1-1-1892

The Southern Tomato Blight

Byron D. Halsted

MISSISSIPPI

Agricultural and Mechanical College

EXPERIMENT STATION.

BULLETIN NO. 19.

The Southern Tomato Blight.

BYRON D. HALSTED,
Special Assistant.

AGRICULTURAL COLLEGE, MISS.

JANUARY, 1892.

OFFICERS OF THE STATION.

TRUSTEES.

His Excellency J. M. STONE, ... Ex-Officio President

Hon. H. M. STREET, ... Meridian

Hon. J. Z. GEORGE. ..... Carrollton

Hon. J. F. McCORMICK, ... Perkinston

Dr. GEO. H. PEETS, ... Woodville

Hon. J. R. CAMERON, ... Canton

Hon. W. B. MONTGOMERY, ... Starkville

Maj. T. C. DOCKERY, ... Love's Station

Hon. A. F. FOX, ... West Point

Maj. W. H. MORGAN, ... Sheppardstown

GOVERNING BOARD.

Gen. S. D. LEE ..... Prest. A. & M. College

Hon. W. B. MONTGOMERY, ... Local Trustee A. & M. College

S. M. TRACY, ... Director

WORKING FORCE.

S. M. TRACY, M. S. ..... Director

W. L. McGEE, M. S. ..... Assistant Director

E. R. LLOYD, M. S. ..... Agriculturist

H. E. WEED. M S. ..... Entomologist

A. B. McKAY, B. S. ..... Horticulturist

TAIT BUTLER, V. S. ..... Veterinarian

W. L. HUTCHINSON, M. S. ..... Chemist

L. G. PATTERSON, ... Chemist

R. C. KING, B. S. ..... Treasurer

The bulletins of the Station are sent free of charge, to all farmers in this State who apply for them.

THE SOUTHERN TOMATO BLIGHT.

[NOTE. For several years the tomato growers of Mississippi have suffered serious losses from the prevalence of an unrecognized disease which, in some cases, has destroyed from one-fourth to one-half of the plants. The cause of the disease was wholly unknown, and none of the preventives used seemed to have any effect. In 1890 the losses from this cause were so severe and so wide spread, that in May, 1891, the Trustees of the Station secured the assistance of Dr. Byron D. Halsted of the New Jersey Station, in an endeavor to ascertain the cause of the disease, as a necessary preliminary to intelligent work with preventives and remedies. Dr. Halsted has been working on similar diseases of plants for many years, and the Trustees knew of no one else who was so well qualified for the work, or upon whose conclusions more reliance could be placed. He commenced his work at the Ocean Springs branch station on May 5, five days after the disease made its first appearance there for this season, and remained there until the weather became so dry as to make further operations in the field impossible. He then examined the fields in several other portions of the state, after which he returned to New Jersey and continued the work in his laboratory until the close of the season. He will continue the investigation during the coming year, both in the field and in the laboratory, but in order to place on record the results already secured, and to assist others who are working in the same line, it is thought best to publish now his report of the work done in 1891, although it is necessarily incomplete.—S. M. TRACY, Director.]

As this disease has been, until the past year or two, most injurious in the gulf states therefore, for the sake of avoiding confusion, it may be termed the "Southern Tomato Blight." While known for several years, it was not until 1889 that it assumed proportions causing alarm among the growers of the tomato.

The blight is quickly recognized by a wilting of the plant and particularly of the young upper leaves and the growing tips of the stem. Usually the older leaves have turned yellow and hang lifeless from the stems before the wilting is noticed. If the plant has two or more branches reaching below the surface of the ground it is not infrequent that only one will at first show the wilting or blighting.

Upon closer inspection it is found that patches of the stem and adjoining leaves of the diseased plants have a moist appearance as in the so-called "water-core" of apples. Such stems, when cut lengthwise, show a very watery pith which, on account of the excessive moisture, has a greener color than that of the center of a normal stem. This watery, greenish, condition of the pith may extend far below ground and occasionally to the end of the stem while upward it generally extends to the succulent stem tips. Plants longer affected have the greenish color replaced by a light brown that is scattered irregularly through the pith and is particularly prominent in the ring of woody substance outside. The lower leaves upon such plants often become yellowish and their bases soft—almost slimy.

Under the compound microscope the diseased portions of the plant showed the presence of large numbers of bacteria while all traces of any of the filamentous fungi common to rusts, smuts, mildews, moulds, and many of the blights were invariably absent in freshly gathered stems that were unmistakably diseased. That bacteria are the cause of the trouble now prevalant in so many tomato fields of the South requires for its establishment prolonged and painstaking experiments in both the laboratory and the field, both of which were impossible at the time of the visit. All that can be done in this report is to put on record the observations in the field, the tests made indoors and the more extensive examinations carried out, so far as suitable material was present, in my laboratory after returning from the south.

After being reasonably assured that the cause of the blight was a minute micro-organism, a large series of attempted inoculations was made, but from lack of proper means and owing particularly to the dry hot weather prevailing during the time no decisive results were obtained upon the growing plants in the field; while in green fruits the disease was sometimes seemingly transmitted, there was nothing warranting a conclusion that the disease had been communicated to the living plant by means of the virus employed.

A BLIGHT OF POTATOES.

While these experiments were in progress visits were made to some potato fields, the suspicion having arisen that the tomato blight was akin to the bacterial disease now quite well known to be practically destructive to the potato crop in some parts of the country. Upon a field owned by Mr. Rupel, it was found that fully one-fifth of the crop was destroyed with a bacterial decay, and the vines generally were badly blighted. According to Mr. Earle, this trouble with potatoes has been more or less prevalent in the vicinity of Ocean Springs for the past three years, the length of time he has lived there, and for aught we know to the contrary may have prevailed to the same extent for a generation or more.

In this connection it is only proper to briefly outline the appearance of the affected potato plants. The blight may be recognized by the premature dying of the vines and, when the trouble is violent, plants exhibit a wilting characteristic of the tomato blight previously mentioned. Below ground the stem is more or less darkened, in patches brown, and occasionally almost black. The old "seed" potato is a soft rotten mass, and the few new potatoes usually small and decayed, invariably at the stem end and almost always at the eye, appearing at first "watery" and afterward brown. It is an interesting fact to be stated in passing that the earth adheres very closely to the surface of the decaying portions. It seems evident from the extended study of these diseased potato plants, hundreds being examined, that the rot passes from the main stem to the tubers, and probably comes originally from the "bud". Often a lateral underground branch including its minute potatoes, as large as peas, is entirely softened. Upon making halving sections of the tubers it is seen that the most diseased portion is in a circle which includes the base of each eye. This portion is a soft, growing layer, rich in nitrogenous substances, and furnishes the avenue through which the disease spreads from one eye to another. From this decayed tract a milky juice quickly accumulates upon the section that is made up very largely of bacteria and contains no other form of fungus.

Without any further evidence than that coming from a thorough field inspection and a microscopic examination of the diseased tubers it would not be difficult to hold a strong opinion that the trouble was due to bacterial germs. Its method of propagation from year to year seems well provided for in the "seed" that is used, for should it contain only a very small amount of the virus not easily detected, the means are supplied by the habit of growth for the communication of the disease to all parts of the plant, young tubers in particular.

INOCULATION.

Having found the bacterial disease of the potato in serious abundance in the neighborhood of the blighted tomato fields, and knowing that the potato and tomato are nearly related plants of

the same family, it was a natural inference that the blight of the two crops sustained a more than accidental relation in the vicinity of Ocean Springs.

Inoculations were therefore attempted between the potato and tomato similar to those with diseased tomato virus upon healthy plants, but the extremely unfavorable conditions in the one case prevailed for all, and results that might otherwise have been hoped for were not forthcoming. All tomato plants were at that time of full size and did not admit of treatment under bell jars, even if such aid to study had been at hand. A large number of inoculations, however, were made indoors by taking sections of healthy stems and keeping them in a moist chamber made by inverting one soup plate over another, the specimens being raised above the water kept in the bottom of the lower plate. These tests were all made in sets of five with an equal number of checks. Thus, there were five slices of small tomato inoculated with virus and five with similar scored or pricked places, but without virus added. Five were also inoculated with bacteria from a potato and five were not. Five three-inch pieces of tomato stems were inoculated with tomato virus, with checks; five with potato virus and checks. Potato stems were treated in the same manner, using tomato virus. The virus under these favorable conditions invariably grew, while the checks nearly always failed to show any indication of the disease. The potato virus was often the most active, but not always so. This was repeated with substantially the same results, only the milky ooze of the diseased potato being used. Only one of the ten checks rotted. The tomato virus worked fully as well as that of the potato.

Sliced healthy potato tubers were inoculated with tomato stem virus and a rapid decay followed from the center of each infection. One check softened but in this case the slice got tipped into the water below. Sliced tomatos inoculated with potato virus gave rottenness in twenty hours while the checks remained sound. The same plate contained slices inoculated with tomato virus in which all "took", but less rapidly than the other set.

As these tests were made and results obtained in twenty-four hours, they were repeated in great numbers until there was

no possible doubt about the tomato, potato, and melon tissue, whether of stem, fruit or tuber, being susceptible to decay from the same germ, and as only bacteria appeared first in these inoculations it seems safe to conclude that there is a bacterium common to the three kinds of plants and to which may be ascribed the cause of the trouble now being experienced in the Southern States.

As there had been complaint of a melon blight, stems of those plants were treated in a manner parallel to those of the tomato and potato and they decayed equally well with the other two.

TESTS WITH SEEDLINGS.

The next point of attack in the problem in hand was to grow seedlings under varying conditions, and the following set of six seed boxes was sown May 8th. In No. 1 the tomato seed was sown in earth with which a considerable quantity of the chopped diseased tomato stems were mixed. Number 2 was sown in the ordinary way. Number 3 had the seed soaked for five hours in the juice of diseased stems and No. 4 was sown without treatment like No. 2, but the young plants were spayed from time to time with bacterial juice. No. 5 was the same as No. 1, with the chopped tomato stems replaced with cut diseased potato. No. 6 was the same as No. 2, a check. These boxes were left in charge of Mr. Earle who faithfully watched and watered them. On May 26th he wrote that the plants each had the rough leaves and no real difference was manifest in the lots. At about the same time a package of seedlings was sent me containing a half dozen plants from each box upon which the following notes were made on the day of their arrival: Only two lots came through in good shape and in three the stems were firm and healthy and only the foliage, which was extremely tender, was withered and slightly decayed. These were the untreated plants. The next best were the two lots in which the plants were equally and badly decayed, the stems being so soft that it was impossible to lift a plant with the fingers: These were numbers 1 and 5; those planted with the diseased tomato stems and the diseased potato tubers respectively. The other two lots were so far gone as to be found with diffi-

culty, the worst being No. 3 where the seed had been soaked in tomato virus and the other (No. 4) sprayed with the bacterial decoction.

It would seem from this that, while the young growing plants may not have showed any signs of the disease, the germs were in some and not in the others, and under the favoring conditions for decay furnished by the package in transit, those which were inoculated were overcome, and the others were not.

On June 8th after ten plants from each of the boxes had been set in the field for a week Mr. Earle made the following report.

No. 1.	Three alive	(chopped diseased tomatoes.)
No. 2.	Eight alive,	(no treatment.)
No. 3.	Six alive,	(seed soaked in water.)
No. 4.	Three alive,	(seedlings sprayed.)
No. 5.	Three alive,	(chopped rotten potatoes.)
No. 6.	One alive	(no treatment.)

By this it is seen that one untreated is highest but the other the lowest in living plants. The general appearance of the boxes at the time of setting out showed that numbers 2 and 6 were best and number 1 decidedly poorest.

On July 5th Mr. Earle wrote, "Of our experimental plants I find that out of the sixty set but nine are still alive. Five of these belong to lot No.2, three to No. 3, and one to No. 4."

It is seen that all plants started with diseased tomato chips or rotting potatoes had failed, and over half that survived were from an untreated box.

The same box experiments were repeated at my labratory, the diseased tomato skins and the decayed potatoes having been obtained by express from an infested field at Ocean Springs, through the kindness of Mr. Earle. The following is a tabulated statement of the results as obtained from the duplicate box experiments, so far as they could under the circumstances be said to be duplicates:

No. 1—Plants came up poorly.
No. 2—Seeds came up well and plants grew finely.
No. 3—Plants did only fairly well.
No. 4—About as No. 3.
No. 5—Only a few plants came up.
No. 6—Was omitted as but five boxes could be placed in the window and it would have been a duplicate of No. 2.

At the end of a month there were only a few second-rate

plants in boxes 1 and 5, No. 2 continued to thrive and was closely followed by No. 4. It should be said that, due to the long distance from supplies, the experiment of spraying with disease germs was not satisfactory, and should be taken as an incomplete test. Box 3 contained many good plants and, so far as these experiments go, it seemed evident that the disease was communicated from blighted tomato stems in the one case and from the rotten potatoes in the other, and to a degree that was ruinous to the seedlings in both cases.

BACTERIAL MELON BLIGHT.

This portion of the paper was presented at the Washington meeting of the American Association for the Advancement of Science and afterward published in "Botanical Gazette" for November 1891, page 303.

Early in July there were many complaints throughout the country that the melon, squash, and cucumber vines were either not doing well or were dying from some unknown cause. The first specimens to arrive were from Bangor, Me., followed by others from the central part of New Jersey, a locality famous for the production of cucurbitaceous fruits.

The attacked vines vary somewhat in their appearance, but generally there is a decay of the stem in proximity to the root, and that the whole plant wilts and fails to grow. Sometimes one or more leaves will fall to the ground and rot away before the balance of the plant is seemingly affected. This is particularly true of cantaloups, while in the case of cucumbers the fruit may be the first to show trouble. Here the half grown cucumber exhibits from 1 to a dozen or more specks looking like water cores; which increase in size, until the whole of the fruit becomes a rotten mass, the firm skin still holding the watery interior in shape.

A microscopic examination of the decaying stems, leaves, and fruit showed that the decomposing tissues were teeming with bacteria. This was to be expected, but it remained to prove that these germs could be the primary agent in the decay. Inoculations of healthy fruits were made in the usual way by means of sterilized platinum wire, taking the germs from the centre of freshly decaying cucumbers. It was found that with no other fungus present these germs were abundantly able to introduce a rapid decay into cucumbers, melons, and squashes. Cucumbers seem to be the favorite, and in them the decay is the most rapid. It will run from one end to the other through the succulent center of

a four inch fruit in a single day. From the placentæ the rot spreads towards the surface until all is a noisome pulp enclosed by the skin which may remain unbroken if the inoculation has been made at the stem end.

The next step in the study was the application of these germs to healthy plants in the field. This was done by means of a flamed glass tube one end of which had been drawn out into a long point. By means of this, the germs in the liquid, after being drawn into the tube, could be introduced into any part of the plant, even into the woody base of squash vines. When the inoculation was made near the end of the vine, the latter rotted away in from three to four days and when nearer the base a longer time was required, but in all more or less rapidly, depending upon the tissues infected. In old stems the decay was almost entirely internal, and did not show much till the disease had spread through the pith to some distant soft parts. A medicine dropper was employed to place a charge in the middle of several petioles of large squash leaves. Upon the next visit, twenty-hours later, all such leaves had fallen to the ground, and the portions of the petioles below the point of inoculation, six or more inches in some cases, were thoroughly decayed. In short the bacterial disease was found in the cucumber and afterwards propagated from fruit to fruit in the labratory, as also upon cut stems and petioles, is readily transmitted to vigorous living vines of the cucumber and squash in the field.

Sixteen seeds of summer crooked squash were divided into two equal lots, and each set of eight planted in a flower pot under a bell jar and in every way treated alike, except that the soil of one pot was watered at the beginning of the experiment with the juice of a cucumber which had decayed with bacteria. The eight seeds not receiving the bacterial liquid germinated quickly, producing large, deep green plants, while in the other pot only two plants appeared above ground, and they were dwarfed, of a sickly, yellow color, and did not continue to grow. These two plants were quite close to the side of the pot and did not receive a full wetting by the bacterial water. The remaining six seeds when removed from the soil were decayed and noisome.

Eight seeds were next placed upon blotting paper, moistened with distilled water, and kept covered in a small artist's saucer, while a duplicate set were similarly placed, but wet with a solution containing bacteria from a decaying cucumber. Here again the untreated seeds all grew with usual vigor, while those in contact with the bacterial germs failed to germinate and soon decayed.

The pure virus was next introduced into the growing stems and green fruit of the tomato, and in both cases quickly produced a decay that caused the stems to fall and the fruit to become a

watery mass enclosed by the skin, similar to the cucumber from which the bacteria were taken for inoculation. At the time of the experiments some boxes of young tomato plants were close at hand, and into the centre of one of them a decaying cucumber was placed. In six hours some of the stems of tomato plants six inches in height had rotted off close to the ground, where the liquid from the decaying fruit had come in contact with the young plants. In ten hours all the plants in the vicinity were destroyed. Drops of the virus placed in the leaf and other plants quickly induced decay and death of the parts.

The virus from a cucumber was also used upon potato vines in the same manner as upon squashes, but both the extreme age of the plants and the dry weather may have been unfavorable, as the decay was slow and comparatively harmless. Healthy tubers, however, when inoculated with the cucumber bacteria rotted with that rapidity characteristic of the bacterial decay of the potato. In all cases the tubers became of a pasty softness, and gave off a most unpleasant odor. This decaying substance when taken back to fresh fruit of the cucumber continued to produce rapid decay.

These results seem to corroborate those that were previously obtained in Mississippi and assist materially in accounting for the failure of melons after tomatoes or vice versa upon fields where the preceeding crop has been blighted.

While it is yet too soon to draw fully substantiated conclusions the following are offered as being those that the investigation in its present fragmentary condition now suggest, but subject to modification in the light of further results from field observations and laboratory experiments.

CONCLUSIONS.

1. The Southern Tomato Blight seems to be due to a bacterial germ.

2. The infested plants first show a wilting, and then lose their green color and die.

3. As far as observations show, the blight is not limited to any kind of soil, situation, or exposure but may be found any where.

4. It seems probable that the plants may be attacked being set in the field as well as afterward.

5. There is a Potato Blight due to a bacteria that is communicable to the tomato, as repeated inoculation show, and the disease of the two plants seems to be the same.

6. A blight of melons and cucurbits generally is of bacterial origin, and seems to be the same as the blight of the tomato and potato.

7. If the above statements be true, it follows that a soil may become so contaminated with bacteria from any one of the three crops as to make it unfit for either of the other two. Repetition of the same crop, of course is not desirable.

8. The potato is the best adapted from the nature of its "seed" to the dissemination of the blight, as it can be carried unobserved in the potatoes used in planting, and with it special care should be taken.

9. As the Bordeaux mixture has proved effective for the bacterial disease of the potato, spraying with this compound is recommended for all three crops where fear from blight is entertained.

10. Care should be taken to burn the diseased plants when found, and also all litter in the field at harvest time.