EPPO Datasheet: *Puccinia horiana*

Last updated: 2024-04-08

IDENTITY

Preferred name: *Puccinia horiana*
Authority: Hennings
Taxonomic position: Fungi: Basidiomycota: Pucciniomycotina: Pucciniomycetes: Pucciniales: Pucciniaceae
Common names: white rust of chrysanthemum
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EPPO Categorization: A2 list
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EU Categorization: RNQP ((EU) 2019/2072 Annex IV)
EPPO Code: PUCCHN



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Notes on taxonomy and nomenclature

Puccinia horiana Hennings is an autoecious microcyclic rust fungus (Pucciniales) that causes chrysanthemum white rust.

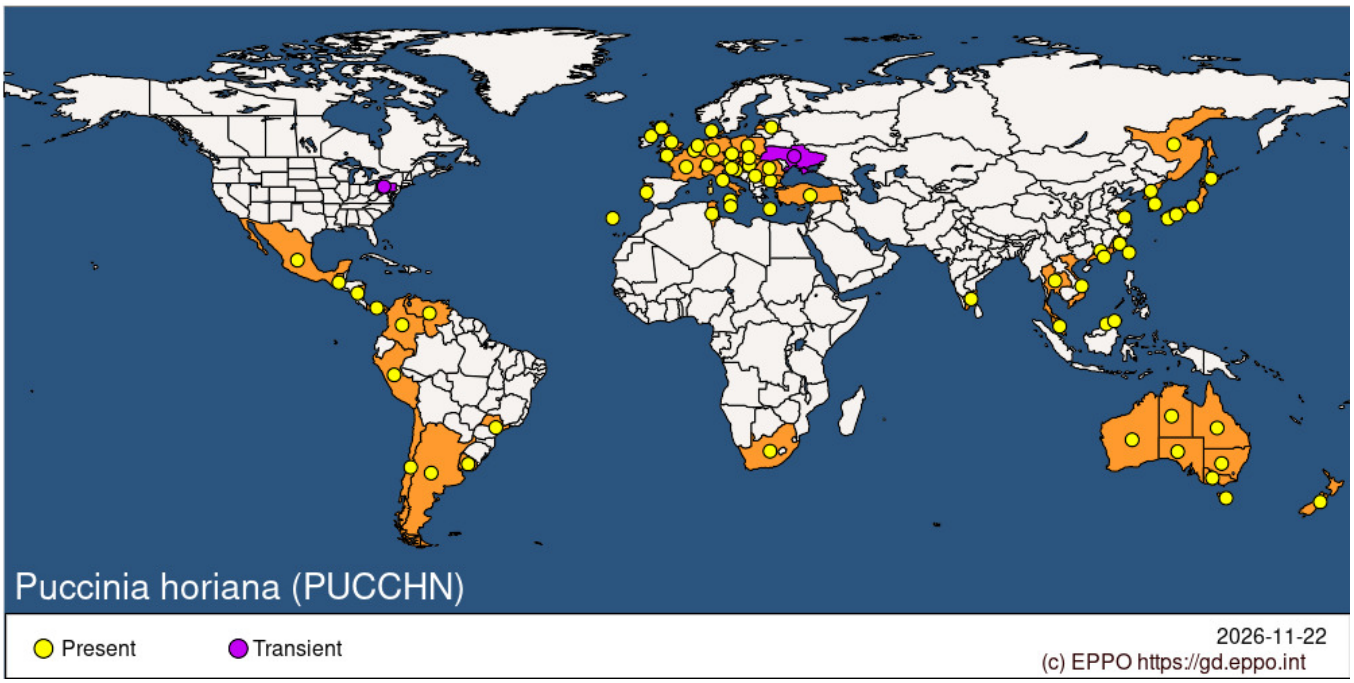
HOSTS

P. horiana is a pathogen of several chrysanthemum and daisy species. Its most important host plants include *Chrysanthemum* × *morifolium* (commonly known as florist's chrysanthemum), *C. indicum*, *C. japonicum*, *C. nipponicum* (nippon daisy), and *Ajania pacifica* (gold and silver chrysanthemum) (Water, 1981; Alaei *et al.*, 2009; De Backer *et al.*, 2011; EFSA, 2013). However, it is predominantly known as a pathogen of *Chrysanthemum* × *morifolium*, due to the economic importance of this hybrid in the cut flower and potted plant industry. The host range of the pest is currently limited to 12 chrysanthemum and daisy species belonging to 5 genera in the plant family Asteraceae (*Chrysanthemum*, *Nipponanthemum*, *Arctanthemum*, *Leucanthemella*, and *Ajania*).

Host list: *Ajania pacifica*, *Ajania shiwogiku*, *Chrysanthemum indicum*, *Chrysanthemum japonense*, *Chrysanthemum lavandulifolium*, *Chrysanthemum makinoi*, *Chrysanthemum x morifolium*, *Chrysanthemum zawadskii*, *Leucanthemella serotina*

GEOGRAPHICAL DISTRIBUTION

The disease is indigenous to Japan, where it was first noted in 1895 (Hiratsuka, 1957). It remained confined to Japan until 1963, from where it spread to China and South Africa (De Backer *et al.*, 2011). Since 1963, *P. horiana* has spread rapidly on infected shipments of cut flowers and has become established in the Russian Far East, Europe, Africa, Australia, Oceania, North and South America (De Backer *et al.*, 2011).



EPPO Region: Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, France (mainland), Germany, Greece (Kriti), Guernsey, Hungary, Italy (mainland, Sicilia), Latvia, Malta, Netherlands, Poland, Portugal (mainland, Madeira), Romania, Russian Federation (Far East), Serbia, Slovakia, Slovenia, Switzerland, Tunisia, Türkiye, Ukraine, United Kingdom (England, Northern Ireland, Scotland)
Africa: South Africa, Tunisia
Asia: Brunei Darussalam, China (Fujian, Guangdong, Jiangsu, Xianggang (Hong Kong)), India (Tamil Nadu), Japan (Hokkaido, Honshu, Kyushu, Shikoku), Korea, Democratic People's Republic of, Korea, Republic of, Malaysia (Sabah, West), Taiwan, Thailand, Vietnam
North America: Mexico, United States of America (Pennsylvania)
Central America and Caribbean: Guatemala, Nicaragua, Panama
South America: Argentina, Brazil (Sao Paulo), Chile, Colombia, Peru, Uruguay, Venezuela
Oceania: Australia (New South Wales, Northern Territory, Queensland, South Australia, Tasmania, Victoria, Western Australia), New Zealand

BIOLOGY

P. horiana is an autoecious rust (Pucciniales) that causes chrysanthemum white rust. The bicellular teliospores are normally formed on the lower side of the host's leaves. These teliospores germinate *in situ* to form a promycelium produced in the pustules (Wang *et al.*, 2020). Promycelia bear a mean of two infective propagules, unicellular basidiospores that are released and carried to new hosts by wind over a distance of up to 700 m (De Backer *et al.*, 2011; Wang *et al.*, 2020). No other spores are known (Wang *et al.*, 2020). High humidity and a film of moisture appear to be necessary for germination of both teliospores and basidiospores. Teliospores are capable of germination as soon as they are mature; germination and discharge of basidiospores occurs at temperature between 4 and 23°C and the optimal conditions for development of the pathogen are high relative humidity and cool temperatures (17–20°C) (Whipps, 1993; De Backer *et al.*, 2011). Basidiospores can germinate over a wide range of temperature and at 17–24°C either surface of the leaf may be penetrated within 2 h. Thus, 5 h of wetness is sufficient for a new infection to become established (Firman and Martin, 1968). Abundant, hyaline, intercellular hyphae are produced with intracellular haustoria. Under high humidity and mild temperature, symptoms appear 7–10 days post infection as chlorotic spots that develop teliospores within a pustule on the abaxial leaf surface within 14–18 days post infection (De Backer *et al.*, 2011; Wang *et al.*, 2020), but short periods of high temperatures (over 30°C) can apparently prolong the incubation period to 8 weeks (Whipps, 1993). Leaf wetness and a high relative humidity are essential for basidiospore formation, survival, and infection. Light does not affect germination of teliospores or basidiospores (Firman and Martin, 1968). Successful aerial transport needs to occur under conditions of high relative humidity, as basidiospores lose their ability to germinate after 5 min at relative humidity of 80% and after 1 h at relative humidity of 90% (Firman and Martin, 1968).

To establish successful infection, pathogens should gain access to the cells of the host plant. Young leaves are more susceptible than mature leaves. Studies have shown that species in family Asteraceae differed in resistance to the white rust of chrysanthemum due to leaf traits, such as trichomes and cuticular wax layer, acting as a protective barrier against pathogen's attacks (Zeng *et al.*, 2013; Wang *et al.*, 2020). Some chrysanthemum cultivars appear to be more resistant than others (Kumar *et al.*, 2021; Zeng *et al.*, 2013). Thus, *C. indicum*, *C. yoshinaganthum*, *C. makinoi* var. *wakasaense*, *C. nankingense*, *C. vestitum*, *C. lavandulifolium*, *C. crassum*, *Ajania tripinnatisecta* were shown to be immune, and strong resistance was demonstrated in *C. japonense*, *C.* × *shimotomaii*, *A. przewalskii* as well as in White Dolly, White Andaman, IIHR6-32, IIHR9-3, IIHR6-41, and other cultivars of *C.* × *morifolium* (Kumar *et al.*, 2011; Zeng *et al.*, 2013). Because wide range of crosses are relatively easy to achieve in the *Chrysanthemum* complex, these immune and highly resistant accessions could be promising for white rust resistance breeding.

For more information, see Water (1981) and De Backer *et al.* (2011).

DETECTION AND IDENTIFICATION

Symptoms

The disease affects mainly leaves, but in the case of severe infestation, spread is seen onto the stems, bracts, and the flowers. Initial symptoms appear as numerous, pale green to yellow spots, up to 5 mm in diameter which develop on the upper surface of the infected leaves (Water, 1981; Mondal and Singh, 2019). Pinkish white coloured telia pustules develop mostly on the lower surface of the leaves and rarely on the upper surface (EPPO, 2020). Under a stereo microscope, telia pustules are tan coloured, covered with slimy layer at an early stage and becoming waxy at a later stage (Water, 1981; EFSA, 2013; Mondal and Singh, 2019). As the spots on the upper surface become sunken, so these pustules become quite prominent and turn whitish when basidiospores are produced. In some cases, a secondary ring of small pustules is formed around the initial pustules (EFSA, 2013). Heavily infected leaves wilt, curl and eventually become necrotic, but they remain attached to the plant and gradually dry up completely (Water, 1981; EFSA, 2013; Mondal and Singh, 2019).

On bracts and stems, sori (complex aggregations of sporangia) sometimes develop when crops are heavily affected, while on flowers infection has been recorded as necrotic flecking with occasional pustules (Dickens, 1970).

Teliospores germinate only *in situ* (on plants, but not on agar medium).

Morphology

Pustules are 2–5 mm, tan to pink, later white, usually on the lower side of the leaves (hypophyllous), rarely on the upper side of the leaves (epiphyllous), stems, bracts or flowers. The teliospores are oblong to oblong-clavate, slightly constricted at the middle, thin walled, bicelled, pedicellate, pale yellow, 32–45 x 12–18 µm, 1–2 µm thick at sides, hyaline (Baker, 1967; De Backer *et al.*, 2011; Mondal and Singh, 2019). The promycelia are tubular, mostly segmented, short, stout, 33 × 8 µm, 1-to-3-celled, the apical cell often with a lobed appearance, and sometimes branched. Usually two basidiospores are formed per promycelium and basidiospores are hyaline, slightly curved, broadly ellipsoid to fusiform, 7–14 × 5–9 µm, with apical scar (Baker, 1967; Kapooria and Zadoks, 1973; De Backer *et al.*, 2011; EFSA, 2013; Mondal and Singh, 2019).

For more details, see Baker (1967) and Kapooria and Zadoks (1973).

Detection and inspection methods

P. horiana can be detected following the EPPO diagnostic protocol PM 7/027 (2): *Puccinia horiana* (EPPO, 2020). Detection of *P. horiana* can be based on the presence of clearly visible symptoms on the leaves (and occasionally also on bracts, stems and flowers) and on morphological features of the teliospores following the EPPO diagnostic protocol (EPPO, 2020). If only chlorotic spots are visible, then detection is possible via incubation or real-time polymerase chain reaction (PCR). For asymptomatic plants, detection can also be done with real-time PCR.

Numerous other rust fungi have been reported on chrysanthemums, but *P. horiana* is easily distinguished from other species by its smooth, hyaline teliospores that always germinate *in situ* on the living leaf (EPPO, 2020).

Identification and verification of *P. horiana* is based on microscopic verification of the morphological characteristics of the teliospores (EPPO, 1994, 2020) and/or on specific conventional or real-time PCR tests after DNA extraction of excised pustule material (Alaei *et al.*, 2009; EPPO, 2020). The PCR tests are based on the ribosomal DNA internal transcribed spacer regions and allow detection of all *P. horiana* strains tested so far. The real-time PCR assays are very sensitive and the lowest proportion of infected plant material that can be detected is 0.001 % (Alaei *et al.*, 2009).

For more information, see EPPO (2020).

PATHWAYS FOR MOVEMENT

The fungus may be spread on infected cuttings and plants, including cut flowers, of glasshouse chrysanthemums. Host plants are widespread in the EPPO region and are susceptible to the pest during their whole growing cycle. Climatic conditions are suitable for infection and sporulation of *P. horiana* over a wide area of the EPPO region. The basidiospores of *P. horiana* are released and carried to new hosts by wind over a distance of up to 700 m (De Backer *et al.*, 2011; Wang *et al.*, 2020). After establishment, aerial spread is assumed to be the cause of local infection. Owing to the absence of physical barriers, the probability of aerial spread is higher when chrysanthemum and daisy species are grown as multiflora plants (in a specific manner of propagation when several or many plants are grown from a single root). This is shown by a higher level of disease incidence in outdoor-grown crops (EFSA, 2013).

No vectors of *P. horiana* are known (EFSA, 2013).

PEST SIGNIFICANCE

Economic impact

P. horiana is a serious pest in nurseries, frequently causing complete loss of glasshouse chrysanthemum crops. The pest can infect 12 chrysanthemum and daisy species, but it is particularly known as a pathogen of the commercially important *C.* × *morifolium* which is grown for the production of cut flowers, potted plants, and garden chrysanthemums. The turnover of chrysanthemum on the Dutch flower auctions was 332 million EUR for cut flowers and 30 million EUR for potted plants in 2008 alone, making it one of the most important floral species (Alaei *et al.*, 2009). An important outbreak of white rust disease caused by *P. horiana* severely damaged the chrysanthemum crops in 12 different glasshouses in Türkiye in 2007, resulting in yield losses of up to 80% (Munilakshmi *et al.*, 2023). India is the second largest world producer of flowers (after China) and this fungus was considered to be the most destructive and devastating pathogen, causing severe yield and quality loss in Himachal Pradesh state of the country (Mondal and Singh, 2019).

Severe outbreaks also occurred in France, England, and Denmark and the pest has since spread rapidly throughout the countries causing extensive losses. At the present time, white rust is established in most western European countries in most chrysanthemum-growing areas (Whipps, 1993; Alaei *et al.*, 2009; EPPO, 2013), where it can cause significant economic loss in the cut flower industry if not controlled properly.

Control

Intensity of disease symptoms depends on susceptibility of cultivars, but temperature and air humidity are also very important factors (Firman and Martin, 1968). Overhead irrigation should be avoided because high humidity stimulates disease (EPPO, 1994). Among the available strategies to control this rust disease, fungicide treatments are a basic method, however, breeding for host-plant resistance is also an effective strategy (Sriram *et al.*, 2020; Munilakshmi *et al.*, 2023).

Studies on the control of *P. horiana* found high effectiveness of some fungicides (Wojdy?a, 2004; Sriram *et al.*, 2020; Munilakshmi *et al.*, 2023), however, considering the rise of resistance to fungicides, there is a necessity of search for alternative management solutions such as biological control (EFSA, 2013; Munilakshmi *et al.*, 2023).

The fungus *Verticillium lecanii* (Ascomycota: Cordycipitaceae), a hyperparasite of rust fungi, was assessed as a potentially good agent for an integrated pest control program on all-year-round chrysanthemums, but its application is technologically complicated (Whipps, 1993). *Cladosporium cladosporioides* and *C. pseudocladosporioides* (Ascomycota: Cladosporiaceae) were also assessed due to their antagonistic and hyperparasitic effects against *P. horiana* and the results suggested that these fungi have a high potential as biological control agents of chrysanthemum white rust (Torre *et al.*, 2017). Some chrysanthemum cultivars, e.g. national varieties of chrysanthemum (Kusumaswasti, Marimar, and Yulimar) from Central Java and certain Chinese cultivars of *C. indicum, C. yoshinaganthum, C. makinoi* var. *wakasaense, C. nankingense, C. vestitum, C. lavandulifolium, C. crassum*, and *Ajania tripinnatisecta* are resistant or less susceptible to the pest as shown by practical observation and resistance screening (Zeng *et al.*, 2013; Bety and Pangestuti, 2021) and at least seven genes are considered to be linked to resistance against *P. horiana* (De Backer *et al.*, 2011). Resistance to white rust in chrysanthemum cultivars is primarily governed by monogenic control, with several species exhibiting resistance. Consequently, it is imperative to adopt sustainable strategies that leverage genetically determined resistance to identify potential sources of resistance. Wide range of crosses emerges as a promising approach for breeding white rust-resistant varieties, capitalizing on the genetic diversity available within different chrysanthemum species and cultivars.

For more details, see also Grouet (1984), Wojdy?a (2004), Sriram *et al.* (2020), and Munilakshmi *et al.* (2023).

Phytosanitary risk

P. horiana is included in the A1 List of quarantine pests of Comunidad Andina (CAN), the A2 List of pests recommended for regulation which are present in the EPPO region (EPPO, 2023), the A2 List of Eurasian Economic Union (EAEU, 2016), as well as quarantine lists of several individual countries of the world.

In the main European chrysanthemums production areas, the incidence of *P. horiana* infections in cut flowers and potted plants is considered low (EFSA, 2013). The incidence of *P. horiana* infections in multiflora plants, which are usually grown outside, is considered higher owing to the exposure to outdoor weather conditions, but the incidence is still limited and with only local effects (EFSA, 2013).

Plant material of chrysanthemum cultivars for propagation purposes originating from infested areas may carry *P. horiana* as teliospores in pustules or as mycelium, both of which are capable of surviving transport and storage conditions and pest management procedures. Moreover, in the main production areas in the EU it is considered that inoculum of the pathogen is generally present (EFSA, 2013) so the intensification of chrysanthemum production with high plant density in humid glasshouses provides an ideal environment for the fungus to develop. In countries in which the pathogen is not established and where no preventive action is taken, the damage could be particularly devastating if the pathogen is unexpectedly introduced and spread with plants for planting (EFSA, 2013).

PHYTOSANITARY MEASURES

When *P. horiana* is not present in a country and where it is regulated as a quarantine pest, appropriate measures may consist of import of plants or cuttings which have come from premises which have been officially inspected at least monthly, during the 3 months prior to dispatch and on which no symptoms of *P. horiana* have been known to have observed during that period, and in the immediate vicinity of which no symptoms of *P. horiana* have been known to have occurred during the 3 months prior to export, or when plants or cuttings have undergone appropriate treatment against *P. horiana* (as it was suggested in the past by the EU Council Directive 2000/29/EC; EU, 2000).

When *P. horiana* is already present in a country and treated as a regulated non-quarantine pest (RNQP), then the following phytosanitary measures can be recommended: (a) plants intended for planting have been derived from mother plants which have been inspected at least monthly during the previous 3 months and no symptoms seen at the site of production; or (b) mother plants showing symptoms have been removed and destroyed, along with plants within a 1 m radius, and an appropriate physical or chemical treatment has been applied to the plants which have been inspected before dispatch and found free from symptoms (Picard, 2018; RNQP, 2018; EU, 2019).

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Datasheet history

This datasheet was first published in the EPPO Bulletin in 1982 and revised in the two editions of 'Quarantine Pests for Europe' in 1992 and 1997, as well as in 2024. 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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