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Phytophthora on *Castanea sativa* Mill. (sweet chestnut)

Julius Kühn-Institut, Federal Research Centre for Cultivated Plants

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Importance of *Castanea sativa*

European (or sweet) chestnut (*Castanea sativa* Mill.) is the only native species of the genus *Castanea* in Europe. The natural distribution range of *C. sativa* is probably located in the region of Asia Minor jutting out across the Black Sea region to the western Caucasus. Currently, this species is widely distributed from Western to Eastern Europe (http://www.discoverlife.org) in areas with mean annual precipitation higher than 600 mm, short drought season, and slightly acidic soils (pH 4.5-6.5) (Urbisz & Urbisz, 2007).

In Europe, the cultivation of *C. sativa* has a long tradition (Conedera *et al.*, 2004). This species has a great rural economic value due to its edible fruits and excellent wood with optimal technological characteristics. Moreover, chestnut stands play an important agro-ecological role, e.g. protection against fire and erosion, habitat for wildlife, and recreation areas.

For commercial nut production, different cultivars (cultivated varieties) have been developed, including hybrids between European and Japanese chestnut (*C. crenata*). Cultivars differ in many characteristics as, for example, size and organoleptic properties of the nuts.

Phytophthora species

From European chestnut trees in forests and nurseries affected by ink disease several *Phytophthora* species have been isolated, either from tissue of symptomatic trees, from the soil, or from streams draining the stands. However, *P. cambivora* and *P. cinnamomi* are the two species most commonly associated with the disease in Europe and considered the most pathogenic to *C. sativa*.

***Phytophthora* species**	**Recovered from**	**Reference**
cambivora	Symptomatic trees, soil	Akilli *et al.*, 2012 ; Ćerný *et al.*, 2008, Vettraino *et al.*, 2001; Vettraino *et al.*, 2005
cinnamomi	Symptomatic trees, soil	Akilli *et al.*, 2012; Crandall *et al.*, 1945, Vettraino *et al.*, 2001; Vettraino *et al.*, 2005
cactorum	Soil	Vettraino *et al.*, 2001; Vettraino *et al.*, 2005
cryptogea	Symptomatic trees, soil	Vettraino *et al.*, 2005 ; Perlerou *et al.*, 2010
gonapodyides	Stream beds	Vettraino *et al.*, 2001
megasperma	Soil	Vettraino *et al.*, 2005
nicotianae	Soil	Vannini *et al.*, 2010
plurivora[1]	Soil	Akilli *et al.*, 2012; Vettraino *et al.*, 2001, Vettraino *et al.*, 2005
pseudosyringae	Symptomatic trees, soil	Pintos Varela *et al.*, 2007; Scanu *et al.*, 2010; Vannini *et al.*, 2010
syringae	Soil	Vettraino *et al.*, 2005

[1]Previously reported as *P. citricola*

Most *Phytophthora* species isolated from European chestnut stands affected by ink disease have a wide host range. Therefore, it cannot be excluded that they infect other tree species in the surroundings.

Disease symptoms (see figures)

Ink disease caused by *Phytophthora* species is one of the most destructive diseases affecting European chestnut (Vannini & Vettraino, 2001). It causes root and collar rot of adult trees and of seedlings in nurseries, plantations, and forests. Symptoms and dieback occur both on single plants and in groups of trees. The most common symptoms are:

Crown: chlorotic leaves reduced in size, thinning of the crown, and immature husks remaining on the tree after leaf-fall. Wilting can be followed by a quick or a progressive death depending on the environmental conditions

Stem: flame shaped dark necrosis evident on the root collar under the bark. On young trees the flame shape is visible as depressed, slightly cracked areas at the base of the stem without debarking. Cortical lesions can be associated to black exudates which gave the name to the disease

Roots: root rot

Possibility of Symptom Confusion

Symptoms caused by the ink disease can be easily distinguished from those induced by *Cryphonectria parasitica*, the causal agent of chestnut blight (Heiniger & Rigling, 1994). Unlike Phytophthoras, *C. parasitica* is mostly associated with extensive necrosis (cankers) of the bark of trunk and branches and does not affect the roots. The plant part distal to the canker wilts and dies and below the cankers trees typically produce numerous epicormic shoots. Adventitious shoots may also develop from the basis of chestnut trees killed by *C. parasitica* but not by Phytophthoras.

Disease development

Usually, the first symptoms are visible in the crown, followed sometimes by bleeding, mainly at the stem base.

In adult trees, disease symptoms can develop over years and can remain undetected at the beginning of the disease. In contrast, infected seedlings in nurseries or plantations undergo a rapid or gradual wilting of the leaves.

The impact of ink disease depends not only on host susceptibility but also on the environmental conditions influencing the spread and survival of the pathogens as well as host predisposition. High precipitation (above 1000 mm/year) could be a useful index in order to classify areas at risk for ink disease.

P. cinnamomi is a thermophilic species (Benson, 1982) and its winter survival is severely endangered by cold temperatures. Global warming could result in a better survival of the pathogen and, thus, in a higher impact of ink disease.

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 or in general are given for example in http://forestphytophthoras.org/key-to-species, http://www.phytophthoradb.org, http://phytophthora-id.org/ and in 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 безопастност 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:
Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, v.v.i
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:

- NaturErhvevstyrelsen, 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:

- Pflanzenschutzdienstellen der Bundesländer, Adressenliste siehe:
  regional plant protection services, address list see: http://www.jki.bund.de/de/startseite/unser-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@agrar.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 Tuscia
  DIBAF-Department for Innovation in Biological, Agro-food and Forest systems, University of Tuscia
  Via S. Camillo de Lellis snc
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  Department of Agri-food and Environmental Systems Management, University of Catania
  Via Santa Sofia, 100 95123 Catania Italy
  Santa Olga CACCIOLA | olgacacciola@unict.it

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@minlnv.nl

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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:

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Research Institute of Horticulture, Dept. of Ornamental Plant Protection
Konstytucji 3 Maja 1/3, 96-100 Skierniewice
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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
  dsfmmp@dgadr.pt

Romania:

Institutul de Cercetari si Amenajari Silvice - ICAS,
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
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Spain:
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SLU, Institutionen för Skoglig Mykologi och Växtpatologi
Dept. of Forest Mycology and Plant Pathology
Box 7026, 750 07 Uppsala
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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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Management and control

Water (i.e. rainfall, dew deposition, and irrigation) is the main environmental factor favoring the spread of ink disease. Therefore, disease management requires, whenever possible, an accurate water management. For example, on sites subjected to waterlogging, drainage and aeration of the soil should be improved (Turchetti & Maresi, 2008). Silvicultural (e.g. reduction of competition among trees) and horticultural (e.g. optimum nutrition) practices aiming to improve health of the trees have also shown to be beneficial for controlling ink disease. To reduce the spread of *Phytophthora* species through contaminated soil, the access to infected chestnut stands may be limited, especially during wet periods.

In Italy, the use of an integrated control protocol including the injection of potassium phosphonate water solution in trunks of healthy or slightly infected chestnut trees has proven to prevent infection or reduce the severity of symptoms (Gentile *et al.*, 2009; Vettraino *et al.*, 2010). Before using any kind of chemicals please contact your national authorities (e.g. plant health service).

In several European countries, hybridization programs have been initiated in order to select hybrids (using *C. sativa*, *C. crenata* and *C. mollissima*) that are highly tolerant to ink disease (Ramos Guedes-Lafargue *et al.*, 2005). The most common French hybrid cultivars are "Marsol" (CA07), "Maraval" (CA74), "Ferosacre" (CA90), "Marigoule" (CA15) and "Marlhac" (CA118) (Salesses *et al.*, 1993).

EPPO quarantine recommendation

The *Phytophthora* species associated with ink disease of European chestnut are not listed on the European and Mediterranean Plant Protection Organisation (EPPO) lists (http://www.eppo.int/QUARANTINE/quarantine.htm).

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Links to further information

Castanea sativa: http://en.wikipedia.org/wiki/Castanea_sativa

Phytophthora in the Forests: http://forestphytophthoras.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 *Castanea sativa* (sweet chestnut)

Left: Chestnut coppice stand heavily affected by ink disease (*P. cambivora*) (1)
Right: Thinned crown of a young chestnut tree (1)

Dark necrosis on the basis of a young chestnut tree (2)

Photos: (1) – S. PROSPERO, (2) – A.M. VETTRAINO