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Data Sheets on Quarantine Pests

Plasmopara halstedii

IDENTITY

Name: *Plasmopara halstedii* (Farlow) Berlese & de Toni
Synonyms: *Plasmopara helianthi* Novotel'nova
Taxonomic position: Fungi: Oomycetes: Peronosporales
Common names: Downy mildew of sunflower (English)
Mildiou du tournesol (French)
Mildiú del girasol (Spanish)
Lozhnaya muchnistaya rosa podsolnechnika (Russian)
Notes on taxonomy and nomenclature: The fungus causing downy mildew of cultivated sunflowers is known in the world literature under two scientific names: (1) *Plasmopara halstedii*, used in many parts of the world to refer to a closely related group of fungi, the "*P. halstedii* complex" (Leppik, 1966), attacking cultivated sunflowers, other annual and perennial *Helianthus* species, as well as a number of additional composites; (2) *Plasmopara helianthi*, a name introduced by Novotel'nova (1966) in Russia, referring to the fungus thought to be confined to members of the genus *Helianthus* with further specialization on intrageneric taxa as *formae speciales*, that confined to *Helianthus annuus* probably being *Plasmopara helianthi* f.sp. *helianthi*. However, Novotel'nova (1966) differentiated between species and forms of this fungus on the basis of minor morphological traits and used local fungus populations for inoculation experiments. Consequently, Novotel'nova's concept of classification appears not to be valid for regions other than the Krasnodar area of Russia (Sackston, 1981; Virányi, 1984). Whether any specialized form of the fungus similar to those described by Novotel'nova (1966) exists in other geographical regions remains to be determined.
Bayer computer code: PLASHA
EU Annex designation: II/A2

HOSTS

Over 100 host species from a wide range of genera in the family Asteraceae have been reported, including wild and cultivated species of *Helianthus*, e.g. sunflowers, the principal economic host. For lists of hosts see Leppik (1966) and Novotel'nova (1966). Sunflowers are grown throughout the EPPO region, except in the north. Wild Asteraceae hosts (e.g. species of the genera *Helianthus*, *Artemisia*, *Xanthium*, etc.) may also occur widely in the corresponding areas but their potential as reservoirs of the pest is not yet known (Virányi, 1984).

GEOGRAPHICAL DISTRIBUTION

EPPO region: Present wherever sunflowers are grown, in Albania, Austria, Bulgaria, Czech Republic, Egypt, Estonia, France, Germany, Hungary, Italy, Moldova, Morocco, Poland (unconfirmed), Romania, Slovakia, Spain, Switzerland, Turkey, Russia (European, Siberia), Ukraine and Yugoslavia.

Asia: Azerbaijan, China, Georgia, India, Iran, Iraq, Israel, Japan, Kazakhstan, Pakistan, Russia (Siberia), Turkey.
Africa: Egypt, Ethiopia, Kenya, Morocco, Zimbabwe, Uganda.
North America: Canada (widespread), USA (California, Kansas, Minnesota, North Dakota, South Dakota).
Central America and Caribbean: Dominican Republic.
South America: Argentina, Brazil, Chile, Uruguay, Paraguay.
Oceania: Australia (not recorded on sunflower, but on cape weed, *Arctotheca calendula*, in New South Wales and South Australia), New Zealand (Hall, 1989; unconfirmed).
EU: Present.
Distribution map: See CMI (1988, No. 286).

BIOLOGY

Virányi & Oros (1990) have presented the life-cycle of the fungus. Starting from a single oospore that germinates and gives rise to a single sporangium (Novotel'nova, 1966; Delanoë, 1972), zoospore differentiation and release follow. In the presence of free water, the zoospore swarms rapidly and, if a host tissue (root, root-hair, stem or less commonly leaf) is available, settles on an infection site where encystment and subsequent germination take place. Penetration of the host is in a direct manner through the epidermis (Virányi, 1988a). Once established, the fungus grows intercellularly and, in a compatible host/pathogen combination, it starts with systemic colonization towards the plant apex. Systemic mycelium may be present in all plant tissues except meristems (Novotel'nova, 1966). When conditions are favourable, asexual sporulation takes place by means of sporangiophores arising primarily through stomata or other openings on the invaded tissue. Oospores are also produced in infected plant parts, primarily in roots and stem (Virányi, 1988b).

P. halstedii is a soil-borne pathogen, its oospores serving as primary inoculum for young sunflower seedlings. It may also be wind-borne, causing secondary, usually localized, infection of above-ground plant parts by dispersed sporangia, or even seed-borne when seed produced by infected plants carries mycelium and/or oospores of the pathogen. The significance of wind-borne sporangia in disease initiation is usually low. However, secondary infection was considered as an important factor in the spread of the disease in certain regions under favourable environmental conditions (Zimmer & Hoes, 1978). In addition, secondary infection by sporangia was found to incite latent infection in plants with no disease symptoms during the season but producing seeds that might carry the fungus in a latent form (Sackston, 1981).

Since seed-borne inoculum is extremely rare and results in a very low percentage of systemically infected plants, it is unlikely that dramatic outbreaks of the disease could be attributed to such inoculum. Instead, soil-borne oospores from a previous sunflower crop or even from volunteer sunflowers are the usual sources of severe attack of downy mildew in the field.

Moisture and temperature are the most important environmental factors affecting infection and spread. Zoospores, originating from either sexual or asexual sporulation, require free water to retain viability and move towards infection sites. Consequently, rainfall or intensive irrigation will be a prerequisite for the initiation of primary infection, particularly during the critical first 2-3 weeks after sowing (Zimmer & Hoes, 1978; Kolte, 1985). Plant age and host tissue are also of significance in determining susceptibility of sunflower to systemic infection by *P. halstedii* (Sackston, 1981). From a practical point of view it can be stated that the earlier the infection occurs in the season, the more severe the disease will be in the plant.

For more information on the biology of this fungus refer to Novotel'nova (1966), Delanoë (1972), Zimmer & Hoes (1978) and Sackston (1981).

Seven races of *P. halstedii* have been recorded so far, and four of these exist in Europe (Gulya *et al.*, 1991). Whether races of the fungus other than race 1 have been introduced by seed or have arisen locally remains to be determined.

DETECTION AND IDENTIFICATION

Symptoms

P. halstedii may induce disease symptoms of various kinds depending on age of tissue, level of inoculum, environmental conditions (moisture and temperature) and cultivar reaction. The main symptoms are: (1) damping-off of seedlings; (2) systemic infection of stem, leaves and flower/seed head, which is the most typical and important; (3) cotyledon-limited systemic infection (Ljubich & Gulya, 1988); (4) localized below-ground infection of roots and/or hypocotyl; (5) localized leaf infections causing angular leaf spotting. Sunflower plants carrying systemic downy mildew infection are stunted and the leaves show characteristic green and chlorotic mottling along the main veins and over the lamella. Under moist conditions, a white downy growth composed of sporangiophores and sporangia of the fungus appears on the lower leaf surface corresponding to chlorotic areas above. For further details, see Zimmer & Hoes (1978) and Sackston (1981).

Morphology

Sporangiophores are monopodially branched, slender, with three sterigmata at the very end with ovoid to ellipsoid sporangia at the tip. The size of sporangia is variable, as is the number of biflagellate zoospores released by one single sporangium (Novotel'nova, 1966). The vegetative thallus is composed of intercellular hyphae that produce globular haustoria which penetrate into host cells allowing the obligately biotrophic fungus to absorb nutrients. Sexual reproduction is by means of oogamy resulting in thick-walled oospores, which act as perennating structures. Fungal morphology is detailed by Novotel'nova (1966), Delanoë (1972) and Hall (1989).

Detection and inspection methods

The pest is primarily soil-borne but can also be carried by seed, although seed infection is usually very low (less than one per thousand in seeds from systemically infected sunflowers). Plants from infected seed usually remain symptomless but may infest the soil with fungal propagules as sporangia or oospores (Sackston, 1981). Seed-borne inoculum is difficult to detect even with time-consuming laboratory procedures. ELISA was reported as a successful tool for detecting seed-borne infection of sunflowers by *P. halstedii* (Liese *et al.*, 1982), and has been suggested for quarantine inspections (either testing imported seed lots or the first-generation crop under quarantine).

MEANS OF MOVEMENT AND DISPERSAL

Local spread of the fungus is mainly by wind-borne sporangia from infected cultivated or volunteer sunflowers and, within a field, by soil particles (e.g. during tillage) as well. Long-distance spread is by man transporting infected seed.

PEST SIGNIFICANCE

Economic impact

As the majority of systemically infected plants either die prematurely or hardly produce viable seed, they make no contribution to yield. Furthermore, reduction in seed yield may also be due to pre- or post-emergence damping-off of severely mildewed seedlings, a

symptom often overlooked and/or underestimated. Disease severity may vary considerably according to region, year and growing conditions. The incidence of downy mildewed sunflowers in a field may range from traces to near 50% or even up to 95% (Sackston, 1981). In Europe, after its first appearance in 1941, the disease increased rapidly and by 1977 it was rated a "major disease" in all sunflower-producing countries of Europe (Sackston, 1981).

Control

P. halstedii is seed-borne and soil-borne, with its oospores (resting spores) capable of surviving for as long as 8-10 years in the soil. Accordingly, the disease is extremely difficult or impossible to eradicate once it is established in an area. Sunflower hybrids resistant to downy mildew are available, but new pathogenic races of the fungus are being formed in nature, making questionable the use of formerly resistant cultivars in a particular area (Gulya *et al.*, 1991). Fungicides with definite systemic and long-lasting properties (e.g. metalaxyl or related compounds) are of significance in controlling the disease (Virányi & Oros, 1990). Even with the use of resistant cultivars, seed dressing with fungicides is highly recommended to prevent underground infection of the seedlings (Virányi, 1978).

Phytosanitary risk

P. halstedii is listed as an A1 quarantine pest by IAPSC, but not by any other regional plant protection organization (however, Australia treats it as a major quarantine pest). EPPO is currently examining its quarantine status. In the EPPO region, it is potentially dangerous everywhere that sunflower is grown, except where high soil temperature (above 25°C) and/or drought is a limiting factor. If control measures are lacking and conditions are favourable, downy mildew can be devastating to sunflower production. Evidently, *P. halstedii* is already widespread in Europe. Possible quarantine status arises from the existence of many pathogenic races of limited geographical distribution. Some of these already exist in Europe (Gulya *et al.*, 1991), but quarantine restrictions may be needed for sunflower seed imported into areas where the pathogenic races of the exporting country have not been reported.

PHYTOSANITARY MEASURES

Introduced seed represents the major quarantine risk and should originate from certified disease-free fields and be treated with a proper fungicide (e.g. metalaxyl or equivalent). Material from imported seed should preferably be monitored for 2-3 years, and any *P. halstedii* found identified to race. If it proves to be a non-indigenous race, the field should no longer be used for sunflower production.

In Australia, where *P. halstedii* is absent and is treated as a major quarantine pest, imported seed is subject to hot-water treatment, dusting with fungicide and growth in containers for at least two seasons (Anon., 1981).

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