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Soybean Cyst Nematode, *Heterodera glycines* (Ichinohe, 1952) (Chromadorea: Rhabdita: Heteroderidae)[1]

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The Featured Creatures collection provides in-depth profiles of insects, nematodes, arachnids and other organisms relevant to Florida. These profiles are intended for the use of interested laypersons with some knowledge of biology as well as academic audiences.

Introduction

The nematode *Heterodera glycines,* known as soybean cyst nematode (SCN) (Figure 1), is the most economically damaging pest of soybean crops in the United States and around the world (Hunt, 2008; Yu, 2011; Zhou et. al., 2017; The SCN Coalition, 2023). Members of the *Heteroderidae* family belong in the order Rhabditida; most are plant parasitic while some are insect parasites. They are obligate parasites that attack different species of crops and weeds. The word heteros in Greek means 'other', deras 'skin' (Siddiqi, 2000). Heteroderidae are divided into two groups, cyst and cystoid, based on morphological alterations in their skin (Nemaplex, 2023). The cyst group are unique in that the female skin changes, transforming into a hardened cyst that protects her eggs. Unlike many plant parasites, there may be little to no aboveground evidence of an infestation with *H. glycines* (Constantino, 2021). They are incredibly damaging to the agricultural economy and impossible to eradicate once established. With proper management, it is possible to minimize *H. glycines* populations and maximize yield.

Figure 1. Heterodera glycines (soybean cyst nematode) 2nd-stage juvenile.
Credits: Zane Grabau, UF/IFAS

Distribution

Heterodera glycines is largely found in places where soybeans are grown commercially. Ichinohe first reported *Heterodera glycines* in Japan in 1915 (Riggs, 1977), though some sources reference material from 1952. It may have been previously identified and grouped as *H. schachtii,* which was reported in the 1880s (Ferris, 2023). As soybeans first originated in China, it is assumed that *H. glycines* originated there as well (Yu, 2011).

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After escaping mainland China, soybean cyst nematode spread rapidly from Asia to other parts of the world through trade, wind, and animal migration. Currently, this pest is found in several countries throughout Africa, Asia, North and South America (Yu, 2011; Mesa-Valle, 2020). It also has a limited distribution in Europe, being found in 3 soybean fields in Italy in 2000 (Manachini, 2000) and 1 field each in 2018 and 2020 (Perin et al., 2021). In the United States, it is concentrated in the Midwest, Mid-South, and Southeast. *H. glycines* was first recognized in North Carolina in 1954 (Schmitt, 1991). Since then, it has spread to more than twenty-five states, including Florida (Figure 2).

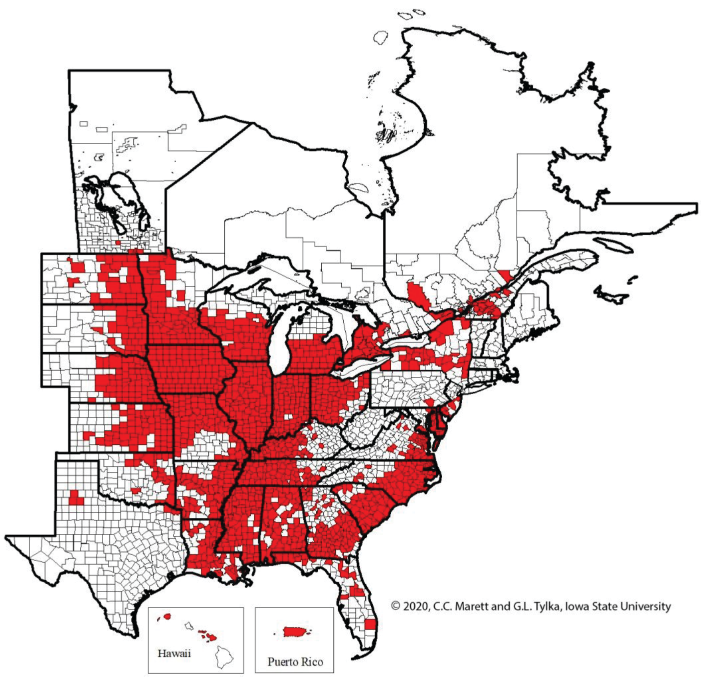

Figure 2. Distribution of *Heterodera glycines* (soybean cyst nematode) in the United States and Canada as of 2020.
Credits: G.L. Tylka and C.C. Marett, Iowa State University. Used with permission.

Description

Heterodera glycines is a nematode that differs in morphological appearance among growth stages. They appear similar to other species in the *Heterodera schachtii* group. The body length of *H. glycines* 2nd-stage juveniles is 375–540 m with a stylet of 22.0–26.0 m. The tail measures between 40.0–61.0 m and the hyaline tail part is 21.0-33.0 m (EPPO, 2018). Stylet knobs are concave anteriorly (Figure 3). Second-stage juveniles have a vermiform shape with a sharp taper at the tail and a slight taper in the head region. The head appears offset with 3–4 annules (Figure 4). The lateral field continues to have four incisures and the tail rounded.

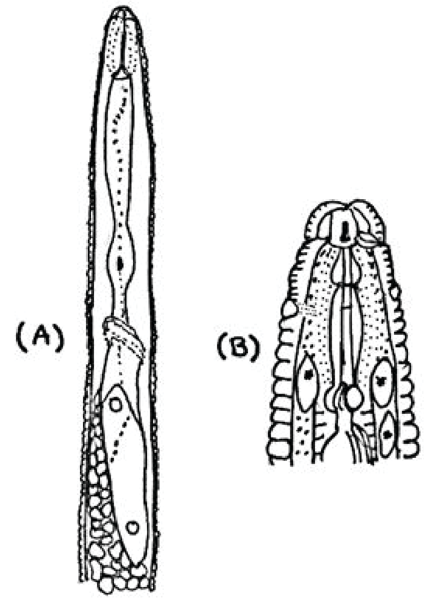

Figure 3. The (A) male anterior and (B) head of male for *Heterodera glycines* (soybean cyst nematode).
Credits: Holly Andres, University of Florida

Figure 4. *Heterodera glycines* (soybean cyst nematode) 2nd-stage juvenile head featuring an offset head and robust stylet with knobs.
Credits: Zane Grabau, UF/IFAS

Males have a rounded tail and regular, annulated cuticle. The head has 4–5 annules and four incisures in the lateral field. Their stylet is stout with lateral knobs protruding anteriorly. The gubernaculum is present. Spicules are well formed and ventrally curved.

Females have a lemon shape and a neck that projects (Figure 5). They are white to light yellow and turn more yellow as they mature. The cysts are also shaped like a lemon with a projecting cone and neck. They are approximately 340–920 m long and 320–610 m wide. Females have reticulate ridges along their bodies with no annulation or lateral incisures. There is a prominent sub-crystalline layer. The head skeleton is hexaradiate. Females contain an egg sac that resembles a gel-like grid which holds 200–500 eggs. Their stylet is narrower with knobs that project at an angle, posteriorly. Young, sedentary females have coiled ovaries that are paired, opening posteriorly through the vulva. The vulva is enclosed by the semifenestrae, which has thin walls and a crescent shape. Bullae are distributed below the well-developed underbridge and are elongated and pronounced. In young cysts, the vulval region remains intact. When the female matures, the body wall changes from yellow to a brown cyst that encases the eggs after death. As the cyst ages, the wall becomes thin and divides, exposing an open fenestra divided by a vulval bridge (Figure 6). These are called ambifenestrate (EPPO, 2018).

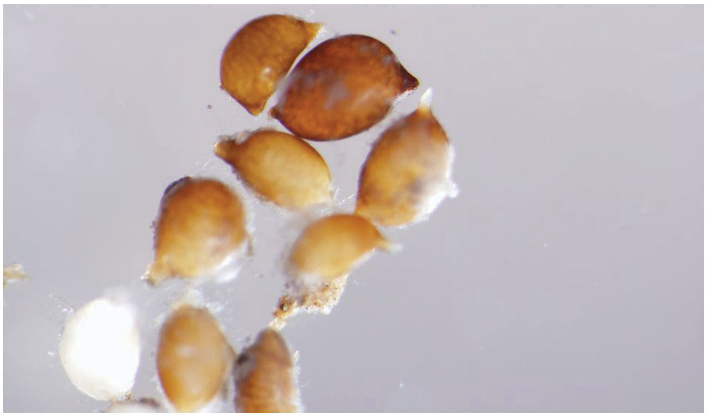

Figure 5. Mature brown cysts and immature yellow cysts of *Heterodera glycines* (soybean cyst nematode). Note the longer protruding neck on the anterior end and shorter posterior cone. Together, these projections give the nematode its characteristic lemon shape.
Credits: Zane Grabau, UF/IFAS

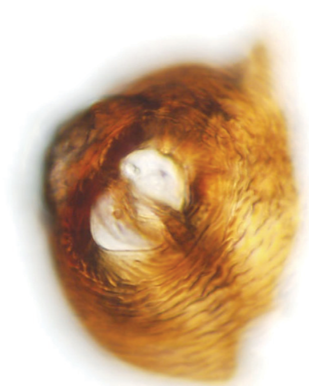

Figure 6. Dissected terminal end of *Heterodera glycines* (soybean cyst nematode) female showing the two crescent-shaped semifenestrae in the vulval region that form the ambifenestrae.
Credits: Zane Grabau, UF/UFAS

Life Cycle and Biology

The life cycle of *H. glycines* lasts between 3–4 weeks, should conditions be favorable (Davis and Tylka, 2021). In *H. glycines,* the cyst serves as a survival or overwintering structure that contains eggs. They undergo J1 molt to J2 inside the egg (Figure 7). At this point, they hatch from the egg using both a stylet and protein enzymes that help dissolve the egg wall (Gardner, 2017).

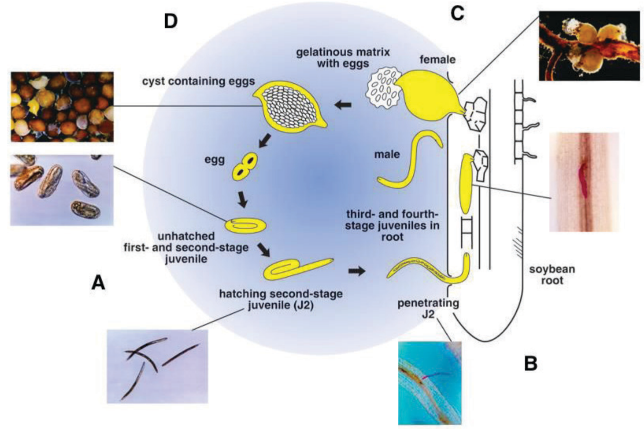

Figure 7. *Heterodera glycines* (soybean cyst nematode) life cycle.
Credits: Dirk Charlson, Iowa State University. Used with permission.

Hatching is a response to chemical signaling from host plants (Giesler and Wilson, 2011). Once hatched, soybean cyst nematodes use their stylet to pierce a host plant's root and move intra- and intercellularly toward the vasculature. Inside the vasculature, the parasite excretes effector proteins which cause a syncytium to form (Figure 8) so that the plant will nourish the parasite continuously as it loses its motility (Koenning, 2004; Gheysen and Mitchum, 2011). Inside of the syncytium, *H. glycines* undergoes three more molts at which point male and female adults will emerge.

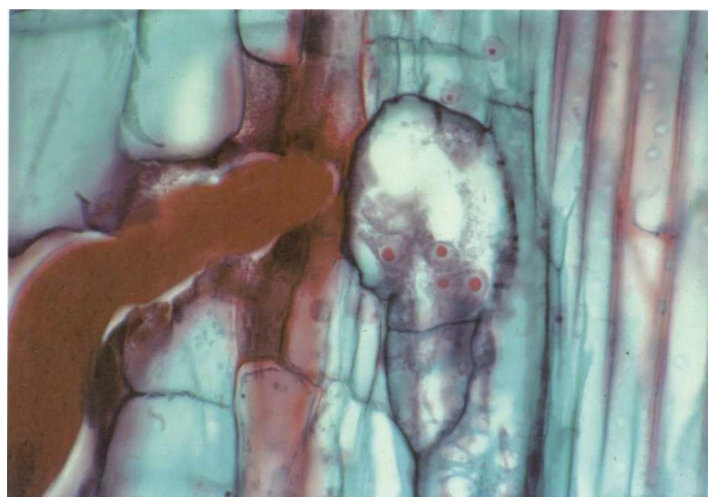

Figure 8. Syncytium (multi-nucleated cell) inside of soybean vasculature tissue functions as a nutrient deposit for *Heterodera glycines* (soybean cyst nematode) feeding.
Credits: Adapted from Burton Y. Endo, National Agricultural Library, Agricultural Research Service, U.S. Department of Agriculture.

SCN reproduce sexually (Koenning, 2004). Males take on a vermiform body type and exit the root to find a female for mating at which point it completes its life cycle. The female are pyriform and remain stationary. After sexual differentiation, the female begins to swell with eggs until her posterior bursts from the root and can be seen on the exterior of the host root (Figure 7) (Chowdhury et. al., 2022). Eventually the female dies; her body darkens to a brown color and hardens, encasing the eggs inside. At this point, the cysts fall off into the soil and eggs inside the cyst remain dormant until environmental cues begin the cycle again (i.e., temperature, seasonality, food resources, host plant chemical signaling) (Davis and Tylka, 2021).

Symptoms and Diagnosis

It can be difficult to diagnose an infestation since aboveground symptoms mimic many other plant ailments. Plants may not exhibit symptoms if the infection rate is low. When *H. glycines* have high populations within agricultural systems, plants could have chlorosis or stunted growth (Figure 9) (Musil, 2016). Often, there are no above ground symptoms and the only indication of infestation is decreased yield. Yield losses of more than 30% are possible with no visible symptoms present (Allen et. al., 2017). Belowground, lemon-shaped female cysts may be visible on roots as signs of infection and are much smaller than nitrogen-fixing soybean nodules (Figure 10). These cysts can be visible with the naked eye or more readily with a hand lens, so can be used as a preliminary diagnostic tool.

Figure 9. Soybeans with stunted growth and lower production indicate soybean cyst nematode infection.
Credits: Senyu Chen, University of Minnesota. Used with permission.

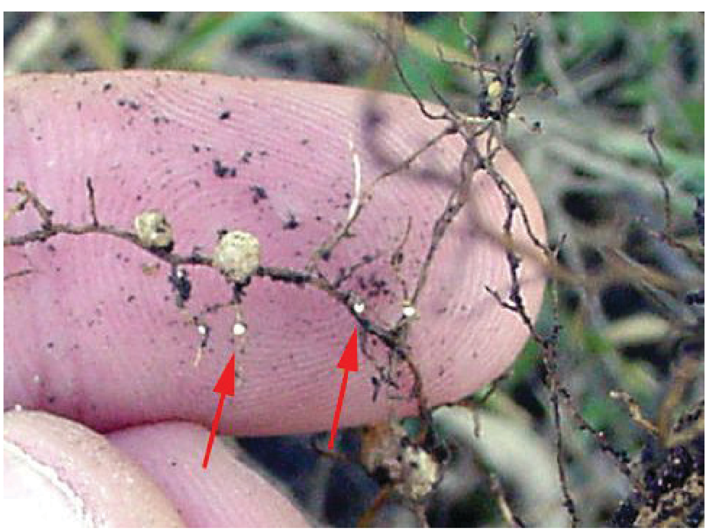

Figure 10. Female *Heterodera glycines* (soybean cyst nematode), indicated by red arrows, on infected soybean root illustrating size relative to larger N-fixing nodules, *Heterodera glycines*.
Credits: Greg Tylka, Iowa State University. Used with permission.

It is important to watch fields closely to detect *H. glycines* infestation early. Aside from monitoring yield, assessing *H. glycines* in soil or root samples is necessary. The presence of *H. glycines* can be confirmed by extracting and quantifying *H. glycines* juveniles from soil using routine extraction for a variety of nematodes, such as that performed in the UF/IFAS Nematode Assay Lab. As described above, checking for cysts on gently washed plant roots (Chen et. al., 2021) is another way to confirm the presence of *H. glycines*. However, these methods do not always provide an accurate measurement of the severity of *H. glycines* infestation. In regions where *H. glycines* is common, quantifying cysts or eggs released from cysts from a soil sample is the recommended method for *H. glycines* quantification. The HG type test is also an important *H. glycines* diagnostic tool (Niblack et al., 2002). This test quantifies the reproduction of *H. glycines* from a given field on various soybean lines that serve as the sources for *H. glycines* resistance in commercial soybean cultivars (Niblack et al., 2002). This is an important tool for selecting a resistant soybean cultivar to grow in a given field, as explained further under “Host Resistance” in the “Management” section. Professional diagnostic clinics in areas where *H. glycines* is common routinely provide services for HG type testing and quantification of cysts or eggs from soil.

Hosts

The primary host is soybean. Anywhere in the United States soybeans are grown, *H. glycines* is often present. However, *H. glycines* attacks several members of crops, primarily from the Fabaceae family, both ornamental and edible species, although plants from a number of other families are also hosts (EPPO, 2008; Rocha et. al., 2021). Several broadleaf species such as field pennycress, common mallow, Canada thistle, common cocklebur have been reported as potential hosts in the Midwest (Johnson et. al., 2008; Venkatesh et. al., 2000; Creech et. al., 2007; Poromarto et. al., 2015). Table 1 highlights some soybean cyst nematode hosts, roughly in order of prevalence.

For crop managers it is important to know which weeds are hosts to *H. glycines*. Practices such as cover cropping or intercropping could potentially exacerbate the problem if a host of *H. glycines* is selected. Particularly in warmer regions, if winter annual weeds (hosting *H. glycines*) are left in crop fields, they could also increase *H. glycines* populations into the spring when crops are sown. This would perpetuate *H. glycines* life cycle through resource amplification.

Economic Importance

H. glycines is the most devastating parasite to soybean producers. It is estimated that total losses from *H. glycines* between 1996 and 2016 were $95.48 billion dollars (Bandara et. al., 2020). As of 2020, economic losses from *H. glycines* are approximately $1.5 billion each year (The SCN Coalition, 2021). *H. glycines* causes double the losses of all other individual diseases, comparatively on soybean crops in the United States (Allen et. al., 2017). When cultivars that are susceptible to *H. glycines* are selected, crop yield can decrease 60% (Hershman, 2015). In the United States, there are more than 70 million acres planted with soybean (USDA-NASS, 2023). The US is the foremost producer of soybeans globally. Soybeans comprise 90% of the US oilseed production sector (USDA-ERS, 2022). Losses in yield can be devastating to both profits and global supply chain demand.

Management

There are several categories of management practices currently utilized among growers and agricultural managers, although not each technique will be applicable in every situation. Agricultural managers may choose the best practices tailored for their needs. Some of these management practices can include: Prevention, Sanitation, Crop Rotation, Host Resistance, Nematicides, Biocontrols, and Cultural Practices.

Prevention: *H. glycines* persists in the soil indefinitely once it becomes established. Therefore, prevention is the best method of management. Soybean cyst nematode quarantine restricts movement of the pest from infected sites, which has been effective in certain states such as California (CDFA, 2021).

Sanitation: Closely related to prevention, sanitation practices are used to limit the movement of *H. glycines* since redistribution is thought to rely largely on human intervention. For example, tillage practices relocate cysts as they move soil within a field (Mangel, 2023). Soil carried on equipment can also transport *H. glycines* among fields, so cleaning equipment between fields can limit spread from mechanization (Ferris, 2023).

Crop Rotation: Once established in a field, current management practices involve managing this parasite to minimal numbers for maximum yield. Crop rotation with nonhost crops is part of an integrated pest management strategy to accomplish this. Since SCN is an obligate parasite, crop rotation with nonhost varieties prohibits it from reaching maturity and producing progeny (Davis and Tylka, 2021). Some nonhost crops include alfalfa, barley, canola, clover, corn, cotton, forage grasses, oats, rye, sorghum, tobacco, and wheat (Wrather and Mitchum, 2010).

Host Resistance: Another useful practice is planting resistant varieties. A single soybean line, PI 88788, has long been the predominant source of resistance in commercial soybean cultivars (Tylka, 2022). A few other sources of resistance, namely Peking, are also available in some soybean cultivars (Tylka, 2022). Because of the reliance on PI 88788-derived resistance, *H. glycines* populations have shifted increasingly such that populations from many fields can readily reproduce on PI 88788 cultivars (Tylka, 2022). In those fields, cultivars with PI 88788 resistance will have reduced efficacy. For this reason, rotating sources of resistance is important to delay population shifts in fields where this has not occurred. Furthermore, conducting HG type testing, as described above, is important for selecting a resistant cultivar that will be effective against the *H. glycines* population in a given field, particularly in areas with a history of this nematode in soybean production.

Nematicides: Some growers prefer to use nematicides to control *H. glycines*. Many nematicides provide temporary control; however, some are less effective due to the rapid growth cycle of *H. glycines*. In addition, nematicides cannot control *H. glycines* through the entire growing season, and infestation populations may be higher at the end of the season even with treatment (Tylka, 1994). Further information on management tips for *H. glycines* can be found in the UF/IFAS EDIS on nematode management in Florida soybean (Grabau, 2023).

Biocontrol: An alternative to chemical usage is biological control. Certain bacteria, fungi, and predatory nematodes can destroy *H. glycines.* It is important to note that only a few species are available for commercial applications, although there is continued research and progress in this field.

Cultural Practices: Controlling annual, winter weeds that host *H. glycines* reduces population density and subsequent pest pressure on profitable crops (Niblack and Tylka, 2008). Lastly, ensuring that plants have optimal nutrients and water will help to maintain yield and prevent susceptibility from stress. When plants are healthy and thriving, they are better able to resist infection and maintain yield.

References

Allen TW, Bradley CA, Sisson AJ, Byamukama E, Chilvers MI, Coker CM, Collins AA, Damicone JP, Dorrance AE, Dufault NS, Esker PD, Faske TR, Giesler LJ, Grybauskas AP, Hershman DE, Hollier CA, Isakeit T, Jardine DJ, Kelly HM, Kemerait RC, Kleczewski NM, Koenning SR, Jurle JE, Malvick DK, Markell SG, Mehl HL, Mueller DS, Mueller JD, Mulrroney RP, Nelson BD, Newman MA, Osborne L, Overstreet C, Padgett GB, Phipps PM, Price PP, Sikora EJ, Smith DL, Spurlock TN, Tande CA, Tenuta AU, Wise KA, Wrather JA 2017. Soybean yield loss estimates due to diseases in the United States and Ontario, Canada, from 2010 to 2014. *Plant Health Progress* 18(1): 19-27. https://doi.org/10.1094/PHP-RS-16-0066

Bandara AY, Weerasooriya DK, Bradley CA, Allen T, Esker PD. 2020. Dissecting the economic impact of soybean diseases in the United States over two decades. *PLOS ONE* 15(4): e0231141. https://doi.org/10.1371/journal.pone.0231141

California Department of Food & Agriculture (CDFA). 2021. California pest rating proposal for *Heterodera glycines* Ichinohe,1952. CDFA Pest Rating Proposals and Final Ratings. (revised 22 July 2021). https://blogs.cdfa.ca.gov/Section3162/wp-content/uploads/2021/06/Heterodera_glycines_ADA_PRP-1.pdf

Chen S, Kurle J, Malvick D, Potter B, Orf J. 2021. Soybean cyst nematode management guide. University of MinnesotaExtension. https://extension.umn.edu/soybean-pest-management/soybean-cyst-nematode-management-guide#management-goals-1497860

Chowdhury IA, Yan G, Halvorson J, Thapa A, Halvorson M, Markell S. 2022. Soybean cyst nematode. PP1732. North Dakota State University Extension. https://www.ndsu.edu/agriculture/extension/publications/soybean-cyst-nematode

Constantino N, Oh Y, Sennik E, Andersen B, Warden M, Oralkan Ö, Dean RA. 2021. Soybean cyst nematodes influence aboveground plant volatile signals prior to symptom development. *Frontiers in Plant Science* 12:749014. https://doi.org/10.3389/fpls.2021.749014

Creech JE, Johnson WG, Faghihi J, Ferris VR, Westphal A. 2005. First report of soybean cyst nematode reproduction on purple deadnettle under field conditions. *Crop Management* 4: 1-2. https://doi.org/10.1094/CM-2005-0715-01-BR

Creech JE, Webb JS, Young BG, Bond JP, Harrison SK, Ferris VR, Faghihi J, Westphal A, Johnson WG. 2007. Development of soybean cyst nematode on henbit (*Lamium amplexicaule*) and purple deadnettle (*Lamium purpureum*). *Weed Technology* 21: 1064–1070. https://doi.org/10.1614/WT-07-079.1

Davis, EL, Tylka, GL. 2021. Soybean cyst nematode disease. *The Plant Health Instructor*. https://doi.org/10.1094/PHI-I-2000-0725-02

Donald P, Hayes R, Walker E. 2007. Potential for soybean cyst nematode reproduction on winter weeds and cover crops in Tennessee. *Plant Health Progress* 8:1-6.

European and Mediterranean Plant Protection Organization (EPPO). 2018. PM 7/89 (2)*Heterodera glycines*. *EPPO Bulletin*48: 64–77. https://doi.org/10.1111/epp.12453

European and Mediterranean Plant Protection Organization (EPPO). 2008. *Heterodera glycines*. *EPPO Bulletin* 38(3): 379-389. https://doi.org/10.1111/j.1365-2338.2008.01249.x

Ferris H. 2023. *Heterodera glycines*. Nemaplex website, UC Davis. (revised 16 October 2023). http://nemaplex.ucdavis.edu/Taxadata/G060s4.aspx

Gardner MN. 2017. Genetic and molecular analysis of soybean cyst nematode virulence. Dissertation. University of Missouri.

Gheysen G, Mitchum MG. 2011. How nematodes manipulate plant development pathways for infection. *Current Opinion in Plant Biology* 14(4): 415-421. https://doi.org/10.1016/j.pbi.2011.03.012

Giesler LJ, Wilson, JA. 2011. Soybean cyst nematode: Identification and management. G1383. University of Nebraska- Lincoln Extension. https://extensionpublications.unl.edu/assets/html/g1383/build/g1383.htm

Goodey J B, Franklin MT, Hooper DJ. 1965. T. Goodey's: The Nematode Parasites of Plants Catalogued Under Their Hosts. Third Edition. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England.

Grabau ZJ. 2023. Management of plant parasitic nematodes in soybean production. ENY-003. *EDIS 2023*. https://edis.ifas.ufl.edu/publication/NG018

Hershman DE. 2015. 2015Soybean cyst nematode (SCN) management recommendations for Kentucky. PPFS-AG-S-24. *Plant Pathology Fact Sheet*. University of Kentucky. https://plantpathology.ca.uky.edu/files/ppfs-ag-s-24.pdf

Hunt D. 2008. *Heterodera glycines* (soybean cyst nematode). CABI Compendium. https://doi.org/10.1079/cabicompendium.27027

Johnson WG, Earl Creech J, Mock, VA 2008. Role of winter annual weeds as alternative hosts for soybean cyst nematode. *Crop Management*7: 1–9. https://doi.org/10.1094/CM-2008-0701-01-RV

Koenning SR. 2004. Population biology. *In*: Schmitt, D. P., Riggs, R. D., & Wrather, J. A. (Eds.) Biology and Management of Soybean Cyst Nematode. Schmitt & Associates of Marceline, Marceline, Mo.

Manachini, B. 2000. First report of *Heterodera glycines* Ichinohe on soybean in Italy. *Bolletino di Zoologia Agraria e di Bachicoltura, Serie II* 32(3): 261-267.

Mangel D. 2023. Soybean cyst nematode. *CROPWATCH*. University of Nebraska-Lincoln Institute of Agriculture and Natural Resources. https://cropwatch.unl.edu/plantdisease/soybean/soybean-cyst-nematode

Mesa-Valle CM, Garrido-Cardenas JA, Cebrian-Carmona J, Talavera M, Manzano-Agugliaro F. 2020. Global research on plant nematodes. *Agronomy* 10(8): 1148. https://doi.org/10.3390/agronomy10081148

Musil KM. 2016. Evaluations of biological control agents for the management of soybean cyst nematode (*Heterodera glycines)* in soybean (*Glycine max* L. Merr.). Thesis. University of Nebraska – Lincoln.

Nemaplex. 2023. Family Heteroderidae. Nemaplex website. UC Davis. (revised 14 October 2023). http://nemaplex.ucdavis.edu/Taxadata/heteidae.htm

Niblack TL, Arelli PR, Noel GR, Opperman CH, Orf JH, Schmitt DP, Shannon JG, Tylka GL. 2002. A revised classification scheme for genetically diverse populations of *Heterodera glycines*. *Journal of Nematology* 34(4): 2379-288.

Niblack TL, Tylka GL (Eds.). 2008. SCN soybean cyst nematode management guide (5th ed.). Plant Health Initiative.

Perin S, Governatori G, Braghin A. 2021. Primo ritrovamento del nematode cisticolo della soia (Heterodera glycines) in Friuli Venezia Giulia. *Notiziaro ERSA* 1: 28-30. http://www.ersa.fvg.it/export/sites/ersa/aziende/informazione/notiziario/allegati/2021/1/8_NEMATODE.pdf

Poromarto SH, Gramig GG, Nelson BD Jr., Jain S. 2015. Evaluation of weed species from the Northern Great Plains as hosts of soybean cyst nematode. *Plant Health Progress*16: 23–28. https://doi.org/10.1094/PHP-RS-14-0024

Riggs RD. 1977. Worldwide distribution of soybean-cyst nematode and its economic importance. *Journal of Nematology* 9(1): 34-39.

Riggs RD, Hamblen M. 1962. Soybean-cyst nematode host studies in the family *Leguminosae*. Arkansas Agricultural Experiment Station Bulletin 50: 1-18.

Riggs RD and Hamblen M. 1966. Additional weed hosts of *Heterodera glycines. Plant Disease* 50: 15.

Rocha LF, Gage KL, Pimentel MF, Bond JP, Fakhoury AM. 2021. Weeds hosting the soybean cyst nematode (Heterodera glycines Ichinohe): Management implications in agroecological systems. *Agronomy* 11(1): 146. https://doi.org/10.3390/agronomy11010146

Schmitt DP. 1991. Management of *Heterodera glycines* by cropping and cultural practices. *Journal of Nematology* 23(3): 348–352.

The SCN Coalition. 2021. SCN keeps spreading, economic losses increasing. Blog. (released 25 January 2021). https://www.thescncoalition.com/news/2021/01/25/scn-economic-loss/

The SCN Coalition. 2023. SCN is the North America's most damaging soybean pathogen. Let's Talk Todes Video Library. (released 20 January 2023). https://www.thescncoalition.com/lets-talk-todes/

Siddiqi MR. 2000. Tylenchida:Parasites of Plants and Insects (2nd ed.). CABI, Wallingford, UK. https://doi.org/10.1079/9780851992020.0000

Tylka G. 1994. Soybean cyst nematode. Iowa State University Extension.https://nematode.unl.edu/scn/scnisu.htm

Tylka G. 2022. More soybean varieties with Peking SCN resistance for 2023, but more needed. *Integrated Crop Management News*. Iowa State University. (released 22 November 2022). https://crops.extension.iastate.edu/cropnews/2022/11/more-soybean-varieties-peking-scn-resistance-2023-more-needed

https://doi.org/10.37578/QACM6312

USDA-NASS. 2023. Crop production: 2022 Summary (January 2023). USDA-NASS,Washington DC.https://downloads.usda.library.cornell.edu/usda-esmis/files/k3569432s/9306v916d/wm119139b/cropan23.pdf

USDA-ERS. 2022. Oil crops sector at a glance. USDA-ERS website. (updated 23 October 2023). https://www.ers.usda.gov/topics/crops/soybeans-and-oil-crops/oil-crops-sector-at-a-glance/

Venkatesh R, Harrison SK, Riedel RM. 2000. Weed hosts of soybean cyst nematode (*Heterodera glycines*) in Ohio. *Weed Technology* 14: 156–160. https://doi.org/10.1614/0890-037X(2000)014[0156:WHOSCN]2.0.CO;2

Wrather A, Mitchum M. 2010. Soybean cyst nematode: Diagnosis and management. Publication No. G4450. University of Missouri Extension. https://extension.missouri.edu/publications/g4450

Yu Q. 2011. Soybean cyst nematode (*Heterodera glycines* Ichinohe). *In:* Soybean Physiology and Biochemistry. El-Shemy H. (Ed.). IntechOpen, London, UK. https://doi.org/ 10.5772/17649

Zhou Y, Wang Y, Zhu X, Liu R, Xiang P, Chen J, Liu X, Duan Y, Chen L. 2017. Management of the soybean cyst nematode *Heterodera glycines* with combinations of different rhizobacterial strains on soybean. PloS one, 12(8): e0182654. https://doi.org/10.1371/journal.pone.0182654

Table 1. Examples of *Heterodera glycines* specific hosts in crop and weed species.

Scientific Name	Common Name	Reference
Hosts for *Heterodera glycines*		
Crop Species		
Trifolium hybridum	Alsike clover	Poromarto et. al., 2015
Lotus corniculatus	Bird's foot trefoil	Goodey et. al., 1965
Vicia sativa, Vicia villosa	Common vetch, hairy vetch	Goodey et. al., 1965
Vigna ungulculata	Cowpea	Goodey et. al., 1965
Trifolium incarnatum	Crimson clover	Poromarto et. al., 2015
Coronilla varia	Crownvetch	Venkatesh et. al., 2000
Phaseolus vulgaris	Common bean	Goodey et. al., 1965
Lespedeza spp.	Peas	Goodey et. al., 1965
Pisum spp.	Legumes	Goodey et. al., 1965
Melilotus officinalis	Yellow sweet clover	Goodey et. al., 1965
Lupinus	Lupines	Goodey et. al., 1965
Weed Species		
Vicia americana, Vicia caroliniana	American vetch, Carolina wood vetch	Donald et. al., 2007
Verbascum thapsus	Mullein	Riggs and Hamblen, 1962
Thlaspi arvense	Field pennycress	Venkatesh etl. al., 2000
Sesbania	Danchi, Sesbania	Goodey et. al., 1965
Lamium amplexicaule	Henbit	Riggs and Hamblen, 1962
Medicago lupulina	Black medic	Riggs and Hamblen, 1962
Vicia sylvatica	Wood vetch	Donald et. al., 2007
Phytolacca americana	American pokeweed	Riggs and Hamblen, 1966
Lamium purpureum	Purple deadnettle	Creech et. al., 2005
Portulaca oleracea	Little hogweed	Riggs, 1962
Capsella bursa-pastoris	Shepherd's purse	Venkatesh et. al., 2000
Rhamphospermum arvense	Field/wild mustard	Venkatesh et. al., 2000