New York Agricultural Experiment Station:

GENEVA, N. Y.

RASPBERRY CANE BLIGHT AND RASPBERRY YELLOWS.

F. C. STEWART AND H. J. EUSTACE.

PUBLISHED BY THE STATION.
BOARD OF CONTROL.

GOVERNOR BENJAMIN B. ODELL, JR., Albany.
STEPHEN H. HAMMOND, Geneva.
FREDERICK C. SCHAUB, Lowville.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
OSCAR H. HALE, North Stockholm.
MARTIN L. ALLEN, Fayette.
JENS JENSEN, Binghamton.
THOMAS B. WILSON, Halls Corners.
EDWARD A. CALLAHAN, Albany.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, President.
WILLIAM O'HANLON, Secretary and Treasurer.

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND, Lyman P. Haviland,
FREDERICK C. SCHAUB, Thomas B. Wilson.

STATION STAFF.


George W. Churchill, William F. Nicholson, M.S.,
Agriculturist and Superintendnent of Labor,
First Assistant (Animal Industry),
Botanist.,
Assistant Botanist.
Chemist.

William H. Andrews, B.S.,
Christian G. Jenner, Ph.D.,
Frederick D. Fuller, B.S.,
Edwin B. Hart, B.S.,
Charles W. Mudge, B.S.,
Andrew J. Patten, B.S.,
Harry A. Harding, M.S.,

Assistant Chemists.

Dairy Bacteriologist

George A. Smith,
Dairy Expert.

Frank H. Hall, B.S.,
Editor and Librarian.

Victor H. Lowe, M.S.,
Entomologist.

Howard O. Woodworth, M.S.,
Assistant Entomologist.

Spencer A. Beach, M.S.,
Horticulturist.

Vinton A. Clark, B.S.,
Assistant Horticulturist.

Orrin M. Taylor,
Foreman in Horticulture.

Frank E. Newton,

Jennie Terwilliger,
Clerks and Stenographers.

Adin H. Horton,
Computer.

Address all correspondence, not to individual members of the staff, but to the New York Agricultural Experiment Station, Geneva, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

*Connected with Fertilizer Control.
†Absent on leave.
SUMMARY.

I. Cane blight is a disease of raspberries which causes the plants, either wholly or in part, to suddenly die, about the time the fruit is ripening. It is caused by a fungus which attacks the canes at some point, killing and discoloring the bark and wood whereby causing the death of the parts above. It occurs more or less abundantly, and often destructively, in most of the raspberry plantations in New York. It attacks nearly all varieties of the raspberry, both red and black, and perhaps also the dewberry; but the blackberry is exempt.

Inoculation experiments have shown that it is caused by the fungus Coniothyrium sp. Both new and old canes succumb to inoculation within two months. Natural infection occurs on new canes during summer and autumn and, probably, also on fruiting canes in the spring. Infection often takes place in wounds, particularly those made by the snowy tree cricket and in “heading back” the new canes.

The fungus is disseminated by means of infected nursery stock; by wind, rain and washing of the soil; and in picking, pruning and laying down the canes.
The bluish-black areas so common on new canes of red raspberry in August and September, and once thought to be the early stage of cane blight, are now believed to be due to the fungus *Sphaerella rubina* and comparatively harmless. Perhaps this is Miss Detmers' bacterial disease.

In an experiment at Charlotte, N. Y., Cuthbert raspberries sprayed three times during the spring with bordeaux mixture gave an average yield of $185\frac{1}{2}$ pints per row, while unsprayed rows in the same plantation averaged $203\frac{3}{4}$ pints. The spraying might have been more successful had it been commenced the previous summer.

No definite and effective line of treatment has yet been established. Among several precautions to be observed the most important are: (1) To secure healthy plants with which to start the plantation; (2) to remove the old canes immediately after the fruit is gathered.

II. Yellows is a name proposed for a raspberry disease which is believed to be chiefly responsible for the so-called running out of the variety Marlboro in the Hudson Valley. It is characterized by stunted growth, mottled yellowish-green foliage and dry, insipid fruit. The cause and remedy are both unknown. In an experiment at Marlboro, N. Y., plants sprayed thirteen times were as much affected as unsprayed plants.
INTRODUCTION.

It is the intention of the writers to publish, at some future time, a complete account of the diseases of the cultivated raspberries, blackberries and dewberries. Studies on this subject have been in progress about three years. It will be at least a year and perhaps longer before the work can be completed and for that reason it is thought best to publish now some of the results which, it is believed, will be of interest to fruit growers.

I. RASPBERRY CANE BLIGHT.

HISTORY, DISTRIBUTION AND BIBLIOGRAPHY.

Raspberry cane blight first came to our attention in 1899 while prosecuting a fruit-disease survey of the Hudson Valley. Although abundant and destructive and evidently not new to fruit growers, the disease was, nevertheless, entirely unknown to science at that time. It seems strange that so conspicuous and widespread a disease should so long have escaped the attention of plant pathologists.

In the season of 1900 our observations were extended to central and western New York where the disease was again found in abundance, and further observations made in 1901 and 1902 indicate that it occurs more or less abundantly in a majority of the raspberry plantations throughout New York State.

Concerning the prevalence of the disease in other states there is, as yet, very little definite knowledge. Through the kindness of Prof. A. D. Selby we have obtained positive evidence of its existence in Ohio. Dr. W. C. Sturgis, formerly botanist of the Connecticut Experiment Station, sent us specimens of the disease from Connecticut in 1900 with the statement that it was destructive there. It has undoubtedly been observed in Wisconsin by Mr. W. C. Thro, a nursery inspector, who kindly sent us typical specimens of the disease collected at Janesville, Wisconsin, in 1900. However, Mr. A. L. Hatch, an observant fruit grower of Sturgeon Bay, Wis., writes that he is unfamiliar with any raspberry disease of this description. Prof. F. D. Chester of the
Delaware Experiment Station informs us that a destructive raspberry disease having the general symptoms of our cane blight occurred in Delaware in 1901; but the specimens which he sent bore none of the fungus (*Coniothyrium*) which is the cause of cane blight. It is possible that these specimens were cut off above the point of attack.

It is believed that the following articles constitute the bibliography of the disease at the present time:


All of the above articles are brief, the most important ones being the first and the third.

**DESCRIPTION**

Both red and black raspberries are attacked, but on red varieties the symptoms are somewhat different from those on black ones. The principal damage is done to fruiting canes although new canes are attacked and occasionally killed during the first season of their growth. The foliage on affected canes wilts suddenly and becomes dry. The whole cane may be involved or only a portion of it. Often a single branch is killed while the
remainder of the cane continues alive and apparently normal. (See Plate I.) In the majority of cases only a part of the cane dies. With black caps the disease frequently starts in the old stub left in pruning. From this point it gradually works downward killing first the uppermost branch, then the next lower one and so on until by the close of the berry harvest one-half or more of the cane may be dead. On black caps, the disease also shows a tendency to work down one side of the cane, killing the bark and discoloring the wood on that side while on the other side the bark remains green. This may occasionally happen with the red varieties, but as a rule they are attacked at some particular point on the cane. Here the bark is dead and the wood brown. For some time the injury extends only part way around the cane and as long as there is a strip of green bark left connecting the parts above the point of attack with those below all goes well; but when the injury at length completely encircles the cane the leaves on the portion above the injury suddenly wilt and die. By the time this happens, the cane at the point of attack is dead throughout a section which is usually from two to four inches in length. Both above and below this dead section the cane itself may be normal, with nothing to indicate the cause of the sudden wilting of the leaves. However, a cane may bear several of these dead sections of various sizes. If the point of attack is near the ground the whole cane dies; if higher up, only a part of it. When part of a cane dies while the remainder continues alive, the point of attack is to be sought at the boundary between the dead and living portions. Usually, the seat of the difficulty may be located by the color of the bark, which is somewhat different from that on the rest of the cane. For the most part it is lighter colored and smutty, with smoke-colored patches of exuded spores. In many cases numerous minute pimples, the pycnidia of the fungus, are visible. By cutting into the cane with a knife the matter may be decided at once. Where the cane is diseased the wood is strongly discolored. A marked characteristic of cane blight is the brittleness of the cane at the point of attack.

While it is common, both with black caps and red varieties, for the disease to be confined to one or more definite areas of infection on the cane there are also many instances in which the
disease pervades a large portion of the cane before death occurs. In such cases it is common for the affected wood to crack and the bark to peel off, particularly on the lower portion of the cane.

Fruiting canes affected with cane blight may die at any time. Almost as soon as the leaves unfold in the spring branches commence to die. As the season advances the disease increases in virulence and reaches the maximum during the ripening of the fruit. Canes loaded with ripening fruit suddenly wilt, either wholly or in part, and dry up. The disease does not spread from an initial center, but canes die here and there all through the plantation. Thrifty, well-cared-for plantations suffer as well as neglected ones.

So far as observed, only the canes are affected. The disease certainly does not attack the leaves, and the fact that new canes in badly diseased plantations make as good a growth as those in healthy plantations, indicates that the roots are not affected.

In August and September the new canes of red raspberries often show bluish-black or brown areas from two to four inches in length and extending nearly or quite around the cane. These discolored areas are very conspicuous and at one time were mistaken for the early stage of cane blight. Probably they have nothing to do with cane blight. The real cause of the discoloration is given on page 354, where a full discussion of the subject will be found.

By careless persons cane blight is often mistaken for the work of the raspberry cane borer, Oecera bimaculata; but the absence of any insect burrow within the affected canes is conclusive proof that the trouble is not caused by a borer. Moreover, according to our observations, the raspberry cane borer is not common in New York. During the four years in which cane blight has been under investigation we have examined many plantations in various parts of the State and have only occasionally found the cane borer.

Cane blight has also been mistaken for the effect of drought and winter injury. While drought at fruiting time may aggravate cane blight it is certainly not the cause. Raspberries injured by drought dry up slowly and with considerable uniformity; whereas plants affected with cane blight die suddenly and a por-
tion of the cane may be wholly dead while the remainder is as luxuriant as ever. In general, cane blight differs from winter injury in that canes injured by winter do not put out leaves on the injured portion, while plants attacked by cane blight may put out leaves normally and flourish until the fruit is nearly ripe, then suddenly die. However, it sometimes happens that canes severely attacked by cane blight during the first season of their growth are particularly susceptible to winter injury and do not put out leaves the following spring.

DAMAGE DONE AND VARIETIES AFFECTED.

In New York, cane blight is so common that it is difficult to find a raspberry plantation wholly free from it, and yet it is probable that in a majority of the plantations the damage done by it is inappreciable. The loss of an entire crop because of cane blight is rare; but in many cases the loss has been as much as one-fourth to one-half of the crop and occasionally as much as two-thirds. In the aggregate the loss from raspberry cane blight in New York must be enormous. Every season the Station receives numerous inquiries concerning the cause of cane blight and means of preventing its ravages. There is a widespread interest in the disease among growers of raspberries.

In general, it is more destructive in old plantations than in new ones, and as the age of a plantation increases the virulence of the disease increases. However, there are exceptions to this rule. At Marlboro, N. Y., a plantation of Coutant No. 1 was so severely attacked in 1900 that the crop was reduced fully one-third. In 1901 and 1902 the loss from cane blight in this plantation was inconsiderable. At Charlotte, N. Y., in a plantation of Cuthbert, the loss, as estimated by the owner, was two-thirds of the crop in 1901 and only one-fourth in 1902. No doubt the virulence of the disease varies considerably from season to season owing to variation in weather conditions. Like most fungi, the fungus causing cane blight probably thrives best and spreads fastest in wet seasons, and yet losses from the disease may be heaviest in dry seasons. This comes about from the fact that canes become infected during the first season of their growth, but do not show the effects until the following season.
It seems likely that the spread of the disease is most influenced by weather conditions during the period of infection and that after infection has once taken place the growth of the fungus within the cane is not materially affected by any weather condition except temperature. Furthermore, the effect of the disease is to restrict the circulation of sap in the canes. The death of the cane at the point of attack hinders the passage of water to the parts above and the leaves wilt from lack of it. It stands to reason that when the soil is full of water the leaves on affected canes would be able to hold out longer than in times of drought when even unaffected plants have difficulty in getting water enough to maintain life. Since the requirements of the raspberry plant for water are greatest when the fruit is ripening, that is the time when the strangling effect of the disease may be expected to do the most damage.

Reasoning from what has just been said it seems probable that cane blight will be most destructive when a warm, wet summer and autumn, suitable to infection, are followed by a warm spring and drought in July when the fruit is ripening; and, \textit{vice versa}, the disease will be least destructive when a dry, cool summer and autumn are followed by a cool spring and wet July. If a part of the infection occurs in spring—a point not definitely determined—the virulence of the disease would be increased by wet weather in April and May.

Raspberry plantations have to be renewed frequently. After three to five crops have been harvested it is a common practice to dig out the plants and start a new plantation. As a rule, old plantations are unproductive, but just why this is so is not clear. With black caps renewal is often necessitated by the increasing virulence of anthracnose (\textit{Glaeosporium venetum}) and red rust (\textit{Caoma nitens}). Our observations lead us to believe that cane blight is often partly responsible for the early decline in productivity of both red and black raspberry plantations.

Nearly all varieties of raspberries are more or less affected by cane blight, but some are more susceptible to attack than others. Of the varieties extensively grown, Cuthbert probably suffers most of all. Marlboro, too, is much subject to the disease. Ohio, Gregg and Kansas are much affected while Columbian,
although not entirely exempt, is notably resistant to the disease. In the Station plantation the varieties Superlative, I. X. L. and Pride of Geneva have shown themselves particularly liable to attack. The wild red raspberry, *Rubus strigosus*, is often attacked.

Some of the canning factories complain that the supply of Cuthbert raspberries is not equal to the demand. Fruit growers explain this by saying that “the Cuthbert has such a tendency to dry up at fruiting time that it can not be depended upon.” Consequently, many who formerly grew Cuthbert are now planting Columbian which is more productive but inferior in quality. We are of the opinion that this “tendency to dry up at fruiting time” is largely due to attacks of cane blight.

The cultivated dewberry is, perhaps, also affected by cane blight. At Portland, N. Y., in June, 1900, we saw canes of Lucretia dewberry wilting like raspberry canes attacked by cane blight and at the base of the wilted portion a short section of cane was dead and covered with *Coniothyrium* as on raspberry canes. The resemblance to raspberry cane blight was so striking that we have not yet abandoned the idea that the raspberry *Coniothyrium* is parasitic on dewberry canes although an inoculation experiment at Highland gave negative results. (See page 344.)

During the past four seasons the writers have had under observation a diseased dewberry plantation⁴ at Highland, N. Y. Each season this plantation has been seriously injured by a disease, the exact nature of which we have been unable to determine. In 1900 the crop was a complete failure. The fruiting canes, wholly or in part, wilt and die as in raspberry cane blight; and the seat of the trouble seems to be located in a dead and discolored section of the cane. Such discolored sections showed no fungus on June 21, 1899, but on July 27, 1900, they were thickly covered with *Coniothyrium* and the wood at this point was brittle. *Coniothyrium* was also found on affected canes on June 27, 1901, and on June 4, 1902. Observations made in 1901 indicate that part of the trouble was due to winter injury and a part to some other cause. Suspicion points to *Coniothyrium* as this other cause.

---

⁴This is the plantation mentioned in Bul. 167 of this Station, page 294.
One fruit grower claims to have seen a blackberry disease similar to the raspberry cane blight, but the writers have never seen anything to indicate that the disease attacks blackberries. In one instance a species of *Coniothyrium* was found on dead blackberry canes, but from the size of its spores and habit of growth on culture media it is evident that it was a different species than the raspberry *Coniothyrium*. (Compare Figs. 7 and 8, Plate V.) An attempt to inoculate blackberry canes with raspberry *Coniothyrium* failed. (See page 344.)

**CAUSED BY A FUNGUS.**

From the time of the first discovery of the disease at Coxsackie, N. Y., June 1, 1899, a Sphæropsideous fungus with small, roundish or elliptical brownish spores borne in pycnidia was suspected of being the cause. Every additional observation strengthened this suspicion until finally the evidence seemed so conclusive as scarcely to need the support of inoculation experiments. The fungus, a species of *Coniothyrium*, was constantly associated with the disease and nearly always in such a manner as to point plainly to it as the cause. Whenever a portion of a cane was killed it was easy to locate the seat of the trouble in a short section of the cane at the base of the wilted portion. At this point the cane was dead and discolored, and microscopic examination invariably revealed the presence of the *Coniothyrium* in abundance. By the time the leaves were fully wilted, and oftentimes earlier, the *Coniothyrium* could be depended upon to show its pycnidia filled with multitudes of ripe spores. In many cases the spores were expelled from the pycnidia and formed brownish or slate-colored patches on the dead bark. Sometimes large portions of the dead and dying canes would be smutty with masses of the exuded spores.

While divers other fungi were frequently associated with the *Coniothyrium* on diseased canes, no fungus except *Coniothyrium* was constantly present. Not only was *Coniothyrium* always found on diseased canes, but it was always absent from perfectly healthy ones; and wherever the pycnidia of *Coniothyrium* were found the bark was dead and the wood underneath discolored.
IDENTITY OF THE FUNGUS.

In our first published account\(^2\) of cane blight the causal fungus was referred to the genus *Phoma*. This was manifestly an error inasmuch as the spores have a decidedly brownish tinge. The genera *Phoma* and *Coniothyrium* differ only in the color of the spores, the former having hyaline spores and the latter colored spores. Seen singly, the spores of the cane blight fungus have a slightly brownish tinge and in mass the brown color becomes pronounced. It is plain that the fungus belongs to the genus *Coniothyrium* rather than to *Phoma*. This correction has already been made in Bulletin 191 of this Station, page 330.

Although the writers are not yet prepared to make a positive statement as to the specific name of the fungus it seems probable that it is *Coniothyrium fuckelii* Sacc. According to Saccardo,\(^3\) *C. fuckelii* occurs on the bark of dead and dying branches of *Rubus, Ampelopsis, Tecomaria, Rosa, Robinia, Berberis* and *Helianthemum*, and on the leaves of *Citrus*. On these different hosts the size and shape of the spores vary somewhat. On *Rubus*, the spores are said to be globose with a diameter of 3 to 4\(\mu\). The spores of the cane blight *Coniothyrium* have, approximately, these dimensions and their usual form may be properly described as globose, although many of the spores might be called ellipsoidal. (Plate V, Fig. 7.)

We have not had the opportunity of examining authentic specimens of *C. fuckelii* on *Rubus* or, in fact, on any of its hosts except *Tecomaria radicans*, the trumpet creeper. Through the kindness of Dr. W. G. Farlow we have been able to examine a fragment of a specimen on *T. radicans* collected by Saccardo. In this specimen the spores are considerably longer than broad and nearly hyaline. They are decidedly different from the spores of the cane blight *Coniothyrium*; but *C. fuckelii*, as described, is a variable species and it may be that our fungus belongs here notwithstanding.

\(^2\) Bul. 167 of this Station, pp. 305-307.
\(^3\) Saccardo, P. A. Syll. Fung. 3: 306.
INOCULATION EXPERIMENTS.

*General statement.*—Inoculation experiments with pure cultures have been made on new canes and fruiting canes of both red and black raspberries and the new canes of dewberry and blackberry. The inoculation has been done in divers ways with cultures from three different sources. These experiments will now be described in detail and in chronological order.

*Experiment No. 1.*—Date of inoculation, July 18, 1900. Five new canes of red raspberry (variety, Pride of Geneva) were inoculated in the following manner: About one foot below the tip of the cane the bark was slightly abraded with a flamed scalpel. On the wound thus made there was placed a bit of the *Coniothyrium* from a pure culture originally isolated in 1899. The culture used for inoculation was a mixture of two cultures—one 46 days old and containing multitudes of spores, and the other six days old, without spores. The final operation consisted in covering the wound with grafting wax which was wound closely about the cane in such manner as to exclude the air and foreign organisms. (See Plate II.)

On September 18, two months after inoculation, it was found that on all five canes the leaves above the point of inoculation were either wilted or dried up. For a short distance, both above and below the wax, the bark was dead and brown and the wood discolored. In every case the dead bark in the vicinity of the wax (both above and below it) was covered with *Coniothyrium* pycnidia containing mature spores. One cane, broken accidentally, was very brittle at the point of inoculation as is the case with affected canes in nature. Although this experiment had no check the results indicated that the *Coniothyrium* is parasitic.

*Experiment No. 2.*—Date of inoculation, July 18, 1900. Four new unbranched canes of black raspberry (variety, Mohler) inoculated, as in Experiment No. 1, by abrading the bark, applying fungus and winding with grafting wax. Two other canes of the same variety but considerably branched were inoculated in a freshly cut stub, such as is commonly left in "heading back" the canes. The stub was covered with grafting wax. The fungus culture used was the same as that used in Experiment No. 1. There were no checks.
On October 1, 1900, two of the unbranched canes were dead and the other two had prominent scars at the point of inoculation. Whether these two canes were killed by *Coniothyrium* is uncertain. One showed an abundance of *Coniothyrium*, both above and below the wax, but on the other there was no sign of *Coniothyrium*. At this date the two branched canes inoculated in the stub were beginning to show the effects of inoculation. On one, the uppermost branch was already involved.

The last observations were made July 8, 1901, at which date one of the two remaining unbranched canes was nearly dead while the other was alive and apparently little harmed by inoculation. The dying cane showed an abundance of *Coniothyrium* pycnidia scattered along one side for a distance of several inches below the point of inoculation. One of the two branched canes inoculated in the stub was dying in the upper portion although it bore a fair crop of fruit. Two of the upper branches were dead. The fungus had worked down the cane about five inches from the point of inoculation and pycnidia were plentiful. The condition of the other branched cane was unchanged since the preceding October. It was uninjured.

In this experiment the symptoms of the inoculated plants were like those of naturally infected plants, but the progress of the disease was slow. It may be that Mohler is more resistant than some other varieties.

*Experiment No. 3.*—Date of inoculation, June 8, 1901. Five new canes of red raspberry (variety, Pride of Geneva) were inoculated with a month-old culture, the source of which was isolated May 1, 1901, from black raspberry. The canes, which were 24 to 30 inches high, were inoculated 6 to 8 inches below the tip by abrading the bark, applying a bit of fungus and winding the whole with grafting wax as in Experiment No. 1. Five check canes were abraded and wounded with wax in the same manner but without application of the fungus.

On August 28 four of the inoculated canes showed more or less discoloration around the wax while the remaining cane seemed normal. None of these canes showed any wilted foliage. At the same date three of the checks were free from all signs of infection, but the other two had pronounced discoloration of the
bark around the wax as on the inoculated canes. Thinking that the checks had become naturally infected by the fungus, which was very common among the plants of this variety, the experiment was abandoned and no further observations were made. Consequently, the ultimate results are not known and the experiment teaches nothing except that variable results from inoculation are to be expected. In 1901 new canes of this variety, inoculated in the same manner, were dead within two months after inoculation. (See Experiment No. 1, page 342.)

Experiment No. 4.—Date of inoculation, June 8, 1901. Five new canes of blackberry (variety, Taylor) were inoculated in the same manner and with the same culture as that used on red raspberry in Experiment No. 3. The canes were about 30 inches high and inoculated 6 to 8 inches below the tip. There were five checks.

On August 28 there was no discoloration of the bark around the wax and no other evidence that the inoculation had had any effect whatever.

Experiment No. 5.—Date of inoculation, June 13, 1901. Ten new canes of Lucretia dewberry were inoculated with a fourteen-day-old culture descended from the culture used in Experiment No. 3. Six to eight inches below the tip the canes were slightly abraded, a drop of water placed on the wound, then the fungus applied and the cane wound with grafting wax in the customary manner. There were ten checks.

On September 12, 1901, there were no signs that inoculation had had any effect. Final observations were made on May 8, 1902, at which time all ten checks and nine of the inoculated canes were found to have been winter killed, with no sign of Coniothyrium about them. However, the tenth inoculated cane, although alive both above and below the wax, was partially dead at the point of inoculation and covered with Coniothyrium pycnidia underneath the wax. It appeared as if infection may have occurred on this cane.

Experiment No. 6.—Date of inoculation, June 14, 1901. Ten new canes of red raspberry (variety, Coutant No. 1) were inoculated 6 to 8 inches below the tip with the same culture used in Experiment No. 5. The fungus was producing spores abund-
The method of inoculation was by abrasion of the bark, application of a drop of water and a bit of fungus and the whole covered with grafting wax. The canes were 26 to 30 inches high. There were ten checks.

On September 2, 1901, all of the inoculated canes (except one broken by the wind July 10) and all of the checks were alive and apparently little worse for inoculation. There was only a little discoloration of the bark around the wax but the canes were somewhat enlarged and cankers were forming.

On May 7, 1902, only three of the inoculated canes were alive above the wax and these were badly cankered. Four had broken off at the point of inoculation and the tops had disappeared. One other cane was all dead above the wax, with Coniothyrium pycnidia, and one had been broken, accidentally, eight inches below the wax. The tenth cane had been broken by wind the previous July. At this date nine of the checks were alive and apparently normal except for being somewhat enlarged under the wax and flattened on the side abraded. The remaining cane was all dead above the wax with a pronounced enlargement and canker at the wax.

In a hasty examination made May 29, 1902, all of the inoculated canes were found to be dead above the wax, while at least eight of the checks were still alive.

Final observations made July 25, 1902, showed the condition of the checks to be as follows: 4 alive throughout, 4 dead throughout, 1 dying and 1 dead above the wax.

The results of this experiment are unsatisfactory and difficult to interpret. The fact that the inoculated canes all died before June 1, while at least eight of the checks were yet alive, indicates that inoculation had some effect. The tendency of the inoculated canes to break at the point of inoculation is to be ascribed to brittleness induced by the attack of the fungus, as is conspicuously the case with plants naturally infected.

Experiment No. 7.—Date of inoculation, June 14, 1901. Ten new canes of red raspberry (variety, Coutant No. 1) were inoculated near the base with the same culture used in Experiments 5 and 6. In all preceding experiments the inoculations had been made well up toward the top of the canes. It was now desired
to learn what would happen if canes were inoculated near the base. Accordingly, in this experiment the bark four or five inches above the surface of the soil was abraded, then a drop of water and bit of fungus applied and the cane wound with grafting wax as usual. There were ten checks.

Within a month after inoculation both the inoculated canes and checks began to show a bluish-black discoloration of the bark above and below the wax. By September 2 all of the inoculated canes were much discolored around the wax. They were also considerably enlarged and badly scarred on the inoculated side. The checks were in practically the same condition.

The following spring, on May 7, 1902, the checks were all still alive and standing, while among the inoculated canes only five were alive, and of these two were broken at the base. The other five had been broken in the process of laying the canes down for winter.

Between May 7 and July 25, 1902, three check canes died and one was lost, leaving only six alive at the latter date. During the same period the condition of the five living inoculated canes remained unchanged.

Here, as in Experiment 6, the brittleness of the inoculated canes at the point of inoculation is to be regarded as evidence that infection occurred. It is not strange that the checks became discolored around the wax. At the time of making the inoculations there was considerable dirt on the canes near the ground. The canes being thickly beset with prickles it was next to impossible to wash them with disinfecting solutions, and it was not attempted. It is probable that spores of Sphacrella rubina (see page 354) and perhaps also those of Coniothyrium got into the wounds and caused the discoloration of the check canes. According to the writers' observation, grafting wax wound about the canes, as in these experiments, causes, at most, only a slight discoloration of the bark and usually no discoloration whatever.

Experiment No. 8.—Date of inoculation, May 17, 1902. This experiment was designed to furnish information on the following points: (1) Is it possible to produce infection by inoculation during the spring of the second season's growth; that is, on fruiting canes? (2) Can infection be brought about more readily by mak-
ing a puncture passing through the pith than by simply abrading
the bark as in all previous experiments? (3) Is it necessary to
use grafting wax to cover the wounds?
Twenty-five fruiting canes of the variety Cuthbert were selected
for the experiment. At the point selected for inoculation, about
one foot below the tip, each cane was first thoroughly washed
with a 1-1000 solution of corrosive sublimate to remove any fun-
gus spores lurking there.

Five canes were abraded with a flamed scalpel, a drop of dis-
tilled water and a bit of fungus applied to the wound and the
cane wound with grafting wax. Five checks were treated in the
same way except that the fungus was omitted.

Five other canes were bored through with a sterilized awl, a
bit of fungus crowded into the hole, a drop of distilled water
applied and the cane wound with grafting wax. There were also
five checks to this part of the experiment.

Finally, five other canes were inoculated by puncturing with
an awl and applying fungus and distilled water, but the canes were
not wound with wax.

The fungus used throughout this experiment consisted of a
mixture of two cultures, one of which was twelve days old and
the other fifty days. It was descended from the fungus used in
Experiments 3-7 inclusive and was originally isolated May 1,
1901.

On August 8, 1902, all 25 canes in the experiment were cut
and each one carefully examined. Of the five canes inoculated
by abrasion four were dead from the wax up and covered with
Coniothyrium pycnidia around the wax, both above and below it.
The bark was dead and the wood discolored from two to three
inches below the point of inoculation. The fifth cane was alive,
but at the point of inoculation the wood was discolored and bore
Coniothyrium pycnidia. Of the five checks belonging to this part
of the experiment four were alive and green with no discoloration
of the bark or wood anywhere and with no sign of Coniothyrium.
The remaining check was still alive, but had a pronounced dis-
coloration of the bark and wood each side of the wax and an
abundance of Coniothyrium was present. In some way it had
become infected.
Of the five canes inoculated in a puncture covered with wax every one showed an abundance of *Coniothyrium* pycnidia in the vicinity of the wax. Four were dead and broken at the point of inoculation, while the fifth one, although still alive, had the bark dead and wood discolored one-half way around the cane for a distance of four inches above and two inches below the wax and thickly covered with *Coniothyrium* pycnidia. This cane was considerably larger than the other four, which probably explains its greater resistance to the disease. The five checks belonging to this part of the experiment were all alive and green with no discoloration of the bark or wood around the puncture in any case and none of the canes were broken.

Of the five canes inoculated in punctures, which were *not* covered with wax, every one showed an abundance of *Coniothyrium* around the point of inoculation. Two were still living, but the bark and wood on both sides of the wax was discolored and one cane was partly broken off. The other three canes were dead from a point three inches below the wax to the tip and two of them were broken at the point of inoculation. This experiment was highly satisfactory and, of itself, proves beyond doubt that the *Coniothyrium* is capable of killing raspberry canes.

*Experiment No. 9.*—Date of inoculation, June 3, 1902. Five fruiting canes of red raspberry (variety, Cuthbert) were inoculated at a point 12 to 18 inches below the tip by first washing the cane with a 1–1000 corrosive sublimate solution, then boring clear through the cane with a sterilized awl, crowding a bit of fungus into the hole, applying a drop of distilled water and finally winding the cane with grafting wax in the customary manner. The culture used was 19 days old and originally isolated May 15, 1902; hence it was different from that used in any of the preceding experiments. Five check canes were treated in identically the same manner except for the omission of the fungus.

On August 8, a little over two months after inoculation, all ten canes were cut and examined. The five inoculated canes were all dead from a point two to four inches below the wax to the tip of the cane. For a short distance on either side of the wax the dead bark was thickly covered with *Coniothyrium*
pycnidia in every case. Three of the canes were broken at the point of inoculation.

At the same time the five checks were alive and green throughout, none broken and none showing discoloration of the bark or wood around the puncture.

*Experiment No. 10.*—Date of inoculation, June 5, 1902. Five fruiting canes of black raspberry (variety, Bishop) inoculated 10 to 12 inches below the tip by puncturing the cane with a sterilized awl, inserting a bit of fungus in the hole and winding the cane with grafting wax. The culture used was 21 days old and of the same strain as that used in Experiment No. 9. Three checks were made.

The eight canes were cut and examined August 9, 1902. Of the five inoculated canes three were dead from the wax up and showed an abundance of *Coniothyrium* pycnidia on either side of the wax. The other two inoculated canes were still alive at the top, but on both there was much discoloration of bark and wood and plenty of *Coniothyrium* pycnidia in the vicinity of the wax. On one, this discoloration extended half way around the cane and to a distance of three inches below the wax, while on the other it extended two inches above and one inch below. In both cases it was plain that the fungus had attacked the canes.

On the same date all three checks were alive and green to the top. On two of them the bark was green under the wax and not the least bit discolored, but the third showed a slight discoloration in the immediate vicinity of the puncture. However, no *Coniothyrium* could be found.

*Experiment No. 11.*—Date of inoculation, June 6, 1902. Ten new canes of red raspberry (variety, Cuthbert) 20 to 30 inches high were inoculated about 8 inches below the tip as follows: The cane was first washed with a 1-1000 corrosive sublimate solution, then bored through with a sterilized platinum needle, a bit of fungus crowded into the hole thus made, a drop of distilled water applied and the whole wound with grafting wax. The fungus used was of the same strain as that used in Experiments 9 and 10. Five checks were made.

On August 8 five of the inoculated canes were all dead above the wax and about one inch below it. The tops of two of these
were lost, but the stubs showed an abundance of *Coniothyrium* pycnidia; and the other three were covered with *Coniothyrium* for an inch above and an inch below the wax. The remaining five inoculated canes were still alive at the top, but all had cankers at the point of inoculation, three of them being bad and one showing *Coniothyrium* pycnidia under the wax. These five canes were considerably enlarged and the bark and wood discolored at the point of inoculation. Thus, on six of the inoculated canes there was undoubted *Coniothyrium* infection and on the other four there was some evidence of it, although no *Coniothyrium* pycnidia could be detected. These ten canes are shown in Plate III.

On the same date one of the check canes was found to have been killed by a borer, but the other four were alive clear to the top. The only thing abnormal about them was a slight discoloration of the outer layer of bark under the wax. In no case was the wood discolored and no *Coniothyrium* was found.

*Remarks.*—Experiment No. 5 was conducted at Highland, N. Y.; Nos. 6 and 7 at Milton, N. Y.; and all of the others on the Station farm at Geneva. Nos. 8, 9 and 11 are the most trustworthy because they were conducted in a small, isolated plantation which was, apparently, entirely unaffected by cane blight. Also, the inoculations were made with especial care.

*Interpretation of the results.*—These experiments prove conclusively that the raspberry *Coniothyrium* is parasitic on raspberry canes (both black and red varieties) and the cause of cane blight. It will attack new canes as well as fruiting canes, but seems somewhat more active on the latter. Although the experiments on blackberry and dewberry gave negative results it should not be considered proven that the fungus is incapable of attacking these plants, for the reason that there was but a single experiment in each case.

Both old and new canes may be expected to succumb to the disease within two months after inoculation, and *Coniothyrium* pycnidia with mature spores may be produced in abundance during the same period.
TIME AND MANNER OF NATURAL INFECTION.

Although new canes are rarely killed by cane blight during the first season of their growth this does occasionally happen, and there is also other evidence to show that infection occurs on new canes. On August 28, 1901, the writers observed a stool of black raspberry in which several of the new canes were wilting and dying. Upon examination it was found that at the very base of the dying canes the bark and wood were dead and brown and bearing Coniothyrium pycnidia. This occurred on the Station grounds at Geneva and appeared to be a case in which cane blight was killing new canes. On September 19, 1900, new canes of black raspberry which had been "headed back" some time during the summer showed mature Coniothyrium pycnidia on the dead stubs.

At one time it was thought that the early stage of cane blight had been discovered in the bluish-black areas found on new canes of red raspberries in autumn. It is now known that these discolored areas are due to another cause. (See page 354.)

In spring, as the leaves are unfolding, one may occasionally find canes already affected with cane blight in a stage so far advanced as to make it certain that they were infected the previous season. For example, on May 5, 1902, a vigorous cane of the variety Conrath was found to be affected with cane blight at a point about a foot below the tip. Here the bark and wood were discolored over an area three-fourths of an inch long and one-fourth inch wide and there were numerous pycnidia of Coniothyrium filled with ripe spores. This cane must have been infected the previous season.

On May 8, 1902, a plantation of the variety Kansas was examined at Poughkeepsie. It was observed that some canes were either dead or putting out leaves very sparingly, indicating that something was wrong. In the majority of such cases it was possible to trace the cause of the trouble to a dead area somewhere on the cane and this dead area showed many pycnidia of Coniothyrium. These infections could not possibly have occurred in the spring of 1902; they must have occurred in 1901 on the new canes.
In several other instances well advanced cases of infection, with mature spores of *Coniothyrium* present, have been observed during the first week in May. In 1900 a plantation in Ulster County was quite seriously affected as early as May 24. There can be no doubt that part of the infection, at least, occurs on new canes.

On the other hand, there are some reasons for believing that infection may also occur on the fruiting canes in the spring. In general, it is difficult to locate affected canes before the appearance of the leaves. On May 1 it may be difficult to find *Coniothyrium* pycnidia in plantations in which, by July 1, the fungus occurs abundantly on almost every cane. If infection occurs only on new canes it seems scarcely possible that the canes could be so generally infected and not show it in the early spring. Inoculation experiments Nos. 8 and 9 (pages 346-348) show that the fungus grows readily in fruiting canes and kills them when artificially inoculated as late as June 3 and under conditions such as might easily occur in nature; that is, in uncovered wounds. However, the results of the spraying experiment at Charlotte (page 359) tend to show that infection does not occur on fruiting canes. This question must still be considered an open one.

As to the manner of natural infection it may be said that it often occurs in wounds of various kinds. A careful examination of an affected plantation will reveal the fact that in a large percentage of cases there is some break in the epidermis of the cane at the point of attack. With black caps, the disease very frequently starts in the dead stubs which result from the "heading back" of the young canes. As the disease works downward the lateral branches are killed one after another. Some fruit growers have attributed this form of cane blight to a green bee which is often found burrowing in the dead stubs during May and June. Frequently, the dead stubs have a hole in the top and upon splitting open such canes the burrow is found to extend downward from one to four inches and contain one or more green bees about one-fourth of an inch in length. This insect is the carpenter bee, *Ceratina dupla*, and is harmless, inasmuch as it bores only in dead wood. It is found, also, in the stubs of blackberry canes.

Cane blight often starts in wounds made by the "heading

---

* Determined by V. H. Lowe.
back" of new canes, by the removal of branches, by the rubbing of canes against each other or against supporting wires, and particularly in crotches where the branches are more or less split apart and in wounds made by the snowy tree cricket, _Oecanthus niveus_, during oviposition. The snowy tree cricket forces its ovipositor into the cane in such a manner as to kill the tissues and cause the cane to split. The wounds thus made furnish a lodging place for _Coniothyrium_ spores and also for water necessary to the germination of the spores, making the conditions exceptionally favorable for infection. That infection does actually occur in snowy tree cricket wounds is shown by the large number of instances in which the cane is covered with _Coniothyrium_ pycnidia in the vicinity of the wounds, usually just below them. The well known tendency of cricket-injured canes to break at the point of attack is probably due, in part, to brittleness induced by the _Coniothyrium_. It appears that the injury done by the snowy tree cricket is often much aggravated by the cane blight fungus.

In some cases _Coniothyrium_ takes possession of the discolored areas caused by _Sphaerella rubina_, but this is not the rule.

While _Coniothyrium_ often takes advantage of wounds as described above it is by no means certain that it should be classed as a wound parasite. Although not definitely proven by inoculation experiments there is considerable evidence that the fungus is capable of penetrating the unbroken epidermis of raspberry canes. It is often found attacking uninjured canes where the bark is smooth and the epidermis seemingly intact except as it is ruptured by the _Coniothyrium_ pycnidia themselves.

**MODE OF DISSEMINATION.**

For the successful application of preventive measures an accurate knowledge of the mode of dissemination of the fungus is essential. It is in the highest degree important to know the means by which the fungus is spread from plant to plant, from one plantation to another and into new localities. It must be admitted that our knowledge of this subject is very incomplete. However, some things are known.

There can be no doubt that the disease is widely disseminated by means of infested nursery stock. Plants taken from badly
diseased plantations are fairly certain to carry the disease with them, on the piece of attached cane or on the dirt about the roots. It is not necessary to assume that every plant is affected at the beginning. If a few plants here and there carry the disease with them it gradually spreads to other plants in the plantation in various ways.

Wind and dashing rains drive the spores from cane to cane, and by the washing of the soil, spores may be carried to other parts of the plantation or even to neighboring plantations. Birds and insects probably carry the spores to a limited extent. The disease must be spread by pickers while gathering the fruit; also in pruning and in cutting out the old canes; and particularly in the process of laying down and covering the canes with soil to protect them from winter injury. Cultivation, too, tends to spread the disease.

The fungus can live on dead and decaying raspberry canes, and fragments of diseased canes lying on the ground are no doubt a prolific source of infection. How long the fungus can live on decaying material is not known. Another important point on which there is as yet very little accurate information is the relation of the fungus to plants other than the raspberry. If it lives on a variety of other woody plants, as suggested by Saccardo (see page 341), such plants must serve to assist its dissemination.

All of the evidence at hand tends to show that the fungus does not travel any considerable distance except on infested plants.

RELATION OF CANE BLIGHT TO THE DISCOLORED AREAS ON RED RASPBERRY CANES.

During August and September the new canes of red raspberries often show brown or bluish-black areas one to four inches long and extending one-half to two-thirds or more of the way around the cane. (See Plate IV, Fig. 1.) These discolored areas are conspicuous and sharply defined. The discoloration is only in the bark and never extends to the sapwood. The cane is but slightly if at all constricted and, until the following spring, there is usually no evidence of any fungus in the fruiting stage. A single cane may bear from one to several such areas which may be located anywhere on the cane, but occur most commonly on
the lower portion. These discolored areas are exceedingly common on many varieties of red raspberries (*Rubus strigosus* and *R. idaeus*) and have been found also on the purple variety Shaffer (*R. neglectus*), but have never been observed on any of the black varieties (*R. occidentalis*). The health of the affected canes does not seem to be impaired.

At one time this discoloration was believed to be the early stage of cane blight, but it has now been determined that they are due to an entirely different cause.

During the winter the dark discoloration gradually changes to a light gray and the areas become indefinite in outline and more difficult to locate. (Plate IV, Figs. 2–4.) In April they are found to be thickly studded with small black perithecia, the numerous asci of which each contain eight two-celled hyaline spores disposed in uniseriate or subbiseriate fashion. (Plates IV and V.) By May 1 the entire lower portion of many canes is light gray in color and thickly covered with the perithecia. Still there is no discoloration of the wood underneath and no other indication of injury to the canes.

Some canes affected in this way were marked and watched for about three months to ascertain if they became affected with cane blight later. On May 2, 1902, ten affected canes of the variety Carleton were selected and labeled. Care was taken to select canes on which the affected areas were well defined. From each, a bit of bark was taken and examined with the microscope to make sure that the fungus present on the gray areas (formerly bluish-black) was the pyrenomycete above mentioned. On August 7, 1902, the ten canes were cut and carefully examined. All were either dead or dying, but in every case the cause was traced to a *Coniothyrium* infection at some other point on the cane, usually higher up. In two cases the *Coniothyrium* had made its attack just above the gray area and here the *Coniothyrium* pycnidia were intermingled with the perithecia of the pyrenomycete. It was plain that the gray areas were not the seat of the trouble and that the pyrenomycete was not succeeded by *Coniothyrium*. This view is supported by numerous other observations and we think that it may be accepted as an established fact.

---

5 See Bul. 191 of this Station, page 359.
that the discolored areas, which are bluish-black or brown on new canes and light gray and inhabited by the pyrenomycete the following spring, do not represent the early stage of cane blight; also, that this pyrenomycete and Coniothyrium are two entirely distinct fungi. In April and May it is sometimes difficult to distinguish, without microscopic examination, Coniothyrium infections from the gray areas inhabited by the pyrenomycete. The color of the bark is similar, but if the Coniothyrium has expelled its spores it may be recognized by the smoke-colored smuttness at the point of attack. In general, the matter may be decided at once by cutting into the cane with a knife. If the wood is discolored it is almost certain to be Coniothyrium. If the wood is not discolored it is most likely to be the pyrenomycete, although Coniothyrium will occasionally occur sparingly where there is scarcely any discoloration of the wood. To the unaided eye the Coniothyrium pycnidia are practically indistinguishable from the perithecia of the pyrenomycete.

The pyrenomycete under discussion appears to be Sphaerella rubina Pk. described by Peck in the Forty-eighth Annual Report of the New York State Museum, Part I, page 114. The description reads as follows:

"Sphaerella rubina n. sp. Perithecia minute, .007 to .009 in. broad, commonly gregarious, sometimes forming extended patches, submembraneous, obscurely papillate, pertuse, subglobose or depressed, at first covered by the epidermis, becoming superficial when the epidermis falls away, black; asci cylindrical, subsessile, .003 to .0035 in. long, .00045 to .0005 broad; spores uniseriate or subbiseriate, oblong, obtuse, uniseptate, generally constricted in the middle, hyaline, .0006 in. long, .00024 to .0003 broad, the upper cell often a little larger than the lower."


"This species is injurious to the plants it attacks. The affected plants either die from the disease or are so weakened by it that they are winter-killed wholly or in part. Generally the epidermis is whitened over the patches of the fungus, but sometimes brown spots indicate the presence and location of the fungus. The mycelium consists of brown septate filaments. From Didymella
applanata, which this fungus resembles in some respects, it is separated by the absence of paraphyses."

With the writers it is an open question whether paraphyses are present or absent, and we must take exception to the statement that the Sphaerella is injurious to the canes on which it occurs. We have seen good crops of fruit produced in plantations in which almost every cane bore more or less of the Sphaerella the preceding spring. Its seemingly injurious effect is due to the fact that it occurs most abundantly on red varieties which are especially liable to winter injury and to attack by cane blight.

Under the microscope, the perithecia quite generally show a conspicuous light-colored, circular area at the center, as shown in Fig. 1, Plate V. This is the ostiolum. When the perithecia are crushed under a cover glass the asci come out clinging together at their bases. They have the shape of a banana and in clusters resemble the banana clusters of six to twelve fruits each offered for sale by fruit vendors. They cling together tenaciously. Mature spores may be found in abundance by May 1 and at Milton, N. Y., we have found them as early as April 8; but, in general, during the month of April the perithecia contain asci which are mostly without spores. According to our measurements the asci are 60 to 70 µ long by 10½ µ wide, and the spores 14 to 19 µ long by 5½ to 8½ µ wide. (For the superior cell.)

Several unsuccessful attempts have been made to obtain pure cultures of the Sphaerella by the dilution method with potato agar. Often there is associated with the Sphaerella, a species of Phoma having small, oblong, hyaline spores. (Plate V, Fig. 6.) The Phoma and Sphaerella are so frequently found together as to arouse the suspicion that the former may be an immature form of the latter. Pure cultures of this Phoma have been obtained and grown for several months on sterilized bean stems, raspberry canes and plugs of sugar beet, but no indication of Sphaerella perithecia appeared in any of the cultures.

In 1901 the Station raspberry plantation, containing many varieties, was carefully watched to ascertain the date of the first appearance of the discolored areas on the new canes. They were first observed July 8 on the variety Pride of Geneva. In 1902 a plantation of the variety Coutant No. 1, at Marlboro, was watched
for the same purpose. The discolorations were plentiful on July 22, after two days of almost continuous rain. A few were observed some days earlier, but on the date mentioned there was a general outbreak.

The writers suspect that the discolored areas discussed above and attributed to *Sphacella rubina* are identical with those described in 1891 by Miss Detmers in Ohio Experiment Station Bulletin, Vol. IV, No. 6, p. 128. At any rate her description answers very well for the trouble under discussion except for the leaf symptoms, which may have been due to other causes. Dr. Burrill, to whom Miss Detmers referred the matter, pronounced it a bacterial disease identical with pear blight. In the literature of raspberry diseases this article of Miss Detmers has been frequently cited, but so far as we know there is no other published evidence that the raspberry is subject to a bacterial disease. Card's⁶ illustration of a raspberry cane affected with the supposed bacterial disease is a good illustration of the discolored areas which we believe to be due to *Sphacella rubina*.

It appears that raspberry canes in England are affected by a disease having similar symptoms. In the *Gardeners' Chronicle⁷*, an English periodical, an inquiry is answered concerning a raspberry disease producing black patches on the canes. Mr. George Massee is quoted as authority for the statement that the discolored patches are caused by a species of *Dothidea*, probably *D. rosae*.

**SPRAYING EXPERIMENT AT CHARLOTTE.**

In the season of 1901 a Cuthbert raspberry plantation belonging to Dobson Bros., of Charlotte, N. Y., was injured by cane blight to the extent of two-thirds of the crop, as estimated by the owners. The writers first became acquainted with the plantation on May 21, 1902. At that date it appeared to be in good condition; the canes were large and strong and the foliage good. The average observer would have said that there was an excellent prospect for a heavy crop; but close examination showed that many of the canes were already affected with cane blight and showing *Coniothyrium* pycnidia. In fact, canes here and there

---

⁶ Card, F. W. *Bush Fruits*. Fig. 46. The Mac Millan Co. New York. 1898.
were already partially dead with the disease, and it seemed likely that there might be a severe outbreak of it a little later.

Arrangements were at once made to conduct a spraying experiment in this plantation to ascertain if the crop of the present season could be saved in that way. Of course it was not expected that the disease could be checked in canes already infected; but it was hoped that the fruiting canes might be protected against further infection.

The plantation contained about 1 1/8 acres, consisting of 44 rows 185 feet long. 24 rows were sprayed and the remaining 20 left unsprayed for checks. Throughout the plantation strips of four sprayed rows alternated with strips of four unsprayed rows.

Bordeaux mixture of the 1-to-10 formula was applied thoroughly three times; namely, on May 26, June 4 and June 16. The spraying outfit used is shown in Plate VI. It was operated by two men and a boy. At each spraying about 100 gallons of bordeaux mixture were used and the time consumed in making and applying it was 5 1/2 hours. Since the area sprayed was a trifle less than two-thirds of an acre, the bordeaux was applied at the rate of about 150 gallons per acre. Both the canes and the foliage were sprayed thoroughly, special attention being given to the canes.

From observations made on August 2 it is plain that spraying did not check the disease. Apparently, there were as many dead canes in the sprayed rows as there were in the unsprayed ones. In one sprayed row, selected at random, the dead canes were counted and found to number 239, while in the adjacent unsprayed row there were but 172. This difference was probably accidental, but certainly there was nothing to indicate any benefit from spraying.

The yield of fruit, likewise, was disappointing. The fruit was gathered under the supervision of Dobson Bros., who also kept the record of the yield. Between July 14 and August 6 the plantation was picked over eleven times. The total yield of the twenty-four sprayed rows was 4446 pints or 185 1/4 pints per row. The twenty unsprayed rows gave a total yield of 4070 pints or 203 1/4 pints per row. Thus the unsprayed rows outyielded the sprayed rows by 18 1/4 pints per row or about 725 pints per acre.
As nearly as can be estimated, the loss from cane blight was 25 per ct. of the crop. Spraying, instead of reducing the amount of the loss, apparently increased it. It seems unlikely that this difference in yield was accidental. The plantation was unusually uniform throughout and such inequalities as existed were mostly equalized by the alternation of sprayed with unsprayed rows. Assuming that no error was made in keeping the record the only way in which the difference could be accounted for is to suppose that the blossoms were injured by the spray. At the time of the last spraying, June 16, a good many blossoms were open. The foliage was not injured by spraying.

Since at least a part of the infection occurs on new canes the best results from spraying are to be expected where the spraying is begun on the new canes and continued on the fruiting canes the following spring. Experiments along this line are now in progress in the Dobson plantation. After the fruit was gathered the sprayed rows were given three more applications of bordeaux mixture, and next spring they will be sprayed three or four times more before the fruit is large enough to be discolored by the bordeaux.

**PREVENTIVE MEASURES.**

*Start with healthy plants.*—Judging from what is now known concerning raspberry cane blight it appears that the first and most important consideration is to secure healthy plants with which to start the plantation. Unfortunately, there is no way of accurately determining, by an examination of the plants themselves, whether or not they are infested by the disease. Unless the planter can personally examine the plantation from which the plants are to be taken (and this must be done the summer before the plants are needed) he must rely on the honesty of the nurseryman or other person who grows the plants. This matter is greatly complicated by two things: (1) Cane blight is widely distributed—the majority of the raspberry plantations in this State contain more or less of it; (2) The difficulty of correct diagnosis. As yet, very few fruit growers are sufficiently acquainted with cane blight to be able to say positively whether it is or is not in their plantations. However, one thoroughly familiar with the
symptoms can usually make a correct diagnosis without resorting to the use of a compound microscope.

By taking reasonable precautions the planter can usually make sure that his plants do not come from badly diseased plantations, at least.

Avoid planting on the site of diseased plantations.—It is scarcely necessary to say that it is unwise to set a new plantation on land where raspberries have been recently affected by cane blight. Probably the fungus survives for a time on and in the soil, but how long is not known. After a severe attack of cane blight the land should not be replanted with raspberries for at least three years.

Removal of the old canes.—Immediately after the fruit is gathered, cut out and burn the old canes. The old canes harbor the fungus. They are covered with multitudes of Coniothyrium spores and if allowed to remain standing in the plantation until winter they must be an important source of infection to the new canes. It is too much to expect that by prompt removal of the old canes cane blight can be entirely controlled, because under favorable weather conditions it is likely that considerable infection of the new canes may occur before the fruit is ripe. However, the virulence of the disease may be lessened in this way.

Spraying.—Judging from the results of experiments thus far made spraying is not a promising line of treatment; and yet, theoretically, the disease should be preventable by spraying. The chief difficulty seems to be to get the spray mixture to adhere to the canes. The new canes are covered with a "bloom" which causes the spray mixture to gather in drops and roll off. If spraying is done it should be commenced when the new canes are a few inches high and repeated at intervals of two weeks until about the middle of September, and again the following spring from the bursting of the buds to the setting of the fruit. In order to avoid spotting of the fruit and possible injury to the blossoms it may be necessary to abandon the spraying for about six weeks at fruiting time. It should be remembered that it is the canes and not the leaves which need protection. Bordeaux mixture is as likely to give good results as any other fungicide.
Other suggestions.—In setting plants suspected of being infected with cane blight remove as much as possible of the old cane and wash the roots. Destroy wild raspberry plants in the immediate vicinity of the plantation since they may be a source of infection.

Some varieties are more resistant to cane blight than others and perhaps this fact may be turned to practical account. It is not now possible to give a list showing the relative susceptibility of different varieties; but it can be stated that among the varieties commonly grown Cuthbert is one of the most affected and Columbian one of the least affected.

It is not always advisable to destroy a plantation because it has been seriously injured by cane blight. It may recover sufficiently to give profitable crops again. Since the disease does not attack the roots the new canes are just as vigorous in diseased plantations as in healthy ones, and if the weather conditions happen to be unfavorable to infection nearly a full crop may be obtained from plantations badly diseased the preceding season. The writers have known of instances of this kind.

II. RASPBERRY YELLOWS.

The Marlboro red raspberry, a once popular variety, is said by fruit growers to be "running out." In Ulster County particularly its culture is said to be no longer profitable; and throughout the Hudson Valley one frequently hears of the ravages of the "Marlboro disease." The foliage and fruit dry up—sometimes gradually, sometimes suddenly. There has been much speculation concerning the cause of the trouble.

According to our observations the so-called Marlboro disease is, in reality, two diseases. It is partly cane blight (to which the variety is much subject) and partly another disease for which we propose the name "Yellows." Plants attacked by yellows have a stunted, yellowish aspect suggestive of peach yellows and Woods' Bermuda lily disease, especially the latter. On fruiting canes the fruit-bearing laterals are dwarfed, often to one-half their normal length. The leaves are small, curled slightly downward at the margins and faintly mottled with yellow. Some of
the berries dry up without ripening and those that ripen are undersized and insipid. Much of the foliage withers at the same time. New canes, for the most part, are not seriously checked in growth although their foliage is usually more or less affected. The foliage on new canes does not wither and there are rarely to be found any dead spots or areas. The leaves on the upper portion of the cane may be much mottled while those on the lower portion are nearly or quite normal. The reverse may also happen. Badly diseased canes and apparently healthy ones may be occasionally found in the same stool. However, it is often difficult to determine whether a particular cane is or is not diseased because the transition from normal canes to badly diseased ones is by imperceptible gradations. Except in the later stages of the disease and when also attacked by cane blight, the canes themselves do not show injury. The roots, too, appear normal but more observations must be made before it can be stated positively that the roots are entirely unaffected.

This disease is a very important one and deserves more attention from pathologists than it has yet received. Although especially destructive to the Marlboro it is by no means confined to that variety. It has been observed on several other red varieties and black caps, among which are Coutant No. 1, Cuthbert and Kansas.

The name yellows is given the disease, not because of any supposed relation to peach yellows, but because it is descriptive of the appearance of affected plants. The red rust of blackberries and raspberries, due to the fungus Caoma nitens, is sometimes incorrectly called yellows. For this disease, red or orange rust is the proper name inasmuch as it is caused by a true rust fungus.

The cause of raspberry yellows is not known. At one time we suspected that the red spider (Tetranychus telarius) was responsible for it, but that idea has been abandoned. It is safe to say that it is not caused by any fungus attacking the leaves. In an experiment made by this Station in coöperation with W. D. Barns & Son of Middle Hope, N. Y., various combinations of commercial fertilizer were applied to the soil in a badly affected plantation without any appreciable effect on the disease. The details of this experiment will be given at a future time.
No remedy or preventive is known. On this subject it can only be said that spraying with bordeaux mixture does not check the disease. During the seasons of 1901 and 1902 the Station conducted a raspberry spraying experiment in coöperation with Mr. J. A. Hepworth of Marlboro, N. Y. The plantation contained 12 rows, 304 feet long, of the variety Coutant No. 1. Six of the rows were not sprayed while the other six were sprayed with bordeaux mixture, 1-to-10 formula, on the following dates in 1901: May 11, 22; June 3, 24, 26; July 10, 23; August 7 and 20. Three of the rows sprayed in 1901 were also sprayed in 1902 on May 10, 20, 31 and June 14.

The original object of the experiment was to ascertain if cane blight can be prevented by spraying; but, unfortunately, cane blight was almost wholly absent from this plantation in 1901 and 1902 although it had been destructive in 1900. Consequently, nothing was learned as to the value of spraying for cane blight. The yellows, on the other hand, attacked the plants over the whole plantation. The attack was a moderate one and a fair yield of fruit was obtained in spite of it; but in 1902 it was sufficiently severe to make it plain that the spraying had had no effect upon it. The three rows which had been sprayed 13 times were quite as much affected as the unsprayed rows.
Plate II.—New Canes Artificially Inoculated.
Plate IV.—The Discolored Areas Caused by Sphærella.
PLATE V.—*Sphaarella rubina*, *Coniothyrium* and *Phoma*.
EXPLANATION OF PLATES.

Plate I.—A typical example of raspberry cane blight. A fruiting cane, variety Pride of Geneva, photographed, two-fifths natural size, June 21, 1901. The cane blight fungus attacked and killed the cane at the point indicated by the arrow. As a consequence, all foliage above this point withered.

Plate II.—Five new canes, variety Pride of Geneva, inoculated with a pure culture of the cane blight fungus (Coniothyrium), July 18, 1900. Photographed, natural size, September 18, 1900. Shows method of using grafting wax to cover inoculations. The discoloration of the bark above and below the wax was pronounced.

Plate III.—Ten new canes of Cuthbert raspberry inoculated with a pure culture of Coniothyrium June 6, 1902. Photographed, natural size, August 9, 1902. Wax removed.

Plate IV.—Four raspberry canes showing the discolored areas caused by Sphaerella rubina. All natural size.
Fig. 1. A new cane of Pride of Geneva. July, 1900. Bark brown.
Fig. 2. A cane of the variety Talbot, showing spring appearance of the areas on fruiting canes. Bark gray and thickly covered with perithecia of Sphaerella rubina. The majority of the perithecia contained only immature asci, but in a few spores were formed. Photographed April 22, 1902.
Figs. 3 and 4. Fruiting canes of Whyte No. 7 and Carleton respectively showing spring condition of the areas. Bark gray and covered with perithecia of Sphaerella rubina, mostly immature. On both canes a few Phoma pycnidia are intermingled with the Sphaerella perithecia. Photographed April 18, 1902.
Plate V.—Figs. 1–5, Sphaerella rubina.

Fig. 1. A peritheciun × 87.
Fig. 2. A fragment of one of the brown hyphae from the base of the peritheciun, × 725.
Fig. 3. An ascus × 580.
Fig. 4. Four ascospores × 966.
Fig. 5. A germinating ascospore × 465.
Fig. 6. Six spores of the Phoma found associated with Sphaerella rubina, × 966.
Fig. 7. Ten spores of the raspberry cane blight Coniothyrium, × 1033.
Fig. 8. Ten spores of Coniothyrium sp. found on dead blackberry canes, × 1033.

All figures original and drawn with aid of camera lucida.

Plate VI.—The spraying outfit used in the experiment at Charlotte.