1908

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Agricultural Experiment Station

OF THE

Louisiana State University

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BATON ROUGE

Diseases of Pepper and Beans

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BATON ROUGE:
THE DAILY STATE, OFFICIAL JOURNAL OF LOUISIANA.
1908
Diseases of Pepper and Beans.

PEPPER BLIGHT.

Symptoms. The first indication of blight or wilt of pepper plants is a slight drooping of the young leaves at the tips of branches during the day. These leaves recover at night and appear perfectly normal the next morning; but this is only temporary, and during the second day the wilting is much more pronounced than before. Usually by the third or fourth day all of the leaves are wilted beyond recovery, and change of color, drying, and dropping off follow shortly; the plant is now evidently dead (Figs. 1 and 2). Such marked wilting is the usual appearance presented by affected plants, but from time to time some are met with that show the yellowing and dropping of the leaves without very evident previous wilting.

If a plant in the early wilting stage of the disease is pulled up, the roots generally are seen to be sound and in good condition; but there is apparent on the stalk a little below the ground level, or perhaps on one of the larger root trunks, a shrunken, discolored area of variable size, usually extending a considerable distance around the stem (Fig. 3). At a somewhat later stage, when defoliation has begun, this area is seen to be larger, more sunken, and more discolored; and in its central portion the bark is in process of disintegration. The wood under such a lesion is apparently unaffected. From this time forward, rotting of the roots lower down may set in and progress rapidly.

Attacks commence when the plants are beginning to form pods, and usually continue until the end of the growing season. There is much evidence of spread from affected plants to adjacent sound ones; this takes place through the soil, as will be seen.

Cause. If the abnormal areas found on the stems just below the surface of the ground, be examined carefully, there can be found permeating the bark and usually spreading over its surface, the fine white threads of a fungus growth (Fig. 6). If
such a part of the stem is placed in a covered dish where a high degree of moisture is maintained, there will appear in the course of twenty-four hours a very abundant growth of the fungus. By exercising proper care portions of this fungus can be transferred to sterile culture media and made to grow entirely separate from other organisms. In this way it has been found that one particular fungus is always associated with the characteristic lesion of pepper blight; and further, that when pure cultures of this fungus are placed in contact with the stems of a sound pepper plant, symptoms of blight appear in three to five days, and the disease runs a typical course, resulting in the death of the plant. The fungus can always be found again in the lesions of such artificially infected plants.

There is no doubt then that the attack of this fungus is the primary cause of the blight of pepper plants. The bark and soft cambium tissue between it and the wood are destroyed; and when this destruction extends around the stems the plant is as completely girdled as though the operation had been performed with a knife. Of course the plant cannot survive such injury, and the wilting and dying of leaf and stem is the expected result of the serious interference with its nutrition. The later decay of the roots is a secondary phenomenon resulting from the attacks of various saprophytic soil organisms.

The fungus. The great majority of fungi have a vegetative part, the mycelium, which produces special propagative parts, the spores; very much in the way that higher plants have a vegetative part consisting of roots, stems and leaves, and special propagative parts, the seeds. The most striking peculiarity of the fungus under consideration is that it does not produce spores in so far as is known. Its increase and spread seem to be accomplished entirely by new growth from vegetative parts in a way that corresponds to propagation by cuttings in the case of higher plants. The spores of fungi, in many instances, have powers of resistance to cold and dryness that are much greater than those of the mycelium, and that make it possible for the fungus to survive unfavorable conditions that would otherwise prove completely destructive.

The pepper blight fungus, although apparently without spores, has the ability to form dense mycelial masses known as
sclerotia, which have thick coverings and can withstand conditions of temperature and moisture that would destroy the delicate, thread-like mycelium. In the case of the pepper wilt fungus the formation of sclerotia is made evident by the appearance of white tufts or flecks of mycelia; these gradually assume a larger and definitely rounded form and become hard and smooth externally. The color changes from white through the lighter shades of brown to very dark brown; the size is that of an ordinary pinhead or a little larger; the shape is spherical or nearly so (Fig. 4).

The lack of knowledge of the spores prevents definite classification and naming of this fungus, since these matters depend so largely on the character of the spores. However, its straight, radial habit of growth is rather distinctive; this and the presence of the small, smooth, brown sclerotia render the recognition of the fungus easy. It is possible, of course, that further study will reveal physiological or morphological differences on the basis of which separation will be made into species or varieties. In the only accounts of the disease that we have seen, which are those by Professor P. H. Rolfs of the Florida Experiment Station, the view is held that the fungus is the same on a wide range of plants, cultivated and wild. In the present study of the fungus, all indications have pointed to the same conclusion.

Prevalence and destructiveness. Pepper blight was first reported from Florida in 1893. It has existed in Louisiana for a considerable time, and has been seen by the writer in a number of widely separated localities in the State. The losses occasioned by it seem to depend largely upon seasonal and other variable conditions. Loss from it is frequently considerable, as much as twenty-five to fifty per cent.; in other seasons it is slight or nothing at all. The writer has seen peppers in a garden patch fully ninety per cent of which were destroyed by this disease. There is much to indicate that the fungus tends to become more abundant in the soil from year to year.

From Florida the pepper blight fungus has been reported as attacking many other plants, including tomato, eggplant, Irish potato, sweet potato, beet, peanut, beans, cowpeas, cabbage, squash, watermelon, rhubarb, fig, cotton, violets, hydrangea,
daphne, chrysanthemum, morning glory, beggar weed, fire weed, Canada fleabane. The writer has observed it in Louisiana attacking pepper, bush and pole beans, and the Japanese fiber plant *mitsumata* (*Edgeworthia papyrifera*) (Fig. 5); it has also been found on the decaying parts of various plants such as cotton boll, fig fruit, grass, cauliflower and tomato leaves, in all cases when these were in contact with the ground. It is also quite common on the leaf sheaths of sugar cane, especially at young stages; the sheaths when affected show a distinctly red disoloration. A similar condition has been described from Java by Dr. J. H. Wakker, and his plates bear a striking resemblance to what is found on the cane in Louisiana. The writer has not found cane to be seriously affected by the fungus; in Java it is reported as causing a disease known as "red mucus" (*Roten Rotz*), which is to some extent injurious to young cane plants.

It is thus seen that the fungus which causes the blight of pepper is of especial importance because of the large number of plants, many of them valuable ones, that may be attacked by it.

**Means of prevention.** From what has been indicated regarding the nature of the injury caused by the fungus, it will be appreciated that little or nothing can be hoped for in the way of cure when once a plant shows signs of blight. And further, since this fungus lives in the soil and attacks the plants on underground parts, no good can be accomplished in the way of prevention by the application of fungicides to the foliage.

Treatment that has been demonstrated to be successful is the application of a clear fungicide such as ammoniacal copper carbonate, or eau celeste, to the ground just at the base of the plants in such a way that it may soak into the ground for five or six inches from the stem and cover the stem itself for some distance; branches that touch the ground should be coated at the place of contact. The solution should be applied with some sort of spraying apparatus, and about a pint used for each pepper plant of good size. The first application should be made as soon as careful watch shows the first indication of blight; or, if blight is expected, it should be made while the plants are in flower or a little before. Other applications should be followed every two or three weeks. By this means the part of the-
plant most subject to attack is very effectively protected. The precipitate in Bordeaux mixture is filtered out by the upper part of the soil; on this account this very excellent fungicide is for the present purpose inferior to the ones mentioned. Formulas for these are given at the end of this bulletin. Unfortunately for some experiments which were planned along these lines, there was too little blight of pepper during the last season for definite conclusions to be drawn from them. There was, however, a severe outbreak among the Japanese fiber plants, and it was found that such treatment protected these appreciably, although the trial was made under very severe conditions.

It has been a prominent characteristic of the fungus that it will not grow on nutrient media unless they have a comparatively high degree of acidity. This suggests that the fungus may find conditions best for its growth only in soils that are more than ordinarily acid. If this is really the case, the use of lime to reduce the acidity of the soil ought to have a good effect in reducing the loss from blight. It is hoped that it will be possible to make some tests along this line at an early date.

Rotted vegetable matter, because of the good feeding ground it furnishes, is likely to become thoroughly permeated with the fungus if any of it is introduced; and the common prevalence of the fungus renders such a thing rather probable. Such material may efficiently spread infection to growing plants.

Inoculation experiments. Inoculation of healthy pepper plants with pure cultures of the peculiar sclerotium-producing fungus has always been followed within a few days by typical symptoms of blight (Figs. 1 and 2). In the first series of experiments removal of the soil and sometimes slight abrasion of the bark were resorted to in making the inoculations. It was found later that infection followed just as readily when the culture material was merely placed on the surface of the ground in contact with the stem and covered with a little earth and watered. Cultures applied above ground to single branches of pepper plants produced the usual lesions at the points of application, and was followed by characteristic wilting of the branches in question. In these cases the parts were cleansed with weak carbolic acid and sterilized water, and a wrapping of moist
sterilized cotton placed over the inoculation material from a pure culture.

After these preliminary tests, which demonstrated the parasitic nature of the fungus, it was thought proper to ascertain (1) whether all varieties of pepper are susceptible to infection, and whether equally so, (2) to what extent other plants of economic importance are susceptible to infection by the fungus causing blight of pepper plants, (3) to what extent strains of the same or a similar fungus from other sources have the ability to infect plants of various kinds. Until now it has not been possible to carry out anything more than a very preliminary set of experiments along these lines.

By careful inoculation tests the following varieties of pepper were found to be susceptible to infection by the fungus obtained from blighted pepper: Ruby King, Monstrous, Cayenne, Bell, Cluster, Red Cherry, Tabasco, Celestial, Chinese Giant, Chili, County Fair, Neapolitan. These were all the varieties tested. All the individual plants inoculated became infected except in the case of the Red Cluster variety; here only one out of three inoculations was successful; the test unfortunately could not be repeated. In 1906 a row of Red Cluster pepper was observed to suffer only slightly, while the adjacent rows of other varieties were almost completely destroyed by the blight. Naturally infected plants of Sweet Spanish and Upright Sweet Salad have been seen.

The sclerotium-producing fungus from pepper was found to infect pole and bush beans, tomato, eggplant, and the Japanese fiber plant, *Edgeworthia papyrifera*; but not okra, although attempts were made at three different times.

Pepper plants were infected by strains of the sclerotium-producing fungus from the following sources: pepper plant, tomato leaf, cotton boll, sugar cane leaf sheath, fig fruit, cauliflower leaf, bean pod, Japanese fiber plant.

Japanese fiber plants were infected by the fungus from Japanese fiber plant, pepper plant and bean plant.

Bean plants were infected by the fungus from bean plant, pepper plant, and sugar cane leaf sheath.

Okra failed of infection by the fungus from pepper plant, sugar cane leaf sheath and cotton boll.
BEAN DISEASES.

In all some ten or twelve diseases of beans have been recognized in the United States. Two of these, pod spot or anthracnose, and bacterial blight or bacteriosis, are of the utmost importance because of their common occurrence and great destructiveness. Two of the minor diseases, a pod and stem rot caused by the fungus *Rhizoctonia*, and a blight or wilt caused by a certain sclerotium-producing fungus, are probably little known, and deserve somewhat more extensive treatment than they have received. These four diseases will be discussed in this writing.

ANTHRACNOSE OR POD SPOT.

This well-known disease is caused by the attacks of a parasitic fungus known technically as *Colletotrichum lindemuthianum*, which is closely related to the several species of fungi causing the anthracnose of cotton bolls, of cucumber, watermelon and cantaloupe, of tomato, of alfalfa, and of lemon, lime, and orange. Anthracnose affects all varieties of kidney beans, the wax varieties to a greater extent than the green-podded ones.

The most conspicuous effect is the spotting of the pods, and from this come the names pod spot and anthracnose, the latter having its derivation from the Greek word meaning ulcer. A third name commonly used for this disease is "rust"; but such usage is to be condemned because the bean is subject to a true rust caused by a fungus belonging to the same general group of fungi as those causing rust of oats, of the fig, of the dewberry, etc., which produces small, brown, powdery pustules on the leaves of beans, but not usually on other parts of the plant. To use the term rust in a loose way to indicate the anthracnose of beans simply creates unnecessary confusion.

The spots on the pods appear at first as small, light brown areas which gradually become larger, darker and distinctly sunken (Fig. 7). Typically, the spots are circular, but neighboring ones may coalesce, giving rise to very large irregular affected areas. These spots are caused by the growth just beneath the surface of the pod of the thread-like mycelium of the anthracnose fungus; this draws its nourishment from the cells which compose the pod tissue, and in doing so destroys them. At
a proper period in its growth the fungus begins to fruit. This it does by sending up from a mass of the mycelium a number of palisade-like branches which break through to the surface and produce at their ends the spores (Fig. 8). These are elongated bodies of microscopic size which can germinate and reproduce the anthracnose fungus (Fig. 9). They are produced in very large numbers, and may be seen in the centers of well-developed spots as pinkish masses hardly visible to the unaided eye; each such mass is made up of tens of thousands of spores. Each spore is surrounded by a gelatinous envelope, which when dry glues it to its neighbors; when moistened the spores readily separate, and the envelopes serve again as means of attachment when they come in contact with a new object. This indicates something of the reason for the spread of pod spot when there is moving about among the vines while they are wet. A spore that reaches a fresh pod of the bean plant will germinate if conditions, especially of moisture, are favorable; and the minute thread of the new fungus plant will penetrate into the tissues, cause their disintegration, and thus produce the external symptoms that indicate a new affected spot. Such indications are not apparent until the fungus has become well established within the tissues, too well established for eradication without serious or fatal injury to the plant itself.

The spread by spores, while the most extensive, is not the only way in which this fungus is propagated. If a badly affected pod be examined, it will be found that the seeds lying directly under the spots are apt to be discolored and to show upon themselves shrunken areas similar to those on the pod. This means that the mycelium of the fungus has worked its way through the entire thickness of the pod hull and has entered the seed. As the seed ripens and becomes dry, the fungus within it ceases to grow; but it does not die. Conditions of warmth and moisture that cause the germination of the bean have a like effect upon the anthracnose mycelium within its tissues. And so it comes about that the bean seedlings as they come up, have brown sunken areas on the seed leaves or the stem in which the fungus is actively growing. Sometimes this early infection is so severe as to kill the seedling and ruin the stand; but usually it is not prominent enough to be noticed. Very soon
masses of spores are formed in the affected spots, and these spread the infection to the leaves and stems of the rapidly growing plants. Here, too, the lesions may be apparent only on close inspection. On the leaves they appear usually as reddish or blackened areas along the large veins on the under surface. Spores are formed in turn in these areas and continue the dissemination of the fungus. When the pods begin to form, there is already present in the field an abundance of spores; and the first observed spotting of the pods is not by any means the beginning of the infection. That goes back to the time of planting, and was brought about by the use of seed which had the living anthracnose fungus in them.

Sometimes serious trouble is caused by the spotting during marketing of beans that were apparently sound when picked. From what has been said, it can be readily understood that such beans may have been affected just before picking, or during the picking, sorting and packing. The handling of one affected pod may result in the infection of many others handled subsequently.

Weather conditions have much to do with the prevalence of the disease in any particular season. Warm showery weather is most favorable for it; heavy dews and fogs also furnish suitable conditions for its spread. Very dry conditions have the opposite effect, and may be so effective that the destructiveness will not be great even though infection is present from the first.

**Means of Control.**

*Seed selection.* From what has been said it is evident that the planting of non-affected seed is a most important factor in the control of bean pod spot. Since the disease is widespread, occurring in every section of the country, the mere getting of the seed from a distant point does not insure its freedom from infection. The presence of the fungus in seed is indicated by a brownish or yellowish discoloration of their coats; and by inspection it can be told whether a lot of seed is badly infected or probably free from infection. Much could be accomplished by going over the seed carefully before planting and rejecting all that show discoloration or abnormalities of all kinds. There are on the market certain so-called "rust proof" varieties of
beans which are supposed to possess a high resistance to pod spot; reports from elsewhere, and the observations of the writer indicate that while there is a difference in the susceptibility of the different bean varieties to anthracnose, there is not one of them completely immune. Seed are also on the market for which the claim is made that the fields in which they were grown were entirely free from anthracnose. No superior resistance is claimed; the merit lies in the absence of seed infection. The writer made the attempt this season to test such seed, as well as seed from a number of other sources. While a greater freedom from infection of seedlings was noted, the test was not as definite as could be wished, because the weather conditions were such that the anthracnose did not affect the plants of any lot to any extent during the later stages of their growth; but bacterial blight was abundantly present and greatly interfered with the experiment.

**Removal of affected plants.** This refers particularly to diseased seedlings as soon as they can be detected. They should be pulled up and burned. At the end of the season all stalks and leaves in any infected field should be collected and burned to prevent the renewal of infection from them the following season.

**Rotation of crops.** It is a good practice in combating bean anthracnose, to avoid planting the same area successively in this crop.

**Care in cultivating, picking and marketing.** In so far as possible the working and gathering of beans should be avoided while the bushes are wet with dew or rain. Affected pods should not be picked, washed or packed with sound ones. Containers should be such as to allow good ventilation, and should be stored in as dry and cool places as possible.

**Spraying.** This is a very efficient means of keeping the disease in check if carried out thoroughly. The object of the procedure is not to accomplish the impossible task of removing the fungus from already affected plants; but it is to protect unaffected plants and parts of plants from infection by spores that may happen to reach them. These cannot penetrate into the tissues if they are coated externally with a good fungicide. This must evidently be applied so as to cover all vulnerable
parts of the plant, and must be renewed as often as may be necessary for this purpose. A somewhat weak Bordeaux mixture, the 5-4-50 formula, is suitable for beans. The first application should be made to the seedlings as soon as the first true leaves have unfolded. A second one should follow in ten days or two weeks. The object should always be to cover thoroughly all parts of the plant above ground. A third application for the special protection of the pods should be made just after blossoming, while the pods are forming. Ordinarily three applications should be sufficient; but if the season is unusually wet, or infection very great, another spraying should be made between the second and third, and still another when the pods are nearly full-grown. Even if the earliest sprayings have not been made, much good can be accomplished in protecting unaffected pods by a thorough application to them after spotting has become apparent in the field.

**BACTERIAL BLIGHT OF BEANS.**

Bacterial blight of beans, or bacteriosis, is caused by a species of bacterium known as *Pseudomonas phaseoli*, which attacks both kidney and Lima beans. These particular bacteria or germs are short rods about twice as long as broad, that are found in the stems, leaves and pods of the affected plant. They are of such very small size that they can be seen individually only with the highest powers of the microscope. Each of these very minute individuals is a living plant, and has the power of growth and reproduction; this last it accomplishes by simply dividing into two. So rapidly do the generations follow each other under favorable conditions that the descendants of a single individual may number many millions in the course of twenty-four hours.

The most marked effect of the disease is to be noted on the affected leaves (Fig. 10). On these the invaded areas are seen at first as small spots of yellowish color and water-soaked appearance; these increase in size until the whole leaflet is involved. The central, or the first invaded portion, of a large affected area consists of brown, dry tissue which may or may not furnish a feeding ground for a miscellaneous lot of saprophytic fungi. Beyond the central dry portion is a zone of
dead leaf tissue not yet brown and only partially dry; beyond this is the most recently invaded portion of the area, which has the greenish-yellow, water-soaked appearance of the first stages. All parts of the affected area are traversed by dark lines of irregular course, which mark the boundary of successive stages in the spread of the bacteria to new portions of the leaf. These lines are more apt to have a broken course, including polygonal areas, than to take the form of concentric circles. This seems to result from the temporary limiting of the spread of infection by the larger veins of the leaf. Affected leaflets usually remain attached to their stalks until they die and shrivel. Later the ends of the leaf stalks shrivel and become dry; and ultimately the infection may extend to the branches and through these to other leaves and to pods (Fig. 11). The diseased areas frequently begin at the margins of the leaves, or where the tissue has been torn by insects or in some other way.

The lesions on the pods are somewhat less conspicuous than those on the leaves (Fig. 12). The usual appearance is that of a circular spot, neither raised nor sunken, water-soaked and brownish-yellow, without a very sharp boundary. The spots vary much in size, and are less regular in outline and more elongated when the edge of the pod—the "string"—is involved. On the surface of the spots are particles of dry yellow gum, just visible to the eye, which are exuded masses of the bacteria that cause the lesion. If a spot is cut across, and the hull pressed between the fingers, a small quantity of the fresh gummy material can be forced out. If a small portion of this be taken up on the point of a needle and introduced into a sound pod or other part of the plant through a slight prick, there will appear after a week or two symptoms of bacteriosis about the new center of infection. A similar transfer of the medium of contagion is probably accomplished very extensively through the agency of insects that feed upon the bean plant.

Sometimes the spots on the pod assume a deeper brown and sunken appearance because of secondary invasion of the diseased areas by saprophytic organisms. But there is never a close enough resemblance to the spots of anthracnose to occasion any confusion.
When the bean plant is severely attacked at a number of points, the normal processes of nutrition are greatly interfered with, and there results a general wilting and shriveling of the younger pods. The seeds in contact with affected areas of the pods become infected with bacteria; but there are not always such marked external indications of this as would enable one to pick out affected beans from a mixed lot with any degree of thoroughness. That the bacteria are present can be determined by microscopical examination, or by following procedures for securing them in culture from the seed tissues. By the latter means these bacteria have been found to remain alive for a number of months; and in this way, through the seed, infection may be carried to a new crop of beans in the same general way as anthracnose may be.

PREVENTION.

Good Seed. Inspection of seed with rejection of infected ones, while desirable, is not wholly practicable because of the impossibility of detecting them with certainty. It would be well to secure, if possible, seed grown in fields free from bacterial blight; but the caution must be given, as in the case of anthracnose, that the disease prevails over a large part of the country.

Seed treatment. The bacteria causing the blight of beans are killed by exposure for ten minutes to water having a temperature of 122 degrees Fahrenheit. Beans will endure a much higher temperature for a longer time without injury, if they are kept dry. The writer has kept beans for 45 minutes at a temperature of 135 degrees Fahrenheit, without any appreciable effect on their germination. Seed placed in water during a like exposure are practically all killed. This suggests that bacteria possibly present in suspected seed might be killed by subjecting the seed to a proper degree of heat. To test this a lot of seed was divided into two parts, and one of them was kept at 131 degrees Fahrenheit for 45 minutes. The two lots were planted in separate rows and closely watched. No difference at any time could be noted in the amount of bacterial blight in the two rows. Of course a single test of this kind is not conclusive, and the practice is not yet to be recommended.
**General measures.** Destruction of affected trash and rotation of crops are important. The bacteria can live over at least one winter in stems and leaves left on the ground. Since insects are instrumental in spreading the disease, all means that serve to keep them in check are useful in the control of the blight.

**Spraying.** Bacteriosis is rather more difficult to control by spraying than is anthracnose; but satisfactory results can be obtained by increasing the number of applications to five or six. During the season of 1907 the writer obtained in the case of a number of varieties an average benefit of 20 per cent from spraying, four applications being given; climatic conditions were very favorable for the development of infection, and it is believed that a more satisfactory result would have been obtained with more frequent applications.

**Varieties.** Varieties of beans show a difference in their susceptibility to bacteriosis when planted under similar conditions. Whether this is due more largely to differences in inherent powers of resistance to the disease than to differences in the condition of the lots of seed, is an open question. During the past season the writer found that a number of varieties of bush beans took the following ranks with regard to susceptibility to bacteriosis, the least susceptible being placed first in order, and the most susceptible last: (1) Schindler's Round Pod Wax, (2) Refugee Wax, (3) Burpee's White Wax, (4) Grenell's Rust Proof Golden Wax, (5) Wardwell's Kidney Wax lot 1, (6) Dwarf German Black Wax, (7) Early Valentine, (8) Wradwell's Kidney Wax lot 2, (9) Wardwell's Kidney Wax lot 3.

Wardwell's Kidney Wax lot 1 and Wardwell's Kidney Wax lot 3 were from the same original package; the former seed was selected for freedom from discoloration and other abnormalities, and the latter was the rejected seed. Wardwell's Kidney Wax lot 2 was from an entirely different source.

**FUNGUS BLIGHT OF BEANS.**

This disease of beans is caused by the same sclerotium-producing fungus that is responsible for the blight of pepper plants. The symptoms in the two cases correspond. There is first a
wilting of the leaves in the sunshine, with temporary recovery at night, then a yellowing and drying, followed by a dropping of the leaves (Fig. 13). The attacks of the fungus are upon the underground parts of the plant, usually upon the stem just below the surface of the ground. The fungus invades the bark as far as the cambium, destroying it, and from this results the fatal interruption of the nutritional processes of the plant.

The fungus itself has been described rather fully in the account of pepper blight which has already been given. It is characterized by mycelium that has a straight, radial growth and produces small, smooth, brown sclerotia (Fig. 4).

The means for control are those that have been suggested for the pepper blight. They are such general measures as the destruction of affected plants as soon as they can be detected, and of all possible trash at the end of the season, and the practice of a rotation of crops that will bring in non-susceptible plants. Special control consists in the application of some clear fungicide to the base of the plants in such way that it may soak into the ground and protect the part just below the surface.

**POD ROT AND STEM ROT DUE TO RHIZOCTONIA.**

Rhizoctonia attacks bean plants in three ways. (1) There is the damping off of seedlings caused by the entrance of the fungus into the succulent tissues of the young plants near the surface of the ground. (2) A dry rot of the stem brought on in older plants by *Rhizoctonia*, and somewhat destructive of them, has been described by B. M. Duggar in Bulletin 186 of the Cornell University Agricultural Experiment Station, as follows: "At a distance of from one to two inches above the surface of the soil there was a place on the stem where the tissues were dead and discolored. Frequently this occurred at the point where the plants commenced to branch. The dead part was dry-rotten clear to the pith, from one-half inch to one inch or more in length, and usually extended entirely around the stem. Being much weakened at the point of attack, it was a common thing for affected plants to be broken over by the wind. When this did not happen, the whole plant slowly dried up and died." (3) G. G. Hedgecock, in Science, n. ser. 19, p. 268,
has given an account of the presence of brown sunken areas on bean pods, due to attacks of *Rhizoctonia*, the mycelium of which penetrates to, and persists in, the seed coat.

During the season of 1907 the writer had occasion to observe the last two effects. During protracted warm wet weather practically every pod in immediate contact with the ground, or with decaying material that touched the ground, showed the characteristic rotten areas. These were circular or irregular in outline, and usually a quarter of an inch to an inch or more in extent; they were slightly sunken and brown, frequently with a darker central portion, and a more or less well-marked series of concentric lines surrounding it (Fig. 14). In the earlier stages only the outer portion of the hull would be involved (Fig. 15), but later the fungus would penetrate the entire thickness and enter the seeds, causing them to rot if young, or merely disoloring them if older.

*Rhizoctonia* was constantly associated with these lesions; and they were readily produced by inoculations with pure cultures of this fungus on pods in all stages of development, both on the bushes and in moist chambers. Infection invariably followed the application of the fungus material when the pods were pricked or slightly injured in some other way. Pods that were similarly injured, but not exposed to *Rhizoctonia* material, did not become infected. When inoculation material was applied to apparently sound pods, infection seldom followed; but there would usually be in such cases a certain amount of bronzing of the surface in contact with the growth of *Rhizoctonia*. The attempts to infect uninjured pods were made at all stages of development, and in a number of different ways, usually by inserting the pod still attached to the bush and properly cleansed, into a test tube culture of *Rhizoctonia* growing on a steamed bean pod.

*Rhizoctonia* obtained from pods caused damping off of seedling beans, and infected stems of month-old plants, when uninjured as frequently, but not so promptly as when slightly injured.

Naturally induced lesions of the stems were observed in the field while the rotting of pods was common, and less abundantly at other times under drier conditions when the pods were not
affected. No inoculations were made in the field for the purpose of securing the stem lesions.

At no time in the field or in cultures grown under a variety of conditions, was any spore stage of the *Rhizoctonia* seen.

Dr. B. M. Duggar very kindly examined cultures of the fungus from pods, and found them to agree with his notes on the *Rhizoctonia* causing the dry stem rot of beans in New York.

**PREVENTION.**

The observations of the writer, in so far as they go, indicate that damage from the rot of pods induced by *Rhizoctonia* becomes serious only when conditions of warmth and wetness are rather extreme. Such general means of prevention as care in the selection of seed, destruction of old stalks and leaves as thoroughly as may be possible, and rotation of crops, will doubtless be of benefit. The fungus is a soil organism, and probably produces spores very infrequently. Such protection as might be expected under other circumstances from spraying would not be as readily secured in this instance, both on account of the habits of the fungus, and the circumstances that invasion is rapid and at a time when weather conditions are unfavorable for adequate spraying.

**LITERATURE.**

Reference to the fungus causing blight of pepper, beans and other plants, is made in the following publications:

Florida Experiment Station, Bulletins Nos. 21 and 47, and Annual Report for 1896. Department of Agriculture, Division of Vegetable Physiology and Pathology, Bulletin No. 17, page 44.

The following experiment station publications contain accounts of diseases of beans:

BORDEAUX MIXTURE.

The most valuable fungicide for use in combating plant diseases is Bordeaux Mixture, which consists of a mixture of copper sulphate (bluestone) and stone lime slaked in water.

The formula for Standard Bordeaux Mixture, sometimes known as the "6-4-50 formula," is as follows:

- Copper sulphate (bluestone), pounds.......... 6
- Lime, pounds ........................................ 4
- Water to make, gallons.............................. 50

The bluestone should be dissolved by tying it in coarse cloth, such as gunnysack, and suspending it near the surface of 25 gallons of water placed in a wooden barrel or tub; or, more quickly, by using a small quantity of hot water and then adding cold water up to 25 gallons.

The lime should be the best quality and carefully slaked with small quantities of water until a thin, smooth paste is obtained. Water should be added to this paste until 25 gallons of milk lime is secured.

The solution of bluestone and the milk of lime should now be poured slowly together in a larger barrel, with thorough stirring to insure proper mixing.

When Bordeaux Mixture is properly prepared, it is of a brilliant sky-blue color. If the lime is air-slaked or otherwise inferior in quality, the preparation will have a greenish cast; and if this is pronounced, the mixture will injure the foliage. To test this, insert the bright blade of a pocket knife in the mixture, allowing it to remain for at least a minute. If the polished surface assumes the color of copper plate, the mixture is unsafe and more lime must be added. If the blade of the knife is unchanged, it is safe to use the mixture.

Iron or tin vessels are quickly injured by either copper sulphate or Bordeaux Mixture. Wooden, graniteware or earthenware vessels should be used.

Peach and eggplant are likely to be injured by full strength Bordeaux, and for use on such plants 60 gallons of water should be used instead of 50.

Formulas often used call for other quantities of bluestone and of lime, such as the 5-5-50 and the 5-4-50.
AMMONIACAL COPPER CARBONATE.

The formula for ammoniacal copper carbonate is as follows:

Copper carbonate, ounces.............................................. 5
Strong ammonia (*Aqua ammoniae fortior*), pints........... 2 to 3
Water to make, gallons ................................................ 50

Dilute the ammonia with about two gallons of water. Add water to the carbonate to make a thin paste, pour on about half of the diluted ammonia, and stir vigorously for several minutes; allow it to settle and pour off the solution, leaving the undissolved salt behind. Repeat this operation, using small portions of the remaining ammonia water until all the carbonate is dissolved, being careful to use no more ammonia than is necessary to complete the solution. Then add the remainder of the required amount of water—that is, up to 50 gallons—and the solution is ready for use. The solution of copper carbonate in ammonia water may be kept for some time if it is tightly stoppered. Before using it should be diluted at the rate of ten gallons of water to every ounce of carbonate in solution.

Ammoniacal copper carbonate is a clear, light-blue solution, which, upon drying, leaves little or no stain. As a fungicide it is somewhat inferior to Bordeaux mixture; but it should be used when the stain of the Bordeaux Mixture upon ornamental plants and maturing fruits is objectionable, and when the precipitate in Bordeaux prevents proper percolation through the soil.

*EAU CELESTE.*

Copper sulphate (bluestone), pounds...................................... 2
Strong ammonia (*Aqua ammoniae fortior*), pints............... 3
Water to make, gallons.................................................. 50

Dissolve the bluestone in a small quantity of hot water, and add the ammonia, and then enough water to make 50 gallons.

This fungicide is likely to scald the foliage of some plants, especially eggplant.
Fig. 1.—Pepper plant artificially infected with fungus blight, and showing appearance typical of affected plants.
Fig. 2.—A sound, uninoculated pepper plant used as a control. In the foreground part of an inoculated plant, well wilted, is shown.
Fig. 3.—Stem of pepper plant affected just below the ground level by the blight fungus, the white mycelium of which is very conspicuous.
Fig. 4.—Pure cultures of the pepper blight fungus. The two are of the same age. a is on glycerine-beef agar, b is on potato agar. In b the fully formed brown sclerotia are evident, and the white flecks that indicate the first stages in their formation. x 5-6.
Fig. 5.—Japanese fiber plant, mitsumata, affected with fungus blight. a is sound, b in the first stages of wilt, c defoliated.
Fig. 6.—Microphotograph of bark from affected area on pepper plant. The threads of the mycelium are seen inside the disorganized cells.
Fig. 7.—Bean pods affected with pod spot or anthracnose.
Fig. 8—Section of a pod through anthracnose spot showing the mass of mycelium, the spore-producing branches and the spores. x 300.
Fig. 9.—Spores of the bean anthracose fungus. $x$ 1000.
Fig. 10.—Bean leaflets showing characteristic effects of bacteriosis; rather early stages.
Fig. 11.—Bean plants badly affected by bacteriosis in the field. Removed to pans for the purpose of photographing.
FIG. 12.—Bean pods showing typical bacteriosis lesions.
Fig. 13.—Bean plants grown in pots and artificially infected from a pure culture of the blight fungus. The bark of the plant at the left was slightly abraded before the application; the middle plant was uninjured and inoculated; the plant at the right was injured, but not inoculated.
Fig. 14.—Pods affected with the rot due to *Rhizoctonia*. 
Fig. 15.—Section through rotted area on pod showing disintegration of tissue and presence of *Rhizoctonia mycelium*.