European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

Data sheets on pests recommended for regulation
Fiches informatives sur les organismes recommandés pour réglementation

Heterodera glycines

Identity

Name: *Heterodera glycines* Ichinohe
Taxonomic position: Nematoda: Tylenchida: Heteroderidae
Common names: Soybean cyst nematode (English)
EPPO code: HETDGL
Phytosanitary categorization: EPPO A1 List no. 167.

Hosts

Soyabeans are the major economic host of *H. glycines*. Other cultivated hosts, mainly Fabaceae, are *Lespedeza* spp., *Lupinus albus*, *Penstemon* spp., *Phaseolus vulgaris*, *Vicia villosa*, *Vigna angularis* and *Vigna radiata*. Sugarbeet and tomatoes have been found to be experimental hosts (Miller, 1983). In general, *H. glycines* has a wide host range, mainly on weeds, of at least 23 families (e.g. Boraginaceae, Capparaceae, Caryophyllaceae, Chenopodiaceae, Brassicaceae, Lamiaceae, Fabaceae, Scrophulariaceae, Solanaceae). Typical weed hosts are *Cerastium holosteoides*, *Lamium amplexicaule* and *Stellaria media*. See Riggs & Hamblen (1962, 1966), Manuel *et al.* (1981), Riggs (1982).

Geographical distribution[1]

The first report of *H. glycines* was from Japan in 1916. Earlier observations date back to 1881. In 1938 the nematode was reported from Manchuria (then an independent state, now in China) and then from several other parts of Asia, including the Amur District in Russia. It was first detected in the USA in 1954 and subsequently found in many states (now 25). It is most likely that *H. glycines* originated in Asia and was introduced from Asia to North America with infested soil in the nineteenth century; it subsequently spread in America with the extension and intensification of soybean cultivation (Niblack & Schmitt, 2008).

In 2000, *H. glycines* was detected in Italy; it was found in three fields of soybeans in Pavia, Lombardia (Manachini, 2000). It is suspected that the species may have been already present for a number of years, as damage symptoms had been observed since 1998.

EPPO region: Italy, Russia (Amur District in the Far East only).

Asia: China (Anhui, Hebei, Heilongjiang, Henan, Hubei, Jiangsu, Jilin, Liaoning, Neimenggu, Shaanxi, Shandong, Shanxi), India (Madhya Pradesh), Indonesia (Java only), Iran, Japan, Democratic People’s Republic of Korea, Republic of Korea, Taiwan (unconfirmed), Russia (Far East).

North America: Canada (Ontario), USA (Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, Ohio, Oklahoma, Puerto Rico, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin).

South America: Argentina, Brazil, Colombia, Ecuador, Paraguay. Denied record for Chile.

EU: Italy.

Note: the pest has been reported in Egypt (Diab, 1968) but it seems that this report is doubtful.

Biology

H. glycines is a bisexual cyst-forming species. First-stage juveniles moult to second stage within the eggs and hatch under stimulation from exudates from host roots. They invade the root and begin feeding on a group of cells which become modified into a multinucleate syncytium. The female nematode remains at this feeding site as it develops through the vermiform juvenile stages into the swollen adult form. The swelling of the female disrupts the tissues of the host root and the body of the nematode finally protrudes from the surface. The males remain vermiform; they leave the root and are attracted towards the female, where copulation takes place. Eggs are formed within the female and some are laid into an egg sac or ‘gelatinous matrix’. Males may sometimes be found in the gelatinous matrix. When the female dies, the body becomes a hardened protective cyst enclosing the eggs.

In the field, there are three to five generations per year. Optimum development occurs at 23–28°C; development stops below 14°C and above 34°C (Riggs, 1982; Burrows & Stone, 1985). Survival of a small percentage of juveniles has been observed after 6 months at minus 24°C (Slack & Hamblen, 1961). In the absence of a host, contents of cysts may remain viable in soil for 6–8 years (Slack *et al*., 1972).

Riggs & Schmidt (1988) proposed a race system based on the reaction of four host differentials to attack by *H. glycines*; sixteen such races were identified. However, additional sources

[1]An updated geographical distribution can be viewed on the EPPO website.

of resistance were subsequently found, with consequent identification of further virulence groups (Niblack *et al*., 2002).

Detection and identification

Symptoms

Affected plants show stunting and chlorosis (yellow dwarf disease), usually occurring as oval patches in the field. At low to moderate infestation levels, there is over-production of lateral roots. A low rate of nodulation may also be observed. In areas of intensive soybean production (e.g. the Midwest USA), above-ground symptoms cease to appear, whereas yield loss can continue to reach up to 30%.

Morphology

H. glycines belongs to a group of many similar species of *Heterodera*, and, thus, identification can require considerable experience. Note that *H. glycines* has been shown to hybridize with *H. schachtii* (Moller, 1983), and this could further complicate identification. For reliable identification, at least cysts and eggs containing juveniles are necessary. Characters of the vulval cone of the cyst and, the length of stylet, tail and hyaline tail terminus of the second stage juvenile, must be measured. The shape of the juvenile stylet knobs is an additional character (Table 1). Detailed and illustrated keys to the species of *Heterodera* are given by Mulvey & Golden (1983), Wouts (1985) and Golden (1986). For measurements see Table 1 and Burrows & Stone (1985). Taylor (1975), Hesling (1978), Graney & Miller (1982) and Mulvey & Golden (1983) give comparative measurements of related species. It should be noted that measurements may vary with hosts and geographical isolate.

Table 1 Measurements of *Heterodera glycines* (after Taylor, 1975 and Graney & Miller, 1982)

		Mean	Average range
Cysts			
Fenestra	length (µm)	55	(30–70)
	width (µm)	42	(25–60)
Vulval slit	length (µm)	53	(43–60)
Juveniles			
Body	length (µm)	440	(375–540)
Stylet	length (µm)	23	(22–24)
	subventral knobs	posteriorly sloping	
Tail	length (µm)	50	(40–61)
	length/anal width = c′	3.4	
	hyaline part (µm)	27	(20–30)
	length/width of hyaline part (µm) = h′	3.0	

Detection and inspection methods

In the field, cysts may be seen with the naked eye on host roots 4–6 weeks after planting, if the infestation is heavy.

Cysts may be extracted from soil, substrates or packing materials after suitable preparation, using the Fenwick can, the Schuiling centrifuge or other suitable techniques. Young females, males and second-stage juveniles may be extracted from fresh soil by sugar flotation techniques, and the motile males and juveniles may be found with Baermann funnel techniques and their modifications.

Additional differentiation between species using biological tests on suitable host plants may be useful, but can take 6–8 weeks. Cysts of *H. glycines* can be differentiated from other *Heterodera* species by polyacrylamide gel electrophoresis of the enzyme superoxide dismutase (Molinari *et al*., 1996). Various molecular methods have been developed to distinguish *H. glycines* from similar cyst nematodes. The most recently described method uses a single randomly amplified polymorphic DNA (RAPD) marker, amplified by PCR (Ou *et al*., 2008).

Pathways for movement

The nematode itself is completely sedentary apart from a small amount of independent movement (at most, a few centimetres) by juveniles and males. However, the durability of the cyst allows considerable passive transport. Cysts with viable juveniles have been recovered from excrement of birds (Epps, 1971). International transport is most likely to occur with soil or growing medium attached to plants or seeds; *H. glycines* was shown to be viable for up to 8 months in soil particles mixed with seed stocks (Epps, 1969). Nematodes can also be readily carried in the roots of infected plants.

Pest significance

Economic impact

H. glycines is a major pest of soybeans in Asia and the USA. In Japan, yield loss was estimated to be 10–75% (Inagaki, 1977; Ichinohe, 1988), whereas, in the USA, Riggs (1977) calculated a loss of 85 million USD from five states only. In North Carolina (USA), *H. glycines* is also a pest on *Phaseolus vulgaris*. In Japan, it interacts with the fungus *Phialophora gregata* on *Vigna angularis*. When the nematodes are controlled, the fungus causes no damage (Ichinohe, 1988).

Control

The nematodes can be controlled by the use of soil-applied nematicides or, more effectively, by nematicides in combination with long crop rotation and the use of resistant and susceptible cultivars in a flexible integrated plant production system. New resistant cultivars are being sought, since populations of resistance-breaking pathotypes are developing in the field.

Phytosanitary risk

EPPO (OEPP/EPPO, 1989) lists *H. glycines* as an A1 quarantine pest; CPPC, IAPSC and NAPPO also consider it of quarantine significance. Based on the distribution of *H. glycines* in Asia and the Americas and its wide host range, it must be assumed that this nematode could survive in the warmer and temperate areas of the EPPO region. However, *H. glycines* would only establish itself and become a pest of economic importance where the principal host, soyabeans, are widely cultivated in close rotations or monoculture.

Although soyabean has not in the past been a significant crop in the EPPO region, in 2007 the EPPO member countries together produced about 2% of the world output of soyabeans. Croatia, France, Hungary, Italy, Kazakhstan, Romania, the Russian Federation and Ukraine are soyabean producers (FAOSTATS, 2007). This makes it particularly important to exclude soyabean pests not yet introduced into the region.

Phytosanitary measures

Imports of soil and rooted plants with soil from countries where this nematode occurs should be restricted (OEPP/EPPO, 1990).

Acknowledgement

This datasheet was revised by Dr D Mc Namara (former EPPO Assistant Director).

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