew as large as those sprayed.

Killing Plants with Formalin. This was tried only in two beds. Formalin at rate of 1 to 15 of water was liberally sprinkled with an ordinary sprinkling can on marked wildfire spots. The next day the plants were all dead; The photograph (Plate XXIX c) shown here was taken several days later. Care was used not to get the liquid outside the spots and the beds had the sash off at the time. No injury showed outside the sprayed spots. We have seen older beds where all the plants were sprayed and many leaves killed but the plants started to grow again. It is evidently harder to kill large than small plants, but in these cases less liquid or a weaker strength may have been used. See Plate XXIX d.

Field Experiments with Infected Seedlings. These were experiments with plants of different varieties selected from various infected beds and transplanted at New Haven and the Windsor tobacco farm, where they could be especially watched to see how the disease progressed later.

Windsor Experiments. The tobacco plants were set out June 7th at the Windsor tobacco farm with eight rows to a plot, except plot 5 which had six. The rows averaged about 150 plants. The Broadleaf, Havana and Round Tip plants in plots 1, 3 and 5 were obtained from seedbeds bad with wildfire, at least in spots, and infected seedlings were selected as far as possible. As check to these, plots 2, 4 and 6 were set with plants free, or nearly free from wildfire. Table IV shows the results of the examination of all the plants on June 28, before there was any appreciable spread of wildfire, but late enough for any masked seedbed infections to show. The check plots had only a few slightly infected leaves and these were all removed on this date, check plot 6 being the worst of these but still with less than 3% slightly infected plants as compared with 67% in the Havana wildfire plots. There was no check, wildfire-free, Broadleaf plot. After the July 4th spread the disease became general in the infected plots and even spread considerably into the check or free plots. In these it appeared most abundantly in the rows next the infected plots and by the end of the season had spread generally through the rows, but never so bad as in the wildfire plots. The west end of all the plots, both wildfire and check, never developed nearly as much wildfire as the east end which was more exposed and better fertilized.

TABLE IV. WILDFIRE PLANTS ON STATION FIELD, WINDSOR.

Plot.	*Row.*	*Locality.*	*Variety.*	*Seedlings Condition.*	*Total Plants.*	*Inf. Plants.*	*% Infected.*
1	1-8,	Rainbow,	Broadleaf,	Bad,	1113	439	39.0
2	9-16,	Suffield,	Havana,	Free,	1375	1	.08
3	17-24,	Suffield,	Havana,	Very Bad,	1254	837	67.0
4	25-32,	Windsor,	Round Tip,	Trace,	1197	13	1.0
5	33-38,	Suffield,	Round Tip,	Bad,	777	386	50.0
6	39-46,	Windsor,	Round Tip,	Trace,	1006	32	3.0

While the examination of June 28 showed that the Havana wildfire Plot 3 had the highest infection, 67%, Round Tip Plot 5 next with 50%, and Broadleaf, Plot 1, the least with 39%, after the favorable weather ending July 4th it was seen that the spread was greatest in the Broadleaf, next in the Havana, and least in the Round Tip. This agrees with our experience elsewhere that these varieties are injured differently in the field. While no counts were made over the whole plots as on June 28th, counts on July 27 of a few of the unsprayed plants, given in Table VIII, at the least injured end of the field bring out this same variation in spread according to variety. For example, all 8 unsprayed Broadleaf plants taken as they came in the row were infected and had 55 infected leaves showing 1576 wildfire spots, as against 19 infected Havana plants similarly counted with only 71 infected leaves containing 602 spots and 16 out of 19 counted Round Tip plants with 48 infected leaves containing 204 spots. Figuring from this data the ratio of spots per plant in each variety, the difference would be still more marked since the Broadleaf plant would have 196 spots, the Havana 32, and the Round Tip only 11, despite the fact that the Havana seedlings were the worst and the Broadleaf the least infected to start with.

New Haven Experiments. At New Haven the plants from different sources were set out in small numbers in a garden plot so that they were all close together. There was no very evident development until July 5th, just at the end of the favorable moist weather for spreading already mentioned. Before this time in most cases the disease became less rather than more evident, as the infected leaves matured and disappeared. In one case (No. 1585) however, the disease became more evident soon after planting as it was masked in the seedlings when set out. The disease-free plants from New Milford remained practically free until July 5th, when they became more or less abundantly infected, largely from infected leaves previously buried under them, but partly by spread from the nearby infected plants. We shall speak of these later. The condition of all plants as regards wildfire on July 11, together with other data, is shown in Table V. An examination of these data shows that no varieties had any pronounced freedom from the disease when closely planted in small plots with others, with no topping, priming, etc., to limit the spread; in other words the Cuban tobacco became infected almost as badly as the Broadleaf.

TABLE V. WILDFIRE PLANTS IN STATION GARDEN, NEW HAVEN.

Exp. No.	Locality.	Variety.	Date of setting.	Seedling cond.	Plants set.	Plants lived.	Condition of Plants on July 11th. No. free.	Little.	Mod.	Bad.
1569	E. Windsor Hill,	Havana,	May 26,	Consid.,	25	24	0	23	1	0
1570	E. Windsor Hill,	Broadl.,	May 26,	Bad,	50	32	0	13	15	4
1576	Windsor,	Havana,	May 28,	Consid.,	25	12	1	9	2	0
1577	E. Granby,	Havana,	May 28,	Consid.,	50	37	0	16	18	3
1579	Suffield,	Round Tip,	June 1,	Bad,	18	13	0	4	8	1
1582	W. Suffield,	Havana,	June 4,	Very bad,	55	48	0	7	26	15
1583	E. Granby,	Cuban,	June 4,	Consid.,	18	13	0	2	5	6
1584	Warehouse Point,	Havana,	June 9,	Bad,	17	17	0	0	8	9
1585	Glastonbury,	Broadl.,	June 9,	Very little,	114	109	1	30	65	13
1587	Ellington,	Broadl.,	June 11,	Bad,	26	24	0	8	14	2
1588	N. Milford,	Havana,	June 15,	Free,	38	38	1	13	17	7
1588a	N. Milford,	Havana,	June 15,	Free,	11	8	2	5	1	0

Infection from the Soil. Certain of the wildfire-free Havana plants (1588, Table V.) from New Milford had wildfire leaves buried in the soil under them on June 15th. After the first field outbreak, showing July 4th, these plants became abundantly infected. As they were near other wildfire plants the infection may have in part come from these, but we believe most of it came from the germs in the soil from the buried leaves, as the eight check plants (1588a) under which no leaves were buried, had only 13% with moderate and bad infections as compared with 63% in the others. These checks, too, were more exposed to the other infected plants nearby. The infections also showed more on the sides of the plants under which the leaves were buried. Later, soil from under the plants where the leaves were buried was sprayed with water onto plants in the greenhouse and a few infection spots appeared. These experiments seem to confirm our field observations that the spattering rains carry infection from the soil to the leaves.

Spread of Disease in Marked Fields. In order to determine the spread of wildfire under ordinary field conditions, six fields were selected that were set out by growers with plants from seed-beds having no, a little, and considerable wildfire. These included all four varieties of tobacco grown in Connecticut. On the first examination or two, up to July 4th before there was any field spread, these infected plants were marked by numbered labels stuck in the ground by them. After the spread, note was merely taken of total infected plants and severity of attack. It was thought that by marking the infected plants at first it could be seen whether or not subsequent infections clustered around these, but the spread when it did occur was usually so rapid and general that no special centers of distribution were noticed. Details of these fields and their inspections are given in the following paragraphs and Table VI.

Field 1, Windsor. This was Havana tobacco planted with seedlings obtained from Portland, where there was no wildfire in the seedbeds or anywhere near them. Care was used not to infect them in any way during transportation and planting. They were put out in a low, somewhat wet and isolated field that at least had never had any serious outbreak of wildfire. Inspection of Table VI shows that this field remained entirely free of infection until July 5th and that no general spread occurred later. Just after the first spread, examination showed on July 5th only seven infected plants in the field,—five of these had only a single spot on a leaf, and the other two had several spotted leaves. These latter appeared as if infected when set out and they might have served as the source of infection for the others. They were pulled up and all the other infected leaves were removed. The second examination on July 21 showed only five additional infected leaves, four with two or three infected spots and one with ten. Most of these leaves were in the vicinity of the moderately infected plants previously pulled up. Priming was begun soon after so no further data were obtained but no injury resulted. This and Field 2 showed the value of setting with wildfire-free seedlings.

Field 2, Rainbow. This was a Round Tip field set with plants from a wildfire-free bed. No wildfire showed on the inspected plants at any of the four examinations made from June 20 to August 3d. As this field was near infected seedbeds that had been destroyed after it was planted, its freedom from wildfire indicates that the disease is not commonly carried any distance. The grower, however, was careful about the disease getting a start, as he did not use any of his own plants. In other rows in the same field with our plot and on Havana tobacco near-by, a few wildfire spots finally appeared.

Field 3, East Granby. In this case the infected Cuban plants were marked under a tent. These came from the grower's seedbeds that showed considerable wildfire, but care was used to avoid infected plants as much as possible. The few found on the 1st and 2d examinations, June 3 and 15, were all seedbed infections and averaged, on the last date, about 1½% for the marked rows. The next examination was delayed until July 14, at which time the field was being primed the first time, so counts could not be made, but it was evident that the spread, while it may have included more plants, was so light on these that no very evident damage occurred, and the subsequent primings would keep ahead of the trouble. Injury to this field, apparently, was not over 1%.

Field 4, Windsor. Broadleaf was planted in this field from a seedbed that showed considerable wildfire. Inspections on June 3 and 20 were before any field spread, and showed on the last date about 6% seedbed infection. After the first spread in the field on July 6, this was over 12%. The grower after the second inspection removed all the infected leaves from the experimental plot, and this may have lessened the spread, for in two rows in which the leaves had not been removed counts on July 6 gave 51% infection. This field was not followed further so the final damage caused was not determined. The infection at the start, however, was abundant enough to cause serious injury judging from other similar fields.

Field 5, Windsor. The field was set with Havana plants mentioned under seedbed spraying test No. 4, so there was a moderate amount of infection to start with. The rows selected happened to have less than other parts of the field, and our first inspection of June 20 revealed no infection whatever. It was quite probable if these plants had been examined earlier, soon after they were set out, some infected leaves would have been found that later disappeared and so gave a false impression of freedom from disease. After the first spread, counts on July 5 showed 10% of these plants infected. This was not nearly so high as in other parts of the field and the amount per plant was not so serious. The grower started in priming about the middle of July so no counts were made on the next inspections. For this particular part of the field the disease was kept in check by the priming and weather so that probably less than 5% injury resulted.

Field 6, Suffield. This Havana field certainly had a good chance for injury as it was set from the grower's badly diseased seedbeds with no particular care to avoid wildfire plants. As a result of our first count on June 3, we found that the average infection for the two marked plots was 36% and twelve days later, before any spread, this increased to 42% because of the masked seedbed infections developing. On July 8 after the first field spread, it had reached 90% and of course was very bad on some of the plants. One of the plots was protected from the wind by a barn and also happened to get fewer infected plants to start with, 31% as compared with 69%, so the final damage here was much less than in the other plot at the further side of the field. We estimated the total damage to the field to be about 20%, and if it had not been harvested early, just before the second infection period (the last of July), this would have been considerably greater. As it was, counts made on July 8th in the badly infected plot showed 23% of the plants badly injured, 41% moderately, 34% slightly, and only 2% free from wildfire.

TABLE VI. INFECTION IN MARKED FIELDS AT DIFFERENT DATES.

Field.	Locality.	Variety.	Condition Seedlings.	Total Plants Marked.	No. Inf. Plants on Examinations: 1st.	2d.	3d.	4th.
1	Windsor,	Havana,	Free,	4294	0 Je. 20	7 Jl. 5	10 Jl. 21	Priming; no injury.
2	Rainbow,	R. Tip,	Free,	2000	0 Je. 20	0 Je. 28	0 Jl. 5	0 Aug. 3
3	E. Granby,	Cuban,	Mod.,	6030	75 Je. 3	84 Je. 15	Priming; Jl. 14	Priming; no damage.
4	Windsor,	Broadl.,	Consid.,	1978	51 Je. 3	104 Je. 20	242 Jl. 6	No later data.
5	Windsor,	Havana,	Mod.,	1733	0 Je. 20	183 Jl. 5	Priming. Jl. 21	Plowed up. Aug. 3
6	Suffield,	Havana,	Bad,	733	265 Je. 3	310 Je. 15	656 Jl. 8	Cut Jl. 26

Removal of Infected Leaves. These plants, Jones' experimental plots with crosses, were set out June 4th at the Windsor tobacco farm. The plants came from a seedbed in which wildfire developed conspicuously, and the plants were kept moist in baskets for one or two days before planting; wildfire was very evident soon after they started to grow. There were four rows in each plot. On June 20 the first counts were made and all infected leaves removed from rows 1-2 of each plot. On July 6 counts were again made and all infected leaves again removed from row 1 of each plot. Unfortunately counts were never made of infected plants and leaves in rows 3-4 and of rows 1-2 after July 6th. However, observations made at this date and later showed little difference in apparent infection between the plants in the rows in which the leaves were never removed and those that had been removed once and twice. In fact the first count showed infected plants (see Table VII) in row 1 of the different plots ranging from 15% to 81%, and yet on the second count the least infected rows had just as high a percent. of infection as the others, the range for all being only 97% to 100%. The first removal average from 1.8 to 5.2 leaves per infected plant for the different plots and the second from 4.1 to 5.4 leaves.

That the first removal had little result in stopping later infection is shown by the great number of leaves removed in each case at the second removal. No harm was done by the first removal, but the second one took off leaves of which 50% were of commercial value. This removal also showed in somewhat lessened growth of the plants subsequently. The second removal was made after the first spread of the disease in early July; if it had been made before this, say about June 27, less harm to the plants and more effect on the spread of the wildfire might have resulted. Again the plants with the leaves removed were so close to those that did not have the leaves removed, that re-infection from them was easy and so may have nullified the effect of their removal. As an experiment under the conditions which it was tried, it did not show any favorable result from the removal of the infected leaves.

TABLE VII. REMOVAL OF INFECTED LEAVES FROM FIELD TOBACCO.

Exp. No.	Plot.	Row.	Total plants.	1st removal. Inf. pl.	1st removal. Inf. lvs.	2d removal. Inf. pl.	2d removal. Inf. lvs.	% Inf. plants. 1st tm.	% Inf. plants. 2d tm.	No. inf. leaves per inf. plants. 1st tm.	No. inf. leaves per inf. plants. 2d tm.
2121	1	1	150	121	254	146	603	81	97	2.1	4.1
		2	...	109	191	...	...	..	..	1.8	..
2122	2	5	155	113	288	152	676	73	98	2.6	4.4
		6	...	90	260	...	...	..	..	2.9	..
2123	3	9	162	139	324	161	759	86	99	2.3	4.7
		10	...	95	253	...	...	..	..	2.8	..
3141	4	13	160	106	292	159	826	66	99	2.8	5.2
		14	...	122	325	...	...	..	..	2.7	..
3142	5	17	142	74	186	142	589	52	100	2.5	4.1
		18	...	...	197	...	...	..	..	2.1	..
3143	6	21	156	110	315	152	733	71	97	2.9	4.8
		22	...	95	290	...	...	..	..	3.1	..
4121	7	25	170	30	98	170	877	18	100	3.3	5.2
		26	...	48	145	...	...	..	..	3.0	..
4122	8	29	164	25	129	161	864	15	98	5.2	5.4
		30	...	38	155	...	...	..	..	4.1	..

Fertilizer Experiments. These rather simple fertilizer tests were made on the infected seedling plots 1-6 at the Station's Windsor tobacco farm. The field had already been given what growers would consider a rather moderate amount of fertilizer, consisting of one application of Olds & Whipple's tobacco manure at the rate of a ton per acre. It was decided to divide the field into three strips running crosswise of the plots. The first thirty-eight feet received nitrate of soda at the rate of 250 lbs. per acre; the second got sulphate of potash at the same rate; while the third and largest strip received no further fertilization. The plants at this time, July 12, had grown considerably. No counts were made as other factors entered into the problem; for example, the greater protection against wind, etc., of the plants at the further end of the field which received no further fertilization. However, it was evident that the first or nitrate of soda strip made the best growth, and had the most wildfire. The sulphate of potash strip also made a fair growth, somewhat less than the nitrate of soda, and had less wildfire. The check was the poorest in growth and had the least wildfire; this plot, however, would not have been considered sufficiently fertilized. Just how much was due to poor fertilization and consequent slow hardy growth of the tobacco, and how much to the greater wind protection, in the limiting of wildfire spread in the check, could not be determined.

Spraying Field Plants. These experiments were conducted on plants at the Station's Windsor tobacco farm. Plants in plots 1-6 already mentioned were used in part. The last ten plants in rows 2 to 46, making 450 plants in all, were sprayed five different times with homemade, 4-4-50, Bordeaux mixture, without lead arsenate, on the following dates: June 20, June 28, July 6, July 14, July 26. These plants had been set out on June 7, and included plants both badly diseased and practically free from wildfire. It happened that the end of the field sprayed was the end in which wildfire did not spread so rapidly or extensively as the opposite end, but this makes no difference between the sprayed and unsprayed plants compared here.

In order to determine the effect of the spraying, the sprayed plants in two rows of each plot (except plot 1 with one row) were compared on July 27 with the same number of unsprayed plants in the same rows and next to them. This count was just before the first priming and at a time when wildfire had completed its spread from the first infections of early July. The details are given in Table VIII. This shows that in every case the sprayed plots had fewer infected plants, leaves and spots than the corresponding unsprayed plots. There had, however, been much less spread in the sprayed and unsprayed wildfire-free or nearly free plants than on those that were badly infected when set out.

The average of the totals showed that the unsprayed had one and a half times as many infected plants, two and a half times as many infected leaves and over eight times as many wildfire spots as the sprayed plants. A plant was called infected if only a single wildfire spot showed on it, so the true value of the control by spraying is shown by the number of spots. It must be remembered, too, that some infections on the sprayed plants were there before spraying began.

A second fact shown in the table is that most of the infections on the sprayed plants were on the end of the rows next to the infected unsprayed plants (see end of Table VIII), as the near end had 17 as compared to 15 infected plants at the further end, and almost twice as many infected leaves, and three times as many wildfire spots. This indicates that had the sprayed plants been entirely isolated there would have been even fewer infections. Where wildfire was bad on the plant to start with, the beneficial effect from the spraying was more marked than where there was little, for the unsprayed plants on the former developed over eight times as many spots as on the sprayed, while the latter only six times as many.

TABLE VIII. EFFECT ON WILDFIRE OF SPRAYING FIELD PLANTS WITH BORDEAUX MIXTURE.

Plot.	Rows.	Variety.	Condition of Seedlings.	Treatment.	Total Plants.	Infected Plants.	Infected Leaves.	Total leaf Spots.
1	2	Broadl.,	Wildfire bad,	Bordeaux,	8	8	31	209
1	2	Broadl.,	Wildfire bad,	Unsprayed,	8	8	55	1576
2	15–16	Havana,	No wildfire,	Bordeaux,	18	6	7	10
2	15–16	Havana,	No wildfire,	Unsprayed,	18	11	21	62
3	23–24	Havana,	Wildfire bad,	Bordeaux,	19	12	21	57
3	23–24	Havana,	Wildfire bad,	Unsprayed,	19	19	71	602
4	31–32	R. Tip,	Trace wildfire,	Bordeaux,	20	3	3	3
4	31–32	R. Tip,	Trace wildfire,	Unsprayed,	20	2	2	7
5	37–38	R. Tip,	Wildfire bad,	Bordeaux,	19	8	11	18
5	37–38	R. Tip,	Wildfire bad,	Unsprayed,	19	16	48	204
6	45–46	R. Tip,	Trace wildfire,	Bordeaux,	19	0	0	0
6	45–46	R. Tip,	Trace wildfire,	Unsprayed,	19	2	2	3
1–6	Totals	all vars.,	Little & much,	Bordeaux,	103	37	73	297
1–6	Totals	all vars.,	Little & much,	Unsprayed,	103	58	199	2454
First	4 Plants	all vars.,	All rows,	Bordeaux,	22	15	24	70
Last *	4 Plants	all vars.,	All rows,	Bordeaux,	22	17	42	215

* Next the unsprayed plants in same row, while the first four, of the ten sprayed plants, were away from them.

Laboratory Studies.

Cultures. Cultures of *Bacterium tabacum* are obtained fairly easily from the wildfire spots on tobacco leaves. The method finally used by us was to soak small pieces of the infected leaf tissue for about one minute in corrosive sublimate solution, 1 to 1,000. After washing these in sterilized water, they were crushed with a sterilized scalpel in a test tube containing about 5 c.c. sterilized beef broth. This was sometimes allowed to incubate for an hour or more, after which one to three drops were introduced into a test tube of melted beef-peptone agar, which, after thorough shaking, was poured into a Petri dish. From the resulting isolated colonies, pure cultures were eventually obtained. Practically all cultures were grown at room temperature without the use of an incubator. A variation of this method, used in the beginning, consisted of grinding the tissue with a few c.c. of water in a mortar with sand, all of which had been sterilized. About three drops of the liquid were smeared over the surface of hardened agar in a Petri dish. See Plate XXXII c-d.

Attempts to obtain cultures from old dried leaves and from seeds were tried in several cases, but it was difficult to isolate the germ, even when it was known to be present. Finally from one of the old dried leaf tissue nine months old, cultures were obtained, but not from the other leaves or seeds. This may have been due to over-sterilization or to faulty technique, since the same crushed unsterilized tissues when applied in moisture directly to pricked leaves often gave quite successful inoculations.

In general, no effort was made to distinguish between the dead center and the living yellow halo of the spots in obtaining cultures. However, to satisfy ourselves that bacteria were not confined either to the dead spots or to the yellow halo surrounding them, material was selected several times from each of these restricted areas and it was equally easy to obtain the germ from either region. No attempts were made to isolate the germ from seed-pods or ribs of the leaves. We have no doubt, however, that the germ can be isolated from either when infected.

Considerable variation existed in the virulence of the germ obtained in pure culture, depending upon the age of the same. In general, young, recently inoculated cultures were more virulent than those several months old that had been frequently renewed. An old culture received from Wolf also seemed to have lost its virulence. However, on Dec. 30th we made successful inoculations with a culture that had not been renewed since June 6th. In this particular case the culture had been kept at room temperature and had been dried out for some time, but before using it was soaked in water for several hours. The manner in which the inoculation is made is also an important factor of its success, a subject which will be discussed later.

The Organism. The germ is readily stained with gentian violet, fuchsin, etc., but these alone do not bring out the flagella. After trying several methods, our best results were with Moore's modification of Loeffler's stain. Our description of the bacteria are based chiefly on slides stained in this manner.

In common with most bacteria it is difficult to distinguish this species entirely by its morphology. Its pathogenicity to tobacco is its striking characteristic. There are, however, certain discrepancies in the characters assigned to it by Wolf and Foster (32.) and those observed by us. For this reason a brief discussion of it here is desirable.

The size of the organism, as stated by them, varies "from 2.4 to 5 by 0.9 to 1.5μ, the most common size being 3.3 by 1.2μ." According to our measurements, we find it varying from 1.3 to 2.5μ in length by 0.6 to 0.8μ in width. Slagg (24, p. 25.) obtained measurements which agree very well with our own, since he gives the length as varying from 1.4 to 2.8μ and the width from 0.5 to 0.75μ. The largest size described by Wolf and Foster may have been due to measuring, as one, individuals which had not been completely divided. In our stained slides the bacteria are frequently seen in pairs in various stages of division, and in measuring these one is sometimes uncertain whether to consider them as a single or two germs. The measurements we have given here are limited to those of isolated individuals. In general, the germs are short rods with rounded ends, about two or three times as long as broad. See Plate XXXII a.

Wolf and Foster distinctly say that these bacteria have one polar flagellum. Slagg, on the other hand, states that the germ isolated by him from Kentucky and Connecticut had from three to six polar flagella. We have found from one to four flagella, with one or two doubtful cases where there may have been five. Most of the bacteria seen by us had one or two flagella. Counts of several hundred show about the following proportion: 40% with one flagellum, 45% with two flagella, 13% with three, and 2% with four. The number of flagella found, however, seems to us to depend somewhat upon the success that attended their staining. Where only one is found, one cannot be sure but that others may have been broken off, especially if a single flagellum comes off at an angle to the polar end. Very frequently one finds detached fragments of the flagella on the slide and the varying length of those attached indicates that portions have been broken off. On one of our slides the appearance of the rather stiff, coarse flagella, commonly one at a pole, suggested that they might have been accidentally coalesced in the manipulations. That this does occur is shown by frequent individuals, in certain slides, where a branching effect is produced by the flagella coalescing for a greater or less extent and then separating into two or more. A forked or pronged effect is thus frequently given. In general, the flagella seem to be two or three times the length of the bacterium, though shorter ones were obtained which were probably broken off. See Plate XXXII b.

In this connection, it might be well to consider the characteristics of *Bacterium angulatum* as given by Fromme and Murray (Journ. Agr. Res. 16: 225.). In table form they mention five points that distinguish this germ from *Bacterium tabacum*. Three of these relate to the manner of liquifying gelatine, acid formation with saccharose, dextrose, etc., and growth in the closed arms of fermentation tubes. These seem to be chiefly differences of degree rather than of kind and so cannot be considered of as great importance as the other two which relate to size of the germ and number of flagella. They state that *Bacterium angulatum* varies from 2 to 2.5μ in length and is 0.5μ wide. Contrasted with Wolf and Foster's measurements of *Bacterium tabacum* these measurements are distinct but vary little from those found by Slagg and us for the latter germ. They give the number of flagella as varying from three to six. This also is quite different from the single flagellum mentioned by Wolf and Foster, but agrees fairly well with the number found by us, and exactly with the number given by Slagg for *Bacterium tabacum*.

From the preceding considerations it will be seen that the morphological differences between *Bacterium angulatum*, angular leaf spot, and *Bacterium tabacum*, wildfire, are not so marked as originally considered by Fromme and Murray. This may account for the confusion of the tobacco bacterial spot from Africa, mentioned by Klerck (19), where the spots are said to resemble those of wildfire while the germ agrees with the angular leaf spot organism. Undoubtedly a comparative study of the two germs and their effects on their host from different regions of the world is needed to bring out their real differences.

Methods of Inoculation. Altogether several hundred infection experiments were tried with the wildfire germ on tobacco. These were mostly under greenhouse conditions; some, however, were carried on outdoors under varying natural conditions. In the greenhouse, inoculations were made at all times of the year. According to the environmental conditions and the manner of inoculation, different results were obtained. The former we will consider later. The latter may be described briefly here as follows:

(1) The first method tried consisted merely of placing pure cultures of the germs, or the crushed tissues containing them, in a moderate amount of water and pouring it over the leaves to be infected. A variation of this method consisted in dropping with a medicine dropper the water containing the germs on the host. This method proved the least satisfactory of any of those tried. It was most successful when the conditions for natural infections outdoors were present. It was not so effective in the greenhouse unless

those conditions were simulated. However, it was very satisfactory when the tissues to be infected were injured so that the germs could gain entrance through the injured places. The injury was usually accomplished by pricking the tissues with a sterilized needle. Unless the environmental conditions were unusually favorable the infections almost always were limited to these pricked spots. This was especially true in our winter experiments. See Plate XXX b.

(2) The second method employed was to spray pure cultures of the germ in water on the plants by means of an atomizer. This was very successful outdoors when natural conditions were just right. In the greenhouse, it was most successful when accompanied by needle pricks in the tissues, as noted before. The disadvantages of this very successful method lies in the fact that the atomizer has to be thoroughly sterilized each time after a culture from a different source is used.

(3) This method consisted of pricking the tissues in definite places with a needle which, after being sterilized, had been introduced into a pure culture. The advantage of this method, which is also almost always successful, is due largely to infection taking place only at definitely marked points.

In any of these methods efforts were made to keep the plants under favorable moist conditions for a few hours after the inoculation. This was done in part by spraying with water, placing them under a bell jar or in a shady position, or by making the inoculations on a cloudy or moist day.

Relation to Environment. As has already been shown in this paper, environmental factors are very important in determining the spread of the disease in nature. The same holds true in relation to artificial infection, especially when no puncturing or injuring of the tissues is provided for entrance of the germ. The two factors of most importance are favorable moisture conditions and rapid growth of the host. In the greenhouse experiments, especially during the winter, these two factors did not always occur, and especially with the very slow growing plants infections were limited unless the tissues were punctured.

To secure more favorable conditions, the plants, some time previous to inoculation, were frequently placed under bell jars to facilitate the opening of the stomates, thus favoring the entrance of the germs. Likewise in the heat of early summer a cheese-cloth tent was built on the ground in the greenhouse to shade the plants and to retain a more moist atmosphere.

It might be stated here that the greenhouse conditions under which we worked were such that there was little or no accidental infection. Very little care was needed to keep the check plants isolated from the infected ones on this account, especially in the cooler months. This failure to spread will not hold true in nature where, under certain conditions, the disease spreads rapidly from infected to free plants. These differences are well illustrated by the following experience. A number of small plants in the greenhouse were artificially inoculated without puncturing, only a few spots appearing on all of them. The plants were kept for some time under these conditions with no spread whatever of the infection, although they were frequently sprinkled. Later the plants were taken out of the crocks and transplanted in an isolated place outdoors. They began to grow more rapidly, and when a moist, favorable period arrived the wildfire spread suddenly and abundantly all over the newer leaves.

Relation to Host. Although in the greenhouse experiments we were most successful with those inoculations where the tissues were punctured, there is no doubt in our minds that in nature, where the disease suddenly spreads under favorable environment, the infections usually take place through the uninjured tissues. This undoubtedly occurs by the passage of the motile germs through the open stomates. Examination of the tobacco leaves shows that the stomates are abundant on both the upper and lower surfaces, although somewhat more numerous on the lower. Under favorable environmental conditions for the opening of the stomates, both outdoors and in the greenhouse, we were able to produce abundant infections on the uninjured tissues by applying the germs alone either to the upper or lower surface of the mature or nearly mature leaves. However, when they were sprayed over the immature leaves rarely did infection occur. Similar freedom from infection of young leaves is seen in nature and indicates that entrance takes place through the stomates, which in these leaves are not so fully developed or liable to be open. Furthermore, that it was a question of open stomates and not of the age of the tissues, is shown by the fact that young leaves are very easily infected after puncturing.

This last statement leads us to a consideration of the age of the tissues in reference to their susceptibility to artificial infection. In several cases we tried comparative tests in inoculating over-ripe and somewhat yellowing leaves, with those in their prime and the young or immature leaves, all on the same plant. Where the puncturing method was used we found that the young leaves apparently show the most successful infections, especially by sharper contrast of the halo spots with the normal tissues, and possibly by their larger size. This contrast was nearly as evident on the leaves in their prime, but much less so on the older over-ripe leaves. On the latter, especially when yellowed, the infections were frequently not very evident, and as the general yellowing progressed they become entirely obscured. To our minds, this is explained by the fact that young leaves have more food for growth, and as the chlorophyll granules are the parts more directly attacked, leaves in their prime furnish a more favorable environment than do the old yellowing leaves.

Tissues Invaded. When we employed the puncturing method of inoculation we found it equally easy to secure infections in the leaf parenchyma, ribs, or the stems of growing greenhouse plants. No attempts were made to inoculate the floral parts or seed-pods. Certain differences showed in the results of infection at these three different points of inoculation. For example, in the leaf blades, round yellow halo spots that eventually reached a diameter of one-half inch or so were the common result. In time, as the spots reached their maximum size, dead centers of more or less extent appeared, but these were not so common or quick to develop as with natural infections outdoors.

If these inoculations were made on the veins, nearly similar results were obtained. When, however, the inoculations were made on the midrib, yellowing was more extended in a linear direction up and down either side of the same and less definitely marked off from the surrounding healthy green tissues. Likewise some of the yellowing extended out along the lateral divergent ribs. Soon dead spots appeared in the tissues parallel to the midrib, and frequently smaller ones along the lateral ribs. This indicates more of an up and down spread, as if the germ or its toxin followed the course of the veins. It made little difference whether the midrib was inoculated near its apex or its base, as the disease seems to spread as readily downward as upward. Plate XXX c.

Where the young stems were inoculated below, but away from the base of the leaf, an elongated blackening of the tissues occurred in the vicinity of the puncture. In time the leaf immediately above showed yellowing and spotting, somewhat similar to that described for the inoculations of the midrib. In some cases upper leaves away from the point of inoculation showed a slight yellowing of the leaf blade in the vicinity of the midrib. Whether this yellowing had anything to do with the immediate presence of the germs, or was merely a secondary result, we did not determine. A single attempt to inoculate plants with such leaves was unsuccessful. Neither did we try to determine, by inoculation tests or staining, the presence of the germs widespread in stems or the midribs. In the parenchyma, however, both in the dead centers and yellow halo spots, the presence of the germs was demonstrated both by staining and by inoculations with tissues from these restricted regions.

Methods of Survival. Cotton Seed Meal. We have already mentioned our failure to secure infection of tobacco plants by means of cotton seed meal. In these tests eighty-one samples of cotton seed meal, recently collected over the State by the Station's sampling agent, were used on greenhouse plants in the spring of 1921. A small amount of each fertilizer was soaked for a short time in water and then sprinkled over a small tobacco plant in a crock. It is to be regretted that no punctures were made in the leaves of the plants to secure more certain infection if the germs were present. However, other plants similarly sprinkled with germs in water at the same time of year were successfully inoculated. These results seem to indicate that this fertilizer is not a means by which the germs are carried over from one year to another. This is the only fertilizer, except tobacco stems, in which it is at all likely that the germs could be carried from the south.

Tobacco Stems. Similar experiments were tried in a few cases with commercial tobacco stems, such as are used in field fertilization, but of unknown origin, and of leaves and stems of wildfire tobacco overwintered in a barn. No results were obtained from any of these. The barn-cured wildfire tobacco when first used was about a year old and the inoculated plants were unpunctured. This may account for our failure to secure successful infection from it, since we later secured successful infection from dried herbarium wildfire leaves equally old when the puncturing method was used. This barn wildfire tobacco was used again on punctured leaves, when it was a year and a half old, but no successful inoculations resulted. We believe, however, with this method we could secure successful inoculations with barn-cured wildfire tobacco that is not over a year old.

Dried Herbarium Leaves. In the winter of 1922 we attempted to isolate the germ from dried, herbarium, wildfire, tobacco leaves of varying ages. We were unsuccessful in all of these except two. Both were from seedling tobacco leaves from the same source collected early in May, 1921, and the cultures were isolated in February, 1922, over nine months later. Successful inoculations were made with the isolated germ. Failure to isolate this germ from the other sources was not due to death, but rather to the presence of other germs and lack of sufficient attempts to secure it. This was proved by the later successful inoculation of pricked leaves with these crushed herbarium leaves soaked in water. By this method infections were obtained from this dried material in twenty out of twenty-seven attempts. The leaves were from thirteen different sources, eight of which were tried successfully from one to three times, and one tried successfully twice and unsuccessfully once, while four were tried unsuccessfully one or two times. Four other inoculations were made with a mixture of tissues from two to four of these sources, but each limited to the dampening off, the halo or the dead center stage, all of which were successful.

The material used was obtained from both seedbed and field plants of several varieties of 1921 tobacco. All but two were from material collected in the State, one from Vermont and the other from Florida. We secured infections with the Vermont, but not with the Florida material. Only one attempt, however, was made with the latter. The leaves in the various experiments had been dried from 198 to 298 days when used for inoculation. Success was had with the oldest, as well as with the youngest. There was considerable variation in the vigor of development of the infection spots, even on the same plant. Material from different sources also seemed to show variation in vigor. These experiments prove that the germs can retain their viability, at least for a considerable period, in dried material that has not been exposed to the elements. There is no question, therefore, that refuse from barn-cured wildfire tobacco is a menace if used on land planted with tobacco the following year.

A single one of these experiments will suffice to illustrate the average results obtained, using Infection Numbers 2042 and 3003: The leaves were gathered from a wildfire field at Somers, Conn., Aug. 26, 1921, and separate inoculations were made Mar. 7 and Mar. 17, 1922. Both were successful. In the first, three leaves on each plant were pricked with a needle about eight times before the water containing the crushed infected tissues was poured over them. Inoculation 2042 was made on three plants and about a week later showed five, nine and sixteen fair to good infection spots at the punctured places. One infection spot appeared at an unpunctured place, which was very unusual in these experiments. Inoculation 3003 was made on a single plant with an indefinite number of pricks in the three leaves. An examination ten days later showed seven good and eight fair infection spots on two of the leaves and none on the third.

Later similar infection experiments were tried with older dried herbarium wildfire leaves collected in 1920. These experiments were made in late April, 1922. The leaves had been dried in these cases from 573 to 651 days when crushed and placed in water on the plants. They were from twelve different fields in Connecticut. In none of these did any of the inoculations take. This seems to indicate that the germs can not retain their vitality much over a year in the old dried leaves.

Seed. We were unsuccessful in six attempts to isolate the wildfire germ from supposedly infected 1920 Round Tip tobacco seed, these being made one or two years after it was gathered. We also failed to secure infection from water in which the same seed had been soaked several hours. Several months previously the same seed planted in the greenhouse had given one infected seedling and we have reason for believing that it was the source of infection in several seedbeds in 1921.

We artificially infected unsterilized tobacco seed with the wildfire germ but in the one or two attempts to re-isolate it we also failed because of the presence of other bacteria. However, one month after the seed was inoculated infections were secured when it was soaked in water and this was applied to punctured plants. The same seed several days after inoculation was placed outdoors, protected from the rain but exposed to the cold, from Feb. 14 to April 18. On the latter date part of it was soaked in water several days and then applied to punctured plants which later showed a few infections. About two weeks later the experiment was repeated with even better results. These experiments, while not entirely satisfactory, indicated on the whole that the germ may retain its viability on tobacco seed for some months.

Overwintered Refuse. We have tried several times to infect punctured greenhouse plants with infected refuse from tobacco plants that had overwintered in the field. Badly disintegrated leaves, from the Station garden plot already mentioned, were gathered at different times. These were ground up further and soaked from one hour to several days in water. This water with some fragments of the tissue was poured over needle-punctured plants. Altogether twenty-seven plants were thus inoculated and on these we succeeded in securing three poor and three fair to good infection spots. These experiments indicate that the germs, to a certain extent, can be wintered over in infected leaves left outdoors in the field and undoubtedly under favorable conditions are the source of occasional infections the succeeding year. From our experience this is not a great menace in the field, but should be a warning to the grower not to leave tobacco refuse in the seed-beds after the plants have been pulled. This overwintering is also shown somewhat by the following experiment. On Feb. 1st artificially infected plants were changed from a warm to a cold greenhouse and on March 1st placed outdoors. They were thus exposed for some time to freezing weather. The soaked crushed infected tissues from these gave vigorious infections on punctured greenhouse plants late in April.

Soil. We have already mentioned the experiment where infected leaves were buried in the soil under disease free plants which later became infected, and the successful inoculations made with the same soil a month or two later after the leaves had become entirely disintegrated. This showed that the germs could be carried in the soil for a short period.

We have further data that indicate that they may be carried over the winter in this manner at least to a limited extent. Samples of soil on different occasions in March and April were taken from the Station garden plot which the previous year had grown wildfire plants that had been allowed to rot in place. After sifting off the coarse particles of soil the fine particles were soaked in water for several hours and applied to pricked tobacco plants in the greenhouse. The first experiment with six plants produced no results. In the second experiment with three plants, each produced a single fair to good infection spot. Of course these germs may have come from the very finely disintegrated tobacco tissues rather than from germs entirely free in the soil, but the general statement that they carry over in the soil is approximately correct since it is difficult to distinguish between the mineral part and the fine humus of the soil.

In a tobacco seedbed, however, on which pure cultures of the wildfire germ were sprayed in the fall, we failed to secure infection of plants the next spring by spraying on pricked leaves water in which this soil was soaked.

Infection of Sprayed Plants. Our field experiments showed that seedlings and field plants sprayed with Bordeaux mixture were partially or entirely protected from infection according to the number and efficiency of the treatments. This was also tested out with artificial infections in the greenhouse and similar results were obtained. On several occasions pricked plants were inoculated by atomizing with the germ as follows: 1, Check plants inoculated but no other treatment; 2, Plants sprayed with Bordeaux mixture immediately before inoculation; 3, Plants sprayed with Bordeaux mixture immediately after inoculation; 4, Plants sprayed with Bordeaux mixture immediately before and after inoculation. In the latter case infection never took place unless the puncture was at a point poorly protected by the spray. Where the plants were sprayed either before or after inoculation there was only an occasional infection. On the unsprayed plants infection took place at practically all the punctured spots.

Infection with African Material. We were very successful in making infections with wildfire tobacco leaves received from Miss Doidge, collected in Rustenburg, Transvaal, Jan. 2, 1922. These inoculations were made in both April and May, 1922, and were equally successful in both cases, infection appearing at most of the many pricked places on which the water containing the crushed infected tissues was applied. These infections were typical and fully as virulent as inoculation from our own cultures made at the same time.

Infection of Other Hosts. In nature we have never seen wildfire on any of the weeds or cultivated plants in or adjoining the seedbeds or tobacco fields. Our experiments to infect other hosts at first were limited to the tomato and a cultivated species of flowering tobacco. In neither were the leaves pricked before inoculating and this may account for the failure in both cases. Later inoculations on pricked leaves of young plants of tomato, pepper, eggplant, jimson weed and pokeweed were tried. Three plants were used in each case and each had from thirty to fifty pricked places. Apparently all of these failed of infection, except possibly the pepper and the eggplant. On the former three or four and on the latter one slight faint yellowish spots appeared at punctured places. These possible infections, however, were quite indefinite as compared with those that appeared in the tobacco plants similarly inoculated at the same time.

Wolf and Foster (32, p. 452.) originally claimed to have inoculated tobacco with wildfire obtained from cowpeas. In a later publication, however, Wolf and Moss (33, p. 32.) state that "all efforts to prove that the wildfire organism is parasitic in plants other than tobacco have thus far failed." These inoculated plants included potatoes, tomatoes, peppers, eggplants, jimson weed and horse nettle, all of which are related to tobacco. Chapman and Anderson (2, p. 74.) succeeded in inoculating "petunia, egg-plant and pokeweed (*Phytolacca decandra*) by spraying with suspensions of bacteria in water in the same way in which tobacco plants were usually inoculated. Some of the leaves in each case were wounded by puncture with a sterile needle." They also isolated the germ from spots on tomatoes growing in an infected tobacco seedbed.

Recommendations for Control.

Seedbeds. (1) If wildfire developed at all in the beds the previous year, either make beds on new land away from all possible sources of infection, or sterilize the old beds and paths with steam heat. Heat the soil for 20 to 30 minutes at a pressure of at least 100 lbs. Boards, sash and cloth used on beds or fields previously infected should be thoroughly sprinkled all over with formalin, 1 to 25 parts of water, and piled in a dry place to slowly dry off; or the cloth can be heated in *boiling* water for one hour.

(2) Use seed known to have come from a wildfire-free field and which has been protected at all times from subsequent contamination. If in doubt place seed in a cheesecloth bag in a jar and soak for 10 to 15 minutes in a corrosive sublimate solution, rate of 1 part of corrosive sublimate [Poison!] to 1,000 parts water. Then wash thoroughly with pure water and dry immediately.

(3) Use as little water on plants as is consistent with good growth and apply at such times as it will most quickly dry off the leaves without sun-scorch injury. Air the beds when feasible both day and night, and especially in moist weather, in the best possible ways to prevent water of transpiration settling on the leaves.

(4) No matter what the previous treatment, as a final precaution spray the plants with Bordeaux mixture; if homemade use the 4-4-50, or if commercial as recommended on package. Begin treatment on the very young seedlings soon after roots start and largest leaves are the size of a finger-nail, and repeat spraying each week until the season for pulling is over. Clean up seedbeds at end of setting and plant beds with a different crop if desired.

Fields. (1) In setting out the fields use only plants known to come from the wildfire-free seedbeds. If impossible to get these, select only the plants apparently free of the disease and from parts of the beds least infected. Plant as soon as pulled and keep water off the leaves while in the baskets.

(2) About a week after setting out plants go over the field and remove diseased plants, and if possible make a second similar

inspection about a week or ten days later. Take plants pulled up off the field. Reset with healthy plants.

(3) In case these inspections show the field badly infected, plow it up and reset with healthy plants, providing this can be done in time to insure the newly set field properly maturing before danger from frosts.

(4) In some cases, especially where the tobacco is primed, it may be preferable, instead of resetting or doing nothing, to go over the field once or twice and remove the infected and non-commercial lower leaves. These also should be taken off the field, instead of being thrown on the ground. The first removal should be made about a week after planting and the second after the plants have started to grow.

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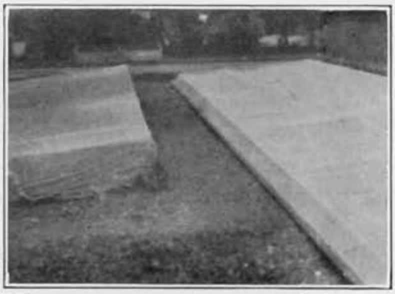
TYPES OF TOBACCO SEEDBEDS.

a. Glass Sash, p. 383.



b. Cloth Covers, p. 383.

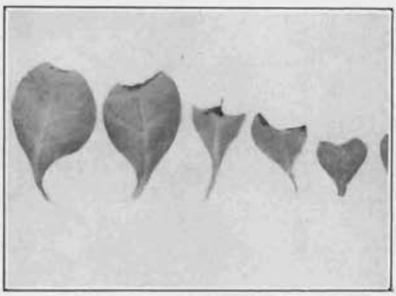
WILDFIRE PLANTS KILLED WITH FORMALIN.

c. Isolated Spots, p. 401.

d. Whole Beds, p. 401.

FIRST OR DAMPENING-OFF STAGE.

e. Dead Spot, p. 380.



f. Infected Leaves, p. 380.

WILDFIRE IN SEEDBEDS.

PLATE XXX.

NATURAL INFECTIONS.

a. Leaves from Seedbed, p. 381.

ARTIFICIAL INFECTIONS.

b. In Leafblade, p. 414.

c. In Midrib, p. 416.

SECOND OR HALO STAGE OF WILDFIRE.

PLATE XXXI.

INDIVIDUAL LEAVES.

a. Second or Halo Stage, p. 387.

b. Third or Sunscorch Stage, p. 387.

BROADLEAF PLANTS.

c. This Field almost completely Ruined, p. 387.

WILDFIRE IN FIELD PLANTS.

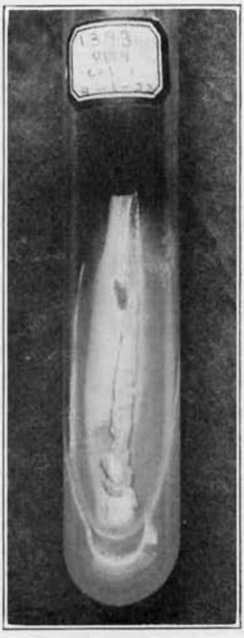
PLATE XXXII.

PHOTOMICROGRAPHS OF THE GERM.

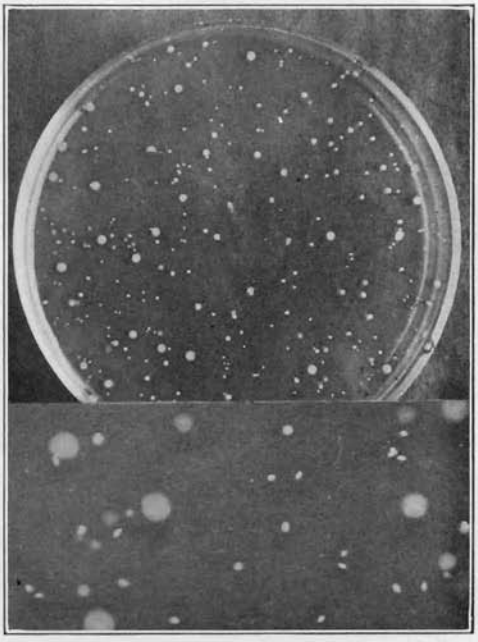
a. Many Germs, p. 412
x 500 diam.

b. Showing Flagella, p. 413.
x 1500 diam.

ARTIFICIAL CULTURES.



c. In Test-tube, p. 411.



d. In Petri Dish, p. 411.

THE GERM OF WILDFIRE.