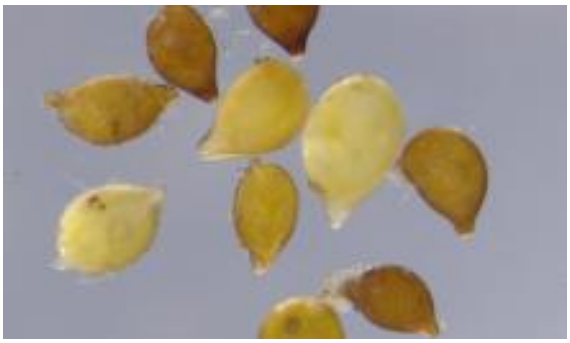
EPPO Datasheet: *Heterodera glycines*

Last updated: 2023-12-12

IDENTITY

Preferred name: *Heterodera glycines*
Authority: Ichinohe
Taxonomic position: Animalia: Nematoda: Chromadorea: Rhabditida: Heteroderidae
Common names: soybean cyst nematode
view more common names online...
EPPO Categorization: A2 list
view more categorizations online...
EPPO Code: HETDGL



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HOSTS

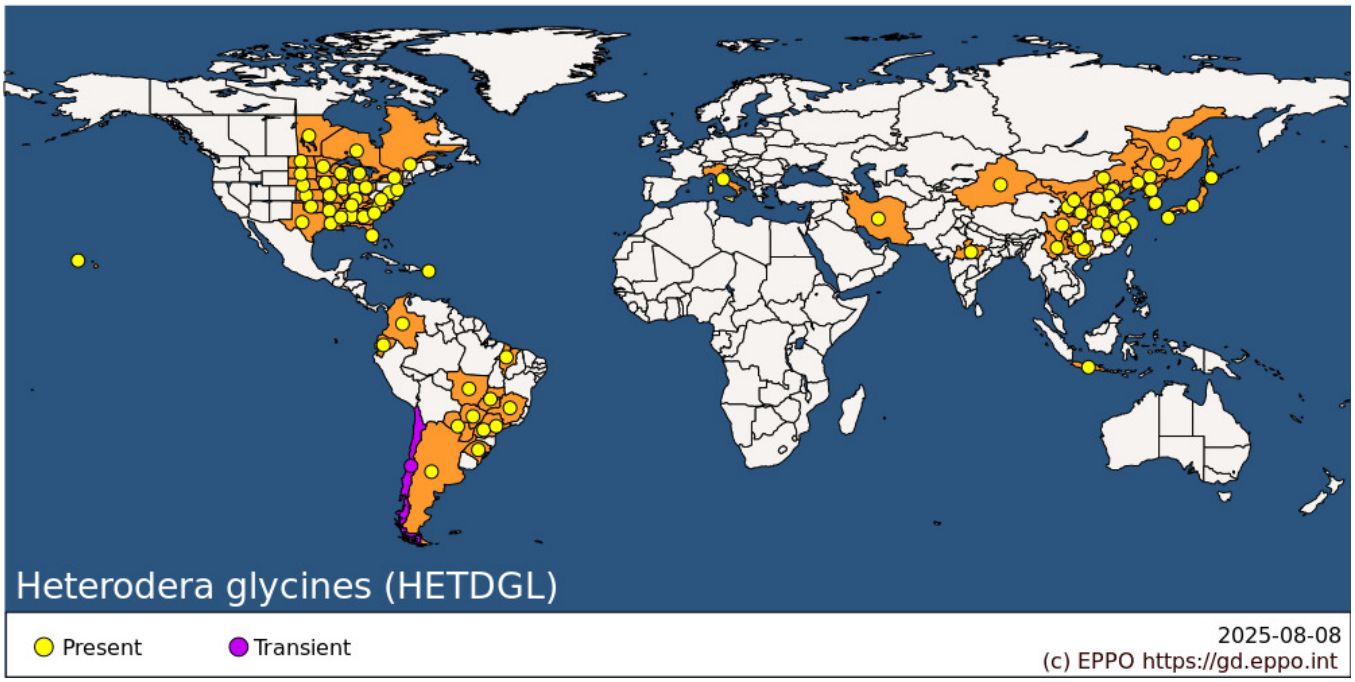
Soybeans are the major economic host of *Heterodera glycines*. It also infests another economically important leguminous crop, dry edible bean (*Phaseolus vulgaris*) (Poromarto *et al*., 2010). In general, *H. glycines* has a wide host range, mainly on weeds, of at least 23 families (e.g. Fabaceae, Boraginaceae, Capparaceae, Caryophyllaceae, Chenopodiaceae, Brassicaceae, Lamiaceae, Scrophulariaceae, Solanaceae). Common weed hosts are common mouse-ear chickweed (*Cerastium holosteoides*), henbit *Lamium amplexicaule*), chickweed (*Stellaria media*) and field pennycress *Thlaspi arvense*). See Riggs & Hamblen (1962, 1966), Manuel *et al.* (1981), Riggs (1982), Poromarto *et al*. (2015). Some of the weed species provide an overwintering option for *H. glycines* which increases the risk of infestation in the subsequent growing season.

Host list: *Abutilon theophrasti, Acacia baileyana, Acacia longifolia, Aeschynomene indica, Aeschynomene virginica, Ageratum conyzoides, Agrostemma githago, Alkekengi officinarum, Alysicarpus vaginalis, Amaranthus blitoides, Amaranthus tuberculatus, Ambrosia artemisiifolia, Antirrhinum majus, Arctium minus, Artemisia biennis, Astragalus canadensis, Bassia scoparia, Bidens pilosa, Borago officinalis, Cajanus cajan, Camelina microcarpa, Capsella bursa-pastoris, Cardamine parviflora, Carum carvi, Cerastium holosteoides, Cicer arietinum, Cirsium arvense, Cleome hassleriana, Cleome serrulata, Commelina benghalensis, Crambe maritima, Crotalaria brevidens var. intermedia, Crotalaria juncea, Crotalaria lanceolata, Crotalaria pallida, Cuphea viscosissima, Datura stramonium, Descurainia pinnata, Descurainia sophia, Desmodium tortuosum, Digitalis purpurea, Dysphania atriplicifolia, Erigeron canadensis, Euphorbia esula, Fallopia convolvulus, Genista canariensis, Genista tinctoria, Geranium maculatum, Glycine max, Guizotia abyssinica, Hibiscus trionum, Indigofera hirsuta, Ipomoea hederacea, Iva xanthiifolia, Kummerowia stipulacea, Kummerowia striata, Lamium amplexicaule, Lamium purpureum, Lathyrus cicera, Lathyrus sativus, Lathyrus tuberosus, Leonurus cardiaca, Lepidium densiflorum, Lespedeza cuneata, Lotus corniculatus, Lunaria annua, Lupinus albus, Lupinus arboreus, Lupinus leucophyllus, Lupinus polyphyllus, Lupinus wyethii subsp. wyethii, Macroptilium atropurpureum, Malva neglecta, Marrubium vulgare, Medicago arabica, Medicago lupulina, Medicago minima, Medicago polymorpha, Medicago sativa, Melilotus albus, Melilotus officinalis, Nepeta cataria, Nicotiana tabacum, Nuttallanthus canadensis, Oxalis stricta, Papaver rhoeas, Penstemon albertinus, Penstemon bradburyi, Penstemon digitalis, Penstemon glaber, Penstemon nitidus var. polyphyllus, Persicaria maculosa, Phaseolus vulgaris, Phytolacca americana, Plantago major, Polygonum aviculare, Portulaca oleracea, Robinia pseudoacacia, Rumex crispus, Salvia reflexa, Senecio vulgaris, Senna occidentalis, Senna tora, Sesbania herbacea, Sida spinosa, Silene noctiflora, Sinapis arvensis, Sisymbrium altissimum, Sisymbrium irio, Solanum rostratum, Solanum villosum, Sonchus arvensis, Spartium junceum, Stellaria media, Strophostyles helvola, Taraxacum officinale, Thlaspi arvense, Trifolium arvense, Trifolium aureum, Trifolium campestre, Trifolium hybridum, Trifolium incarnatum, Trifolium repens, Tripleurospermum maritimum, Ulex europaeus, Verbascum thapsus, Vicia benghalensis, Vicia hirsuta, Vicia sativa, Vicia tetrasperma, Vicia villosa, Vigna angularis, Vigna radiata, Vigna unguiculata, Viscaria vulgaris, Wisteria floribunda, Wisteria sinensis, Xanthium strumarium*

GEOGRAPHICAL DISTRIBUTION

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 North Carolina in 1954 and has spread throughout almost all the soybean-producing areas of the USA and Canada except West Virginia and Prince Edward Island (Tylka & Marett, 2021). 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 the Americas 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. Subsequently, the nematode was also found in a small number of soybean fields in Veneto and Friuli Venezia Giulia (Perin *et al.*, 2021).



EPPO Region: Italy (mainland), Russian Federation (the) (Far East)
Asia: China (Anhui, Beijing, Gansu, Guangxi, Guizhou, Hebei, Heilongjiang, Henan, Hubei, Jiangsu, Jiangxi, Jilin, Liaoning, Neimenggu, Ningxia, Shaanxi, Shandong, Shanghai, Shanxi, Sichuan, Xinjiang, Yunnan, Zhejiang), India (Madhya Pradesh), Indonesia (Java), Iran, Islamic Republic of, Japan (Hokkaido, Honshu, Kyushu), Korea, Democratic People's Republic of, Korea, Republic of
North America: Canada (Manitoba, Ontario, Québec), United States of America (Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin)
Central America and Caribbean: Puerto Rico
South America: Argentina, Brazil (Goias, Maranhao, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Parana, Rio Grande do Sul, Sao Paulo), Chile, Colombia, Ecuador, Paraguay

BIOLOGY

H. glycines is a dioecious cyst-forming species which has six life stages including eggs, four stages of juveniles and adults. First-stage juveniles (J1) molt to second-stage (J2) within the eggs and may 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. While continuing to feed at this site, they then become immobile and molt into third-stage juveniles (J3), fourth-stage (J4), and adult females or males. 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, and this is where copulation takes place. Eggs are formed within the female and some are laid into an egg sac or 'gelatinous matrix' outside the female body. Males may sometimes be found in the gelatinous matrix. When the yellowish-white lemon-shaped female dies, the body becomes a hardened protective brown cyst enclosing the eggs. One cyst may contain as many as 500 eggs.

The life cycle of *H. glycines* may take about 24-30 days to complete. 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, eggs within 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. Niblack *et al.* (2002) reported system to classify populations of *H. glycines* based on their abilities to infest and reproduce on seven soybean differential lines as additional sources of resistance had been found since the first system was developed, allowing identification of more virulence groups.

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), soybean fields can have up to 30% yield reduction without showing any obvious above-ground symptoms of *H. glycines* infestation.

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 morphological identification, at least cyst and second-stage juvenile specimens 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, should be measured. The shape of the juvenile stylet knobs is an additional character. Detailed and illustrated keys to the species of *Heterodera* are given by Mulvey & Golden (1983), Wouts (1985) and Golden (1986). For measurements see Burrows & Stone (1985) and the EPPO diagnostic protocol (EPPO, 2018). 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 isolates.

Detection and inspection methods

In the field, during the growing season white-yellow females may be seen with the naked eye on host roots 4–6 weeks after planting, if the infestation is heavy. Soil sampling is considered the best method to detect *H. glycines* in the field before and after the growing season. Guidance on sampling is available in the EPPO Standard on procedures for official control of *H. glycines* (EPPO, 2008).

Cysts may be extracted from soil, substrates or packing materials after suitable preparation, using the Fenwick can, the Schuiling centrifuge, the sieving and decanting or other suitable techniques. The motile second-stage juveniles and males may be extracted from fresh soil and other substrates by sugar flotation techniques, Baermann funnel techniques or 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* spp. by polyacrylamide gel electrophoresis of the enzyme superoxide dismutase (Molinari *et al.*, 1996). Various DNA-based molecular methods have been developed to distinguish *H. glycines* from similar cyst nematode species (Ou *et al.*, 2008; Baidoo *et al.*, 2017; Baidoo & Yan, 2021).

Guidance on extraction, detection and identification of *H. glycines* is provided in two EPPO Diagnostics Standards (EPPO, 2013, 2018).

PATHWAYS FOR MOVEMENT

The nematode itself is completely sedentary except 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. Movement of the infested soil can result in the nematode movement (Arjoune *et al*., 2022), for example via farming tools, wind, flooding, birds and other animals, infested seed, plant parts, and footwear. The infested soil particles may adhere to the farming equipment and machinery and be transported to a new area. 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 plants.

PEST SIGNIFICANCE

Economic impact

Heterodera glycines is a major pest of soybeans in Asia and the USA. In Japan, yield loss in infested plants was estimated to be 10–75% (Inagaki, 1977; Ichinohe, 1988). In the USA, this nematode is responsible for more than 1.2 billion USD in yield losses (Koenning & Wrather, 2010). This nematode caused soybean yield losses of up to 617.4 billion bushels in 28 states in the USA and in Ontario, Canada during 2010 to 2014 (Allen *et al.*, 2017). *H. glycines* is also a pest on *Phaseolus vulgaris* (Yan *et al.*, 2017). In dry edible bean, field research has demonstrated that *H. glycines* can cause seed yield reduction up to 50% in susceptible cultivars (Poromarto *et al*., 2010). It also affects nodule formation on roots by interfering with the activity of nitrogen-fixing bacteria. *Heterodera glycines* can facilitate infection by other pathogens or enhance severity of other diseases in soybean such as sudden death syndrome and brown stem rot.

Control

Once in the field, it is almost impossible to eliminate *H. glycines* completely, so it is important to prevent the nematode spreading to new fields. The nematodes in infested fields can be controlled by the use of resistant cultivars, crop rotation and nematode-protectant seed treatments or, more effectively, by nematicides in combination with long crop rotation and the use of resistant cultivars in a flexible integrated plant production system. New resistant cultivars and germplasm are sought, since populations of resistance-breaking pathotypes are developing in the field.

Phytosanitary risk

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. Its presence in Northern Italy demonstrates that it has the potential to establish, at least in some parts of the EPPO region. However, *H. glycines* would only establish itself and become a pest of economic importance where the principal host, soybeans, are widely cultivated in close rotations or monoculture.

Although soybean 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 soybeans. Croatia, France, Hungary, Italy, Kazakhstan, Romania, the Russian Federation and Ukraine are soybean producers (FAOSTAT, 2007). With the rising demand for plant proteins, the soybean production areas across Europe have increased rapidly in recent years, with a production up to 2.9?million?tonnes in 2018 (FAOSTAT, 2022). This makes it particularly important to exclude soybean pests not yet introduced into the region, and to limit the spread of pests that are not widely present.

PHYTOSANITARY MEASURES

Imports of soil, rooted plants and seed with soil from countries where this nematode occurs should be restricted.

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ACKNOWLEDGEMENTS

This datasheet was revised in 2023 by Dr. Guiping Yan, North Dakota State University. Her valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2025) *Heterodera glycines*. EPPO datasheets on pests recommended for regulation. Available online. https://gd.eppo.int

Datasheet history

This datasheet was first published in the EPPO Bulletin in 1989 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 2023. It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', ‘Hosts’, and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

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Co-funded by the
European Union