HISTORICAL INFORMATION ON PHYMATOTRICHOPSIS OMNIVORA (DUGGAR) HENNEBERT , THE ROOT ROT FUNGUS

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Abstract

Phymatotrichum root rot (PRR) is considered to be one of the most serious plant diseases with respect to host range and crop destruction. Over 2000 species of dicotyledonous plants can be affected by this disease. This disease was first described on cotton by Pammel late in the 19th century and was called Ozonium root rot. Since that first description, Phymatotrichum root rot has been identified by several names including cotton root rot and Texas root rot. This fungus has the potential to destroy entire cotton crops grown on infested soils of the southwestern United States and Mexico.

Causal Organism

The causal agent of this disease is the fungus *Phymatotrichopsis omnivora* (Duggar) Hennebert [syn. *Phymatotrichum omnivorum* (Shear) Duggar.] *P. omnivora* is a filamentous soilborne fungus with a nonspecific mode of parasitism. While history of this organism reports it to be pathogenic only to dicotyledonous plants, several studies support the ability of the organism to survive and propagate on monocotyledonous plants. *P. omnivora* has a very simple existence and survives in specific edaphic environments.

The fungus perseveres in nature by either vegetative hyphae or sclerotia in the soil. The vegetative hyphae is the means in which the fungus moves through the soil and moves up into the root tissue; while the sclerotia is the primary means in which the organism can overwinter. Hyphae of *P. omnivora* is multifarious in size and normally, abundantly branched. A thick rhizomorph is intertwined by hyphae of smaller diameter. This aggregation of mycelium gives the vegetative structure a fuzzy appearance. Characteristic branching of the mycelium is at right angles and the branches form the distinguishing cruciform shape of *P. omnivora*. The acicular, cruciform branches on the strands of *P. omnivorum* distinguish this fungus from other soilborne fungi. Irregularly shaped sclerotia are formed from strands as the nutrient supply diminishes. Sclerotia are large enough to be seen with the naked eye and are of various shapes and sizes. Generally sclerotia take on the shape of the soil pore which the mycelium has passed. Immature sclerotia have an outer rind that is white in color which changes to dark brown-black as they mature. This outer rind protects the fungus from harsh conditions or conditions not conducive for growth.

Under moist and humid conditions, the fungus occasionally sporulates on the surface of the soil. However, this occurrence is rare in cotton fields. Spore mats are composed of hyphae with globose condiophores which produce enormous quantities of single-celled spores. The spores produced on the mats are not capable of germinating or causing disease.

Symptoms

Symptoms on cotton plants from *P. omnivora* infection are normally not visible until the plant has reached the flowering stage of development. It is important to realize that the severity and symptoms of the disease depend heavily upon environmental and geographical conditions. The most identifying symptom of root rot is the sudden wilting of young leaves which in turn is immediately followed by plant death. A rapid death of the plant is indicated by dry, necrotic leaves remaining attached to the stem. Another indicator of Phymatotrichum root rot is plants with elevated temperatures. This phenomenon can be observed by walking through a cotton field and touching the wilted foliage; the plants feel as if they have a fever. This increase in temperature is caused by a decrease in transpiration due to infection of the pathogen. In most cases, dead plants are observed in localized spots, however, with favorable environmental conditions these spots can coalesce until an entire field is dead.

Below ground symptoms and signs aid in the identification of Phymatotrichum root rot. Upon removing a cotton plant's tap root from the soil, strands of hyphae are entwined the length of the root. The mycelium is more obvious on the root portion, 2 - 4 inches, below the soil surface. Young hyphae are hyaline in color and as the strands mature their pigmentation darkens to a buff or brown. Under moist conditions, a white cottony growth can be observed on the root below the soil surface. A red to burgundy lesion can be observed under the root periderm. This characteristic lesion increases in area and deepens in color as the infection process advances.

Disease Cycle and Epidemiology

The primary inoculum for initiation of Phymatotrichum root rot is found in the soil either as sclerotia or as mycelium. The fungus primarily survives adverse nutritional and environmental conditions as propagules known as sclerotia. Sclerotia can be fund along the surface of a root or away from the root as clusters in the soil profile. Sclerotia are known to remain a viable source of inoculum for periods up to 12 years. *P. omnivora* survives in specific edaphic environments. The distribution of sclerotia in the soil depends on the physical and chemical properties of the soil. The fungus is indigenous to alkaline, calcareous, montmorillonitic clay soils of the southern United States and northern Mexico. This root rot belt is not uniformly infested. Actually only a small portion of the total soil volume is infested -- less than one percent. Sclerotia have been found as deep as 8 ft, but the majorities are located 20 – 60 centimeters below the soil surface. The sodium content of the soils normally found in areas of infestation by this fungus influences the production of sclerotia. It is abnormal to find root rot in soils with exchangeable sodium levels > 500 ppm. The blackland region of central Texas has soils with low sodium levels. Therefore, conditions in this agricultural area are optimum for growth and propagation of this fungus.

The life and disease cycles of this pathogen and disease are very simple. For reasons still unknown to farmers and scientists alike, a sclerotium germinates to form vegetative mycelium. This mycelium develops into thicker strands, rhizomorphs, that move through the soil. This advancement continues until a suitable nutrient source, i.e., cotton root, is encounter. Following contact, the strands proceed up the root toward the soil surface. At this interface, an organized mass of hyphae forms an infection cushion and the mycelium penetrates the root through natural openings or by mechanical or chemical action. The actual means of penetration still remains a mystery to researchers. The fungus colonizes the inner root obstructing the vascular elements and blocking the movement of water and photosynthates. Once the host is fully parasitized, new strands are created. These nascent strands serve two purposes: 1. to infect another plant or 2. to generate new sclerotia; thus completing the simple cycle. Therefore, disease development is uncomplicated, but devastating.

Control of Phymatotrichum Root Rot

Since the discovery of this disorder, researchers, scientists and common laymen have searched for the means to stop this fungus. All of the principles of plant disease control have been applied as means of control for this disease. Host plant resistance, eradication, protection and quarantine have been of minimal benefit for the cotton grower, while avoidance is successful.

Disruption of the soil profile by various means has shown to be able to reduce the severity of the disease. Methods ranging from dynamiting to deep chiseling have been used to disturb the network of sclerotia and mycelium. Soil infraction can be beneficial if the microorganism is within the profile of soil disturb. However, because of the depth of the location of some sclerotia is greater than can be reached by conventional equipment complete eradication of the fungus is nearly impossible.

Enhancing the microbial population of the soil has show to be beneficial for reducing level of disease within an infested environment. P. omnivora is a poor competitor when other microorganisms are present. Research studies have shown several soilborne fungi and bacteria capable of feeding on vegetative hyphae and sclerotia of *P. omnivora.*

Control by chemical methods have shown promise, but can be costly and difficult for cotton production. Chemical fumigation is an effect means for killing both the vegetative mycelium and sclerotia, however application deep within the soil profile is not economical and many fumigates are difficult to utilize under field environments. Use of traditional fungicides also has proven to have less than optimum affects in the field. Many fungicides show promise in the laboratory or under controlled greenhouse conditions, however, as the efficacy studies are shifted to the field; disease control is not as good as it needs to be. Few fungicides can move in the soil profile to the depths that sclerotia are often found, or have efficacy potential as long into the season as is need to control PRR. The application of site directed fungicide placement when cotton is at the flowering state presents its own set of challenges.

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