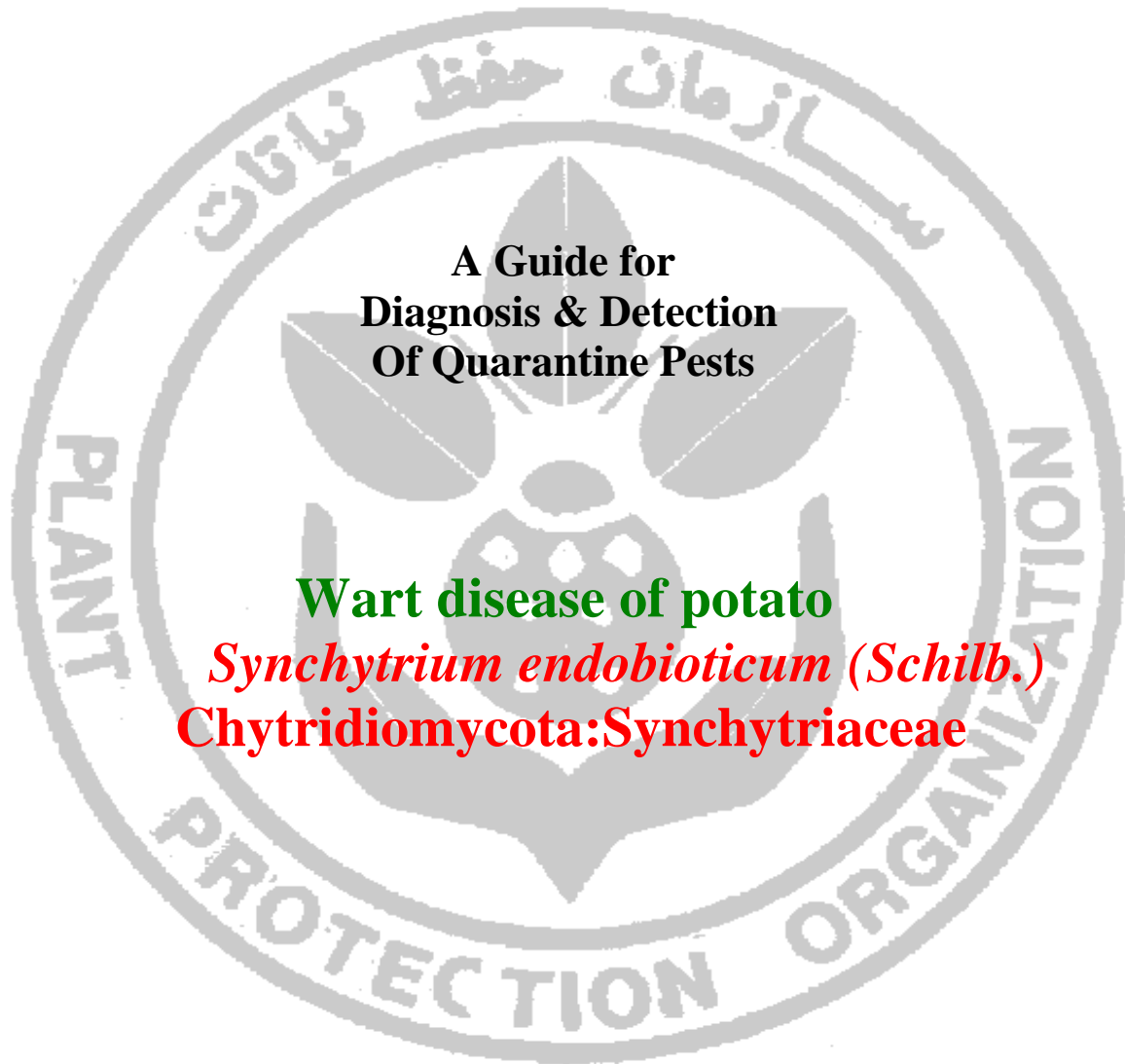




Islamic Republic Of Iran
Ministry of Jihad-e-Agriculture
Plant Protection Organization



**A Guide for
Diagnosis & Detection
Of Quarantine Pests**

Wart disease of potato
***Synchytrium endobioticum* (Schilb.)**
Chytridiomycota:Synchytriaceae

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***Synchytrium endobioticum* (Schilb.) Percival**

Domain: Eukaryota

Kingdom: Fungi

Phylum: Chytridiomycota

Class: Chytridiomycetes

Order: Chytridiales

Family: Synchytriaceae

Synonyms:

Chrysophlyctis endobiotica Schilb.

Synchytrium solani Masee

Common name:

wart disease of potato

potato wart disease

black wart of potato

potato black scab

Economic impact:

Wart disease of potato is so important that quarantine and domestic legislation has been in force globally for more than 65 years to prevent its spread and dissemination. In the 1950s and 1960s numerous EPPO publications were devoted to the disease. Once the pathogen has been introduced to a field of potato cultivation the whole crop may be devastated and unmarketable. Moreover, introduction into the soil not only renders the crop unusable but the soil itself cannot be used for further crop production due to the longevity of the fungus. Crops other than potato grown in this soil cannot be used for export. EEC Council Directive 69'464/CEE, 1969-12-08, requires the use of officially specified resistant potato cultivars in a protection zone around infested land. These (mainly applied domestically) stringent quarantine and sanitation measures have contained the disease in the EPPO region, and direct losses resulting from the pathogen are minimal. *S. endobioticum* generally has a much more limited distribution outside of Europe. Indirect losses arising from restrictions on the export of plants from infested areas present a problem to European countries.

Hosts:

The only cultivated host is potato, but wild species of *Solanum* are also infected in Mexico. Tomato and a number of other solanaceous plants, including *Schizanthus* sp., *Capsicastrum nanum*, *Physalis franchetii*, *Datura* sp. and *Solanum dulcamara* are hosts by artificial inoculation.

Affected Plant Stages: Post-harvest and vegetative growing stage.

Affected Plant Parts: Growing points, leaves, stems and vegetative organs.

List of hosts plants

Major hosts

Solanum tuberosum (potato)

Wild hosts

Solanum (nightshade)

Geographic distribution:

S. endobioticum originates in the Andean zone of South America, from where it was introduced into Europe in the 1880s. It spread widely in Europe, but statutory measures finally restricted its distribution and it has spread only to a limited extent to other parts of the world.

Europe:

S. endobioticum originates in the Andean zone of South America, from where it was introduced into Europe in the 1880s. It spread widely in Europe, but statutory measures finally restricted its distribution and it has spread only to a limited extent to other parts of the world.

EPPO region: *S. endobioticum* occurs locally in almost all EPPO countries (Austria, Belarus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, Germany, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Romania, Russia (European), Slovenia, Sweden, Switzerland, Tunisia, UK, Ukraine and Yugoslavia (Montenegro)), with a fragmentary distribution resulting from many years of statutory control (OEPP/EPPO, 1954-1968). According to national reports, it has been found but is not established in Algeria, Belgium, France and Luxembourg; it is not clear whether such records really correspond to a different situation from that in the other listed countries. Also Egypt (unconfirmed), Lebanon (unconfirmed). Found in the past but eradicated in Portugal (unconfirmed).

Asia: Armenia, Bhutan, China (unconfirmed), India (Assam, Sikkim, West Bengal), Iran (unconfirmed), Japan (absent; earlier reports by EPPO are erroneous), Korea Democratic People's Republic (unconfirmed), Korea Republic (unconfirmed), Lebanon (unconfirmed), Nepal.

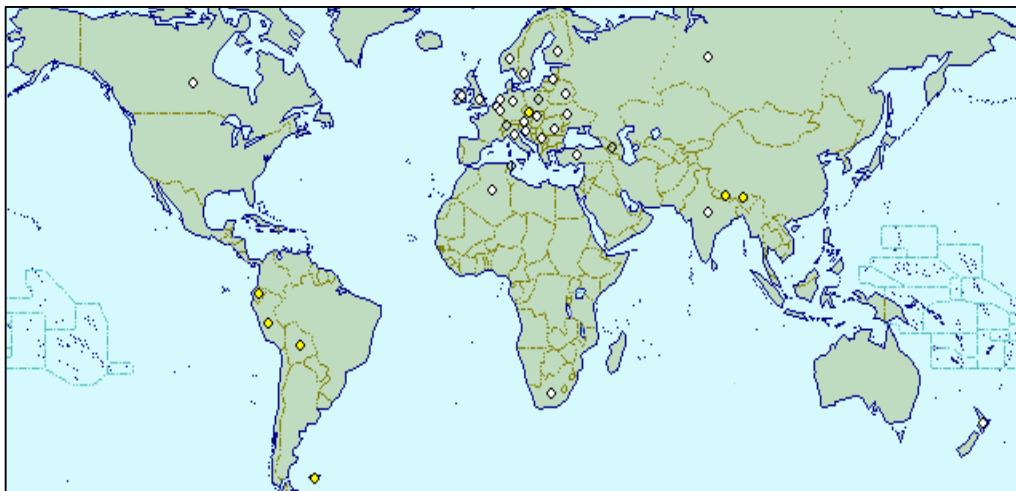
Africa: Algeria, Egypt (unconfirmed), South Africa, Tunisia, Zimbabwe (unconfirmed).

North America: Canada (Newfoundland only), Mexico (on wild potato only, and even this record not confirmed by the Mexican authorities), USA (Pennsylvania, West Virginia -

eradicated in 1950s and 60s, respectively; Maryland, thought to have been eradicated in 1974 but found again in 1974; finally declared eradicated in 1994).

South America: Bolivia, Chile (found in the past but eradicated), Ecuador (unconfirmed), Falkland Islands, Peru, Uruguay (early record now strongly denied by Uruguayan authorities).

Oceania: New Zealand (South Island).



Distribution map of *Synchytrium endobioticum*

Morphology:

Resting spores (winter sporangia) are mostly spherical, thick-walled, about 30-80 μm diameter. They tend to be integral components of aggregates or crumbs of soil.

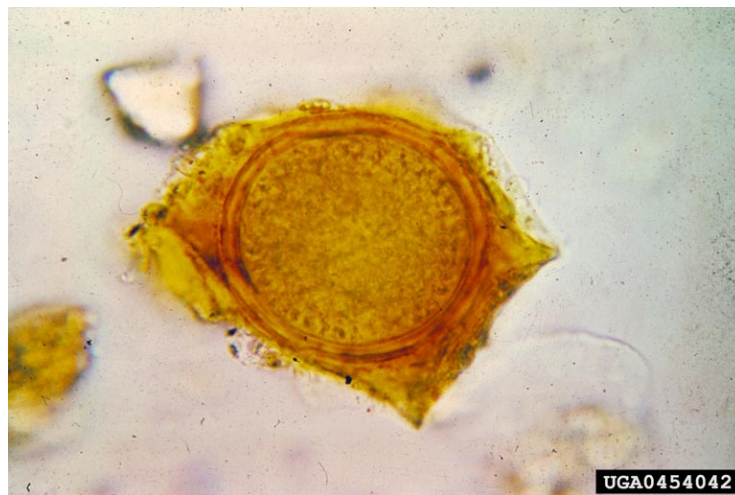
Sporangia: *Synchytrium endobioticum* produces sporangia, which contain 200 to 300 mobile zoospores (EPPO, n.d.; Franc, 2007).

There are two different sporangia, the winter sporangia (long-lived stage) and the summer sporangia (short-lived, quickly reproducing stage) (EPPO, n.d.).

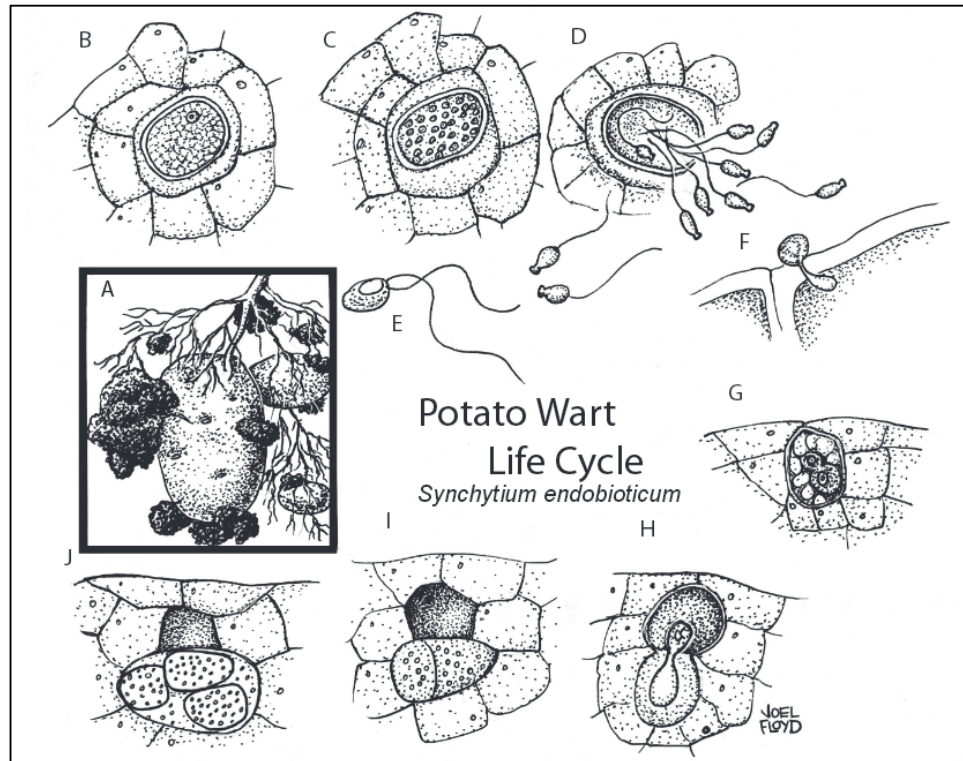
Winter sporangia (also called resting sporangia): “Winter sporangia (Fig. 1) are mostly spherical, thick-walled, about 50 μm in diameter (25-75 μm); tend to be integral components of small aggregates or crumbs of soil, 0.1-2.0 mm in diameter” (EPPO, n.d.; 1982). These can be irregular in shape (spherical to ovoid) with brown walls (Cakir, 2000). “As the host galls decay the host cell wall disintegrates, slightly changing the appearance of the outer surface of the sporangia” leaving it with a characteristic angular appearance (Byrne, 2008).

Summer sporangia: “Summer sporangia are thin-walled and transparent. Zoospores may be visible within the summer sporangia” (Byrne, 2008).

Zoospores: “The swimming zoospore of *S. endobioticum* is approximately 3 μm in diameter, spherical to elongate in shape, and normally has a single lipid body protruding anteriorly or at one side. The zoospore has a single whiplash flagellum that is about 17 μm long with a whiplash portion that is ca. 2.5 μm in length as measured from negatively stained EM preparations. In the light microscope, the lipid body is the only structural detail which may be observed. The zoospores encyst readily in water; even in the absence of the host...the ribosomes are evenly dispersed in the cytoplasm” (Lange and Olson, 1977).



Live resting (winter) sporangium of *Synchytrium endobioticum*. Image courtesy of Central Science Laboratory, York (GB) British Crown



Life cycle diagram of *Synchytrium endobioticum*. A, infected tubers, stem and stolons with wart symptoms; B, resting sporangium; C, resting sporangium with maturing zoospores; D, discharged motile zoospores; E, two zoospores form a (diploid) sporangium to later form a zygote; F, zoospore entering a host cell by direct penetration; G, young prosorus in host cell; H, contents of prosorus passing into host cell; I, cross section of sorus with two (haploid) sporangia and remains of empty prosorus; and J, three mature (haploid) sporangia in sorus with zoospores beginning to be released. The haploid sporangia are summer sporangia and the diploid sporangia are resting winter sporangia (Stevenson et al., 2001; illustrations after Walker, 1957).

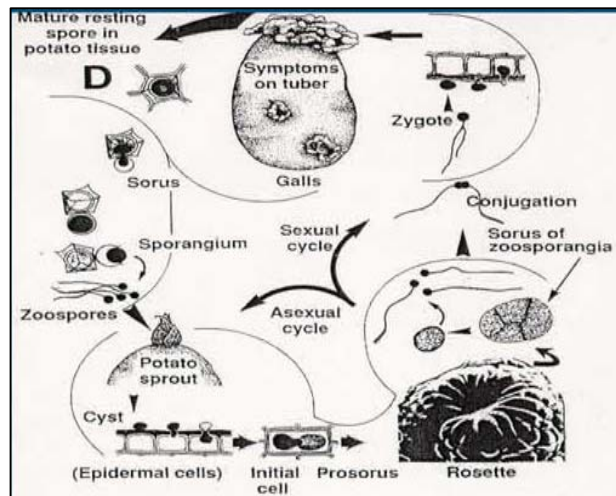
Biology and ecology:

S. endobioticum is an obligate, holocarpic, endobiotic parasite. It is long-cycled chytrid which does not produce hyphae but a thallus comprised of sporangia. Two forms of sporangia exist, so-called summer and winter sporangia (resting spores), which contain 200-300 motile zoospores. The summer or swarm stage results from host infection by haploid zoospores in which a sorus of one to nine sporangia form, and the winter or resting stage results from infection by conjugated (diploid) biflagellated zoospores. Both sporangial types germinate to release pear-shaped (1.5-2.2 μm diam.) zoospores. Motility is by means of posterior flagella. The resting (meio-)sporangia are golden brown, ridged and spheroidal (ca 35-80 μm diam).

If infection conditions are suitable, i.e. soil temperature and water, the rapidly reproducing summer sporangia release their zoospores thus setting up repeated infection cycles. At the same time, (meio-)sporangia (resting spores) are formed and, while conditions no longer favour the summer stage, the resting spores will overwinter in the infection zones of the potato. The resting spores induce hypertrophy of the infected tissue resulting in the so-called warts. This tissue will rot down in the soil during the winter months to release the resting spores into the soil. Resting spores can remain viable for decades. The ultimate lifespan has yet to be determined. The commonest means of spreading resting spores are by wart or soil distribution. Other limited means of distribution are by wind (over dried infested soil) or through animal droppings. The chitinous/melaninized wall of the resting spore is extremely chemo-resistant to common soil agents. Its resistance and longevity impact directly on control measures.

Pathotypes

The fungus exists in many pathotypes. The pathotypes are defined by their virulence on differential potato cultivars. The common Pathotype 1 (European race 1) is found throughout the EPPO region and is the only one in many of the other countries. Other pathotypes, up to 19, occur in the wet montane areas of central and eastern Europe (e.g. Alps, Carpathians, Germany, Poland, former USSR). In Newfoundland, Canada, the common pathotype is #2, with pockets of #8. The pathogen persists in small garden plots and horticultural holdings but is not a problem in commercial potato crops. The private plots, nevertheless, present a control problem as the long-lived fungus can be disseminated through carelessness...



Symptoms:

The diagnostic symptoms of wart disease are galls produced on several plant parts.

Aerial symptoms

Aerial symptoms are not usually apparent. There may, however, be a reduction in vigour. Warts can be found in severe attacks on the upper stem, leaf and flower. Leaf stalks may develop hypertrophic 'wings'. Above-ground galls are green to brown, turning black at maturity, and later decaying.

Subterranean symptoms

Galls vary in shape but are mostly spherical, with corrugated surfaces, and range from pea-size to fist-size (cm to >8 cm diam.). Below ground galls are white to brown, turning black as they decay. These galls appear at stem bases, stolon tips and tuber eyes. They may not be evident until harvest-time. At harvest, galls may desiccate or decay. Tubers may be disfigured or completely replaced by galls. Tuber galls may develop after harvest, in storage. The host potato may not be killed but the meristematic tissue of sprouts may be so severely attacked that plants may fail to emerge from seed tubers. *S. endobioticum* does not attack the roots of potato but it does attack the roots of other hosts (e.g. tomato).

Symptoms by affected plant part

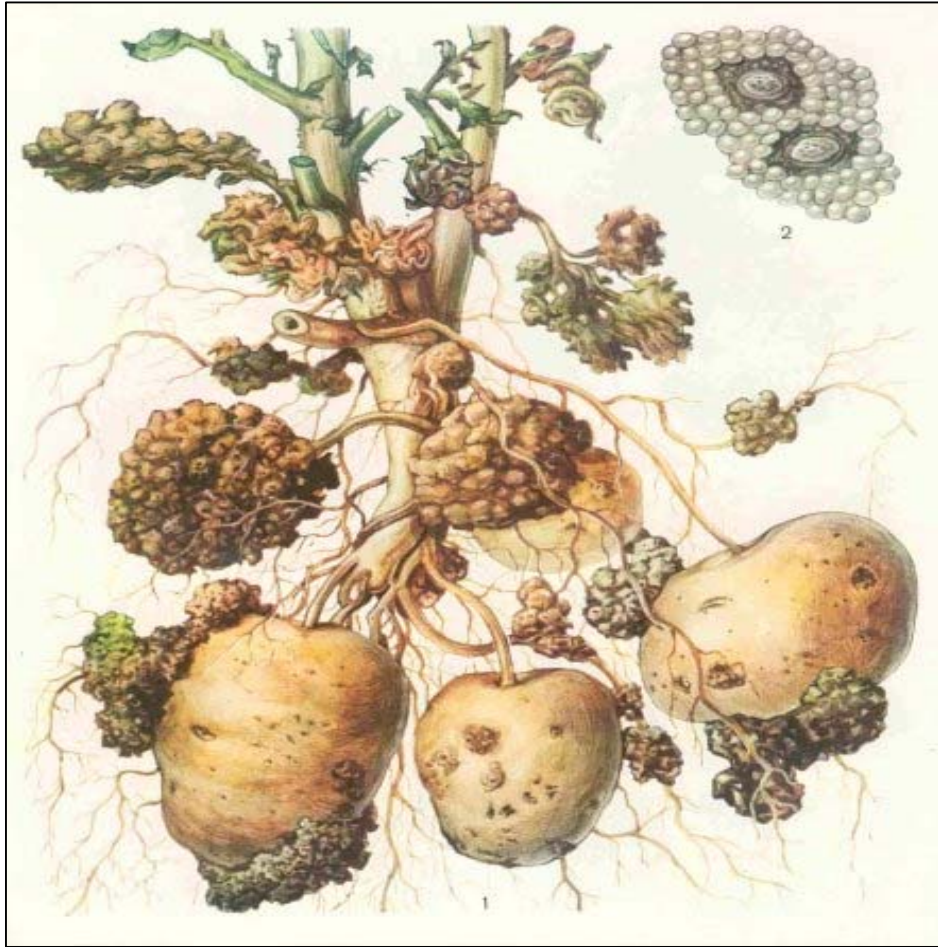
Growing points: abnormal forms.

Leaves: abnormal forms.

Stems: canker; abnormal forms.

Vegetative organs: external discoloration; internal discoloration..

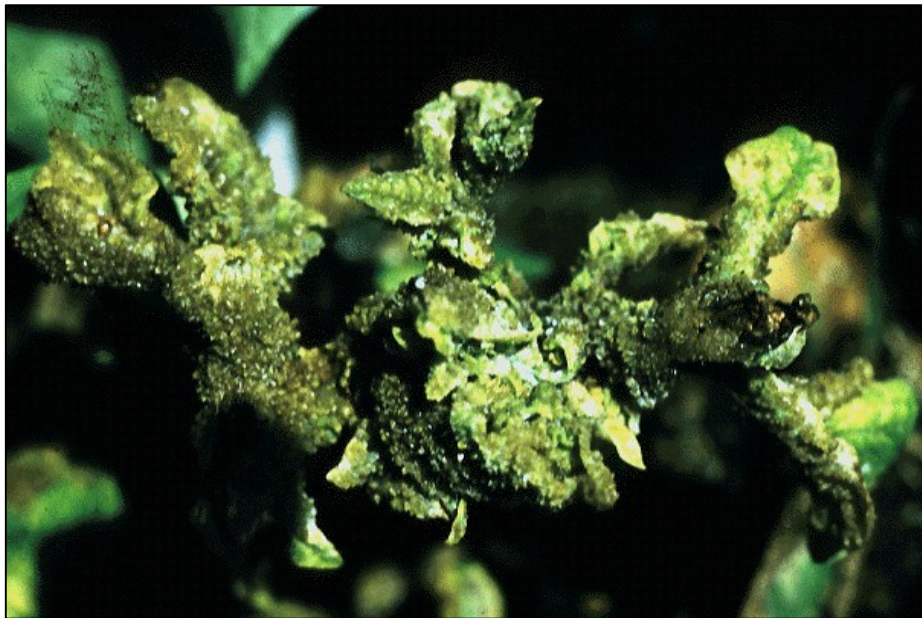








Symptoms in the field



Leaf symptoms



Symptoms on stem base



Symptoms on tubers and stolons

Means of movement and dispersal:

S. endobioticum has a very limited means of spread and dispersal. Spread in soil by zoospores is limited (50 mm or less) to the infection zones of the plant. Soil water can carry zoospores downstream, although the lifespan of a released zoospore is 1-2 hours. Earthworms can move resting spores short distances. Wind is an active dispersal agent in regions of strong dry summer winds. Local dispersal has been shown in resting spores in soil attached to vehicles and contaminated manure. Long-range dispersal by tuber-movement, especially in international trade, attached soil and plants presents problems of control. Control through statutory methods has been largely successful due to the fungus' self-limited means of dispersal. The disease is essentially social, dependant on commercial crop and soil movement.

Plant parts liable to carry the pest in trade/transport

- Bulbs/Tubers/Corms/Rhizomes: Sporangia; borne internally; visible to naked eye.
- Growing Medium Accompanying Plants: Sporangia; borne externally; invisible.
- Leaves: Sporangia; borne internally; visible to naked eye.
- Stems (above Ground)/Shoots/Trunks/Branches: Sporangia; borne internally; visible to naked eye.

Plant parts not known to carry the pest in trade/transport

- Bark
- Fruits (inc. Pods)
- Flowers/Inflorescences/Cones/Calyx
- Seedlings/Micropropagated Plants
- Roots
- True Seeds (inc. Grain)
- Wood..

Phytosanitary significance:

According to the EPPO specific quarantine requirement (OEPP/EPPO, 1990), potatoes should derive from a stock found free from *S. endobioticum*. Potatoes, and indeed any kind of plants with roots (including bulbs and tubers) for export, should not be grown in fields where *S. endobioticum* has occurred and is still present.

In practice, this means an extensive system of "scheduling" of wart-infested fields which goes back to the wart epidemic in the first decades of the 20th century. An EPPO-recommended method for "descheduling" fields, i.e. determining that the pathogen has disappeared, is under study (see, for example, OEPP/EPPO, 1983). However, *S. endobioticum* resting sporangia are extremely long-lived (Pratt, 1976b; Laidlaw, 1985) and there is still debate how soon fields can safely be descheduled. Countries in which only pathotype 1 occurs are advised to require that imported potatoes come from areas where the other pathotypes do not occur. And listed as a quarantine pest for Iran .

Detection and inspection:

A number of methods have been elaborated for routine soil testing. The principal method is to employ a wet-sieving technique; dry sieving is also used. Flotation on chloroform is also useful...

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