The Granville tobacco wilt / by Erwin F. Smith.

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THE GRANVILLE TOBACCO WILT.

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HISTORY.

Attention was first called to the Granville tobacco wilt in September, 1903, by McKenney, then connected with this Department. He attributed it to a fungus (Fusarium) nearly related to those studied by the writer on cotton, melon, and cowpea. No proofs from inoculation were obtained by McKenney.

A few days after the appearance of McKenney's paper a bulletin was published by Stevens and Sackett, of the North Carolina Agricultural Experiment Station, describing this disease and attributing it to bacteria. Their diagnosis also depended solely on field observations and microscopic studies, but this part of the work was well done.

In 1905, as the result of personal examinations of infected plants, studies of the microorganism in pure cultures, and successful inoculations therefrom, the writer confirmed the findings of Stevens and Sackett as to the bacterial nature of this disease. Numerous successful infections of tobacco were obtained both by needle puncture from pure culture and by plantings in infected soil.

The organism was identified provisionally as closely related to *Bacterium solanacearum*, a species described by the writer in 1896 as the cause of a widespread and destructive brown rot of the potato, tomato, and eggplant. This conclusion was based on the similar behavior of the tobacco bacterium and of undoubted *Bacterium solanacearum* (derived from tomato and potato) in a variety of culture media. The shade of doubt remaining in my mind at that time was due to the fact that many cross-inoculations (potato to tobacco and tobacco to tomato), while showing multiplication of bacteria in the inoculated tissues and some other signs of disease (brown stain in the bundles, and on tomato stems the development of incipient aerial roots), did not contract the wilt.

THE CONTINUED PREVALENCE OF THE DISEASE.

Both in North Carolina and in Florida this wilt of tobacco has continued with increasing severity, the losses in 1908 being greater than those of any previous year. In North Carolina quite a number of

planters have lost whole fields and others considerable parts of fields. Still others have harvested their tobacco green to save some part of it. The entire loss in 1908 in North Carolina is not known, but is estimated at upwards of $100,000.

In Florida the disease has also made great inroads in several places, causing serious losses for three or four years. In 1908, one man lost 20 acres of tobacco under shade by reason of it. The same year a company lost nearly every plant on 12 acres of home-grown Sumatra under shade and also a considerable part of 95 acres of imported Sumatra, also grown under cover (cloth). On many of these fields tobacco has followed tobacco for a long series of years (eighteen years in one field).

The worst feature of this disease is the fact that fields once infected remain infected indefinitely, or at least for many years, and are also useless for growing any other plant of this family, e. g., potatoes, tomatoes, eggplants, or peppers. The disease is therefore a very serious one. If it continues at its present rate of progress, tobacco growing in the infected districts will become impossible within a few years, and if it should extend to all the tobacco-growing sections of the United States this industry would be destroyed. It is therefore of the utmost importance to keep it out of sections which are still free from it. To this end correct information respecting its nature should be disseminated as widely as possible. An ounce of prevention is worth tons of cure—and, moreover, *a cure* is not in sight. Something may be done, however, by good field hygiene to restrict its progress.

BACTERIAL ORIGIN OF THE DISEASE.

The writer no longer has any doubt as to the bacterial origin of this disease. On two or three occasions he has found Fusarium on tobacco stems affected by this disease, but not commonly, nor ever exclusively. Generally there were also a great many bacteria present in the stems occupied by the fungus. Once I have observed Fusarium to be a secondary infection—in one plant out of many inoculated with the bacterium some years ago.

Almost all of the diseased tobacco plants examined by me from North Carolina and from Florida, a hundred or more, in several different years, were attacked by bacteria to the exclusion of fungi. Fusarium certainly was not present. Nothing here said, however, need be construed as a denial of the occurrence in this country of a Fusarium disease of tobacco, since it is very reasonable to suppose the existence of such a disease. There are many such diseases, as the writer was the first to point out. One occurs on the tomato and another on the potato. Why not one on tobacco? The evidence necessary to establish such a contention, however, is yet to be procured. Meanwhile we may consider the Granville wilt as solely bacterial in its origin.

NEW EXPERIMENTS.

Experiments by the writer in the summer of 1908 have demonstrated that the Carolina tobacco disease is readily communicated to tomatoes through the root system. These infections were obtained by transplanting healthy tomatoes into a bed of good hothouse soil in which tobacco plants affected by the Granville wilt had been buried recently. The stems of these tobacco plants, which were obtained from North Carolina, were swarming with the bacteria peculiar to this disease. The tomato plants were infected through *broken roots,* the plants being of considerable size when set into the infected bed.

The experiment was begun at the end of July, and up to this date (August 18) nineteen tomato plants have contracted the disease. This disease is typical tomato wilt, the vascular bundles of stems and midribs being browned and their vessels filled with the grayish white bacterial slime peculiar to the genuine tomato disease. Dissections showed the brown stain and the bacteria in the bundles to be more abundant as one passed from the top of the plant toward the roots, and always one or more broken roots were found *diseased to their very end,* i. e., browned and occupied by the bacteria. Most of the roots, however, as well as all of the underground stem and all of the parts above ground, were free from external appearance of disease other than the wilt, i. e., from wounds, spots, or stains. The wilting was sudden, i. e., not preceded by any yellowing of the foliage. Numerous incipient roots developed on the stems. No other tomato plants in the houses or on the grounds (several hundred) showed any signs of this disease.

The Jimson weed (*Datura stramonium*) planted in this bed also contracted this disease through the root system.

Moreover, with bacterial slime taken from the interior of four of these wilting tomato plants (upper part of the stem) I have caused the Granville tobacco wilt inside of two weeks on four large healthy tobacco plants, the bacteria being introduced into leaves and stems by means of needle pricks, and also by pulling off leaves and rubbing the scars with the crushed tomato stems. The signs of this tobacco disease so obtained were in every way characteristic—wilt of foliage, darkening of the veins of the leaves, longitudinal dark stripes on the stem originating from internal staining, brown stain of the vascular bundles of the stem and leaves, and vessels gorged with the characteristic bacteria. Some of the uninoculated leaves also dried out irregularly, and the apical leaves on the inoculated side of the stem became dwarfed and distorted. The inoculations were made in another hothouse (where no other Solanaceae were grown), the checks remained healthy, and when the wilting plants were cut for examination the root system in three of the four plants was still free from disease, the inoculations having been made at the top of the plants. Moreover, in all cases (four places on each plant) the disease began in the pricked and rubbed areas.

SPECIFIC GERM INVOLVED.

The cultural characters of the tobacco organism are the same as those of *Bacterium solanacearum* derived from tomato or potato, and now that good cross-infections have been obtained no doubt remains that the Granville wilt of tobacco and the brown-rot of potato, tomato, and eggplant are one and the same disease, i. e., due to the same organism, all of these plants belonging to the nightshade family and being rather close relatives. The Florida tobacco wilt at Quincy and Hinson appears to be the same thing. I examined diseased plants from Florida some years ago and again this year.

The writer formerly stated (1896) that he did not succeed in cross-inoculating *Bacterium solanacearum* into tobacco and peppers, and at that time he believed tobacco to be exempt, but not many experiments were made, and we may assume either that the cultures used had lost their virulence or that the particular plants selected were too old or growing too slowly, or for some other reason were unusually resistant. The writer now believes that *Bacterium solanacearum* does frequently lose its virulence by continued culture; that, in general, old and slow-growing plants are difficult to infect; and that some individuals and some varieties are more resistant than others. This, I believe, sufficiently explains the former failures. We may conclude, therefore, in searching for remedies that we have one disease to deal with and not several.

METHOD OF ENTRANCE OF THE BACTERIUM.

If stomatal infections occur, which is not unlikely, especially in wet weather, they have not yet been demonstrated. So far as we know, this organism enters the plant only through wounds. Van Breda de Haan found the root system especially subject. Stevens and Sackett state that the infection is first in the root. A large number of infections undoubtedly take place under ground, the organism present in the soil entering the plant through wounds made in transplanting or cultivating, or by small animals infesting the soil. Roots broken in transplanting and leaves pulled or pinched off at that time are responsible for many infections, and it would seem that by care the number of such wounds inviting infection might be greatly reduced.

It has been observed in Sumatra, where occurs a destructive bacterial wilt some years ago identified by Hunger as due to *Bacterium solanacearum*, that the tobacco plants are peculiarly subject to it when grown on land infested with eelworms (nematodes) or with insects which attack the roots or base of the stems. Rainy weather is favorable to the progress of this disease, although the wilt may be detected first in dry weather. In this country it has been observed, especially by Earle on tomatoes in Alabama, that wet soil is peculiarly favorable to the spread of this disease. All observers agree that the root system

is peculiarly liable to attack. To a very considerable extent the destructive prevalence of this disease seems to hinge on the occurrence of root-infesting nematodes. They are common in the diseased tobacco soils of Florida and probably occur also in those of North Carolina.

REMEDIES AND PALLIATIVES.

(1) This organism is to be regarded as a very bad weed liable to be distributed in many ways. It is worse than ordinary weeds because it is invisible. On plantations free from the disease a rigid quarantine should be erected against plantations subject to the disease: Nothing should be received by the farmer from the latter—seeds, young plants, raw tobacco, cured tobacco, packing cases, wagons, tools, fertilizers, laborers, horses, cattle, etc., all should be excluded. Avoid also the manuring of fields with tobacco waste even when it is believed to originate from clean sources.

(2) Do not plant tobacco on lands subject to this disease. Rent healthy land at a distance if necessary. To plant infected land invites disaster. *It is not safe to do so even after several years.* Stevens and Sackett have recorded several cases where the disease returned after five to eight years rest of the soil, and one instance where it did not return after a rest of fifteen years.

(3) Do not cultivate any other similar plants on infected land. Tomatoes, potatoes, eggplants, peppers, and pepinos are all more or less subject to this disease, and their growth will help to continue the organisms in the soil. Grow plants of some entirely different family. Look out also for Solanaceous weeds. It is not known whether these are actual harborers of the bacteria, but it is well to destroy them. In the hothouse the writer has found the plant called Stramonium, jimpson, or Jamestown weed quite subject to this disease. The disease is also readily inoculable into the black nightshade (*Solanum nigrum*).

(4) Search the affected tobacco fields carefully, especially toward the end of the season, in the hope of finding resistant plants from which seed may be saved for the breeding up of resistant sorts. There is some hope that this may be accomplished. The intelligent planter can serve himself in this matter as well as help to excite general interest in the subject. The end in view is worth the expenditure of much time and trouble.

(5) If it is impossible to avoid the use of infected lands, then certainly avoid planting the wettest spots, and underdrain such fields as speedily as possible.

(6) Select for the seed beds soil which is uncontaminated, and transplant to the field *early*, i. e., while the plants are quite small, *and with the greatest care to avoid breaking the roots.* Cultivate shallow with the same thought in mind. Under no circumstances use large plants

on such lands. The roots are certain to be broken more or less in transplanting and equally certain to become infected, with subsequent infection of the whole plant. Probably half the trouble on such lands, if they are free from nematodes, might be avoided by careful attention to this one particular. Under tents, sowing the seed in the place where the plant is to stand might also be given a trial.

(7) Wound as little as possible the base of the plants and the tops by pruning or pulling away leaves. Do not jerk off leaves when setting out. It is a good rule under ordinary circumstances to balance root and top by removing a portion of the leaves at planting time, *but not when this disease is present*, since infection is liable to occur in this way. The same end may be accomplished with less danger to the plants by using greater care in transplanting, and especially by transplanting when the plants are small. Top the plants in dry weather.

(8) Avoid fields known to be infected with root nematodes. They wound the roots and enable the bacteria to gain an entrance. Hunger demonstrated this on tomatoes in the Dutch East Indies. If such fields must be used, the nematodes may be reduced in number by rotation with winter grains (oats, rye, wheat) followed by velvet beans but not by cowpeas (except Iron), since ordinary cowpeas are much subject to root nematodes and will increase the number of them in the soil. Velvet beans are not subject to nematodes. The number of nematodes in the soil may also be reduced by a skillful use of trap crops, but an unskillful use of the same will increase their number. The object of a trap crop is to get as many nematodes as possible encysted in the roots, which are then pulled up and burned. Cowpeas may be used as a trap crop. They should be removed and burned as early as the fourth week, i. e., before the nematodes have escaped again into the soil in increased numbers. It would be best, however, to put this work into the hands of persons having some knowledge of biology, since trap-cropping for nematodes is still in the experimental stage.

(9) Remove and burn affected plants as soon as they are detected. They are swarming with innumerable millions of infectious particles[1] which plowed under or allowed to fall to the ground are washed into the earth and will serve to increase the soil infection. Such plants are also a source of danger to your own free fields and to those of your neighbors. There are enough neglected tobacco plants in Granville County to infect the whole United States if properly distributed.

(10) Under no circumstances throw tobacco refuse on your fields, or into your barnyard, or into streams or roadways. Such refuse is a good fertilizer, but it may also prove the carrier of this disease and the danger is too great. The organism may live in the dead stems for some time—just how long is not known. Do not take any risks. The

[1] A single tobacco plant may contain ten thousand million of these bacteria.

organism is not known to produce spores and is believed to be destroyed by a short exposure (ten minutes) to 52° C. (125° F.), but until it has been confirmed on a large scale in the field it is best to be cautious about using waste material from the curing house. Some portion of it containing these bacteria may not have been heated hot enough to destroy them.

(11) Strive to keep uninfected fields free from infection. To this end look out for the tobacco refuse; also for wash of rain water from infected lands (this to be turned aside by ditches and dikes). Be watchful also for other sources of infection, e. g., dirt or fragments of infected tobacco carried on tools, feet of horses and cattle, etc.

Tools may be disinfected (after removing the dirt) by a short exposure to live steam, boiling water, or the open flame (gasoline torch). Five minutes exposure ought to be ample. They may also be disinfected by the use of germicides, e. g., 5 per cent carbolic acid (poison) or one-fifth per cent mercuric chlorid (poison). Carbolic acid or mercuric chlorid (corrosive sublimate) are better than formalin, since the latter is volatile and likely to be under the certified strength (40 per cent formaldehyde) in broken packages or old corked bottles. Mercuric chlorid tablets prepared for this purpose, so that weighing is not necessary, are on the market. Wooden pails and clean boiled water should be used. The germicidal action of mercuric chlorid is destroyed by contact with metal dishes. These substances should be kept out of reach of children.

(12) Avoid also the increasingly common southern practice of sowing fields with dirt from other fields, the idea being to inoculate the soil with nitrogen-fixing organisms. This method of inoculating soils is a bad practice under any circumstances, i. e., one well calculated to disseminate plant parasites and one particularly reprehensible in localities where this disease prevails or is liable to occur. Nematodes, injurious insects, parasitic fungi, club-root of cabbage and other Crucifers, and plant-destroying bacteria, not to mention animal parasites, are all liable to be disseminated in this way. To let loose a whole menagerie for the sake of obtaining an ox or an ass is not a good policy. Obtain pure cultures for soil inoculations from the Department of Agriculture or the State Agricultural Experiment Station.

(13) Those who grow Sumatra wrapper-leaf tobacco under tents erected at great expense and whose annual crop is worth $1,000 or $1,500 per acre can afford greater expenditures in combating this disease than the ordinary planter. Such persons should endeavor to free the soil of this organism by fire or by steam heat. They should also combat the nematodes. *Bact. solanacearum* is quite sensitive to heat, and if the whole body of the soil could be warmed up to 125° F. for fifteen minutes this organism would be destroyed. If such attempts are made great care must be taken that the sterilized portions are not

reinfected by careless workmen from the parts not yet treated. Live steam under considerable pressure conveyed through parallel lines of buried gas pipes and let loose into the soil at short distances by suitable *small* openings is probably the best method of applying steam. It may be applied, however, as Shamel has recommended for seed beds, i. e., under large shallow metal pans, which are then moved to a fresh portion of the field, and so on until all is treated. A lettuce grower in Boston has invented a sort of drag-tooth device of gas pipe which is driven down into the soil and steam turned on for a half hour or more. This is then lifted and driven down in another place, and so on until the whole bed is covered. It effectually sterilizes the soil, but the labor is very considerable.

(14) Get your neighbors to unite with you in carrying out these measures.

RECAPITULATION.

The tobacco wilt is due to bacteria. They occur in the diseased plants in enormous numbers. They infest the soil and remain alive in it a long time. The plants are commonly infected through injuries due to nematodes (eelworms) which cause swellings on the roots, or through roots broken in setting out. Late transplanting from the seed bed is very disastrous when this microorganism is in the soil. Potatoes, tomatoes, eggplants, and other members of the nightshade family are also subject to this disease.

Sound plants depend on planting in uninfected land. To keep uninfected fields free and to reduce the amount of infectious material in diseased fields, remove and burn the diseased plants and practice the other hygienic measures here recommended.

Immediate remedial measures should look to reducing the number of nematodes in the soil; to greater care in transplanting, so that the plants, and more particularly the roots, shall not be wounded; and under tents, if the cost is not prohibitive, to destruction of the bacteria by steam heat.

Remote remedial measures should look to breeding up races of tobacco which shall be resistant to this disease either directly, or indirectly by being resistant to root nematodes.

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