Data Sheets on Quarantine Pests

Meloidogyne chitwoodi

IDENTITY

Name:*Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley
Taxonomic position: Nematoda: Meloidogynidae
Common names: Columbia root-knot nematode (English)
Nématode cécidogène du Columbia (French)
Bayer computer code: MELGCH
EPPO A2 list: No. 227

HOSTS

M. chitwoodi has a wide host range among several plant families (Santo *et al*., 1980; O'Bannon *et al*., 1982), including crop plants and common weed species. Potatoes (*Solanum tuberosum*) and tomatoes (*Lycopersicon esculentum*) are good hosts, while barley (*Hordeum vulgare*), maize (*Zea mays*), oats (*Avena sativa*), sugarbeet (*Beta vulgaris* var. *saccharifera*), wheat (*Triticum aestivum*) and various Poaceae (grasses and weeds) will maintain the nematode. Moderate to poor hosts occur in the Brassicaceae, Cucurbitaceae, Fabaceae, Lamiaceae, Liliaceae, Umbelliferae and Vitaceae. *Capsicum annuum* and tobacco (*Nicotiana tabacum* and *N. rustica*) are not hosts of *M. chitwoodi*. Lucerne (*Medicago sativa*) is a good host for race 2 but not for race 1, whereas carrots (*Daucus carota*) are a non-host for race 2 but a good host for race 1. Ferris *et al.* (1994), investigating suitable crops for rotation with potato in the presence of race 1 in USA, recommend *Amaranthus*, lucerne, rape (*Brassica napus* var. *oleifera*), *Raphanus sativus* var. *oleifera* and safflower (*Carthamus tinctorius*). In the Netherlands, host crops recorded to be attacked by *M. chitwoodi* are carrots, cereals, maize, peas (*Pisum sativum*), *Phaseolus vulgaris*, potatoes, *Scorzonera hispanica*, sugarbeet and tomatoes (OEPP/EPPO, 1991).

GEOGRAPHICAL DISTRIBUTION

M. chitwoodi was first described from the Pacific Northwest of the USA in 1980, its common name deriving from the Columbia River between Oregon and Washington states. It is not clear whether this is its area of origin. It was first detected in the EPPO region in the 1980s, in the Netherlands, but a review of old illustrations and old specimens of *Meloidogyne* suggests that it may have occurred earlier (in the 1930s) and may have been present throughout the intervening period (OEPP/EPPO, 1991). It is possible that *M. chitwoodi* has a wider distribution, undetected, in Europe than is currently known; the question is now actively under investigation.
EPPO region: Belgium, Germany (Heinicke, 1993), Netherlands (Brinkman & Van Riel, 1990).
Africa: South Africa.
North America: Mexico, USA (California, Colorado, Idaho, Nevada, Oregon, Utah, Washington - Walters & Barker, 1994; isolated record in Virginia - Eisenback *et al*., 1986). Surveys conducted in Canada (British Columbia and Alberta) failed to detect this species.

South America: Argentina.
EU: Present.

BIOLOGY

The life cycle of *M. chitwoodi* takes approximately 3-4 weeks under favourable conditions. Larvae hatch from eggs in the soil or on the root surface. Second-stage larvae (infective juveniles) penetrate root tips through unsuberized epidermal cells or wounds and move into the cortical region. Soon after entry, nematodes stimulate giant cell and gall formulation in the host tissue. Necrotic lesions occur in the cortex. Larvae then swell to become sausage-shaped, stop feeding and undergo three rapid successive moults to become adult males or females. Adult males have slender, vermiform bodies; they leave the root and are found free in the rhizosphere or near the protruding body of the female. However, as in the case of other *Meloidogyne* spp., it is probable that males are functionless and reproduction is nearly always parthenogenetic. Adult females have characteristically pear-shaped, pearly-white bodies and they are found embedded in host tissue. Eggs are laid by the female in a gelatinous sac near the root surface. In potato tubers, modified host cells form a protective layer or 'basket' around the egg mass and the juveniles as they hatch. The egg shell itself is hyaline with no visible markings.

The species passes the winter as eggs or juveniles and can survive extended periods of sub-freezing temperatures. *M. chitwoodi* can begin development when soil temperature rises above 5°C and requires 600-800 degree-days to complete the first generation; subsequent generations require 500-600 degree-days. *M. hapla* requires a similar number of degree-days for development but does not begin development until temperatures rise above 10°C. Population dynamics in relation to degree-day accumulation have been considered by Pinkerton *et al*. (1991).

Several races of *M. chitwoodi* have been described, distinguished by slight differences in host range. The first two, known as race 1 and race 2, were in particular distinguished with regard to carrot and lucerne (Santo & Pinkerton, 1985; Mojtahedi *et al.*, 1988). Race 3 has recently been described in California (Mojtahedi *et al.*, 1994), and another race has possibly been identified in the Netherlands (Van Meggelen, 1994) and is being described as a new species (*M. fallax*) (Karssen, 1996).

DETECTION AND IDENTIFICATION

Symptoms

Symptoms of *M. chitwoodi* vary according to host, population density of the nematode and environmental conditions. Above-ground symptoms are often not obvious but may consist of varying degrees of stunting, lack of vigour and a tendency to wilt under moisture stress, all leading to reduced yield. The galls produced on potato tubers by *M. chitwoodi* differ from those caused by other species of *Meloidogyne*. *M. hapla*, for example, forms small but distinct galls (together with extensive root proliferation) while *M. incognita* forms large, easily noticeable galls. The symptoms caused by *M. chitwoodi* are often not easily detected and are more apparent in some cultivars than in others; tubers may, in some cases, be heavily infected without visible symptoms. When present, the galls appear as small raised swellings on the tuber surface above the developing nematodes. A number of galls may be concentrated on one area of the tuber or single galls may be scattered near eyes or lesions. Internal tissue below the gall is necrotic and brownish. Adult females are visible just below the surface as glistening, white, pear-shaped bodies surrounded by a brownish layer of host tissue. Potato roots may also be infected, but this is difficult to detect without a magnifying lens, as little or no galling occurs, even in heavy infestations. The spherical bodies of

females may protrude from the surface of small rootlets surrounded posteriorly by a large egg-filled sac which becomes dark-brown with age.

In other crops, root galls and reduced root production decrease yields and marketability. Gall formation occurs on most cereals but is more noticeable on wheat and oats than on barley or maize. In tomatoes, *M. chitwoodi* produces root galls in some cultivars but not in others.

Morphology

Adult males and the second-stage juveniles are vermiform, motile animals, similar in general appearance to free-living soil nematodes. Females are characteristically pear-shaped, pearly-white and sedentary. The male is 887-1268 nm in length and 22-37 nm in width with a slight taper at each end. The tail is short, 4.7-9.0 nm and rounded. Cuticular annules are distinct and are more prominent near each end. The female is 430-740 nm in length by 344-518 nm in width. Second-stage juveniles are 336-417 nm in length by 12.5-15.5 nm in width, tail short, 39-47 nm, scarcely tapered and hyaline. Eggs are 79-92 nm in length and 40-46 nm in width.

M. chitwoodi closely resembles *M. hapla*; it can be distinguished from this and other species by the perineal pattern, the appearance of vesicles or vesicle-like structures in the median bulb of the adult female and by the short, blunt, larval tail which has a hyaline, rounded (not tapered) terminus (Golden *et al*., 1980; Nyczepir *et al*., 1982; Jepson, 1984). The species can also be distinguished from other *Meloidogyne* species likely to be found under similar conditions. Schemes have been described to differentiate *M. chitwoodi* from *M. hapla*, *M. micotyla* and *M. incognita* by differential hosts (Townshend *et al*., 1984) and also to distinguish the two races of *M. chitwoodi* (Mojtahedi *et al*., 1988). Biochemical methods have also been used (Karssen, 1995; Zijlstra *et al*., 1995). A diagnostic DNA probe which distinguishes *M. chitwoodi* from *M. hapla* has been developed by Piotte *et al.* (1995).

Detection and inspection methods

The presence of *M. chitwoodi* in infested soil can be determined by sampling and extraction of the second-stage juveniles, using a standard nematode extraction procedure for free-living nematodes of this size. External symptoms on tubers are obvious in the case of heavy infestations but, where nematode numbers are low or in the early stages of infection, such symptoms are not obvious. Clearing and staining of the tissues can show the presence of nematodes (Hooper, 1986) but this can be a laborious procedure. Storage of lightly infested tubers may lead to the development of obvious external symptoms.

MEANS OF MOVEMENT AND DISPERSAL

M. chitwoodi has very limited potential for natural movement; only second-stage juveniles can move in the soil and, at most, only a few tens of centimetres. The most likely method of introducing *M. chitwoodi* into a new area is through the movement of infected or contaminated planting material. Infected host plants or host products such as bulbs or tubers can easily transport the nematode. The movement of non-host seedling transplants, nursery stock, machinery or other products which are contaminated with soil infested with *M. chitwoodi* could also result in spread. Infective larvae of this genus have been known to persist for more than one year in the absence of host plants. Nematode movement can also be facilitated by contaminated irrigation water.

PEST SIGNIFICANCE

Economic impact

M. chitwoodi reduces the market value of potatoes as a result of the internal necrosis and external galling. Necrotic spots in the flesh of tubers of as little as 5% of a crop make it commercially unacceptable. Overall yields of tubers are also reduced. This species is considered to be the major nematode pest of potatoes in the Pacific Northwest states of the USA and the annual predicted loss there would be approximately 40 million USD if control measures were not applied (Santo, 1994). No information is available on the economic impact in European countries. Effects on other crops are not as marked nor as well documented, but yields of cereals (wheat, barley, oats and maize) have been shown to be significantly reduced (Santo & O'Bannon, 1981). In the Netherlands, *M. chitwoodi* has recently damaged potato crops (and certain vegetables) in a limited area in the east of the country; this damage is apparently associated with sandy soils and a succession of warm summers. As mentioned under Geographical distribution, it is possible that *M. chitwoodi* has been present in the area for many years, undetected because it caused no significant damage.

Control

Control measures currently used against other root-knot nematodes have proved to be less effective against *M. chitwoodi*. For example, treatment trials with the nematicides aldicarb, dichlorpropene, ethoprop and metham-sodium have not been as consistently successful as against *M. hapla* (Pinkerton *et al.*, 1986; Santo & Wilson, 1990). In north-western USA, crop failures in several potato fields have been attributed to *M. chitwoodi* despite the use of spring soil fumigations.

Crop rotation with cereals is often used to reduce populations of *M. hapla*. *M. chitwoodi*, however, reproduces well on wheat, oats, barley and maize. Rotation with any of these crops will, therefore, favour a build-up rather than a decrease of *M. chitwoodi* populations in infested soils. There are, however, other crops which will reduce populations (see Hosts) and could be used in rotations. Some success has been achieved by the incorporation of green manure into the soil, which reduces population densities of *M. chitwoodi* (Mojtahedi *et al.*, 1993a, b).

Potato cultivars differ in their tolerance of *M. chitwoodi* (Van Riel, 1993). There is interest in breeding for host resistance to *M. chitwoodi*, e.g. in potatoes, using resistance from *Solanum bulbocastanum* and other sources (Brown *et al.*, 1991; Austin *et al*., 1993; Janssen *et al*., 1995) and cereals (Jensen & Griffin, 1994).

Phytosanitary risk

M. chitwoodi is an EPPO A2 quarantine pest, but is not considered to be a quarantine pest by any other regional plant protection organization (though it is rated as a quarantine pest by Canada). Tiilikkala *et al.* (1995) conducted an exhaustive pest risk analysis (PRA) of *M. chitwoodi* as a risk for Finland (and for Europe more generally) and concluded that this species qualified as a quarantine pest. A comparison of the air temperatures of Finland with those in the present distribution of the pest indicated that the nematode could survive and produce two generations per year in the southern part of Finland. Baker & Dickens (1993) concluded from their PRA that *M. chitwoodi* would be likely to produce three generations in the UK. They did not feel capable of predicting the likely economic impact of the pest, since this could depend on a number of other unknown factors such as soil wetness, varietal susceptibility and quality control thresholds. Countries further south in the EPPO region would provide climatic conditions suitable for as many as four generations per year. A recent PRA for Germany (Braasch *et al*., 1996) led to the conclusion that *M. chitwoodi*

was most likely to be damaging on potatoes in the northwest of the country, in the area adjoining the Netherlands.

Potato is the crop that would be most at risk from *M. chitwoodi* in the EPPO region. For a number of reasons, it represents a greater threat than other Meloidogyne species already widespread in the EPPO region, in particular *M. hapla* with which it often forms mixed populations. *M. chitwoodi* is less easily controlled by nematicides, it has a wider host range, it produces more severe tuber symptoms and is tolerant of lower soil temperatures. In fact, the soil temperature requirements for population development of *M. chitwoodi* are rather similar to those of *Globodera rostochiensis* (Tiilikkala *et al.*, 1995), suggesting that the former species could occupy the same geographical distribution as the latter.

PHYTOSANITARY MEASURES

EPPO has not yet decided specific quarantine requirements for *M. chitwoodi*. Measures similar to those for potato cyst nematodes (EPPO/CABI, 1996) would appear relevant, i.e. that consignments of rooted plants should come from areas where the pest does not occur or from fields found free from the pest. Suitable survey and test methods have still to be established. Freedom from *M. chitwoodi* should be specifically assured by certification schemes for seed potatoes.

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