Pythium spp. (Pythium root rot)

387 The whole root system of this lettuce shows a dark brown colouration.
Pythium sp.

388 This young plant attacked by *Rhizoctonia solani* is not prematurely dead. The root system is rather reduced; many roots and rootlets have not formed or are missing after turning brown and necrotic.
R. solani

Rhizoctonia solani
('Rhizoctonia root rot')

Ask some questions!

Sometimes, in simply answering the following questions, you can provide an explanation to your problem (each affirmative response to one of the questions will confirm the possible action of the incriminating cause):

- Have you watered the plants too much?
- Are the diseased plants situated in a place where they receive too much moisture?
- Have you planted during a time or in a soil that is still cold and wet?
- Has the irrigation of the nursery or plantation been excessive?
- Has the application of fertilizer before planting or during cultivation been too large?

Yellowing, browning, blackening of roots

Possible causes

- *Olpidium brassicae* (virus vector) (fact file 14)
- *Phymatotrichopsis omnivora* (fact file 10)
- *Plasmopara lactucae-radicis*
- Various types of Pythiums (*Pythium* spp., *Phytophthora* spp) (fact file 8)
- *Rhizoctonia solani* (fact file 7)
- *Thielaviopsis basicola* (fact file 9)
- *Rhizomonas suberifaciens* (parasitic 'Corky root') (see page 197) (fact file 19)
- *Pratylenchus* spp. (semi-endomigratory nematodes) (fact file 37)
- Other nematodes predominantly on the roots (*Longidorus* spp., *Rotylenchus robustus*, *Merlineus brevidens*, *Tylenchorhynchus omnivorus*, and so on)
- Root suffocation
- Damage associated with an activator of the decomposition of organic matter
- Non-parasitic corky root, ammonium toxicity (see page 197)
- Various types of chemical injury (certain herbicides can cause necrosis of the roots and/or reduce or prevent their formation; see page 83)

The majority of diseases and predators affecting the root system of l.s.v. cause widespread yellowing, browning (localized or widespread), necrosis, and the disappearance of numerous rootlets and sometimes even the roots. In more serious cases, their root system is completely destroyed and the vessels located in the taproot may become yellow and slightly brown. Damage sometimes spreads to the crown and leaves (consult the heading 'Damage to leaves, in contact with the soil, and the crown').

Sometimes these diseases may attack at the same time or, more specifically, some of them may make the plants more susceptible to other diseases. For example attacks of Pythiums and *Rhizomonas suberifaciens* appear more serious in heavy, poorly-drained soil. Drowned plants are more receptive to these pathogenic agents.

Arguments in support of the diagnosis

- ***Pythium* spp.**
  ('Damping-off', 'Pythium root rot')

In a fairly general way, *Pythium* spp. especially attacks seeds and young plantlets after sowing in the nursery, pre- and post-emergence. It is capable of inhibiting germination, rapidly colonizing succulent, tender and non-lignified young tissues, the roots and the crown. Subsequently it is fairly common to see plantlets, located in the same place (in groups), which wilt, go yellow, dry out, and disappear fairly rapidly (fig. 17). This is a classic syndrome which is called 'damping-off'. In addition to *Pythium* spp., other pathogenic agents can be responsible for this damping-off; and some of their characteristics are indicated in table 20. As you will see, the symptoms they cause on the roots are fairly similar and so it is quite difficult to differentiate between them with the naked eye. They affect both the roots and the part of the stem located close to the soil or the substrate, thus constricting the latter. In certain situations, the effects of these types of fungus on l.s.v. persist throughout the season. Sometimes we notice reduced growth of plants, to a greater or lesser degree, or the plant abruptly wilting. In all cases, when the plants are pulled up, we note the effects of *Pythium* spp. on the roots: more or less widespread browning of the roots, disappearance of numerous rootlets (387) and sometimes vascular damage, and damage to the crown. For example in California, *P. uncinulatum* is responsible for the poor development of the root system of l.s.v. as well as for a deterioration of the tips of the roots. In addition, in Holland this same species is associated with damage to the lower leaves of l.s.v., just like *P. aphanidermatum*, in India, which colonizes leaves in contact with the soil and produces damp translucent rotting which may spread to the entire head (see page 180).

Table 23: Some characteristics of the principal micro-organisms responsible for attacks on seeds and young lettuce plants

Some characteristics	*Pythium* spp.	*Rhizoctonia solani*	*Botrytis cinerea*	*Sclerotinia sclerotiorum* or *Sclerotinia minor*
Principal symptoms observed	Absence of germination, widespread root browning, constricting of tissues present on the surface of the soil, damping-off.	Absence of germination, widespread root browning, constricting of tissues present on the surface of the soil, damping-off.	Absence of germination, widespread root browning, constricting of tissues present on the surface of the soil, presence of a 'web' consisting of greyish white mycelium covering the plantlets, damping-off.	Rotting of leaves in contact with the soil, rotting of the crown, death of plantlets.
Frequency of attacks	Fairly frequent.	Fairly frequent.	Fairly frequent.	More rare.
Structures allowing them to be identified on and/or in damaged tissue	Oospores and chlamydospores visible in the root cells (**394**).	Partitioned brown epiphytic mycelium showing constricted ramifications.	Greyish white mycelium frame-work, grey mould consisting of numerous conidiophores and conidia (**366**).	White mycelium and large black sclerotia, sometimes apothecia in the plant environment (**367**). White mycelium scattered with small black sclerotia (**369**).

Figure 17: Development of damping-off on a young lettuce plantlet.

Several other species of *Pythium* spp. are likely to attack l.s.v. They have only been accurately identified in a fairly restricted number of situations worldwide. Some of these are *P. dissotocum*, *P. irregulare*, *P. megalocantum*, *P. polymastum*, *P. spinosum*, *P. sylvaticum*.

A 'systemic' *Pythium*, *P. tracheiphilum* also attacks l.s.v. We recommend that you consult the section entitled 'Internal and/or external damage and abnormalities of the taproot and stem'.

Only the observation of oospores (sometimes other structures such as sporangia or chlamydospores) on and in the affected tissues, or carrying out isolation on artificial media, will allow you to diagnose the action of this type of fungus with certainty (**394**).

• *Rhizoctonia solani* ('Bottom rot')

This fungus is mainly predominant in lower leaves of l.s.v. which are in contact with the soil. It may attack young plantlets causing damping-off. The results are the appearance of dry damage, light brown to chocolate brown in colour, on the part of the stem or taproot located on the surface of the substrate or the soil. Attacks of *R. solani* may occur subsequently on plantlets. This may essentially affect the roots, causing them to go brown. A large number of the latter may disappear (388). In this case, the presence of its characteristic brown mycelium (395) will help you to identify it without too much difficulty.

• *Thielaviopsis basicola* ('Black root rot')

This soil fungus is responsible for black root rot on numerous plants, particularly in the market garden (bean, eggplant, and so on). It is particularly responsible for damage to witloof chicory, damaging and deforming the roots. It has rarely been reported on other types of l.s.v. Attacks have been recorded on lettuce in Queensland, Australia. Affected lettuces grow poorly, with small heads. Yields are low.

In France, although the fungus is present in numerous types of soil, no damage had been observed on lettuces to date. Recently we have recorded *T. basicola* on curly endive growing poorly (389) in the open field in the Eastern Pyrenees. Numerous roots of these plants were brown to black in colour (390–393); and the largest of these had damage and a corky root.

As this fungus is not well known on l.s.v., no hypothesis has been issued about its action on these plants, and therefore none has been retained. Only microscopic observations of fragments of damaged roots allow us to observe the chlamydospores typical of *T. basicola* on and in the cells of the cortex (396).

389

390

391

392

393

Thielaviopsis basicola (‘Black root rot’)

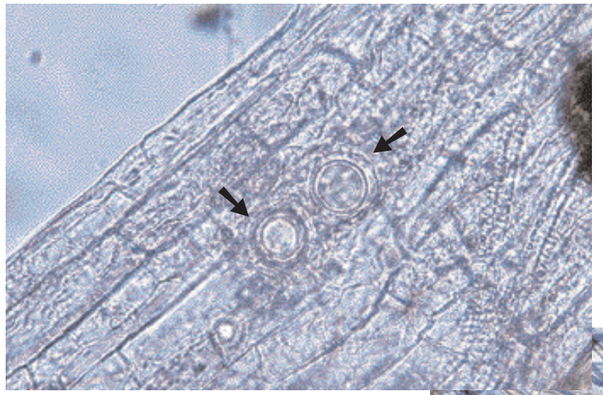
389 These four plants of curly endive, attacked to greater or lesser degree by *T. basicola*, are very different in size, in spite of being planted on the same date.

390 Their root system has been damaged to a greater or lesser degree, which explains the poor growth of the plants.
T. basicola

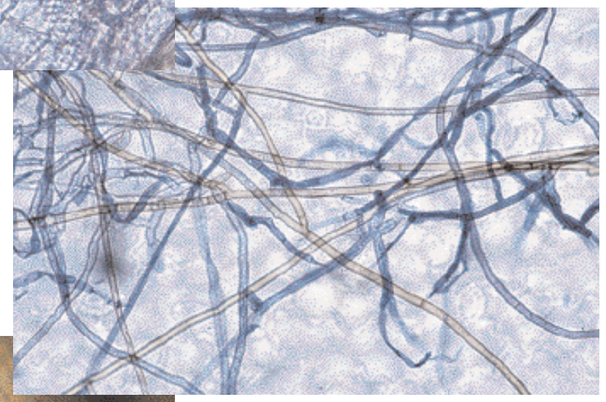
391 The root systems are fairly varied. We can see corky root and cracking.
T. basicola

392 *T. basicola* is also responsible for dark brown to black rotting affecting numerous roots; this damage lies at the origins of the English name for the disease: ‘Black root rot’.

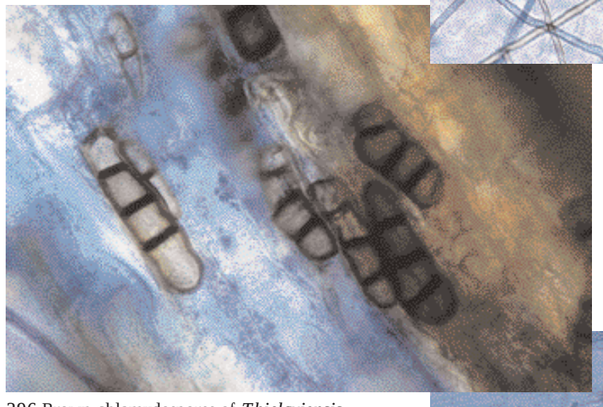
393 Damp, brown damage is also visible. The rotting deep inside the tissues causes the roots to rupture when the plants are pulled up.
T. basicola



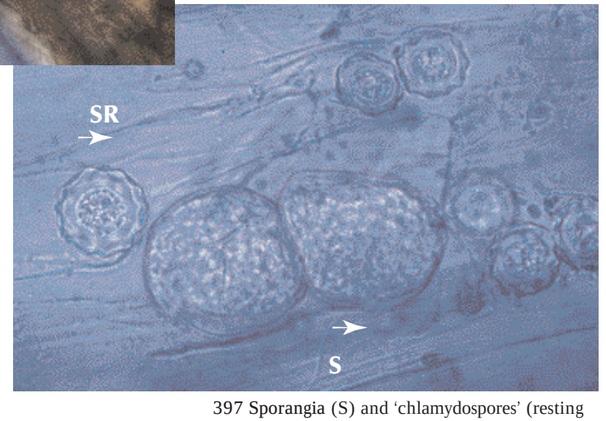
394 Round oospores, with a thick wall, are present on or in the root tissues; they frequently show parasitism by *Pythium* spp.



395 *Rhizoctonia solani* is characterized by a brown, partitioned mycelium, which is constricted at the base of its branches.



396 Brown chlamydospores of *Thielaviopsis basicola*, in chains, are clearly visible on this root.



397 Sporangia (S) and ‘chlamydospores’ (resting spores) (SR) of *Olpidium brassicae* are contained within several cells.

Principal types of fungus which predominate in the root system of l.s.v. plantlets and adult plants

• *Olpidium brassicae*

As far as we know this aquatic fungus is not pathogenic to lettuce. However we frequently see its fruiting bodies (sporangia and chlamydospores or resting spores) in the cells of the epidermis and cortex of l.s.v. roots (397), whether grown in or out of soil.

The presence of this fungus, an obligate parasite, in the roots does not seem to have an adverse effect on plant development. However it is not entirely harmless since it is the vector of two very damaging viral diseases: big vein disease and orange spot disease (see pages 63, 73, and 119).

It is obvious that the conditions of the medium, particularly soil temperature and oxygenation, the substrate or nutrient solution, and more specifically the state of the roots, must have an influence on the behaviour of this fungus. We know that it is totally suited to aquatic life. Like *Pythium* spp. and other aquatic fungi it has mobile zoospores which allow it to spread easily in water.

• ***Phytophthora* spp. ('*Phytophthora* rot and root-rot')**

Phytophthora spp. are fairly rare in l.s.v. Two species have been recorded on this plant:

- ***Phytophthora porri*** which causes stem rot mainly located in the crown, but ultimately destroys the head. The strain responsible seems to have a fairly low thermal optimum explaining the fact that attacks occur mainly in winter, in poorly-drained soil in southern Australia;
- ***Phytophthora cryptogea***, responsible for browning and rotting of roots of lettuces grown out of soil in southern California. In France this fungus is rife among endives, if they are grown in beds covered by soil.

• *Plasmopara lactucae-radicis* **('Root downy mildew')**

P. lactucae-radicis is a fungus which was discovered fairly recently in some hydroponic crops of lettuce grown in Virginia. This fungus mainly develops on the roots, which it colonizes and on which it fructifies abundantly. It probably possesses parasitic features similar to those of sunflower mildew, *Plasmopara helianthi* f. *helianthi*. *P. lactucae-radicis* colonizes the interior of the roots; it is responsible for brown root necrosis varying in severity. This certainly causes the lower yields observed in infected greenhouses. In addition, it forms numerous sporangiophores on the roots, which produce a multitude of sporangia (**fig. 18**). The latter ultimately release mobile zoospores which spread easily in the nutrient solutions used in hydroponic cultures.

In the few areas where it is rife, the observation of sporangiophores and sporangia on diseased roots and aplerotic oospores in the cortical tissues, can confirm the presence of this root mildew which affects lettuce.

• ***Phymatrichopsis omnivora* (Dugger) Hennebert (*Phymatotrichum omnivorum*) (Shear) Dugger ('Texas root rot')**

This very polyphagous fungus, whose thermal optimum is high (28–30°C) appears mostly in semi-desert zones. It has only been reported as affecting l.s.v. in the USA, where it is responsible for sudden wilting while crops are growing, caused by rotting of the roots and mycelial colonization of the vessels.

Damage is mainly observed in alkaline soils, low in organic material. Acid soils, whose pH is close to 4.7, do not seem to favour the development of this fungus or the production of sclerotia ensuring its ongoing presence. These sclerotia also cause the initial contamination. They are produced by the mycelium in the soil, often on and close to the roots. We find them in the soil, 15–60 cm under the surface, going down to over 2 metres in depth, according to certain authors. They can survive easily for several years. Conidiospores also form on its mycelium (**fig. 19**).

Several measures are recommended in order to limit the damage caused by this fungus:

- avoid planting l.s.v. in plots where particularly susceptible crops have been grown, notably alfalfa and cotton;
- get rid of as many diseased plants as possible, especially the root system;
- establish a fairly long period for crop rotation of at least 4 years, introducing monocotyledons which are not susceptible. Pea crops are also likely to reduce the presence of this fungus in the soil significantly, especially if numerous plants are buried in it (see page 179).

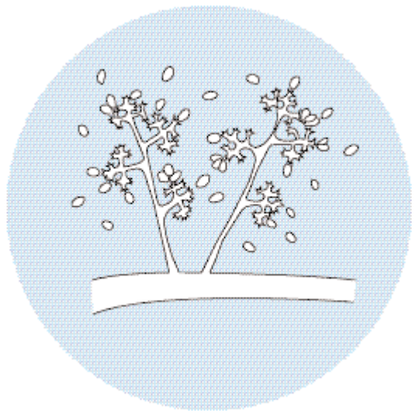


Figure 18: *Plasmopara lactucae-radicis* forms branched sporangia on the roots of infected lettuce. They are extended by short sterigmata on whose extremities elliptical sporangia develop.

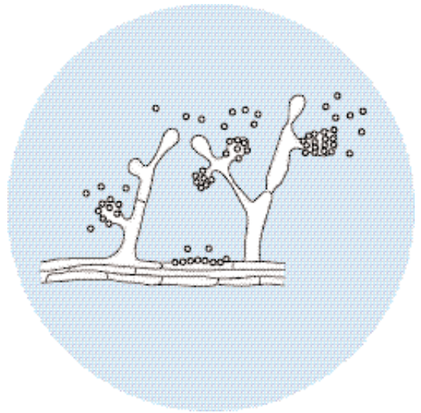


Figure 19: *Phymatotrichopsis omnivora* produces conidiophores which originate laterally on the mycelium. Their terminal part is swollen and they produce globular to oval-shaped conidia, often forming a mass.