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NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

FIG. 1—A Wilting Plant.

The Granville Tobacco Wilt; a Preliminary Bulletin.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

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Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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THE GRANVILLE TOBACCO WILT;* A PRELIMINARY BULLETIN.

By F. L. STEVENS and W. G. SACKETT.

INTRODUCTION.

A disease of tobacco so destructive that its spread throughout the country would imply annihilation of the industry of tobacco growing has made its appearance in Granville County, North Carolina. Since the chief symptom of the disease is a wilting of the leaves it is appropriate to know the disease as a wilt. Inasmuch as other wilts may have been or may later be found to affect tobacco plants, this wilt may further be distinguished as the Granville wilt, naming it after the county in North Carolina whence it was first accurately described.

The disease is spreading and the object of the present bulletin is to call attention to its nature, and to indicate such measures of prevention as may check or stop its spread into regions at present unaffected.

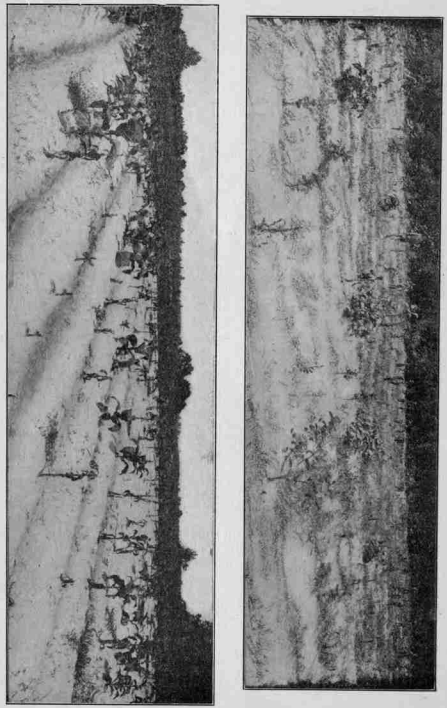
Description.

The Wilting.—The first indication of the disease is given through the leaves which droop, becoming soft and flabby as though suffering from want of water. This symptom is not accompanied by any change in color; the leaves remaining green for some time after the wilt appears. As a rule the lower leaves droop first, the wilting gradually proceeding from the ground upward. A typical case is shown on the front page of this bulletin. Frequently the leaves on one side of the plant, as is shown by one of the plants in fig. 5, succumb earlier than those on the other side. Some growers believe that one side of the plant may occasionally survive to maturity, though the other side be wilted, but that is not usual. Frequently even a single leaf will show one-sided infection.

The wilted leaves soon die, dry up and eventually the whole stalk dies. It then remains standing with its dead leaves still hanging as in fig. 8. It is thus not to be confounded with temporary wilting due to lack of moisture, excessive heat, etc.

The Stem.—At the stage of earliest wilting a section across the stem shows a yellowish discoloration of the woody portion. In more advanced stages, or in sections taken lower on the stem, the wood is

* This disease has been known to the Station for two or more years. The number of queries concerning it and its evident seriousness leads to special investigation of it at this time. A press bulletin has already been issued by this Station (August 22) under the caption "A Dangerous Tobacco Disease."



FIGS. 2 and 3—Two badly wilted fields near Creedmoor, N. C.

found either on its inner or outer parts to be penetrated longitudinally by black streaks, varying in size from that of a cambric needle to that of a knitting needle. These streaks are so abundant in stages immediately preceding death that the whole or nearly all of the wood seems to be so affected. Frequently similar streaks penetrate the pith, though this is only in the most extreme cases. The black streaks in the wood are usually more abundant adjacent to the cambium than to the pith, and simply removing the bark from near the base of sick plants, discloses them in abundance. The blackening often progresses from the wood outward through the bark, producing shrunken, blackened patches on the surface of the stem.

In more advanced stages when all the leaves are wilting the wood and bark at the base of the plant are blackened nearly throughout and the pith has decayed leaving the stem hollow or filled with a soft, rotten residue. The bark near the level of the ground turns black, and becomes dry and hard. The pith and wood in the upper portions of the plant usually dry up before decay overtakes them resulting in the collapse of the upper portions of the plant in irregular longitudinal folds in parts where the woody layer is too soft to maintain the shape of the plant when the support of the distended pith is withdrawn.* If a badly diseased plant be cut off near the ground, a dirty yellowish exudate issues from the cut wood, accumulating in a layer one or two millimetres thick. This exudate is slightly viscous, hanging together in strands two to four millimetres long when picked with a knife point.

The Root.—The root seems to be the seat of the original infection, and any plant in a stage of disease advanced enough to show symptoms in its foliage will be found to possess roots already in an advanced stage of decay. In early stages one root or more may be diseased (fig. 10); in later stages all succumb (fig. 11); in the more advanced stages of disease in any root the bark is black, soft and dry, a spongy mass of fibre left by the decay of the more watery parts. In the worst cases even this spongy covering may drop off leaving the wood of the root bare and dry. Usually, however, the bark remains as a spongy layer, surrounded by a dry papery jacket more or less cracked transversely, the remains of the epidermis. The decay is characteristically a dry one, although if the soil be wet with rain the decayed residue may become slimy, wet, and mushy.

The wood of the root undergoes changes similar to those of the stem. In the root as in the stem the disease manifests itself earlier in the wood than in the bark, appearing first as longitudinal streaks of black, in that portion of the woody cylinder lying close to the bark. The disease is most conspicuous in the largest roots, but the

*The stem consists of three portions: the innermost portion is the pith; surrounding this is a hard layer of wood, and the outermost layer is the bark. The wood and the bark are separated by a very thin juicy layer known as the *cambium*.

FIG. 4—Portion of a wilted field showing all stages of the disease.

FIG. 5—Dead plants replaced by cow peas. Plant on left shows wilt on half of one leaf.

FIG. 6—Two plants wilted, others healthy.

FIG. 7—In middle stage of wilt.

FIG. 8—In last stage of wilt.

smallest fibres, upon close examination, are seen to be similarly affected. In cases where the woody cylinder is blackened before the adjacent bark shows injury the smaller feeding roots, which pass from the diseased wood through the still healthy bark die. They are infected by or they infect the wood of the central cylinder.

When all the roots of a plant are diseased death is naturally more rapid than when a few only are affected, and in such cases the progress of the decay of the stem is cut off by the death of the plant. Thus in the plants most badly diseased the disease does not reach so high as in plants less affected. The wood midway up or near the top of such plants shows no blackening, barely a slight yellowish tinge is evident.

Spread of the Disease Through the Plant.

If one root only be primarily infected the blackening of the woody parts progresses to that side of the stem nearest the affected root, spreading much more rapidly longitudinally than transversely. Thus it happens that frequently a blackened streak may be traced from a single diseased root for a considerable distance through the length of the plant; sometimes even to a leaf, or to one side of a leaf. In such cases the side of the leaf bearing the affected woody strand is the first to wilt, and conversely if a section be made through the stem of a leaf, one side of which is wilted, it will be found that the corresponding woody strands of the stem are blackened.

It seems that the infection is first in the root, and that the spread in the plant is principally longitudinal, although a lateral spreading leads eventually to the involution of the whole plant.

How the Disease Differs from "Sore Shin."

Several diseases are classed by tobacco growers under the general names of "sore shin," "sore leg," etc. The Granville wilt may readily be distinguished from these by the diseased roots and the black streaks in the wood. In "sore shin," too, the plant usually topples over, while in the Granville wilt the stem remains erect.

Facts Known Concerning the Spread of the Disease.

Corroborative evidence from tobacco growers seems to establish definitely that this disease increases in violence upon a given field year by year after the first infection. In the first year of its occurrence in a field, a few plants only may be affected. The next year that tobacco follows on this field larger regions are affected. A third year without protracted rest from tobacco growing would probably in every case bring on conditions as deplorable as those shown in figs. 2 and 3, a common sight near Creedmore.

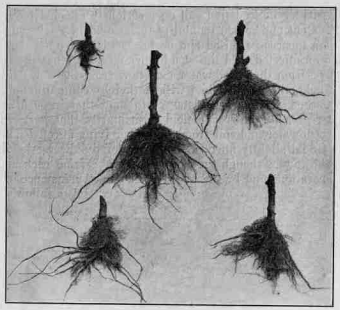


Fig. 9—Root in center healthy, others in various stages of disease.

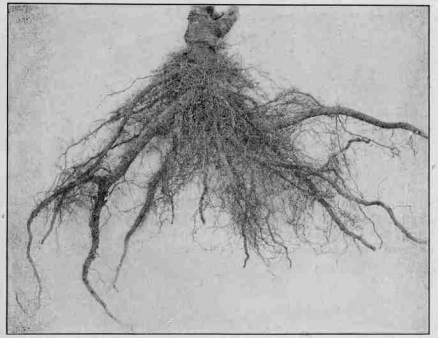


Fig. 10—Root to left badly diseased; from plant similar to the wilting one shown in Fig. 5.

It is further noticed that soil once seriously affected may recover to some extent and regain its ability to raise healthy tobacco if crops other than tobacco be raised and no tobacco be put upon the ground.

When an affected field lies at a higher level than healthy soil, and in such position that flood-water may flow from the sick field to the healthy field, the healthy field will be thereby contaminated. There are numerous well marked instances to show that in such cases the affected region of the second field is primarily that part which received wash-water and soil from the higher lying affected field. So, too, in a field slightly affected the spread of the disease is with, not across, the row as though the contagion were carried back and forth in the operations and by the tools of tillage. An instance of this is presented in fig. 13, where the diseased spots tend to follow the row.

FIG. 11—Root from a plant like that shown in Fig. 8.

DAMAGE.

In regions where the chief money crop must be tobacco, where the soil is preeminently a tobacco soil, the damage wrought by this disease is very great. It does not take merely an occasional plant, but rather the majority of those in the field. The accompanying illustrations present to the eye a general appearance of some fields near Creedmore, while the map, fig. 13, may convey still more accurately an idea of its devastating effect. So great is the injury on those fields that it may be called practically complete destruction of the crop.

The disease resides in the soil. A field with only a few sick plants one season on the next planting will have many, and another planting in tobacco would mean that practically all of the plants must

succumb. The damage therefore is not measured merely by the loss of one crop. The greatest loss is the permanent injury to the soil, prohibiting further culture of tobacco unless some remedy be happily discovered.

HISTORY AND DISTRIBUTION.

This disease while apparently new to literature has been known by the farmers of Granville County for some years. There is some difficulty in securing reliable data concerning its first appearance on account of vagueness and inaccuracy of descriptions, and the confusion of the disease with other diseases. It seems quite certain however that at least as long ago as 1881 there was a serious outbreak of the wilt near Hester, and that in 1890 and '91 it was destructive near Bennehan, the regions between these points meantime becoming involved. More recently a field near Tar River has been badly stricken.

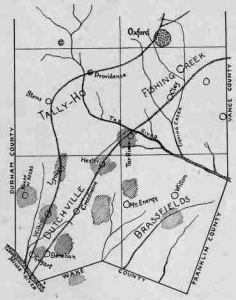


FIG. 12—Map of portion of Granville County showing diseased regions.

On the accompanying map the shaded regions represent places where the disease is now known in North Carolina. In many cases the land in the intermediate country is also sick, and the disease probably exceeds the limits here assigned, though it is positively stated by people who are familiar with the section that no wilt is found except between the Tar and Neuse rivers. Further inquiry may show the disease to be of much wider distribution than is here indicated.

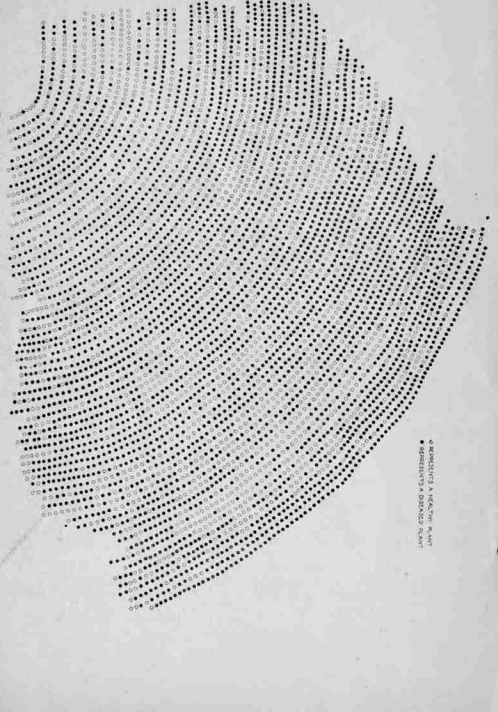


FIG. 13—Map of the field pictured in Fig. 3, showing distribution of diseased plants.

In its bounds as known at present the disease is not of great significance to the State, however great may be its burden to individuals living in the affected sections. It is hardly to be hoped, however, that in the natural course of events the wilt will remain so confined. It has spread and will continue to spread unless checked by intelligent management.

THE CAUSE.

Various theories have been advanced by the farmers as to the cause of the malady. Fertilizers, guano, improper crop rotation, climatic conditions, tillage, worms, bugs, conditions of the seed bed, etc., etc., have all been invoked; but a general concensus of opinion among careful, observant tobacco growers pronounces each of these insufficient to explain the existing conditions. A careful examination of the stem and root fails to reveal the constant presence of any insect enemy.

If portions of black strands from root, stem, or leaf be examined microscopically the vessels are invariably found to be filled with myriads of bacteria.* These are always present in the diseased parts in great multitudes. They are never present in healthy parts. The known facts concerning the spread of the disease as stated above, agree with the idea that it is of bacterial origin. It is therefore strongly presumptive that these germs cause the Granville wilt.

The final death of the plant may be due to either of two causes: the stoppage of food and water supply, through the inability of the diseased roots to longer absorb these from the soil in the case of very badly diseased root systems, or probably more often to a plugging of the water conducting tubes in the woody parts of the stem, thus effectually cutting off the water supply of the plant. A full-sized tobacco plant transpires or evaporates many ounces of water daily from its leaves, and any cause that operates to diminish or stop this supply must inevitably result in a wilting of the foliage.

That the action is of the nature of a plugging is evident in the case of one-sided wilt of a plant or leaf when the blackened strands indicating the plugged water vessels are clearly seen to be those leading to that part of the leaf or stem showing the first signs of the wilt.†

There seems to be no doubt that the efficient cause of this disease is a thrombosis of the vessels by bacteria. Whether these organisms constitute likewise the initial cause, and can, unaided, affect an entrance into the plant can be determined only by more complete study. In the present status of the investigation, in the light of the evidence of both laboratory and field, the only tenable hypothesis is that of bacterial origin, although such a cause can not be considered as posi-

*Small living plants or germs, so small that 25,000 of them placed end to end would reach only an inch.

†The materials on which this study was made were collected at and near Creedmore and Hester.

FIG. 14—A healthy field near Creedmore, N. C.

FIG. 15—A diseased field on similar soil near Creedmore, N. C.

tively established, until the disease has been produced artificially by inoculating a healthy plant with a pure culture of these germs, an operation that has as yet not been possible, owing to lack of plants in suitable condition for experimentation.

MEANS OF DISTRIBUTION OF THE GERMS.

The germs grow and multiply in the affected plants. Upon the death and disintegration of the plant they are liberated in the soil where they seem to be able to live for considerable time. The immensity of their number in a diseased plant furnishes inconceivable hosts, so that even a few diseased stems, roots, or leaves in the field will stock the soil plentifully with the germs. Infected plants or soil in which infected plants have been or which bears parts of infected plants, can therefore convey the disease to healthy fields.

Instances have been cited in previous pages where the contagion has been spread by WASHING from higher land to lower, so, too, may it be carried by any means which can convey soil from a sick to a healthy field, notably through TOOLS, which have been used on diseased soil. Though apparently reasonably clean, such tools, if they bear even a fraction of a spoonful of infected soil, may carry hundreds of germs and thus start an epidemic in the field next cultivated. The HOOFS of animals or the FEET of laborers, may in a similar way bear the disease-laden soil. WIND passing over an infected field may pick up broken bits of sick tobacco plants or germ-laden soil, and convey these to healthy fields. Infection by wind, however, seems to be rare, possibly because of the germicidal action of the sun's rays upon the surface layer of soil upon which the wind must act. It is still an unanswered question whether the germ can live through the heat of the curing-house. If it can, an additional means of dispersal obtains in the manure made from the refuse stalks and stems derived from such plants.

LENGTH OF LIFE OF THE GERMS IN THE SOIL.

It is unknown how long the germs can live in the soil without their favorite food, the tobacco plant. That they can live from one season to the second season following seems certain. A field slightly affected one year if put to tobacco the second year after will be more seriously diseased, and the affection will grow in destructiveness so long as tobacco be cultivated with so short an intervening period. This seems to prove that the increase of germs in the soil is much more than enough to counter-balance the loss occasioned by the winter season.

If tobacco be planted on an affected field that has had no tobacco for several years, it is found that the field has become more healthful.

The germs have died in the soil, probably for lack of that food to which they are particularly adapted. In one case by rotating the crop so that tobacco did not come again upon the field in fifteen years the disease was completely eliminated. Several cases are known where a rest of five, and even eight years, did not materially restore the soil to health. From the evidence at hand it appears that the germs may live as many as eight, but less than fifteen years in the soil without the tobacco plant. Further evidence upon this point is needed.

Methods of Prevention.

It is hopeless to attempt to cure a plant after it is once diseased. Prevention must be relied upon. With the knowledge that the disease is caused by living germs rational methods may be adopted to prevent its spread.

Prevention of Spreading by Soil.

Any means which can carry soil from a diseased field to a healthy field may spread the disease. One of these ways is by washing. In some cases a field now healthy may be protected from higher land that is infected by proper arrangement of dykes.

A second means of soil conveyance is by tools. A cultivator or a hoe used in an affected field carries myriads of germs. If such a hoe be used in an unaffected field these germs will be distributed and the disease spread. This means of spreading is largely within the control of the farmer. All that is required is such thorough cleansing of tools that no possibility of conveying the germs remains. First, the dirt should be knocked off, then wiped off and the implement finally cleaned by being thoroughly wet with a solution consisting of two per cent formalin or five per cent carbolic acid. It is difficult to insure complete protection against spread by the feet of animals and man, but every possible precaution should be exercised in this particular.

Prevention of Spread by Diseased Plants.

Every diseased plant is veritable culture ground for the germs. Therefore every such plant and every part of such a plant should be destroyed by fire. Pull the plants up by the roots, getting all of the roots possible. Let them dry and then burn them. This precaution in a badly diseased field diminishes the nourishment at the disposal of the germs and will probably enable the land to recover more rapidly. Burning is, however, especially important where but a few plants in a field are affected. Prompt action here may materially lessen the rapidity of spread of the disease in the field. It should be borne in mind that every particle of sick plant burned means the destruction of millions of the germs.

Possibilities of Soil Treatment.

The germs reside in the soil. The possibility of killing them in the soil therefore arises. Experience with other diseases which in a similar way winter in the soil leads to but slight hope that any method of soil sterilization will ever be practicable. This germ is different from others that have been experimented upon, however, and the importance of the problem demands that a thorough trial be made.

The fact that the seed-bed seldom if ever bears diseased plants indicates that the heat generated by burning the bed, suffices to kill the germs. Diseased land could doubtless be made healthy by burning it over in this way, but such a method is clearly out of the question. Some chemical cheap enough to render its use practicable may be found to accomplish the same end, still no great hope of this is to be entertained.

Crop Rotation.

A long rotation of crops, one that will bring tobacco back upon the affected field only after an intervening period of several years, perhaps after a period of eight or ten years, seems at present to be the only recourse for one whose field is now infected. Even with this precaution it is doubtful whether the disease can be completely eradicated.

The tobacco wilt germ has not been proved to be injurious to other crops, and tobacco-sick soil can probably be safely planted with any other crop, with the possible exception of such close relatives of the tobacco as the Irish potato and the tomato and egg-plant.

A Wilt Resistant Kind of Tobacco.

The one means of overcoming the wilt which is most promising to farmers who own affected soil lies in the discovery of some variety of tobacco that will not wilt even when planted upon sick soil. Varieties of cotton that can resist the cotton wilt, and of cow peas that can resist the cow-pea wilt have been discovered. There is similar hope in regard to the tobacco wilt. If several plants grow under the same conditions in infected soil and one of them survive while the others wilt, this survival may be due to a special resistance on the part of the plant which prevents the encroachment of the parasite. Such a plant should be caused to seed, and its seeds saved with great care, since this ability to resist the disease is a character that may be transmitted to the plant's offspring. Seeds from resistant plants should be tested on sick soil, and any plants that prove resistant should again be saved as seed plants. A few years of such selection of seed from resistant plants may result in the development of a race of wilt-resistant tobacco similar to the wilt-resistant cotton and cow peas, which were developed in a similar manner.

Other Wilts.

Bacterial wilts are known to occur among other cultivated plants, notably the Irish potato, tomato and egg plant. Whether these are communicable to the tobacco, and vice versa, is as yet unknown. The diseases have many points in common.

Very similar diseases affect the cotton, cow pea and watermelon, though in each of these cases the wilt is due to an organism (a fungus) distinctly different from anything found associated with the tobacco wilt. In these diseases also the rot of the root is not characteristic, as it is with the tobacco, nor is the plugging of the vessels by bacteria a feature.

Conclusion.

The tobacco wilt is a very serious enemy which not only injures the crop, but also depreciates the value of the land affected, inasmuch as it prohibits the growing of tobacco in the affected soils.

It is a contagious disease, spreading largely through infected soil.

There is a little hope of restoring land that is once affected. The utmost care should be taken therefore to prevent the spreading of the germ by means of infected tools or by any means.

The number of germs should be diminished by cleaning up old fields and by burning all diseased plants in slightly affected fields as soon as they are discovered.

The greatest hope for the redemption of land now affected lies in the development of a variety of tobacco that can resist the disease.