

DISEASES OF GINSENG CAUSED BY SCLEROTINIAS.

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The diseases of ginseng may be divided into two main classes; first, those which attack primarily only the part above ground, and second, those which directly affect the root of the plant. Of the former class, the two most destructive diseases are the *Alternaria* Blight and *Phytophthora* Mildew. Of the latter class, four or five of the most important ones may be mentioned, among which are: Wilt, End or Fiber Rot, Soft Rot, and those diseases caused by *Sclerotinias*—the Black and Crown Rots. It is with the two last named diseases that this paper deals.



Fig. 1. Photograph of a portion of a ginseng garden, showing a spot in one of the beds killed by Black Rot fungus.

The Sclerotinias are characterized during the vegetative stage by the formation of sclerotia. The sclerotia are white when first formed, but soon the outer cellular layers become black and more or less roughened. These sclerotia are usually formed abundantly on the diseased root, especially during the later stages, thus affording an easy means of distinguishing these diseases.

There are two distinct types of Sclerotinial diseases of ginseng; one in which the entire root becomes black and covered with hard black sclerotia and the other in which the root retains its natural color, but in which a number of black sclerotia are developed on the outside. The former type is known as Black Rot and is familiar enough in those gardens infested by it. The diseases of the latter type have collectively gone under the name Crown Rot, although it is by no means certain that the various diseases given this name have all been caused by the same organism.

It was with the object of determining the name and characteristics of each organism connected with these diseases and of finding some means for successfully combating them that the present investigation was undertaken. The work during the summer of 1910 was carried on at Cornell University under the direction of Prof. H. H. Whetzel, to whom grateful acknowledgments are due for the use of his private notes collected during his work on ginseng diseases. The work was continued during the past winter in the laboratories of the Botanical Department of Wabash College under the direction of Prof. M. B. Thomas.

BLACK ROT.

The first recorded mention of this disease was by Van Hook ('04) from a ginseng garden in New York. However, with the increased cultivation of ginseng it has spread, until last summer it was reported not only from several counties in New York but from other States as well. While to the author's knowledge, its destruction has been extensive in only a few cases, it is well worth while to be on the lookout for it, as this disease is very difficult to eradicate when once it obtains a foothold.

Roots attacked by Black Rot are coal black in color when dug, changing to a dirty gray when dried. They are devoid of all their small fibrous

('04) Van Hook, J. M. Diseases of Ginseng. New York (Cornell) Agr. Exp. Sta. Bul. 219: l. c. 181-182. 1904.

roots and are covered with many black protuberances or sclerotia. The disease is caused by a soil fungus which penetrates the epidermis of the root, attacking and breaking down the tissue, which is replaced by a tangled compact mass of mycelial threads. The fungus is apparently able to gain entrance into any part of the root, as some infections were found which had started at the crown while others seemed to have originated in the smaller roots. The outer tissue is first attacked, the mycelium gradually turning black and giving the root its characteristic appearance. At this stage the center of the root still retains its natural color, but instead of being compact and brittle is rather soft and watery, while the whole root is tough and pliable. Infected roots which have lain in the soil two or three years gradually become black throughout and finally decay.

One of the peculiar things about this fungus is that its period of attack is during the winter. Healthy roots with well-formed buds, when set in the fall in infected soil, fail to send up shoots the following spring, and on examination are found diseased with Black Rot, the blackening by this time usually extending one-fourth of the way to the center. After the plants come up in the spring, with the return of warm weather, there is no further spread of the disease until the next winter. In working with the fungus in pure culture in the summer, an ice-box is necessary, as it will not grow at the ordinary temperature.

The organism causing this disease is a new species of fungus belonging to the genus *Sclerotinia*. The mycelium is septate, branching, and when old becomes more or less blackened. In pure culture it grows luxuriantly on almost any medium if kept at a temperature of 40° Fahr. On nutrient agar or potato agar, sclerotia are produced in three to six days. The sclerotia are at first white compact masses of tangled mycelium, which soon become black on the outside. They are for the purpose of producing the perfect stage and carrying the fungus over unfavorable periods for growth, being able to withstand submersion in boiling water for three minutes without having their germinating power destroyed. Under favorable conditions of moisture and temperature, these sclerotia send out germ tubes just as do spores. Under other conditions they may give rise to the perfect stage, although this has never been obtained in pure cultures. However, last spring, (1910), the perfect stage¹ was found in one

¹ NOTE.—A technical description of this fungus is to be published in an early number of *Phytopathology* by Mr. W. H. Rankin.



Fig. 2. Ginseng roots attacked by Black Rot and showing sclerotia.

of the ginseng gardens in New York. This perfect stage developed from sclerotia on roots which had lain in the garden during the winter, very near the surface of the ground. In the spring short stalks were sent up, bearing large cup-shaped apothecia containing the asci with their ascospores. These spores when mature are shot up into the air to be disseminated by the wind and rain.

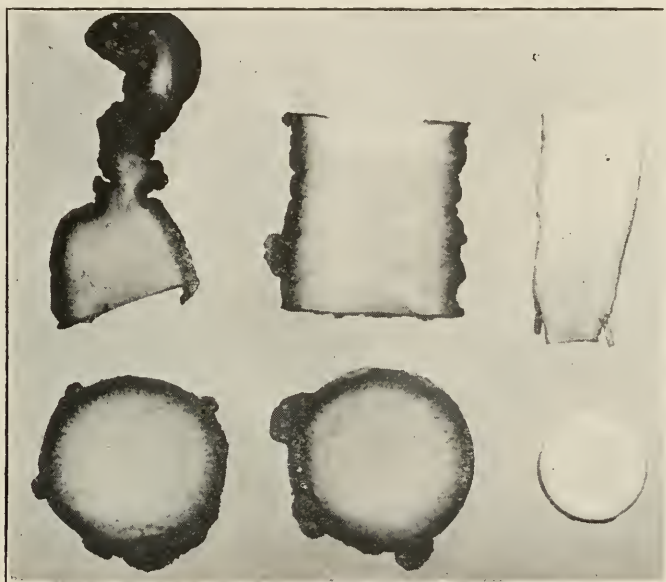


Fig. 3. Black Rot. Cross and longisections of root and bud of diseased and healthy plants. The blackening of the diseased roots will later extend to the center of the diseased root. Section of healthy plant on right. (After H. H. Whetzel.)

When once established in the garden the parasite apparently spreads by the mycelium growing through the soil from one plant to another, killing all that come in its path. It is also spread by the tools used in weeding or spading the beds, especially in the fall. Its distribution from one garden to another is probably brought about by infested soil or perhaps by spores being carried on the shoes of people visiting the various gardens, or by the importation of diseased roots.

A number of experiments were performed to determine if possible some method of eradicating this disease by soil treatment. It was found

that the fungus would grow equally well on alkaline and acid media in any strength which could be used on the soil. From this it seems probable that changing the acidity of the soil would be of no benefit here, as it is in the case of some other ginseng diseases. Until some other means for its control is found, it would be advisable to keep a sharp lookout for black roots when digging in the fall, and to examine all spots where plants fail to come up in the spring. If any diseased roots are found, search the area carefully and remove and burn all of them. The soil in the infested area should then be sterilized with formalin, diluted 1-100, care being taken not to injure the adjacent healthy roots, or if suitable apparatus is at hand, steam sterilization may be used. If the garden becomes too badly infested, the only remedy is to move the seedlings to another garden, carefully sterilizing all tools with formalin or corrosive sublimate before using them in the new garden. Van Hook ('04) cites a case where a grower had set roots in a bed from which black roots had been taken six or seven years before. The roots failed to come up in the spring, and on being examined were found to be infected with Black Rot, thus showing that this fungus is apparently capable of remaining in the soil as a saprophyte for several years.

CROWN ROT.

This disease has been known to ginseng growers for several years, but except in a few cases it has not been found very abundant. The first mention of it was by J. H. Koehler ('03)¹ in a letter to *Special Crops*. Since then it has been reported from various counties in New York and from States as far west as Wisconsin.

There are two different types of the disease; one in which it attacks the upper part of the stem, and the other in which it attacks the root at or near the crown. In the latter type, the organism causing the trouble seems to gain entrance into the plant through the base of the stem near the surface of the ground, or in some cases through the upper part of the root. It works slowly up the stem and quite rapidly down, soon entering and rotting the root. The stem loses its green color and the tissue becomes shrunken, so that the fibro-vascular-bundles stand out sharply as long striations or ridges. The stem soon becomes hollow and inside are found large black sclerotia. These are also found on the roots. The tissue of the diseased root generally becomes soft and "doughy." The

¹('03) Koehler, J. H. Letter to Editor. *Special Crops* 2 : 148. Sept. 1903.

mycelium is abundant throughout the diseased tissue and seems to travel between the cells, dissolving the middle lamella.

In case the disease attacks the upper part of the stem, the first effect noticed is that the petioles all droop, or the leaflets droop from the petiole. The leaves soon fall off, and on examination the stalk will be found to contain several black sclerotia. In one garden, examined by the writer last summer the plants had been attacked by this disease in June after they had attained their growth, and when examined in August the leaves



Fig. 4. Black Rot of ginseng showing apothecia. (After Rankin.

had fallen off, leaving only the straight dead stems containing sclerotia. In this type of injury the root may send up a new stalk the next year, but in the year of the attack no growth is added.

From observations in the diseased gardens it would seem that the trouble is increased by the presence of too much moisture; that is, if the fungus occurs in the soil with these conditions present it will produce the disease. One man, whose garden was troubled with this disease, stopped it almost immediately by removing the shade and aerating the enclosure.

The cup fungus, *Sclerotinia libertiana* Fuckel, has been connected with this disease. This is a soil parasite which is widespread and common on other plants such as hemp, rape, cucumber, tobacco, many forced

vegetable and bulbous plants. The mycelium is septate, irregularly branching, and frequently very much vacuolated. It grows from the cracks in the root as a white felt, later giving rise to large, hard, black sclerotia. When first formed, these are white, but later they change to brown, and finally black. Mature sclerotia are white or dirty-white within, of densely woven threads and with a black cellular outer coat. As in the case of the Black Rot fungus, they are for the purpose of carrying the organism over periods unfavorable to growth and for giving rise to the perfect



Fig. 5. Crowa Rot of ginseng showing large, well developed sclerotia. (After Whetzel.)

stage. Under suitable moisture and temperature conditions, they send out germ tubes directly, just as the Black Rot fungus. The perfect stage has never been obtained by the writer in pure culture, although during the past winter an effort was made to do so. A large number of sclerotia, grown on various media, were placed out of doors in sterile sand, contained in earthen pots, and this spring one-half of them were brought into the greenhouse. Some of the pots containing the sclerotia were kept very

moist, some fairly moist, and others rather dry, but in no case did any fruiting stage appear. However, in the spring of 1910, in a ginseng garden near Apulia, N. Y., the perfect stage was found, having developed from some old sclerotia which had lain near the surface of the soil over winter. Specimens of this perfect stage sent to Dr. E. J. Durand of Cornell University were pronounced by him to be *Sclerotinia libertinia* Fuckel.

It is possible that some of the diseases reported by ginseng growers and described as Crown Rot have been caused by other species of *Sclerotinia*. During the past winter, the writer has grown several different

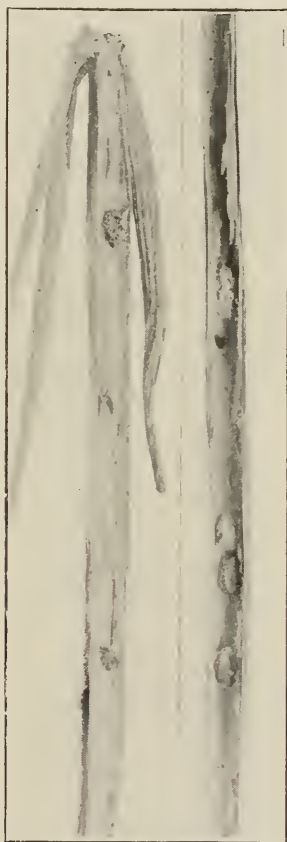


Fig. 6. Crown Rot showing sclerotia inside the old dead stems. In this case the roots were not diseased.

strains of this Crown Rot fungus—secured from various parts of the country—on culture media in an effort to classify them. Cultures were made on a large number of media, including nutrient agar, potato agar, bean plugs, potato plugs, ginseng plugs, sweet potatoes, turnips, nutrient gelatin, corn-meal, Raulins' culture fluid, and several others. On all the media mentioned the various strains made a good growth, the optimum being at the temperature of 20° C. On several of the media the growths of a number of the strains were unlike, so there may be more than one species, but as the fruiting stages were not obtained, this could not be determined definitely.

The Crown Rot is apparently disseminated in two ways; by the mycelium and by spores. The mycelium may grow through the soil to other roots or it may be distributed by implements used in spading or weeding the beds. The spores may be scattered by the wind and rain or they may be carried on diseased seedlings or on the shoes and clothes of people visiting the various gardens. As stated before, this fungus grows on a number of plants other than ginseng and it may also gain entrance to the ginseng garden directly from these other plants by any of the agencies given above.

The growth of this fungus does not seem to be affected by any change in the acidity or alkalinity of the soil which could be brought about in the field. Until some better means of combating it is found, the old rotted roots should be carefully dug and burned so as to remove the danger of infection from the cup stage in the spring. The attacked stems should also be removed and burned as soon as noticed. Spraying with bordeaux mixture will probably lessen the injury to the stems above ground. In addition to this the garden should be well-drained, and if the disease becomes very prevalent, it would be well to remove part of the over-head covering and loosen the soil around the plants so as to allow them to dry out.

Wabash College,

Crawfordsville, Ind., June 17, 1911.