Radopholus similis

**Radopholus similis**, or burrowing nematode, is one of the most damaging and widespread nematodes attacking bananas, causing toppling or blackhead disease. It is considered to be the main nematode problem of intensive commercial bananas, especially Cavendish types. It is also commonly found in plantain and cooking bananas cultivated in the lowlands of central and eastern Africa, and the Caribbean. It is however generally absent in plantain roots in west Africa and central America.

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**Distribution**

*Radopholus similis* was first described by Cobb[1]. Although the first observations were made in Fiji, the nematode is found in almost all tropical and subtropical banana growing regions of the world, with some exceptions including Israel, the Canary Islands, Cape Verde Islands, Cyprus, Crete, Mauritius, Taiwan, the highlands of Eastern Africa, most of South Africa, Mozambique and parts of southern Mexico[2][3][4]. The present geographical distribution is a reflection of historical movements of infested planting material and of the temperature preference of the pathogen, which ranges between 24 and 32°C. Optimum reproduction occurs at around 30°C. It does not reproduce below 16-17°C or above 33°C.

**Biology**

*Radopholus similis* is a migratory endoparasite, spending its adult vermiform life in the root and corm tissues where it completes its life cycle in 20-25 days, but is also capable of emerging in adverse conditions. The species exhibits a pronounced sexual dimorphism. Males have an atrophied stylet and are considered to be non parasitic. Juveniles and adult females are active and have mobile forms that may leave the roots in case of adverse conditions. Migratory stages in the soil can easily invade new roots.
Nematode penetration occurs by preference near the root apex, but *R. similis* can invade any portion of the root length. After entering the roots, the nematodes occupy an intercellular position in the cortical parenchyma where they feed on the cytoplasm of nearby cells, as such destroying them and causing cavities to develop\(^5\)\(^6\)\(^7\). These cavities coalesce and are continually enlarged by the nematodes, feeding and tunnelling laterally and towards the endodermis. The endodermis seems to act as a barrier to nematodes; the stele is not invaded\(^8\). The nematodes can migrate from infected roots into the rhizome cortex.

**Symptoms**

Nematode infections are difficult to diagnose without looking at underground symptoms, but some above-ground symptoms can give some indication (although they can also be symptomatic of other stress factors): stunted plant growth and lack of vigour; reduction in the number and size of leaves; leaf yellowing; premature defoliation; increased susceptibility to wilt; reduced yield, small bunches; increased harvest-to-harvest time and plant toppling.

Collecting root samples and looking at the underground symptoms provide better information. If a root is cleared of soil and then cut in half longitudinally, reddish-brown necrosis can be seen extending from the surface extending towards the centre, but not entering the stele.

The corm may show reddish-brown necrosis. The feeding and tunneling of the nematodes produces characteristic reddish brown lesions throughout the cortex, but not in the stele. Three to four weeks after infection, when extensive cavities have formed, one or more deep cracks with raised margins appear on the root surface. Fungal and bacterial invasion of the lesions causes necrosis that penetrates the stele, resulting in root atrophy. Eventually, the root system may be reduced to a few short stubs. When the nematodes migrate into the rhizome cortex, they cause diffuse black lesions\(^9\).

The symptoms can be easily distinguished from those of fusarium wilt, because symptoms of the latter are confined to the vascular tissue in the stele and do not extend to the root surface. In general, there will be a reduced root system, i.e. a lower number of secondary and tertiary roots and root hairs.

The destruction of root and corm tissues reduces water and mineral uptake. This results in a reduction of plant growth and development and may lead to severe reduction of bunch weight and a significant increase of the time period between two successive harvests\(^10\). The destruction also results in a tendency for plants to uproot or topple, particularly during strong winds and heavy rain periods, with a high economic impact\(^11\). Other symptoms include lack of vigour, leaf yellowing, premature defoliation, reduction in size and number of leaves and susceptibility to wilt. Crop losses caused by *R. similis* strongly depend on soil fertility, and can be as high as 75% in extreme
Resistant cultivars

Two widely confirmed sources of resistance to *R. similis* are *Pisang Jari Buaya* and *Yangambi Km 5* (AAA). The resistance of *Pisang Jari Buaya* has been incorporated into the parental lines used in the breeding of improved hybrids and is the source of resistance found in FHIA-01.

Other possible sources of resistance or lower susceptibility include *Pisang Batuau* (AA), *Pisang Oli* (AA), *Pisang Mas* (Sucrier, AA), *Pisang Lidi* (Pisang Lilin, AA), *Ney Poovan* (AB), several wild *Musa balbisiana*, *Musa acuminata* ssp. *malaccensis*, *microcarpa*, *zebrina* and *burmannicoides*, *Rimina* (Fei), *Menei* (Fei), *Focanah* (Pome subgroup, AAB), *Figue Pomme Ekonah* (Silk, AAB), *Pisang Kelat* (AAB), *Pisang Ceylan* (Mysore, AAB), *Gros Michel* (AAA) and *Ducasse*.

Control measures

Nematodes by themselves can only move about 1 meter per year. They may, however, be moved over longer distances in infested planting materials, on equipment, through irrigation water, etc. Once introduced, eradication of *R. similis* from the soil is virtually impossible and populations will build up more or less rapidly after planting.

Yield losses may also be reduced through propping or guying of pseudostems to avoid toppling. Application of amendments (mulching, manure, agricultural wastes) or any other measures that improve soil fertility and root development may increase plant tolerance to nematodes. Adding of organic materials also improves the microbial activity and thus acts as a natural biological control. Improved drainage is also an important factor in reducing nematode damage in high-rainfall regions.

Preventive measures

Tissue-cultured plantlets are the only planting material source guaranteed to be absolutely free of nematodes and should be the only method allowed for the introduction of banana plant material into virgin land.

If tissue-cultured materials are difficult to obtain, planting materials from clean nursery blocks can be used. For the set-up of clean nursery blocks, check the status of the soil in the nursery area (e.g. no prior history of banana growing) and prevent movement of nematodes into the nursery area on tools, vehicles and footwear. The area can then be planted with tissue-cultured plantlets, and suckers can be collected from these clean blocks.

Conventional planting materials can be cleaned and pared prior to planting. All diseased tissue, characterized by necrotic lesions, is cut from the corm. Do not carry out the paring in the new planting site and clean your knife or machete in between paring of different corms. However, nematodes located deep within the cortex in non-necrosed tissues may escape removal. Sun exposure of pared material for 2 weeks may further reduce the nematode population, but such techniques cannot be applied to small suckers which are quite fragile and need to be replanted rapidly. Paring followed by hot-water treatments (52-55°C for 15-20 minutes) has been a common and effective practice, but it is labour intensive and requires careful monitoring of temperature and exposure time as these are critical to be efficient and to limit the negative effects on the plants. Planting material disinfestation using chemicals can also be achieved by dipping plant material in a...
nematicide solution, e.g. cold fenamiphos (100 ml of Nemacur® 400 in 100 l of water) for 10 minutes. Thoroughly clean and trim all planting material for optimal adherence of the nematicide. Make sure that the dip is fresh and strictly follow the label recommendations in the use of the product. These products are very toxic; properly dispose the remaining dip solution by applying it to plots where nematode treatment is required. The technique known as “pralinage” is a significant improvement over dipping. This involves the use of a nematicidal mud mixture which permits instantaneous coating of the plant. It is recommended to use either bentonite (15 kg in 100 l of water + 400-500 g of active ingredient) or a natural clay (proportion of clay to be mixed with water must be adapted). This method has the advantage that the treated material can be removed immediately from the dip and there is much less splashing of dangerous chemicals.

Other preventive measures include strict quarantaine measures, cleaning of machinery and equipment, avoidance of contaminated irrigation water and removal of plants with symptoms.

**Cultural practices**
Reducing nematode populations in the soil before planting is of primary importance in the control of *R. similis*.

Fallowing the land for 6-12 months or longer after destruction of all hosts can be a method to reduce the nematode populations in the soil to an undetectable level. A bare fallow means you have no plants at all in your field. During a non-host crop fallow, only plants that are not a host for the nematode species are grown in the field (e.g. *Panicum maximum* and *Chromolaena odorata* against *R. similis*). The method may become uneconomic if a small residual population can survive the fallow period, thus it is very important to pay attention to weeds, remains of bananas and alternative hosts, as these may be survival sites for nematodes. Passion fruit (*Passiflora edulis*), pineapple (*Ananas comosus*) and sugarcane (*Saccharum officinarum*) can be used as rotation crops against *R. similis*. Rotating with low-land rice creates anaerobic conditions due to flooding which will reduce the nematode infestation.

Complete flooding during 6-7 weeks can be as effective as 10-12 months of fallow in reducing nematode populations. However, this method is often not practicable as flooding requires the land to be levelled and a permanent water supply. In addition, it is only effective if the land is thoroughly cleared of all remaining banana parts. Pre-planting heat treatment of the soil will reduce the field infestation. You can do this through the use of steam or by covering the field with a black polyethylene cover during summer. Deep ploughing during summer will also reduce the initial nematode populations in the field. Although soil fumigation is quite effective in controlling nematodes, few fumigants are still authorized today and application costs may be prohibitive. Moreover, these chemicals are broad-spectrum biocides with a detrimental effect on soil organisms.

**Biological control**
*Paecilomyces lilacinus* is a fungus that parasitizes eggs, juveniles and adults of *R. similis*. It can be applied as dip, soil drench or incorporated into the soil. Liquid and powder formulations containing *P. lilacinus* and *Paecilomyces oxalicum* are marketed commercially. Purified extracts of *Penicillium oxalicum*, *Penicillium anatolicum* and *Aspergillus niger* have shown high nematicidal activity. Strains of the bacterium *Pseudomonas fluorescens* have been found to inhibit the invasion of banana roots by *R. similis*.

**Chemical control**
Nematicides are generally non-volatile organophosphates or carbamates. Their mode of action is
mainly nematostatic, which means they do not kill nematodes, but act on the nematodes’ nervous system and interfere with their ability to hatch from eggs, move, penetrate the roots, feed and reproduce.

Nematicides are applied as granules on the soil surface around the mat. Emulsifiable compounds are applied as liquid sprays or through irrigation systems. In order to avoid build-up of resistance of the nematodes to the chemicals, alternation with different compounds is recommended. It is important to always immediately irrigate after application and not apply nematicides when flooding occurs. The chemicals should be incorporated as quickly as possible.

Nematicides are often applied routinely without regard to the severity of the problem, but it is better to strategically schedule application based on the population density and amount of damage in the crop. The optimum application time, dose and frequency are determined by nematicide efficiency, environmental conditions, as well as pathogenicity of local nematode strains and population dynamics. In most production areas, nematicide applications vary between 2 to 3 g of active ingredient per mat and 2-3 applications per year.

Though nematicides are generally effective in controlling nematodes and are easy to use, they are expensive, highly toxic and may have a negative impact on the environment.

References


Further reading
