

EPPO Datasheet: *Hirschmanniella oryzae*

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IDENTITY

Preferred name: *Hirschmanniella oryzae*

Authority: (van Breda de Haan) Luc & Goodey

Taxonomic position: Animalia: Nematoda: Chromadorea: Rhabditida: Pratylenchidae

Other scientific names: *Anguillulina oryzae* (van Breda de Haan) Goodey, *Hirschmannia oryzae* (van Breda de Haan) Luc & Goodey, *Hirschmanniella abnormalis* Renubala, Dhanachand & Gambhir, *Hirschmanniella apapillata* (Imamura) Siddiqi, *Hirschmanniella exacta* Kakar, Siddiqi & Khan, *Hirschmanniella exigua* Khan, *Hirschmanniella nana* Siddiqi, *Radopholus oryzae* (van Breda de Haan) Thorne, *Tylenchus oryzae* van Breda de Haan

Common names: rice root nematode

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EPPO Code: HIRSOR



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Notes on taxonomy and nomenclature

Among about 29 documented species of rice root nematodes (*Hirschmanniella* spp.), *Hirschmanniella oryzae* is the most predominant and recorded species (Khun *et al.*, 2015). It was first reported on rice grown in Java (Indonesia) by Van Breda de Haan in 1902 under the name of *Tylenchus oryzae*. Since then, this nematode has been referred to by different names and later changed name to *Hirschmanniella oryzae* (Luc & Goodey, 1963). On rice, *H. oryzae* is often found together with other closely related species; *H. imamuri* (Ichinohe, 1988) *H. spinicaudata* (Babatola, 1984). Therefore, it is likely that the literatures earlier than 1968 might report mixed species of *Hirschmanniella* found in rice root as *H. oryzae* (Siddiqi, 1973; MacGowan, 1979).

HOSTS

Rice (*Oryza sativa*) is the major host of the rice root nematode *Hirschmanniella oryzae*. Damage to rice caused by *H. oryzae* is widely reported (Cuc & Prot, 1992; Peng *et al.*, 2018); however, population levels of the nematode vary depending on rice varieties (Maung *et al.*, 2010; Anwar *et al.*, 2011).

Several authors (Ibrahim *et al.*, 2010; Anwar *et al.*, 2011; Abd-Elbary *et al.*, 2012) have reported that weeds growing in and around rice fields are hosts of *H. oryzae*. Plants in the families of Cyperaceae, Poaceae, Sphenocleaceae are classified as good hosts (Ibrahim *et al.*, 2010; Anwar *et al.*, 2011; Abd-Elbary *et al.*, 2012; Maung *et al.*, 2013).

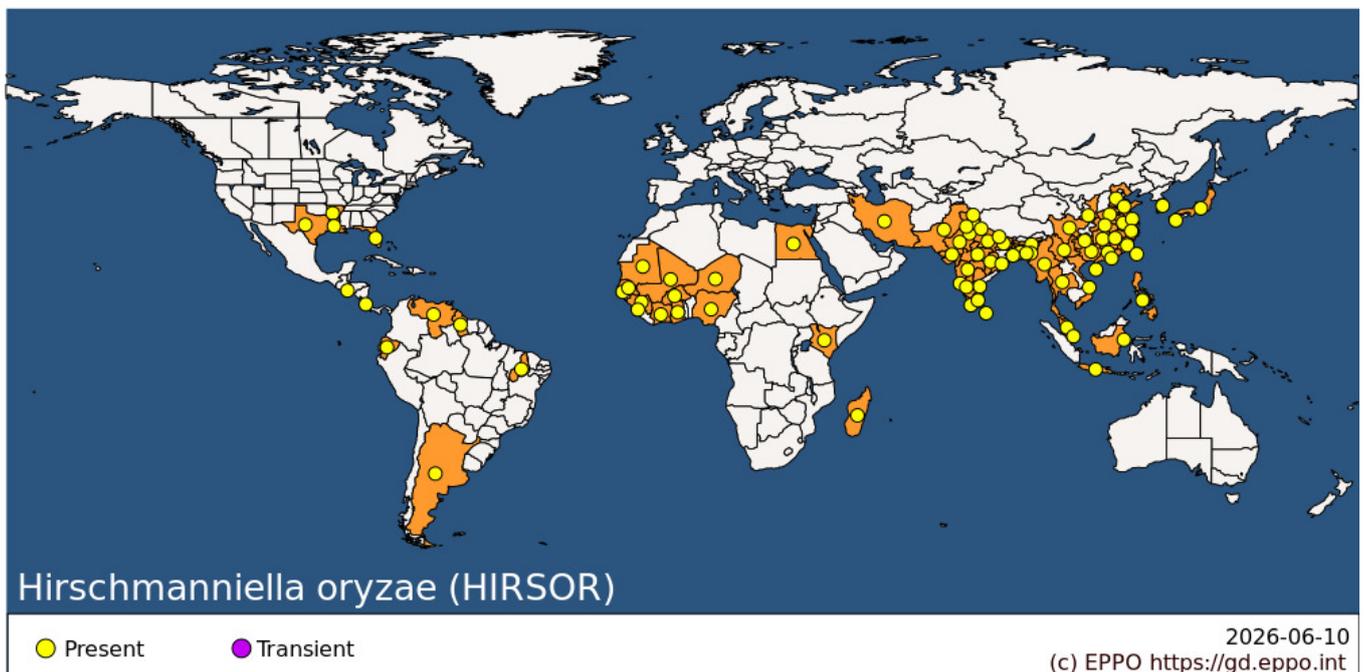
There are diverging reports in the literature regarding the association of *H. oryzae* with cultivated crops other than rice. Babatola (1979) and Prasad *et al.* (1987), citing other authors, refer to findings of *H. oryzae* in association with cotton (*Gossypium hirsutum*), sugarcane (*Saccharum officinarum*), wheat (*Triticum aestivum*) and pearl millet (*Cenchrus americanus*). Other authors have reported that *H. oryzae* does not infect or multiply in the roots of cotton, maize and wheat (Mathur & Prasad, 1973; Youssef & Eissa, 2014). In Egypt, although low population levels of *H. oryzae* could be found in soil from wheat crops (Eissa *et al.*, 2013; Korayem *et al.*, 2019), no *H. oryzae* was extracted from wheat roots (Eissa *et al.*, 2013). In experiments, wheat, cotton, sugarcane, pearl millet, maize (*Zea mays*), okra (*Abelmoschus esculentus*) and tomato (*Solanum lycopersicum*) were documented as susceptible to *H. oryzae* (Babatola, 1979; Prasad *et al.*, 1987). However, for cotton, wheat and maize and other crops, Abd-Elbary *et al.* (2012) and Mathur & Prasad (1973) do not support these findings since the nematode failed to penetrate and/or multiply inside roots of tested crops. Finally, *H. oryzae* was found associated with rhizomes of the aquatic ornamental plant *Cryptocoryne* spp. (Araceae) imported into Europe (EPPO, 1976), though no further information was documented afterwards.

Host list: *Amaranthus caudatus*, *Bolboschoenus maritimus*, *Chenopodium murale*, *Chenopodium album*, *Cryptocoryne crispata* var. *albida*

, *Cryptocoryne*, *Cyperus compressus*, *Cyperus difformis*, *Cyperus elatus*, *Cyperus haspan*, *Cyperus iria*, *Cyperus pilosus*, *Cyperus platystylis*, *Cyperus procerus*, *Cyperus pulcherrimus*, *Cyperus rotundus*, *Cyperus sanguinolentus*, *Echinochloa colonum*, *Echinochloa crus-galli*, *Echinochloa glabrescens*, *Echinodorus grisebachii*, *Echinodorus hybrids*, *Eleocharis spiralis*, *Eleusine indica*, *Fimbristylis ferruginea*, *Fimbristylis globulosa*, *Fimbristylis quinquangularis subsp. quinquangularis*, *Hydrolea zeylanica*, *Kyllinga brevifolia*, *Lepidium didymum*, *Leptochloa chinensis*, *Marsilea crenata*, *Marsilea minuta*, *Oryza sativa*, *Paspalum distichum*, *Paspalum scrobiculatum*, *Pontederia vaginalis*, *Rotala rosea*, *Rumex dentatus*, *Sagittaria subulata*, *Schoenoplectiella supina*, *Sphenoclea zeylanica*, *Vallisneria nana*, *Vallisneria spiralis*

GEOGRAPHICAL DISTRIBUTION

H. oryzae is widely distributed in major rice growing areas of the world and commonly found in tropical and subtropical regions. According to Singh *et al.* (2022), *H. oryzae* is present in different regions and countries in Asia, the Asia-Pacific region, South America, Central America, Africa and the United States (Arkansas, Florida, Louisiana and Texas).



Africa: Burkina Faso, Cote d'Ivoire, Egypt, Gambia, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone

Asia: Bangladesh, China (Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shandong, Sichuan, Xianggang (Hong Kong), Yunnan, Zhejiang), India (Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Mizoram, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal), Indonesia (Java, Kalimantan), Iran, Islamic Republic of, Japan (Honshu, Kyushu), Korea, Republic of, Malaysia (West), Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam

North America: United States of America (Arkansas, Florida, Louisiana, Texas)

Central America and Caribbean: Costa Rica, El Salvador

South America: Argentina, Brazil (Piaui), Ecuador, Guyana, Venezuela

BIOLOGY

H. oryzae is a migratory endoparasitic nematode. All life stages are infective except eggs. Nematodes enter the young roots through the epidermis at some distance from the tip, feeding intracellularly in parenchyma cells of the cortex and migrate within the root (Keoboornrueng, 1971; Babatola & Bridge, 1980). Males are needed for reproduction, oviposition occurs some days after females have penetrated the roots (Fortuner & Merny, 1979;

Karakas, 2004). Juveniles hatch 4-6 days after egg deposition and the life cycle is completed in about a month under favourable conditions ($28 \pm 2^{\circ}\text{C}$ and 87% - 90% relative humidity) (Siddiqi, 1973; Karakas, 2004). In Myanmar the multiplication factor in roots ranged 1.1 to 7.2 depending on the rice variety (Maung, 2011), while according to Siddiqui (1973) it can be as high as 13 per generation. However, there is no correlation between the initial population and the multiplication factor (Maung, 2011; Abd-Elbary *et al.*, 2012). The maximum root population occurs between the tillering and the heading stage of rice crops, decreases afterwards and is lowest at harvest (Fortuner & Merny, 1979; Maung *et al.*, 2013; Peng *et al.*, 2018). The population pattern in soil is similar to that in the roots during the growing season (Maung *et al.*, 2013). The number of generations of *H. oryzae* per growing season varies in different areas, for example one generation is reported per growing season in India, two in Japan and three in Senegal (Fortuner & Merny, 1979; Peng *et al.*, 2018). The nematode can be found in different rice ecosystems but mainly in irrigated and lowland rice. *H. oryzae* can survive longer in roots than in soil, but under flooded conditions nematodes survival inside the root is shorter due to the faster decay of roots (Fortuner & Merny, 1979; Peng *et al.*, 2018). *H. oryzae* can survive in weeds and rice stubble left in the field between crops (Mathur & Prasad, 1973; Peng *et al.*, 2018). Soil temperature ranging from 21 to 28°C is optimal for multiplication. Maung *et al.* (2013) observed that *H. oryzae* can survive in fields with average soil temperatures between 20°C and 34°C . In the absence of a host, *H. oryzae* can survive in the soil for at least 5 months and, by means of a quiescence stage, nematodes can survive up to 12 months in soil that is not continually wet. *H. oryzae* can survive a wide range of pHs and adapts better to clay soils than to sandy soils (Mathur & Prasad, 1973; Fortuner & Merny, 1979; Babatola, 1981; Peng *et al.*, 2018). The pest survives under anaerobic conditions which are suitable for rice production (Babatola, 1981).

DETECTION AND IDENTIFICATION

Symptoms

Symptoms induced by *H. oryzae* are not specific, and are therefore not easily identifiable and usually unrecognizable in the field. In general, the infected rice seedlings show some chlorosis, retardation of growth, reduced and delayed tillering, and delayed flowering by 15-21 days (Keoboonrueng, 1971; Babatola & Bridge, 1979; Babatola & Bridge, 1980; Siddiqi, 1973; Goswami *et al.*, 2015; Peng *et al.*, 2018). Thirty to forty five days after transplanting of rice seedlings, infected rice roots may show yellowish to brown lesions that eventually darken. Heavily infected roots may decay after turning brown or black if the root system is heavily infected (Goswami *et al.*, 2015; Peng *et al.*, 2018). The browning of roots caused by *H. oryzae* may be enhanced by soil micro-organisms (Lee & Park, 1975).

Morphology

Morphological characters of *H. oryzae* are mentioned in Siddiqui (1973). The nematode is long and slender, and there is no sexual dimorphism in the head region between females and males. The lip region is not hemispherical. The stylet is strong with round basal knobs. The tail terminus is pointed or round with a sharp mucron.

The female body is straight or slightly arcuate ventrally. The median oesophageal bulb is oval and well developed. Oesophageal glands are elongate and ventral overlapping the intestine. The secretory excretory (SE) pore is anterior to the pharyngeal-intestinal valve. The female genital system is prominent, vulva median with two functional and equally developed genital tracts. The spermatheca is oval or sometimes round, containing sperm. 'Thorneian cells' appear to be of hypodermal origin and serve to connect the intestinal epithelial cells with the hypodermis, sometimes showing up to 3 nerve-like branches. The intestine does not overlap the rectum. The tail is elongate-conoid, and in length measures 4.3-5.5 times the body width at the anus.

Bursa is present in the males, arising near the head of spicule and ending near phasmids. The spicule is distinctly cephalated, slightly arcuate but not reaching the tail tip, the gubernaculum is simple and not-protruding.

Measurements are provided in Khun *et al.* (2015).

Detection and inspection methods

The EPPO diagnostic protocol PM 7/94 (2) *Hirschmanniella* spp. (EPPO, 2022) provides information for the detection and identification of nematodes belonging to the genus *Hirschmanniella*.

Hirschmanniella nematodes can be detected by extraction from soil and roots (EPPO, 2022). Extraction methods are given in EPPO Standard PM 7/119 (1) (EPPO, 2013). Both root and rhizosphere soil samples should be taken to detect the presence and to provide a more reliable estimate of *H. oryzae* numbers. Cutting roots into small pieces or macerating them in a blender before extraction can improve the detection efficacy.

The EPPO diagnostic protocol (EPPO, 2022) provides dichotomous keys to Pratylenchidae genera, as well as a key to *Hirschmanniella* species (based on Khun *et al.*, 2015). Using morphological and morphometrical characters is the common technique to identify *Hirschmanniella* to genus and species level (Ahmad & Jairajpuri, 1976; Siddiqi, 2000, EPPO, 2022). However, because of the potential presence of closely-related *Hirschmanniella* spp. in the same fields (Babatola, 1984; Ichinohe, 1988), and sometimes intraspecific morphological and morphometric divergences within the same species (Khun *et al.*, 2015; Mwamula *et al.*, 2022), species level identification by morphology and morphometrics alone is complicated. Molecular tests for the identification of the genus *Hirschmanniella* are not yet available (EPPO, 2022). Khun *et al.* (2015) suggested using molecular tests to confirm species level identification. Few reports exist so far of molecular research on *H. oryzae* to identify the nematode, to distinguish morphologically closely-related species, and to re-evaluate the characters of species that have been already reported (Katsuta *et al.*, 2016; Khun *et al.*, 2015; Indarti *et al.*, 2020; Mwamula *et al.*, 2022; Alma *et al.*, 2023). The DNA barcoding protocols for nematodes in EPPO Standard PM 7/129 (EPPO, 2021) have not been validated for *Hirschmanniella* spp. including *H. oryzae* (EPPO, 2022).

PATHWAYS FOR MOVEMENT

H. oryzae is normally spread by rice plants, especially seedlings from nurseries to the field and widely spread where there is long history of rice cultivation (Peng *et al.*, 2018). Direct seeding of rice rather than transplanting, whenever possible, prevents the spread of *H. oryzae* from infested nurseries to the fields. Dispersal over longer distances is possible by irrigation water, plants for planting (including aquatic plants according to Jeger *et al.* (2018) in relation to *Hirschmanniella* spp.), soil associated with plants for planting, agricultural machinery, tools and field workers (Siddiqi, 1973). In international trade, infested plants for planting (except seeds) of rice and infested growing medium are the main pathway of *H. oryzae*. Plants for planting of other hosts (including weeds), their underground plant parts and associated growing medium may also be a pathway for the nematode.

PEST SIGNIFICANCE

Economic impact

It is difficult to determine yield losses under field conditions as they depend upon several factors such as rice varieties, nematode population density in relation to crop growth stage, cultural practices and soil conditions (Ichinohe, 1988; Maung, 2011). In Japan, no clear data was obtained on the actual yield reduction caused by *H. oryzae* (Ichinohe, 1988). Nevertheless, there have been reports of 24-56% yield reduction caused by *H. oryzae* (MacGowan, 1979; Youssef & Eissa, 2014; Peng *et al.*, 2018). Different inoculation experiments showed varying degrees of yield losses, depending on rice varieties, inoculum density and soil fertility (Babatola & Bridge, 1979; Fortuner & Merny, 1979; MacGowan, 1979; Prasad *et al.*, 1987; Maung, 2011; Youssef & Eissa, 2014; Peng *et al.*, 2018). In fields that are not well fertilized, economic damage is expected when 800 *H. oryzae* are present in the roots of a single plant at the heading stage, which may correspond to as few as 40 *H. oryzae* in a plant one week after transplanting (Khuong, 1987). In Egypt, Youssef & Eissa (2014) reported that the presence of 1000 *H. oryzae* per 2 kg soil is a critical population density where damage was observed.

Control

The recommended management practices for *H. oryzae* include:

Chemical treatments such as soaking of the seeds, bare root dips before transplanting in nurseries, soil incorporation, application in standing water and 'mud ball' application in field.

Use of resistant or tolerant varieties when available.

Crop rotation with non-host dry season crops such as cowpea, groundnut, onion, pigeon pea, sorghum, soybean, sweet potato and tobacco (Babatola, 1979), mungbean, black gram and sesame (Maung, 2011), Egyptian clover (Youssef & Eissa, 2014).

Including green manure crops in crop rotation as trap crops (e.g. *Aeschynomene afraspera*, *Sesbania rostrata*) can reduce *H. oryzae* population in soil and add soil nitrogen as an additional benefit (Germani *et al.*, 1983; Hendro *et al.*, 1992; Prot *et al.*, 1992).

Prolonged dry fallows (at least 12 months) after crop rotation can help decreasing soil population densities (Siddiqi, 1973; MacGowan, 1979). Weed management in rice fields during the growing season and in the absence of rice can reduce nematode populations.

Other cultural measures include tillage and mechanical disturbance, thermal control such as soil solarization of nursery beds and burning of stubble in the field, and incorporation of organic manures (Fortuner & Merny, 1979; Abd-Elbary *et al.*, 2012; Youssef & Eissa, 2014; Peng *et al.*, 2018).

Phytosanitary risk

The warmer regions of the European Union are expected to be suitable for establishment (Jeger *et al.*, 2018). Using a CLIMEX model to study the potential establishment of *H. oryzae* in new areas Singh *et al.* (2022) projected that *H. oryzae* could establish in the Mediterranean area, although this area was less favourable for the pest than more tropical and subtropical regions. *H. oryzae* could potentially have an economic impact on rice production in the EPPO region.

PHYTOSANITARY MEASURES

Phytosanitary measures are especially relevant for plants for planting with roots of *Oryza sativa*, and possibly for growing medium on its own or associated with plants for planting. Potential phytosanitary measures identified by Jeger *et al.* (2018) against *Hirschmanniella* spp. include pest free production site with inspection, testing and soil treatment. In addition, for similar organisms associated with plants for planting or growing medium, EPPO recommends options such as pest free area, pest free place of production, pest free production site, as well as cleaning of used machinery and vehicles.

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Datasheet history

This datasheet was first published online in 2023. It is 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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