

JKI Data Sheets

Plant Diseases and Diagnosis

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Phytophthora on *Juglans* spp.
(walnuts)



Imprint

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Importance of *Juglans* species

The genus *Juglans* consists of about 21 species occurring over North and South America, Europe and Asia (<http://www.discoverlife.org>). Five main species can be considered as representative of the three main continental blocks since *J. hindsii* and *J. nigra* are from North America and they are included in the black walnut group, *J. mandshurica* and *J. sieboldiana* are from Asia and they are included in the Asian butternuts, while *J. regia*, known as common walnut or English (Persian) walnut, can be included within the Asian-European species. *Juglans regia* is the most widely cultivated walnut species worldwide, either for fruit or timber production. The origin of Persian (English) walnut is reported to extend from Asia over Easter Europe such as the Balkan and the Carpathians. Over 10% of potential walnut production is lost due to pests and diseases annually. For many of the major diseases, chemical forms of control are either unavailable or ineffective. *Phytophthora* root and crown rot can be considered as an increasing source of loss in the major walnut growing areas in Europe as well as in America. The incidence and severity of *Phytophthora* root and collar rots are closely linked to soil moisture. For some *Phytophthora* spp. and some rootstocks (i.e. *J. regia*) the duration of soil saturation dramatically affects the disease which severity increases with the duration of the saturation.

Phytophthora species

From *Juglans* with characteristic disease symptoms the following *Phytophthora* species have been isolated directly from the tissue or from the soil (Table 1).

Among all the *Phytophthora* species associated with walnut root and collar rot followed by die-back, *P. cinnamomi* represents the most damaging species worldwide. It is responsible for severe losses on a great number of host species. Root and collar infection on *Juglans* spp. are not recent in Italy. Actually, this disease was first recorded in this country by Curzi in 1933 on English walnut under the names of 'nerume', 'mal nero', or 'ink disease', and it was attributed to *P. cambivora*. Successively, walnut root and collar rot were detected in the United States and attributed to *P. cinnamomi* by Crandall (1936). Since then, more than 10 species of *Phytophthora* have been recovered in association to root and collar rot in walnut orchards in the United States, but *P. cinnamomi* and *P. citricola* were determined to be the most consistent and virulent.

In recent years in Italy, up to six species of *Phytophthora* have been associated to walnut decline and death namely, *P. cactorum*, *P. cinnamomi*, and more recently *P. cambivora*, *P. citricola*, *P. cryptogea* and *P. nicotianae* (Belisario *et al.*, 2006).

While *P. cinnamomi* is well known as an aggressive primary pathogen of English walnut, the other species of *Phytophthora* may act as predisposing factors to walnut decline, affecting root system development and increasing host vulnerability to environmental stress. *P. cinnamomi* has to be considered the most serious threat since, on top of all, causes significant root and collar rot without soil saturation that makes this pathogen more damaging supporting its role as primary pathogen in the decline of walnut stands.

Most of the *Phytophthora* species isolated from diseased walnut have a wide host range. That means it cannot be excluded that they attack other tree species in the surroundings.

Table 1: *Phytophthora* isolates on *Juglans* spp.

<i>Phytophthora</i> species	<i>Juglans</i> species	Country	Disease symptom	Reference
<i>P. cactorum</i>	<i>J. californica</i> <i>J. hindsii</i> <i>J. nigra</i> <i>J. regia</i> <i>J. pyriformis</i>	America (Chile, USA) Europe (France Hungary and Italy)	dark brown, triangular, flame-shaped lesions extending in the inner- bark from the collar level at the margin of which it can be isolated	Belisario <i>et al.</i> , 1996 Erwin & Ribeiro, 1996 Lakatos <i>et al.</i> , 2009
<i>P. cambivora</i>	<i>J. regia</i>	Europe (Italy and Spain)	dark brown, triangular, flame-shaped lesions extending in the inner- bark from the collar level up into the trunk at the margin of which they were isolated	Belisario <i>et al.</i> , 2006 Erwin & Ribeiro, 1996
<i>P. cinnamomi</i>	<i>J. nigra</i> <i>J. regia</i>	America (USA) Australia New Zealand Europe (Spain, Portugal, Italy, France)	dark brown, triangular, flame-shaped lesions extending in the inner- bark from the collar level up into the trunk at the margin of which they were isolated	Belisario <i>et al.</i> , 2001; 2006 Erwin & Ribeiro, 1996 Pennycook, 1989 Sampson & Walker, 1982 Spaulding, 1961
<i>P. citricola</i>	<i>J. nigra</i> <i>J. regia</i>	America (USA) Australia Europe (Italy, Hungary)	root decline	Belisario <i>et al.</i> , 2003 Cook & Dubé, 1989 Erwin & Ribeiro, 1996 Lakatos <i>et al.</i> , 2009
<i>P. citrophthora</i>	<i>J. hindsii</i> <i>J. regia</i>	America (USA, Argentina) Europe (Greece)		Erwin & Ribeiro, 1996 Holevas <i>et al.</i> , 2000
<i>P. cryptogea</i>	<i>J. hindsii</i> <i>J. regia</i>	America (USA), Australia Europe (Italy)	rot of feeder and lateral roots	Cook & Dubé, 1989 Erwin & Ribeiro, 1996 Vettraino <i>et al.</i> , 2002
<i>P. drechsleri</i>	<i>J. hindsii</i> <i>J. regia</i>	America (USA)		Matheron & Mircetich, 1983, 1985
<i>P. hedraiandra</i>	<i>J. regia</i>	Europe (Hungary)		Lakatos <i>et al.</i> , 2009
<i>P. megasperma</i>	<i>J. regia</i>	America (USA) Europe (Greece)		Matheron & Mircetich, 1983; 1985 Holevas <i>et al.</i> , 2000
<i>P. nicotianae</i>	<i>J. regia</i>	America (USA) Australia Europe (Italy)	root decline	Belisario <i>et al.</i> , 2003, 2006 Erwin & Ribeiro, 1996
<i>P. palmivora</i>	<i>J. regia</i>	Europe (Italy)		Curzi, 1933
<i>P. plurivora</i>	<i>J. regia</i>	Europe (Germany and Italy)		Jung <i>et al.</i> , 2009

Disease symptoms (see figures)

Phytophthora species can attack different plant tissues and cause different disease symptoms on *Juglans* spp. The most common symptoms are:

Crown: small leaves, yellow discoloration of the leaves, wilting; usually the whole crown shows the disease symptoms, sudden death with defoliation or retaining leaves and nuts.

Stem: bleeding canker mainly at the collar, cambium necrosis; the bleeding can be visible at single spots on the bark ("tarry spots") but can also be large dark areas surrounding the stem or expanding up into the trunk with a triangular or flame-shape involving the phloem and the first layers of xylem.

Roots: rot of young feeder roots, later rot of older roots

Nuts: retention and shriveling

Possibility of Symptom Confusion

The disease symptoms presented in the previous chapter are not specific to *Phytophthora* infection. Other pathogens can cause similar symptoms as well as nutritional disorders, or water excess or deficiency. Bacteria, insects and mechanical damage can also cause bleeding. To specify the cause of the disease samples must be examined in the laboratory.

Disease development

Usually the crown shows the first visible symptoms, followed by bleeding, mainly at the stem base. Disease symptoms can develop over years and can remain undetected at the beginning of the disease. Root rot, cambium necrosis starting at the stem base, bleeding, death of the plants. The harmfulness of this pathogen is due to root infections that often results in the death of the plant, with earlier symptoms including wilting, yellowing and retention of dried foliage/fruit with rot of young feeder roots and occasionally of larger roots (Vettraino *et al.*, 2003). These damages cause water deficiency symptoms which can result in tree death, displaying a slow or sudden decline. The latter is more common during summer.

In general it can be considered that *P. cinnamomi* is associated with a severe decline of walnut trees, often followed by sudden death during summer time. In case of sudden death fruit and leaves remain attached to the tree with marked symptoms of dehydration. Declining trees often showed a dark brown to black sap oozing from humid patches at the collar level. *P. cinnamomi* lesions could reach over 1.8 m above the ground level. *P. cambivora* has been more often detected in woody plantations located close to chestnut stands. *P. citricola* has been isolated from obvious necroses at the insertion point of lateral roots of walnut trees that showed a general slow decline with a progressive reduction of foliage and fruit production over several years. It could be inferred that *P. citricola* in European walnut orchards could be responsible of chronic decline. Some trees can survive root reduction without appreciable crown symptoms, even though their water relations and nutrition are affected.

Diagnosis

It is not possible to identify a *Phytophthora* infection only by disease symptoms. Different diagnostic techniques like direct isolation, molecular and serological methods help to identify *Phytophthora* as the cause of the tree disease and to specify the *Phytophthora* species. Information on *Phytophthora* diagnosis on trees are given for example in <http://forestphytophthoras.org/key-to-species>, <http://www.phytophthoradb.org>, <http://phytophthora-id.org/> and Martin *et al.* (2012). Please contact your national authorities (see next chapter) for help with diagnosis.

What to do in case trees are suspected to be infected?

Contact your responsible national authorities, for example:

Austria:

- Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft (BWF) Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) Seckendorff-Gudent-Weg 8, 1131 Vienna, Austria; <http://www.bfw.ac.at/>
- Österreichische Agentur für Gesundheit und Ernährungssicherheit Austrian Agency for Health and Food Safety, Institute for Sustainable Plant Production Spargelfeldstraße 191, 1220 Vienna; <http://www.ages.at>

Belgium:

- Département Sciences du Vivant, Centre Wallon de Recherches Agronomiques Life Sciences Department, Walloon Agricultural Research Centre Rue de Liroux 4, B-5030 Gembloux; Anne CHANDELIER | a.chandelier@cra.wallonie.be
- Instituut voor Landbouw- en Visserijonderzoek (ILVO), Eenheid Plant -Gewasbescherming Institute for Agricultural and Fisheries Research, Plant Sciences Unit – Crop Protection - Gewasbescherming Burg. van Gansberghelaan 96 bus 2, 9820 Merelbeke Kurt HEUNGENS | kurt.heungens@ilvo.vlaanderen.be

Bulgaria:

- Българска Агенция по безопасност на храните: Централна лаборатория по карантина на растенията plant protection regional services: <http://www.babh.government.bg/en/labs.html>
- Агробиоинститут, Селскостопанска Академия бул 8, Драган Цанков № 8, София 1164 Biotic Stress Group, AgroBioInstitute, Agricultural Academy 8 Dragan Tsankov blvd., 1164 Sofia Славчо Славов, sbslavov@abi.bg Slavtcho SLAVOV | sbslavov@abi.bg

Czech Republik:

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The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Institute
Květnové náměstí 391, Průhonice, 252 67, Praha západ
Matěj PANEK | panek@vukoz.cz

Denmark:

- NaturErhvervstyrelsen, Ministeriet for Fødevarer, Landbrug og Fiskeri
The Danish AgriFish Agency, <http://www.naturerhverv.fvm.dk>
- Skov & Landskab, Det Biovidenskabelige Fakultet, Københavns Universitet
Forest and Landscape, Faculty of Science, University of Copenhagen
<http://www.sl.life.ku.dk>

Finland:

- Elintarviketurvallisuusvirasto Evira, Kasvinterveysyksikkö
Finnish Food Safety Authority Evira, Plant Health
Mustialankatu 3, FI-00790 Helsinki
http://www.evira.fi/portal/fi/kasvit/viljely_ja_tuotanto/metsanviljely/valvonta/
- Metsäntutkimuslaitos
Finnish Forest Research Institute
P.O. Box 18, FI-01301 Vantaa
Anna RYTKÖNEN | anna.rytkonen@metla.fi
- Maa- ja elintarviketalouden tutkimuskeskus MTT
Agrifood Research, MTT
FI-31600 Jokioinen
Päivi PARIKKA | paivi.parikka@mtt.fi

France:

- Services Régionaux de l'Alimentation (SRAL) des Directions Régionales de l'Alimentation, de l'Agriculture et de la Forêt (DRAAF)
Regional Plant Protection services
<http://agriculture.gouv.fr/suivi-de-la-sante-des-forets>
<http://agriculture.gouv.fr/services-deconcentres>
- Laboratoire de Santé végétaux, unite de Mycologie, ANSES
French Agency for Food, Environmental and Occupational Health & Safety (ANSES)- Plant Health Laboratory, unit of mycology
Domaine de Pixérécourt Bat E., 54220 Malzéville, France; <http://www.anses.fr/PNTC01.htm>;
Nathalie SCHENCK | Nathalie.schenck@anses.fr
Renaud IOOS | renaud.ioos@anses.fr
- Pôle interrégionaux du Département de la santé des forêts:
Regional forest health survey organisation:
<http://agriculture.gouv.fr/departement-de-la-sante-des-forets>

Germany:

- Pflanzenschutzdienststellen der Bundesländer, Adressenliste siehe:
regional plant protection services, address list see: <http://www.jki.bund.de/de/startseite/unsere-service/linksammlung.html>
- Julius Kühn Institut – Bundesforschungsanstalt für Kulturpflanzen (JKI), Institut für Pflanzenschutz in Gartenbau und Forst (JKI-GF)
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Forest Research Institute, 570 06 Vassilika, Thessaloniki, Greece
<http://www.fri.gr>, info@fri.gr
- Ινστιτούτο Μεσογειακών Δασικών Οικοσυστημάτων & Τεχνολογίας Δασικών Προϊόντων, Τέρμα Αλκμάνος, 115 28 Ιλίσια, Αθήνα, Ελλάς
Institute of Mediterranean Forest Ecosystems & Forest Products Technology, Terma Alkmanos, 115 28 Ilisia, Athens, Greece
<http://fria.gr>, tsop@fria.gr

Hungary:

- Megyei Kormányhivatalok Növény- és Talajvédelmi Igazgatóságai
Regional offices of NFCSO, Directorate of Plant Protection and Soil Conservation
<http://www.nebih.gov.hu/elerhetosegek>
- MTA ATK Növényvédelmi Intézet
Plant Protection Institute, Centre for Agricultural Research, Hungarian Academy of Sciences
Herman Ottó u. 15, H-1022 Budapest, Hungary;
József BAKONYI | bakonyi.jozsef@agr.ar.mta.hu

Ireland:

- Department of Agriculture, Food and the Marine, Horticulture and Plant Health Division
Backweston Agri-Campus, Celbridge, Co. Kildare, Ireland
oliver.mcevoy@agriculture.gov.ie

Italy:

- COSVIR XI - Servizio fitosanitario centrale
Italian Phytosanitary Service
cosvir11@pec.politicheagricole.gov.it, <http://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/2341>
- Dipartimento per la Innovazione nei sistemi Biologici, Agroalimentari e Forestali, Università degli Studi della Toscana
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Latvia:

Valsts augu aizsardzības dienests

State Plant Protection Service <http://www.vaad.gov.lv/english/contacts/departments.aspx>

Netherlands:

Nationaal Referentie Centrum,

Nederlandse Voedsel- en Warenautoriteit (NVWA)

National Reference Centre, NPPO

Netherlands Food and Consumer Product Safety Authority

Ministry of Economic Affairs, Agriculture and Innovation

Postbus 9102, 6700 Hc Wageningen, Nederland

Johan MEFFERT | j.p.meffert@minInv.nl

Norway:

Bioforsk Plantehelse

Norwegian Institute for Agricultural and Environmental Research, Plant Health and Plant Protection Division

Høgskoleveien 7, 1432 Ås, Norway;

Venche TALGØ | venche.talgo@bioforsk.no

Poland:

Instytut Ogrodnictwa

Research Institute of Horticulture, Dept. of Ornamental Plant Protection

Konstytucji 3 Maja 1/3, 96-100 Skierniewice

Leszek B. ORLIKOWSKI | leszek.orlikowski@inhort.pl

Portugal:

- Instituto de Conservação da Natureza e das Florestas – ICNF

Institute for Nature Conservation and Forestry - INCF

<http://www.icnf.pt/florestas>

- Direcção de Serviços de Fitossanidade e de Materiais de Multiplicação de Plantas

Directorate of Plant Health and Materials Multiplication of Plants

Tapada da Ajuda, 1349-018 Lisboa

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Romania:

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Forest Research and Management Institute

Statiunea Brasov; Closca 13, 500040, Brasov, Romania,

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Serbia:

- Институт за шумарство, Одељење за заштиту шума

Institute of Forestry, Department of Forest Protection

Kneza Višeslava 1

11030 Belgrade, Serbia

www.forest.org.rs

- Institut za nizijsko šumarstvo i životnu sredinu, Zaštita šuma

Institute of Lowland Forestry and Environment, Forest Protection

Antona Čehova 13, 21000 Novi Sad, Serbia

www.ilfe.org

Slovenia:

Kmetijski inštitut Slovenije
 Agricultural Institute of Slovenia
 Hacquetova 17, 1001 Ljubljana, Slovenia
 Alenka MUNDA | alenka.munda@kis.si

Spain:

Grupo de Investigación en Hongos Fitopatógenos, Instituto Agroforestal Mediterráneo, Universitat Politècnica de València
 Polytechnic University of Valencia (UPV), Mediterranean Agroforestry Institute (IAM), Research group on Plant Pathogenic fungi
 Camino de Vera s/n, 46022 Valencia, Spain
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SLU, Institutionen för Skoglig Mykologi och Växtpatologi
 Dept. of Forest Mycology and Plant Pathology
 Box 7026, 750 07 Uppsala
 Jan STENLID | Jan.Stenlid@slu.se

Switzerland:

Eidg. Forschungsanstalt für Wald, Schnee und Landschaft (WSL)
 Competence Center of Forest Protection (WSL)
http://www.wsl.ch/dienstleistungen/waldschutz/index_EN

Turkey:

- Çankırı Karatekin Üniversitesi, Fen Fakültesi, Biyoloji Bölümü, Çankırı, Türkiye
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- Tree Health Diagnostic & Advisory Service, Forest Research, Northern Research Station, Roslin, Midlothian EH25 9SY; ddas.nrs@forestry.gsi.gov.uk
- Tree Health Diagnostic & Advisory Service, Forest Research, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH; ddas.ah@forestry.gsi.gov.uk

Management and control

For direct control with chemicals it would be advisable to contact your national authorities (see chapter above). If feasible, the following measures might help to prevent infection and to keep the trees healthy: no stagnant moisture, optimum nutrition and soil aeration. Twig and branch cutting should not be done in wet periods to enable a quick drying of the wound and a quick periderm development. Injury of the stem, for example by mechanical weed control should be avoided. Although *Phytophthora* species can invade plant tissue actively any kind of wounds increases the risk of infection. Treatments with phosphite or fosetyl-Al has proven to reduce symptoms and pre-

vent host tissue colonization by *Phytophthora* spp. (Belisario *et al.*, 2009). Before you use any kind of chemicals contact your national authorities.

Different levels of resistance to *Phytophthora* spp. are known to be present among walnut species. Up to now, no species or hybrids of *Juglans* are known to have a good resistance or tolerance to *P. cinnamomi*. Paradox hybrid (*J. hindsii* × *J. regia*) rootstock are significantly more resistant than Northern California black (*J. hindsii*) or English walnut rootstock to *P. citricola*. Only Chinese wingnut (*Pterocarya stenoptera*) has proven highly resistant to *P. cinnamomi* as well as to *P. citricola*. Though wingnut is not generally graft compatible with all English cultivars, for some walnut cultivars it could offer some potentiality.

EPPQ quarantine recommendation

The *Phytophthora* species associated with *Juglans* are not listed on the European and Mediterranean Plant Protection Organisation (EPPQ) lists (<http://www.eppo.int/QUARANTINE/quarantine.htm>).

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Links to further information

Juglans: <http://www.botanical.com/botanical/mgmh/w/walnut06.html>

Phytophthora in the Forests: <http://forestphythopthoras.org/>

Phytophthora determination keys: <http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-08-11-0636>

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Disease symptoms of *Phytophthora* on *Juglans* spp. (walnut)



Left: Dead walnut trees killed by *Phytophthora cinnamomi*

Right: Sudden death with leaves and nuts retained



From left to right:

- Cambium necrosis at the stem base
- Bleeding from the brown wet spot at the lower part of the trunk
- Cambium and xylem necrosis extending from the collar level up into the trunk
- Dark brown, triangular, flame- shaped lesions extending from the collar