University of Illinois Extension
College of Agricultural, Consumer and Environmental Sciences

report on
PLANT DISEASE

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DEPARTMENT OF CROP SCIENCES
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ROOT ROTS OF PEA

Root rots occur wherever peas are grown in the world. Crop losses are probably greater from root diseases than from any other type of pea disease. Damage is usually most severe in wet seasons. Low-lying areas and slowly drained fields or gardens suffer greater losses than well-drained, fertile ones. Root rot generally occurs in patches that progressively enlarge during the season.

Figure 1. Healthy pea plant on left and plants infected with Aphanomyces root rot on right.

Root rot may start when the pea plant is in the pre- or post-emergent seedling stage. Death soon follows such early infections, resulting in a poor stand. Root decay generally begins on the fine feeder roots and progresses gradually to the main taproot. Sometimes, however, the taproot is the first to be attacked. In some cases all roots are destroyed, leaving only remnants below the attachment of the seed. Root-rotting fungi can also reduce the quality of shelled peas. Infected plants produce peas which are irregular in size and variable in maturity with a lowered sugar content.

Root rot of pea may be caused by any one or a combination of several common soil fungi. The most common pathogens are *Aphanomyces euteiches*, *Pythium ultimum*, *Fusarium solani* f. sp. *pisi*, and *Rhizoctonia solani*. Other fungi that can be associated with pea root rots include *Thielaviopsis basicola*, *Fusarium oxysporum*, *Ascochyta pinodella*, and *Sclerotinia sclerotiorum*. *Aphanomyces euteiches* and *Pythium ultimum* are probably the most important of the fungal species reported.

It is often difficult or impossible to differentiate the common types of root rot, especially in an advanced stage or late in the season. At this time, it may be difficult to determine whether root rot or a wilt disease has killed the plants. Pea plants damaged by root rot usually may be pulled from the ground easier than those affected by wilt, whose roots are still intact. The common root-rotting fungi may attack the same plant at the same time. Species of *Pythium*, as well as lesion, stunt, and other nematodes are all commonly a part of the disease complex and can increase the severity of root rot. If plants in the field or garden are stunted, or the leaves are pale yellow, dig up some of the plants, carefully wash off the soil, and examine the roots for decay.

For further information contact Dean Malvick or Mohammad Babadoost, Extension Specialists in Plant Pathology, Department of Crop Sciences, University of Illinois at Urbana-Champaign. (Phone: 217-333-8375; email: dmalvick@uiuc.edu; babadoos@uiuc.edu).

SYMPTOMS

The symptoms for the four common types of root rot are as follows:

1. *Aphanomyces root rot* can infect plants at any age. The central part of the taproot (vascular tissue) separates easily as a long, fiber-like string from the outer, softened, water-soaked portion (cortex) of the root when the plant is pulled from the soil. The fine branch or feeding rootlets are killed. The decay may extend up the stem to slightly above the soil line. The decayed surface is often slimy in wet soils turning gray, then yellowish or pink, and finally brownish black as secondary microorganisms invade the diseased tissue.

   The leaves shrivel progressively upward on the stem. Plants are usually stunted, and the leaves progressively turn yellow starting at the bottom of the shoot. Pods may be few with a reduced number of small seeds. In severe cases, the plants collapse and die before forming any pods (Figure 1). Late-infected plants appear almost normal aboveground and often produce normal peas. Aphanomyces root rot is the most common and destructive disease of peas in the Midwest.

2. *Pythium* commonly causes seed rot as well as pre- and post-emergence damping-off of pea. Root rot of older plants also occurs, and often results in root-pruning that significantly reduces root length. Damage is most common in wet soils and is characterized by soft rot. Roots infected with *Pythium* are typically light brown in color and soft and watery to the touch. Infected plants are frequently stunted and pale green to yellow in color. Although it primarily causes a seed rot, damping-off, and seedling root rot, *Pythium ultimum* can cause a watery, soft decay of older plants in wet soils at an optimum temperature of 64° to 75°F (17° to 23°C).

3. *Fusarium root rot* affects mainly the taproot with infection starting close to where the seed is attached. Reddish brown streaks form in the primary and secondary roots and later merge. The external portion of the stem shows brick red, dark reddish brown, or chocolate-colored lesions. The advancing lesion may be wedge-shaped with the point upward. The central part of the taproot is a deep red. Plant growth is stunted, the foliage turns grayish, then yellow, the lower leaves wither, and the plant eventually dies. The lower stem is often girdled, causing the plant to fall over. *Pythium ultimum* is often found in Fusarium-infected roots and vice versa.

4. *Rhizoctonia* root rot can attack plants at any stage of growth. Seeds may turn dark brown and decay. Water-soaked, then reddish brown to brown lesions form in the seedling epicotyl and hypocotyl. The growing point may die as it emerges from the soil. Seedlings damp-off or recover to produce a normal plant. On older plants, scurfy, reddish brown, sunken lesions form on the underground stem and roots. The stem may be girdled causing severe plant stunting and yellowing. The brown, thread-like filaments (mycelium) of the causal fungus may be seen with a hand lens on the surface of the lesion or canker.

DISEASE CYCLES

All root-rotting fungi are "soil inhabitants" and once introduced will persist in the soil for several years or longer. Rhizoctonia root rot will damage peas at relatively low soil temperatures (65°F or 18°C) but is most aggressive under warmer conditions (76° to 86°F or 24° to 30°C). *Rhizoctonia* infection and disease development can occur over a wide range of soil moistures. Fusarium root rot, on the other hand, is favored by higher soil temperatures (optimum between 77° and 87°F or 25° to 30°C) and moderate soil moisture. Aphanomyces root rot, most damaging at soil temperatures between 72° and 82°F (22° to 27°C), is favored by excessive soil moisture. It is most serious when a cool, wet spring is followed by an early, warm, dry summer. Although *P. ultimum* primarily causes a seed rot, damping-off, and seedling root rot, it can cause a watery, soft decay of older plants in wet soils at an optimum temperature of 64° to 75°F (17° to 23°C).

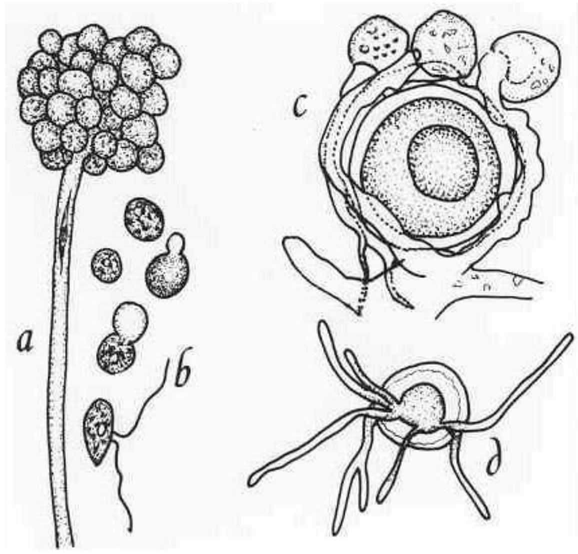

Figure 2. Aphanomyces euteches as seen under a high-power microscope: (a) primary spores encysted at the tip of a sporangium; (b) evacuation of encysted zoospores and motile stage after evacuation; (c) oospore with antheridia after fertilization; (d) oospores germination with formation of germ tubes (drawing by L. Gray).

The *Aphanomyces* fungus (Figure 2) also attacks alfalfa, snap beans, cowpea, spring vetch, sweet clover, spinach, sweet pea, and some weed species. The fungus produces large numbers of asexual, microscopic spores (zoospores) capable of swimming in soil water before contacting a susceptible pea root. If contact is made, the zoospores attaches to the root and produces a germ tube that penetrates the root. The developing mycelium invades and ramifies through the host tissues.

Tremendous numbers of thick-walled sexual spores (oospores) are formed in root tissue infected by *Aphanomyces*. As the roots decay the oospores are released into the soil. The oospores are highly resistant to adverse environmental conditions and remain viable in soil organic debris for up to 10 years or longer in the absence of a pea crop. When they germinate, the oospores form hyphae or sporangia. The sporangia, which closely resemble the tubelike hyphae, in turn produce the primary spores which cluster (encyst) at the mouth of the sporangium before releasing their zoospores (Figure 2).

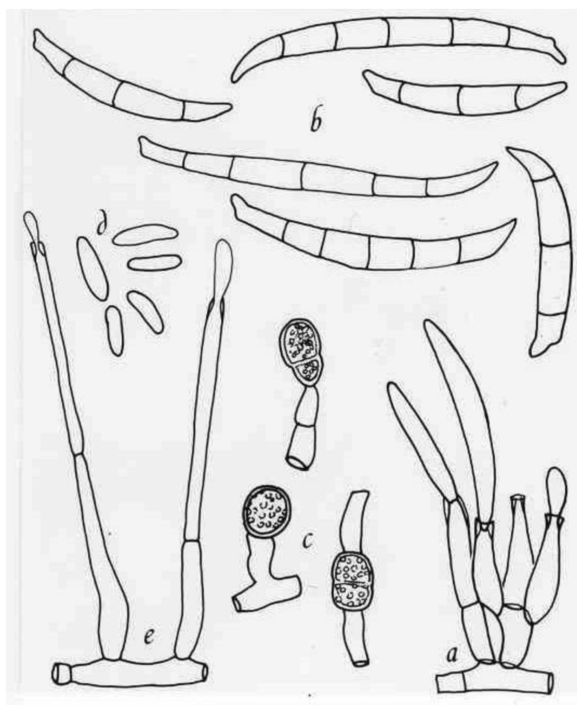

Figure 3. Fusarium solani f. sp. pisi as seen under a high-power microscope: (a) macroconidia at the tips of spore-bearing conidiophores; (b) macroconidia;(c) chlamydospores; (d) monoconidia; (e) two conidiophores bearing microconidia at their tips (drawing by L. Gray).

The spores of *Aphanomyces* are readily carried over long distances by surface-drainage and splashing water, in movement of soil from one area to another, and in infected seed. The oospores can be mixed with the seed and be introduced into new fields or gardens when such contaminated seed is planted. The zoospores are produced and germinate in abundance between 57° to 68°F (13° to 20°C) with some germination occurring as low as 48°F (8°C) and as high as 86°F (30°C). The optimum temperature for infection occurs at 61°F (16°C) but symptom development is markedly more rapid at warmer temperatures.

Fusarium solani f. sp. *pisi* produces three types of microscopic spores: small, one-celled, elliptical, microconidia; much larger, septate, slightly curved macroconidia; and thick-walled, rounded chlamydospores (Figure 3). The chlamydospores are resistant to unfavorable environmental conditions and can persist in soil for 5 years or more in the absence of peas. Any activity that moves infested soil from one area to another spreads the fungus. *Fusarium* root rot is most severe at soil temperatures of 79° to 82°F (26° to 27°C) and at moderate soil moistures whereas *Pythium ultimum* is more of a problem in cool (64° to 75°F), wet soils. Peas planted in soil infected with both *Fusarium* and *Pythium ultimum* are more severely attacked than plants infected with only one pathogen at any soil temperature or moisture level.

Germination of overwintering chlamydospores is stimulated by the release of nutrients from germinating pea seeds. Maximum germination of chlamydospores occurs 20 hours after seeds are planted in soils with a minimum of 9 percent soil moisture. Hyphae from germinated chlamydospores penetrate the epicotyl and hypocotyl through natural openings (stomates), wounds, or directly through the epidermis. The fungus then invades the root system where it causes a reddish brown discoloration of the vascular system. As tissues senesce, spores are formed abundantly in and on pea debris.

The *Rhizoctonia* fungus (sexual stage *Thanetophorus cucumeris*) is common in most soils and attacks hundreds of different plants. It is subdivided into many strains and anastomosis groups that differ in the hosts and tissues they attack. *Rhizoctonia* persists indefinitely in soil as a saprophyte and survives extremes in temperature and soil moisture as small, brown, rounded sclerotia. Under favorable conditions the sclerotia germinate by producing delicate hyphae (Figure 4) that grow through the soil and invade roots directly, through wounds or natural openings when sufficient soil moisture is present. The *Thanetophorus* sexual state plays little or no part in the disease cycle.

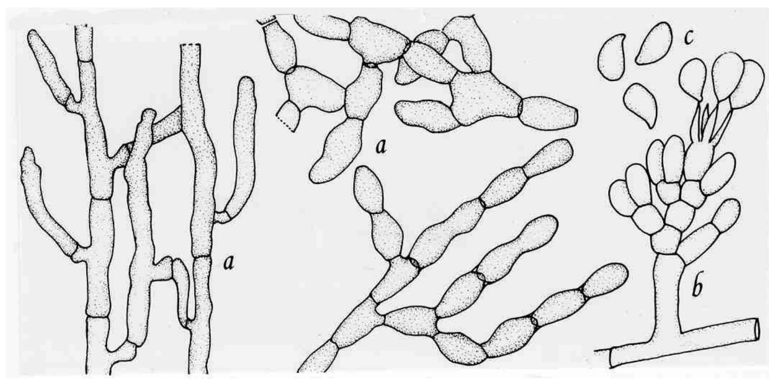

Figure 4. Rhizoctonia (Thanatephorus cucumeris) solani as seen under a high-power microscope: (a) three types of Rhizoctonia hyphae; (b) sexual Thanatephorus state with basidium bearing three basidiospores; (c) basidiospores (drawing by L. Gray).

CONTROL

1. There is no completely satisfactory control for the root-rot diseases of pea once the causal fungus or fungi is/are introduced and becomes prevalent in the soil. Control measures for all root rots are the same.

   Plant early in fertile, well-prepared, well-drained soil using seed grown in semiarid areas of the Pacific Northwest. Treatment of the seed with a seed-protectant fungicide may provide young roots some protection. For information on procedures and fungicides recommended for seed treatment, read C1373, Midwest Vegetable Production Guide for Commercial Growers, available from ITCS, University of Illinois P345, 1917 S. Wright St., Champaign, IL 61820.

3. Follow a crop rotation scheme in which peas are grown in the same area only once in 5 years or more. If *A. euteiches* is the primary problem, do not include alfalfa, beans, sweet clover, cowpeas, spinach, or vetch in the rotation. Crucifers are suitable for rotation.

4. Field indexing, a method of determining the inoculum potential of *Aphanomyces euteiches* prior to planting, was developed at the University of Wisconsin and is useful for commercial growers. The soil-assay or "root rot potential" procedure estimates the amount of infective inoculum in soil and the level of disease that can be expected if peas are planted in the field. Growers should avoid planting in moderately to highly infested fields with an index of 75 or higher. Information on field indexing can be obtained by contacting an Extension Plant Pathologist at the University of Illinois, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61810.

5. Do not spread unfermented pea straw and other crop refuse on fields to be planted in peas.

6. Maintain an adequate to high, balanced soil fertility level, based on a soil test. The addition of at least 3 tons per acre of rock phosphate, hydrated lime, or calcitic limestone may reduce losses from root rot. The optimum soil pH is 6.5 to 7.0.

7. Avoid overcrowding, deep planting, overfertilizing, soil compaction, and mechanical damage to the roots and stems.

8. Any cultural practice that enables peas to maintain a good, steady rate of growth from the start helps to prevent losses from root rots.

9. No acceptable commercial cultivars of peas are currently available that are highly resistant to any root-rotting fungi although some have low/moderate resistance. Planting cultivars that perform well in Illinois may reduce the amount of stress-related loss. Refer to publication mentioned above for more information.