PATHOGENIC SOIL FUNGI

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Pathogenic soil fungi are responsible for important plant diseases such as damping-off, stem and root rots and the vascular wilt diseases. These fungi attack the underground parts of the plant causing damage in a number of different ways.

Damping-off

Rhizoctonia solani and Pythium spp. are fungi which cause damping-off of seedlings of stock, snapdragon, and many other plants. Pre-emergence damping-off occurs if the seed is rotted or if the seedling rots before it emerges from the soil. Post-emergence damping-off occurs if the emerged seedling is infected near the soil level or at the root tips and rotted so that it falls over.

Root and Stem Rot

Pythium spp., Phytophthora spp., Rhizoctonia solani and Thielaviopsis basicola are fungi which cause stem and root rots of ornamental plants. Some specific examples are listed below:

Disease	Fungus
Pythium root rot of Aloe variegata	Pythium ultimum
Calla root rot	Phytophthora richardiae
Rhizoctonia stem rot of carnation and poinsettia	Rhizoctonia solani
Poinsettia root rot	Thielaviopsis basicola or Pythium sp. or Rhizoctonia solani

These organisms attack the roots or that portion of the stem near the soil surface. This attack may result in the sudden death of the plant or in a gradual decline due to a gradual depletion of the root system.

Vascular Wilts

Vascular wilts of ornamental plants are caused by Verticillium albo-atrum and specialized forms of Fusarium oxysporum. Some examples are:

Disease	Fungus
Fusarium wilt of carnation	Fusarium oxysporum f. dianthi
Fusarium wilt of aster	Fusarium oxysporum f. callistephi
Verticillium wilt of snapdragon, chrysanthemum, geranium, rose and many other ornamental plants	Verticillium albo-atrum

These organisms usually enter the plant through the roots and invade the water-conducting system, eventually growing throughout the plant causing a general wilt and in some cases death of the plant.

Soil Inhabitants and Soil Invaders

For the purpose of this discussion the soil fungi may be divided into two large groups, the soil inhabitants and the soil invaders.

Soil inhabitants, although capable of attacking plants, are able to make free and independent growth in the soil and compete successfully with other soil organisms. Some fungi which belong to this group are Rhizoctonia solani, Pythium spp., Phytophthora spp., Fusarium oxysporum, and Thielaviopsis basicola.

Soil invaders are fungi which cannot make much free and independent growth in the soil since they are not able to compete successfully with other soil organisms. The presence of such fungi in the soil is generally closely associated with that of their host plants. In the continued absence of their host plants these fungi may die out in the soil. The best example of a fungus in this group attacking ornamental plants is Verticillium albo-atrum. It does not entirely fit the definition of this group, however, since it can survive by means of resistant sclerotia formed in dead plant material. This phase of its life cycle will be discussed later.

Spread Through the Soil

The spread of soil fungi can be active or passive. Active spread is accomplished by direct growth of the fungus through the soil while passive spread involves movement of living fungus structures by outside agencies such as water, wind, and man.

Soil inhabitants make active growth through the soil and can spread readily in this manner. Soil invaders can spread in an active way only to a limited extent.

Both groups of fungi can be spread readily by passive means. Examples of this are spread in water, in soil moved from one area to another, and in the soil on tools, flats, and workers' shoes.

Influence of Soil Temperature

For the purpose of this discussion the term low soil temperature will be used for soil temperatures approximately 70°F or below, while the term high soil temperature will be used for soil temperatures above 70°F.

Soil temperature exerts a strong influence on the pathogenic activity of soil fungi. The disease caused by Rhizoctonia solani and Fusarium oxysporum are favored by high soil temperature, while those caused by Pythium spp., Phytophthora spp., Verticillium albo-atrum and Thielaviopsis basicola are favored by low soil temperature.

Soil temperature may affect the fungus directly by either favoring or hindering its growth in the soil or in the plant, or indirectly by affecting some other factor in the disease complex. For example, if the soil temperature is unfavorable for good growth of the host plant but is favorable for good growth and development

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of the fungus the disease is likely to be intensified. If the converse is true the organism may cause only minor damage. An example of this is poinsettia root rot caused by Thielaviopsis basicola. When poinsettias are grown at high temperatures, which are favorable for plant growth, the effects of the disease are not severe. However, should these plants be placed at a low temperature to hold them back, conditions become unfavorable for good growth of poinsettias and root rot may become very severe, resulting in defoliation of the plants.

Influence of Soil Moisture

Most of the diseases of ornamentals caused by soil pathogens are favored by high soil moisture. Soil moisture may exert a direct or indirect effect on the activity of a soil fungus.

Pythium spp. and Phytophthora spp. are directly affected by soil moisture. They belong to a group of fungi which infect plants either directly or else by means of free-swimming spores. In order for the spores of these fungi to infect plant roots and stems they must have free water available in the soil. This condition will exist only when the moisture content of the soil is high. High soil moisture also may affect these diseases by injuring the plant roots and making them more susceptible to attack by the fungi.

In the case of Verticillium albo-atrum and Fusarium oxysporum the effect of soil moisture is more indirect. High soil moisture content along with a high nitrogen level in the soil promotes a "soft" or "lush" type of plant which favors the development of the vascular wilt diseases. The opposite conditions, which result in "hard" plant growth, seem to reduce the incidence and severity of these diseases not so much by reducing the original number of root infections as by restricting the active development of the vascular parasite within the plant.

Rhizoctonia solani is favored by high soil moisture so long as the soil aeration is good. When the soil moisture content reaches a point at which it begins to interfere with soil aeration Rhizoctonia is hindered rather than favored.

Other soil conditions which may influence the occurrence and activity of pathogenic soil fungi are soil texture, soil aeration, organic content of the soil, the acidity or alkalinity of the soil and the concentration of plant nutrients in the soil.

Location and Persistence of Pathogenic Soil

In general soil pathogens are found in the uppermost 12 to 18 inches of the soil. They may occur at greater depths than 18 inches but in fewer numbers than at the shallower depths. For example, Verticillium albo-atrum has been found in soils to depths of 36 inches, but the first 12 inches of the soil were found to contain 3 to 4 times the amount of inoculum found in the 12 to 36 inch layer.

Many pathogenic soil fungi will persist in the soil for indefinite periods of time either by actively growing and multiplying in the soil or by persisting in a dormant stage in the form of resting structures. These resting structures are called sclerotia or chlamydospores.

Sclerotia are hard, black or brown, seed-like bodies formed when fungus threads clump together. These may be relatively long-lived in soil and may serve to carry the fungus to new areas. Verticillium albo-atrum forms sclerotia which can persist in the soil in a dormant state for periods of 10 to 14 years. When a suitable host is again planted in the soil they germinate and infect it. When a Verticillium-infected plant

dies the fungus forms large numbers of these sclerotia in the dead tissues which are then incorporated into the soil. This results in large numbers of sclerotia being added to the soil each year a susceptible crop is grown there.

Chlamydospores are very thick-walled spores formed by such fungi as Fusarium oxysporum and Thielaviopsis basicola. These chlamydospores are formed in infected plant tissue and aid in perpetuating the fungus.

Effects of Environment on Inoculum Potential

Inoculum potential may be defined as the quantity of a disease-producing fungus in a given unit of soil. This qiamtotu can be affected and altered by a number of environmental factors. If a non-susceptible host is grown in this soil the inoculum potential may fall, but if a susceptible host is grown the inoculum potential may increase. The inoculum potential may also be affected by soil texture, soil aeration, organic content of the soil, soil reaction, and the concentration of plant nutrients in the soil.

Summary

The pathogenic soil fungi cause a variety of plant diseases such as damping-off, stem and root rots, and vascular wilts. Some are regular inhabitants in the soil, while others invade the soil only when a suitable host plant is grown. They spread readily in soil either by making active growth in the soil or by means of outside agencies such as water, wind, and man. They are influenced by soil and air temperature and other soil conditions. They can persist in the soil by making continual growth or by forming resistant structures such as sclerotia or chlamydospores.

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