Screening of the COGEM lists of non-pathogenic bacteria and fungi for postharvest diseases and plant pathogens

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ONDERZOEKSRAPPORT

Screening of the COGEM lists of non-pathogenic bacteria and fungi for postharvest diseases and plant pathogens

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Preface

In the Netherlands the handling and containment of GMOs is regulated by law. In this law the rules with respect to containment of GMOs are based on the environmental risks these organisms may pose such as their pathogenicity for humans, animals and plants. If an organism is considered to be non-pathogenic, the lowest containment level applies for their handling and containment.

COGEM documents CGM/141218-01 (entitled 'Advies Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene bacteriën') and CGM/141218-03 (entitled 'Advies Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene schimmels') list bacteria and fungi in different pathogenicity classes. In the lowest level class 1, the organisms are classified which are not pathogenic. It was noted however, that the lists with non-pathogenic bacteria and fungi contain organisms that are known to cause postharvest diseases. This raised the question whether or not these particular organisms should be considered pathogenic and belong to a higher pathogenicity class.

With respect to plant pathogens and post- harvest diseases, COGEM commissioned a research project for an update of the lists with non-pathogenic bacteria and fungi. The resulting report starts with the definitions to distinguish micro-organisms that are 'true' plant pathogens and those that can only cause disease in harvested products. Following is a procedure to make an inventory of possible plant pathogenic bacteria and fungi. Subsequently, the available lists with 'non-pathogenic' bacteria and fungi were screened on bacteria and fungi which could be plant pathogens and/or can cause harvest diseases. Finally, based on additional literature search, the bacteria and fungi which probably are true pathogens were identified. A closer look to these organisms is needed to review whether they should be advised to classify as organisms of pathogenicity class 2.

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Samenvatting

De COGEM lijsten van niet-pathogene bacterien en schimmels zoals gepubliceerd in CGM/141218-01 ('Advies: Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene bacteriën') en CGM/141218-03 ('Advies: Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene schimmels') zijn nagelopen op micro-organismen die mogelijk incorrect geclassificeerd zijn als niet pathogeen voor planten.
In de context van GMO-risico beoordeling wordt er een onderscheid gemaakt tussen micro-organismen welke 'echte' plantpathogenen zijn en welke alleen ziekten kunnen veroorzaken in geoogste producten ('bewaarziekten'). Dit onderscheid is niet altijd duidelijk en daarom richt het eerste deel van dit rapport zich op het omkaderen van de term 'bewaarziekte' zoals die gebruikt kan worden om op de twee bovengenoemde COGEM lijsten de micro-organismen te identificeren die bewaarziekten veroorzaken. Zo kan een beter onderscheid gemaakt worden tussen 'echte plantpathogenen', 'bewaarziekten' en 'niet plantpathogenen'.

Aan de hand van onder meer lijsten van 'common names of plant diseases' gepubliceerd door de American Phytopathological Society (APS) en lijsten van plantpathogene bacteriën, zijn 35 micro-organismen geïdentificeerd welke mogelijk ten onrechte op de Klasse 1 lijst vermeld zijn (3 bacteriën en 32 schimmels). Op basis van de definitie van een 'bewaarziekte', zijn binnen die 35 micro-organismen vijf micro-organismen (vijf schimmels) geïdentificeerd die bewaarziekten kunnen veroorzaken, maar niet bekend zijn als plantpathogeen. Als zodanig zijn deze vijf micro-organismen correct geplaatst op de lijst van niet-pathogenen. Het nalopen van de resterende 30 micro-organismen resulteerde in de identificatie van veertien schimmels waarvoor op basis van literatuurgegevens wetenschappelijk bewijs werd gevonden voor hun pathogeniteit op planten (en voor tien schimmels ook aanwijzingen voor hun pathogeniteit op mensen, dieren of insecten). Deze micro-organismen lijken daarmee incorrect te zijn geplaatst op de lijst van niet-pathogenen. Voor twaalf schimmels en twee bacteriën konden in de wetenschappelijke literatuur geen aanwijzingen voor hun pathogeniteit voor planten gevonden worden. Voor één schimmel en één bacterie kon op basis van de literatuurgegevens geen duidelijke uitspraak over hun mogelijke plant pathogeniteit gedaan worden.

Summary

The COGEM lists of non-pathogenic bacteria and fungi as published in CGM/141218-01 (‘Advies: Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene bacteriën’) and CGM/141218-03 (‘Advies: Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene schimmels’) were screened for microorganisms that were possibly incorrectly classified as non-pathogenic on plants.
In the context of GMO-risk assessment a distinction is made between the micro-organisms that are ‘true’ plant pathogens and those that can only cause diseases in harvested products (‘bewaarziekten’ or postharvest diseases/postharvest pathogens). This distinction is not always clear and therefore the first part of this report focusses on a definition of a ‘postharvest disease’ which can be used to identify postharvest pathogens on the above mentioned lists of non-pathogenic micro-organisms. In this way one can make a distinction between true plant pathogens, post harvest pathogens and non plant pathogens.

On the basis of the lists of common names of plant diseases as published by the American Phytopathological Society (APS) and lists of plantpathogenic bacteria, 35 microorganisms (3 bacteria and 32 fungi) were identified which could possibly have been incorrectly classified as non-pathogenic. Using the definition of a ‘postharvest disease’, the screening of the ‘non-pathogens’ lists identified five microorganisms (five fungi) that can cause postharvest diseases but are not known as plant pathogens. As such these are correctly placed on the list of non-pathogens. The screening of the remaining 30 micro-organisms resulted in the identification of fourteen fungi, for which scientific evidence was found for their pathogenicity on plants (and for ten species also pathogenicity for humans, animals or insects). These appear to be incorrectly placed on the list of non-pathogens. For twelve fungi and two bacteria no scientific evidence could be found for their possible pathogenicity for plants and these appear to be correctly classified as non-pathogenic. For one fungus and one bacterium the scientific literature did not provided sufficient data to allow a decision on their possible plant pathogenicity.

1. Introduction

Organisms may be subject to genetic modification. They can either serve as a donor organism from which particular genetic information is transferred to another organism, or they may serve as an acceptor organism that is supplemented with new genetic information from another organism.

In case micro-organisms serve as an acceptor of new genetic information, they become a genetically modified organism (GMO). In the Netherlands, the handling and containment of GMOs is regulated by law (Besluit genetisch gemodificeerde organismen milieubeheer 2013. Staatsblad van het Koninkrijk der Nederlanden 2014(157) https://zoek.officielebekendmakingen.nl/stb-2014-157.html). In this law the rules with respect to containment of GMOs are based on the environmental risks these organisms may pose and one of these risks is pathogenicity.

If an acceptor organism is considered to be non-pathogenic and if, for creating the GMO, a vector is used that is generally regarded as safe and this vector does not contain any insertions potentially dangerous for humans and the environment (such as genes coding for toxins, virulence- or pathogenicity-factors and viral or cellular oncogenes), the lowest containment level applies for their handling and containment. If a micro-organism is considered pathogenic, higher containment levels may apply depending on, amongst others, the pathogenicity classification of that particular organism.

COGEM documents CGM/141218-01 (entitled 'Advies Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene bacterien') and CGM/141218-03 (entitled 'Advies Actualisatie van de lijsten met de indeling in pathogeniteitsklassen van een groot aantal apathogene en pathogene schimmels') list the bacteria and fungi that are regarded as non-pathogenic (Class 1) and pathogenic (Class 2 or higher). It was noted, however, that these lists contain organisms that are known to cause postharvest diseases ('bewaarziekten'). This raised the question whether or not these particular organisms should be considered pathogenic. If so, higher containment levels should apply when used as acceptor or donor organism in the laboratory.

1.1. Report scope

The first part of this report focuses on the criteria used to distinguish between the micro-organisms that are 'true' plant pathogens and those that can only cause diseases in harvested products ('bewaarziekten' or postharvest diseases). The aim was to generate a definition of a 'postharvest disease' which can be used to identify postharvest pathogens on the above mentioned lists of non-pathogenic micro-organisms in the COGEM documents CGM/141218-01 and CGM/141218-03.

The criteria in this report are based on a risk assessment in accordance to GMO-regulations i.e. the risks micro-organisms may pose for human health and the environment. It should be noted that within the context of GMO-based risk-assessment, economic damage on harvested products resulting from an infection with a postharvest pathogen is in itself not a criterion to classify that micro-organism as pathogenic. However, such economic damage may be noted during the risk-assessment procedure and as such may lead to an advice by COGEM for additional containment measures for a GMO based on or derived from the micro-organism.

The second part of this report deals with screening of the non-pathogenic (Class 1) bacteria and fungi of both COGEM lists to identify the micro-organisms that, according to the definition, may be incorrectly classified as non-pathogenic.

2. Definition of a post-harvest disease

2.1. Current definitions

Within the current Dutch Regulations Genetically Modified Organisms (Regeling genetisch gemodificeerde organismen milieubeheer 2013. Staatscourant 2014 (11317); https://zoek.officielebekendmakingen.nl/stcrt-2014-11317.html) micro-organisms are grouped in four pathogenicity classes ranging from the lowest pathogenicity Class 1 to the highest Class 4, according to the following criteria:

2.1.1. Four classes of Micro-organisms

A **Class 1** micro-organism complies at least with one of the following conditions:

a. the micro-organism does not belong to a species of which representatives are known to be pathogenic for humans, animals or plants
b. the micro-organism has a long history of safe use under conditions without any containment measures
c. the micro-organism belongs to a species that includes representatives of class 2, 3 or 4, but the particular strain does not contain genetic material that is responsible for the virulence.
d. the micro-organism has been shown to be non-virulent through adequate tests

A micro-organism is grouped in **Class 2** when it can cause a disease in humans or animals whereby it is unlikely to spread within the population while an effective prophylaxis, treatment or control strategy exists, as well as an organism that can cause a disease in plants.

A micro-organism is grouped in **Class 3** when it can cause a serious disease in humans or animals whereby it is likely to spread within the population while an effective prophylaxis, treatment or control strategy exists.

A micro-organism is grouped in **Class 4** when it can cause a very serious disease in humans or animals whereby it is likely to spread within the population while no effective prophylaxis, treatment or control strategy exists.

2.2. Definitions of plant disease and plant pathogen

In order to define a non-pathogenic organism it is necessary to define what a pathogen is. Initial searches on web-sites of foreign organisations dealing with GMOs and biosafety rendered no results with respect to clear definitions of a 'pathogen'.

Searches were, therefore, extended to other websites, including organisations focussing more on Plant and Animal Health:

- Int. Plant Protection Convention: www.IPPC.int
- European and Mediterranean Plant Protection Organisation: www.eppo.org
- US Department of Agriculture: www.usda.gov.
- World organisation for animal health: http://www.oie.int/en

Also websites of National Plant Protection Organisations (NPPOs):

- Animal and Plant health Agency of DEFRA (UK): https://www.gov.uk/government/organisations/animal-and-plant-health-agency
- Institut für nationale und internationale Angelegenheiten der Pflanzengesundheit: http://pflanzengesundheit.jki.bund.de

And websites more generally focussed on food and food safety

- Food and Agriculture Organization of the United Nations: www.fao.org
- European Food Safety Authority (EFSA): www.efsa.europe.eu

Although all these organisations (and their web sites) deal with plant pathogens and pests and phytosanitatry issues and regulations only very limited information can be found on how they define a plant pathogen. Information obtained from these and additional web sites are further described and discussed in paragraph 2.10. In addition to these web sites different text books and literature resources were consulted for their definitions of a plant pathogen. The results are listed in the paragraphs below.

2.2.1. Definitions of a plant disease

The International Plant Protection Convention (IPPC) has published a glossary of Phytosanitary terms (ISPM-05, 2013; https://www.ippc.int/sites/default/files/documents/20140214/ispm_05_en_2014-02-14cpm-8_201402141055--559.25%20KB.pdf.) The Int. Standards for Phytosanitary Measures (ISPMs) are internationally recognized as standards. ISPM-05 contains the following definitions:

Pathogen = Micro-organism causing disease [ISPM 3:1995]
Pest = Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. Note: In the IPPC, plant pest is sometimes used for the term pest [FAO, 1990; revised FAO, 1995; IPPC, 1997; revised CPM, 2012]
plant products = Unmanufactured material of plant origin (including grain) and those manufactured products that, by their nature or that of their processing, may create a risk for the introduction and spread of pests [FAO, 1990; revised IPPC, 1997; formerly plant product]
plants = Living plants and parts thereof, including seeds and germplasm [FAO, 1990; revised IPPC, 1997]
EPPO as an organisation focuses on so-called regulated pests and pathogens. They do not define plant pathogens in general only regulated pests:

- *Regulated non-quarantine pest*: a non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party.
- *Regulated pest*: a quarantine pest and/or a regulated non-quarantine pest.

EPPO defines a Quarantine pest as 'A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.
For additional definitions EPPO refers to the above mentioned IPPC definitions as published in ISPM-05 (2013).

Different literature resources define a plant disease in different ways:

G. N. Agrios (2005, Glossary p. 890) defines **disease** as '*Any malfunctioning of host cells and tissues that results from continuous irritation by a pathogenic agent or environmental factor and leads to development of symptoms.*' In addition, Agrios (2005) defines **infectious disease** as '*A disease that is caused by a pathogen that can spread from a diseased to a healthy plant.*'

The Merriam-Webster Online Medical Dictionary (Anonymous 2005) defines **disease** as: '*an impairment of the normal state of the living animal or plant body or one of its parts that interrupts or modifies the performance of the vital functions, is typically manifested by distinguishing signs and symptoms, and is a response to environmental factors (as malnutrition, industrial hazards, or climate), to specific infective agents (as worms, bacteria, or viruses), to inherent defects of the organism (as genetic anomalies), or to combinations of these factors*.'

Windham and Windham (2004): '*A **disease** is the result of a dynamic, detrimental relationship between an organism (emphasis added) that parasitizes or interferes with the normal processes of cells or tissue, or both, of the plant. The organism that incites or causes the disease process with the host is called a pathogen. … Plant stresses or plant injuries are not diseases because they are not dynamic; that is, they do not change over time.*'

Bos and Parleviet (1995) describe that '*within plant pathology **disease** is widely accepted to be any deviation from normal functioning of physiological processes, of sufficient duration to cause disturbance or cessation of vital activity*'.

This report will refer to disease as the occurrence of symptoms (external and/or internal adverse effects, or damage on a living plant) that result from the presence of a particular pathogen. Throughout this report 'symptoms' will explicitly refer to these adverse effects or damage on a living plant.

2.2.2. Definitions of a plant pathogen

Textbooks on plant pathology make the distinction between pests and pathogens as disease-causing agents. Generally insects are termed 'pests' while the smaller (micro-)organisms like viruses, bacteria (including phytoplasma's), fungi, oomycetes and nematodes are termed pathogens. Many of the definitions of disease also include environmental or abiotic factors. However, the scope of the current report is on biotic factors that cause diseases in plants, in particular bacteria and fungi.

Agrios (2005), as a standard textbook, contains a list of definitions related to plant pathology. In this report the following definitions (as listed in Agrios 2005) will be used:

Pathogen = An entity that can incite disease.
Symptom = The external and internal reactions or alterations of a plant as a result of a disease.

2.2.3. Definitions of terms in plant-pathogen interactions

The specific interaction between a particular micro-organism and a plant can be complicated and both will influence each other. Different terms are used to describe the different components of the relationship between the host and the pathogen.

Bos & Parleviet (1995) define 'pathogenicity' as '*the quantitative capacity to cause disease*'. Biology Online defines it as '*The ability of a parasite to inflict damage on the host*'. Mosby's Medical Dictionary, (8th edition 2009, Elsevier) defines it as '*the ability of a pathogenic agent to produce a disease*'. Pirofski and Casadevall (2012) define it as '*the capacity of a microbe to cause damage in a (susceptible) host*'.

The paper by Pirofski and Casadevall (2012), deals with pathogenicity of human pathogens. The authors state that '*it is important to recognize that pathogenicity and virulence are microbial properties that can only be expressed in a susceptible host*'. The ability of a microbe to cause damage is not solely a microbial property but it can only exist in a susceptible host. According to the authors this implies that there is no difference between an opportunistic pathogen and any other kind of pathogen. Both are microbes and have the potential to cause disease however the host is a determining factor in this. The authors state that: '*attempts to classify microbes as pathogens, non-pathogens, opportunists, commensals and so forth are misguided because they attribute a property to the microbe that is instead a function of the host, the microbe and their interaction*'.

In their advices COGEM states in general that scientifically the pathogenicity of a given pathogen can be proven, however, the absence of pathogenicity is much harder to proof. In addition to that particular cases of pathogenicity are reported, however, non-pathogenicity is hardly ever reported. Therefore for many micro-organisms there is little literature available on non-pathogenicity. A long documented history of safe use, during which no adverse effect was reported, constitutes an important reference point for non-pathogenicity. In this respect it should be noted that effects of pathogenicity may be hard to notice if they are not very pronounced and if they are not really looked for. On the other side it should be noted that most micro-organisms are non-pathogenic by nature. Therefor micro-organisms, in the absence of explicit indications for pathogenicity during prolonged use, are considered to be non-pathogenic. Opportunistic pathogens, that can only cause disease in individuals with compromised immune systems, are generally also regarded as non-pathogenic (see also COGEM advice CGM/140905/01)

From the above it becomes clear that it is not always easy to clearly separate a pathogen from a non-pathogen as the interaction of micro-organism, host and environment will determine the possible presence or absence of disease symptoms.

In 1890 the German microbiologist Robert Koch published a set of criteria that can be used to establish a causative relationship between a microbe and a disease. These criteria are known as Koch's postulates:

1. The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy organisms.
2. The microorganism must be isolated from a diseased organism and grown in pure culture.
3. The cultured microorganism should cause disease when introduced into a healthy organism.
4. The microorganism must be re isolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

Over the years it has become clear that not always all criteria must be met (i.e. certain organisms can cause latent infections and certain micro-organism are obligate parasites and cannot be grown in pure culture). It is therefore generally regarded that Kochs postulates are sufficient but not necessary to establish the causal relationship between an microorganism and a disease.

2.3. Postharvest disease(s)

Many pre- and postharvest factors directly and indirectly influence the development of postharvest disease. This makes it difficult to clearly define a postharvest disease as such.
Coates and Johnson (1997) consider two groups of postharvest diseases, according to how infection is initiated. The so-called 'quiescent' or 'latent' infections are those where the pathogen initiates infection of the host at some point in time (usually before harvest), but then enters a period of inactivity or dormancy until the physiological status of the host tissue changes in such a way that infection can proceed. The other major group of postharvest diseases are those which arise from infections initiated during and after harvest. Often these infections occur through surface wounds created by mechanical or insect injury.

2.4. Distinction between pathogens, postharvest pathogens and true postharvest pathogens

In general there is consensus on the fact that the pathogenicity of a micro-organism, defined as "*its ability to cause a disease or damage in a host*", does not only depend on the characteristics of the pathogen but also on that of the host and the circumstances under which they interact.

Some micro-organisms are present in certain hosts but do not cause disease unless circumstances change. This can be changes in the environment (e.g. temperature, humidity) or in the physiology of the host (senescence, ripening but also weakened defence mechanisms). Therefor a clear distinction between a '*pathogenic*' micro-organism (one that will always cause a disease) and a '*non-pathogenic*' micro-organism (one that will not cause a disease) is not always possible. Too many (external) factors are involved in the development of 'disease'.
In relation to the project aim it does therefore not seem possible to generate a clear and general definition of a 'postharvest disease', or define clear criteria that can be applied to the lists of a-pathogenic micro-organisms to always distinguish '*pathogenic*' from '*non-pathogenic*' micro-organisms.

A more pragmatic definition might be that a micro-organism that can cause a postharvest disease is characterized by the fact that it may be present (but not necessarily is) in or on the plant in the growing stage but it is not known to cause any obvious symptoms on the living plant or its parts. Adverse effects only develop after the plant products have been harvested (see Figure 1).

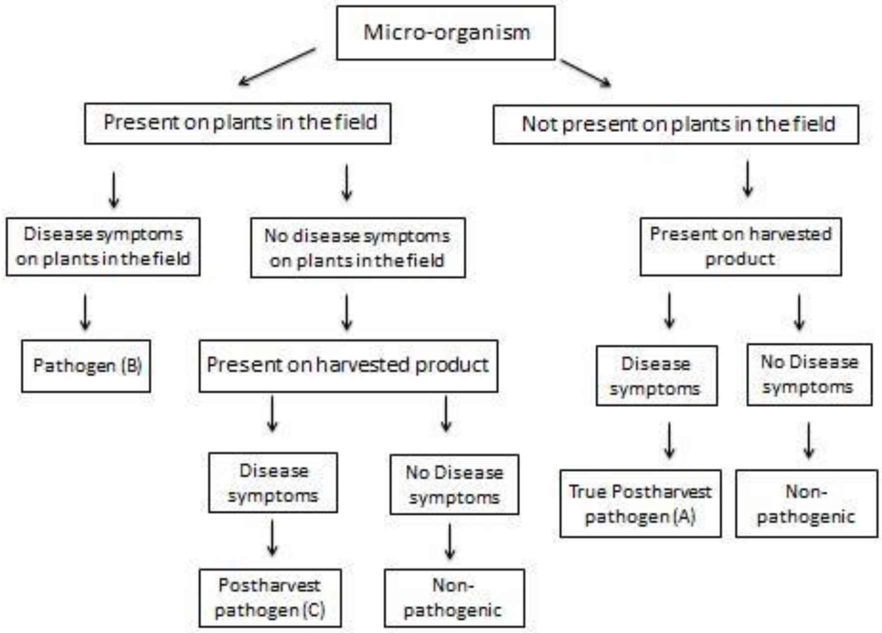

Figure 1: Scheme depicting the different classifications of micro-organisms on plants and/or harvested products; A = true post-harvest pathogen, B = pathogen and C = postharvest pathogen.

Following the definition above, three groups (A, B and C, see Figure 1) of micro-organisms can be distinguished:

A. True postharvest pathogens: micro-organisms that are not present on plants in the field and only are present on harvested products where they can cause disease, are .
B. Pathogens: micro-organisms that do cause symptoms in growing plants are always classified as pathogenic, whether or not they present and cause, or do not cause, symptoms in harvested products.
C. Postharvest pathogen: micro-organisms that may be present on, but do not cause disease symptoms in growing plants, but only cause symptoms in harvested plant products.

In terms of risk-management one could question whether the postharvest pathogens (Group C) pose any risk to the environment, i.e. is there a risk that they can serve as a potential inoculum source for a new infection cycle and cause disease symptoms on plants in the field? If they do not spread back, or do spread back but do not cause adverse effects on plants in the field, they do not pose an environmental risk in the context of the GMO regulations. As a consequence, according to the GMO regulations, such organisms can be considered as non-pathogenic (see Figure 2).

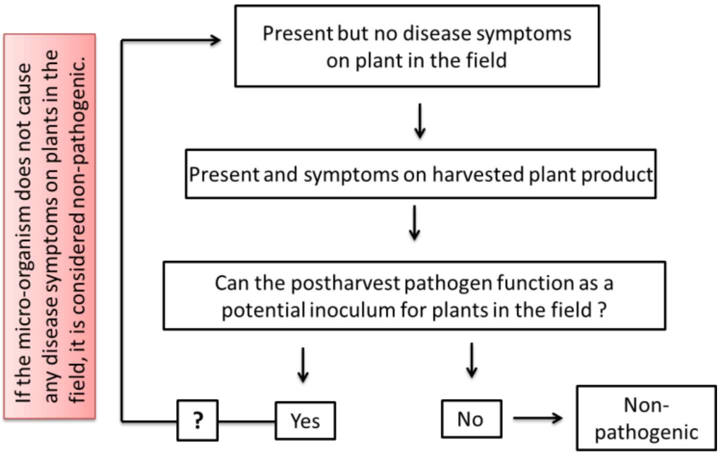

Figure 2: Scheme depicting the possible risks of postharvest pathogens.

2.5. Current COGEM classification.

Micro-organisms are classified in Class 1 if no representatives of that particular species are known to be pathogenic (i.e. cause disease) in plants.

2.5.1. Micro-organism of Class 1

A micro-organism that at least complies with one of the following conditions:

a. the micro-organism does not belong to a species of which representatives are known to be pathogenic for humans, animals or plants.
b. the micro-organism has a long history of safe use under conditions without any containment measures
c. the micro-organism belongs to a species that includes representatives of class 2, 3 or 4, but the particular strain does not contain genetic material that is responsible for the virulence.
d. the micro-organism has been shown to be non-virulent through adequate tests

N.B. In this classification two key terms are interpreted as follows

- Pathogenic = to cause disease symptoms
- Plant = living and growing plant (excluding harvested plant products)

2.6. Definition for a postharvest disease

Based on the above a pragmatic definition of a 'postharvest disease' might be that a micro-organism that can cause a postharvest disease is characterized by the fact that it may be present (but not necessarily is) in or on the plant in the growing stage, but it is not known to cause any obvious disease symptoms on the living plant or its parts. Symptoms only develop after the plant products have been harvested (see Figure 1).

As stated earlier, economic damage on harvested products resulting from an infection with a postharvest pathogen is in itself not a criterion to classify that micro-organism as pathogenic. However such economic damage may be noted during the risk-assessment procedure and as such may lead to an advice for additional containment measures for a GMO based on the micro-organism.

2.7. Procedure for the identification of pathogenic micro-organisms on the "COGEM Classificatielijsten"

Following the application of the definitions of a 'plant pathogen' (a micro-organisms that can cause symptoms in growing plants). and 'postharvest pathogen', that it '*is characterized by the fact that* *it may be present (but not necessarily is) in or on the plant in the growing stage but it is not known to cause any disease symptoms on the living plant or its parts. Symptoms only develop after the plant products have been harvested*', the following procedure was followed to identify possibly 'miss-labelled" micro-organism on the COGEM "Classificatielijsten met apathogene bacterien en schimmels":

1. the current lists of a-pathogenic micro-organisms (for Bacteria CGM/141218-01 and for FungI CGM/141218-03) were screened for the plant-associated genera and species.
   - For the bacteria the publication by Bull *et al*. (2010) and recent updates (Bull *et al*, 2012, 2014) served as a starting point. Additionally different databases and internet sources were investigated.
   - For the fungi CGM/141218-03 was screened by experts for plant pathogenic and platn associated fungi and different databases and internet sources were cross-referenced to CGM/1401218-03 cllass 1 listed organisms.
2. the species thus identified as plant-associated were investigated by database/internet/literature search for scientific evidence that they can cause symptoms in plants or plant products before harvest (= plant pathogen, group B), or after harvest and/or upon storage (= postharvest pathogen, group C).

2.7.1. Information sources used

Due to their nature, there is little specific information available on post-harvest pathogens as defined above; i.e. micro-organisms that only cause symptoms in a harvested product and not in a living and growing plant. Below a number of starting points are listed.

APS Press (American Phytopathological society) has published an extensive series on books (Compendium series) that list and describe diseases on a large number of different crops: https://www.apsnet.org/apsstore/shopapspress/Pages/Diseaseid.aspx

Over 26 books of that series are listed as being available in the Wageningen University library.

The APS Journal Plant Disease has extensive records of first descriptions of diseases in crops and countries.
The Journal of Plant Pathology and Australasian Plant Disease notes have similar reporting services.

Different internet links are available with specific information on reported plant pathogens (see also below in References and Literature):

- EPPO Global database: https://gd.eppo.int/
- USDA ARS Fungal database: http://nt.ars-grin.gov/fungaldatabases/
- Mycobank; http://www.mycobank.org
- PHI-base is a web-accessible database that catalogues experimentally verified pathogenicity, virulence and effector genes from fungal, Oomycete and bacterial pathogens, which infect animal, plant, fungal and insect hosts.
- http://www.phi-base.org/about.php
- Postharvest Information Network Article Database
- http://postharvest.tfrec.wsu.edu/pages/Article_Table/d/D/No

Additional information was obtained from experts:

Dr. J van der Wolf, bacteriologist Wageninging University (WU)
Dr J Kohl, phytopathologist Wageningen University (WU)
Dr. G van Leeuwen, phytopathologist Nederlandse Voedsel- en Warenautoritiet (nVWA)
Prof. Dr. P. de Vos, bacteriologist, Universiteit van Gent

2.8. Proof of principle

As a proof of principle of the procedure proposed to identify pathogenic microorganisms on the "COGEM Classificatielijsten", the following micro-organisms were selected by the advisory committee members as possibly wrongly identified as non-pathogenic on the classification lists of non-pathogenic fungi and bacteria, and were subjected to the previously mentioned procedure:

1. *Aspergillus niger*
2. *Trichoderma viride*
3. *Xantobacter autotrophicus*

2.8.1. Aspergillus niger

Searching different databases yielded the following results:
USDA ARS Fungal database: http://nt.ars-grin.gov/fungaldatabases/

1. Aspergillus niger: 210 reported fungus/host combinations and 174 literature citations.

However the non-pathogenic fungi COGEM list explicitly mentions:

2. Aspergillus niger var. niger: 0 reported fungus/host combinations and 0 literature citations
3. Aspergillus niger var. awamori: 0 reported fungus/host combinations and 0 literature citations

A search on the APS database of Common names of Plant diseases using the search term *Aspergillus niger* returned a large number of disease reports related to this fungus. However, no new hits appear following a more specific search with *A. niger* var. *niger*.

According to the Species Fungorum database *A. niger* var. *awamori* was renamed *A. awamori*. A search using the term *Aspergillus awamori* returned a number of disease reports including a report of infection of figs in California by both *A. niger* var. *niger, A. niger* var. *awamori, A. japonicus,* and *A. carbonarius* (Doster *et al*, 1996). This paper describes the detection of these species inside figs showing symptom of '*fig smut*' that were collected from Californian orchards. The paper suggests that infection occurs though an opening in the fruit, the ostiole, although no proof for this is presented nor any indication at what time point in fruit development this infection might occur.

Additional information
Doster *et al*, (1996) report Aspergillus infections from Californian fig orchards. Infections with *Aspergillus* species were assessed only on figs collected from the ground (normal way of harvesting figs). These figs were cut open and visually examined for fungal spores. Figs with *Aspergillus* specific sporulation were used for plating on media.
The paper only states that from smutted figs different *Aspergillus* spp. were isolated. It is not clear if 'smut' symptoms are caused by any of the mentioned species or combinations of species. Koch's postulates (see paragraph 2.2.3) are not fulfilled. It remains unclear if the figs became infected when still attached to the trees or when they had already fallen on the ground. It is also unclear if infections of the figs could lead to new infection of previously healthy trees or fruits attached to these trees. The paper does contain a few references to a positive correlation between fig smut and A. niger.
In addition the paper states that "*Aspergillus spp have been involved in nut decay of trees crops such as pistachios, almonds and pecans*." It contains a reference to an APS meeting abstract (Michailides and Morgan, 1991) which states that *A. niger* propagules were counted on fresh leaves and the incidence of fig smut on fresh and dried fruits was determined.
Another reference (Doster and Michailides, 1994) describes the infection of split pistachio nuts by *A. niger* when still attached to the trees (so before harvest).

Conclusion
Based on this information it is likely that *A. niger* can be regarded as a plant pathogenic fungus as it is capable of causing symptoms on pistachio nuts (and most likely figs) before harvest.

The status of the other *Aspergillus* spp mentioned above is unclear as clear information on their capability to infect figs (or other fruits/nuts) could not be found.

2.8.2. Trichoderma viride

USDA ARS Fungal database: http://nt.ars-grin.gov/fungaldatabases/ lists 220 reported fungus/host combinations and 136 literature citations for *Trichoderma viride*.

Species Fungorum lists *Hypocrea rufa* as the teleomorph name. Using this name a search in the USDA ARS fungal database yields exactly the same results as for *Trichoderma viride*.

T. viride is known to cause a disease in cultivated mushrooms ("green mold of mushrooms") resulting in deformed fruiting bodies. Although technically speaking, cultivated mushrooms (*Agaricus bisporus*) are not plants but fungi, they are nevertheless grown and harvested as a crop and sold on the market. In the context of this report they are therefore regarded as 'plants'.

The search in the American Phytopathological Society (APS) database of common names of Plant diseases for *Trichoderma viride* yielded a large number of papers. A quick scan showed that nearly all are associated with its apparent mycoparasitic nature, i.e. its use as a biological agent to control other plant parasitic fungi.

Conclusion
Besides its apparent myco-parasatic nature it is also capable of inciting disease symptoms in onion plants (Schwartz and Krishna, 2008) and edible mushrooms. From this it can be concluded that *T. viride* is a plant pathogen.

2.8.3. Xanthobacter autotrophicus

The genus *Xanthobacter* is on the COGEM list of non-pathogenic bacteria. A search in Bull *et al* (2010) showed no hits for this name or any other species for the genus *Xanthobacter*.
A general Google search yielded a significant number of hits with links to studies on enzymatic compounds generated by this bacterium (or closely related relatives).

A search in the APS common names database found no matching results. No scientific literature could be found that identifies *Xanthobacter autotrophicus* as a plant pathogen.

Wiegel (2006) mentions that "*So far, no Xanthobacter-like strains have been associated with any plant disease. However, the work of Kawai et al. (1989) indicates the possibility that because of the properties of the slime produced, Xanthobacter could indirectly mediate plant diseases by fostering the adherence of pathogenic microorganisms to plant cells*".

Sampaio Videira *et al* (2013) investigated the bacterial communities in stems and roots of five different genotypes of elephant grass (*Pennisetum purpureum*). From 16S sequences analyses they conclude the presence of *Xhantobacter autotrophicus* sequences in both stems and roots of several elephant grass genotypes.. The authors also conclude that the presence of these is likely to be associated with N2-fixing and not with any disease or symptoms.

Conclusion
Based on the information above it is unlikely that *Xantobacter autotrophicus* is plant pathogenic.

2.9. Conclusion on proof of principle

The proposed procedure for the identification of pathogenic micro-organisms on the "COGEM Classificatielijsten" seems to work well based on the results obtained for the three microorganisms used in the above described proof of principle.

2.10. References and Literature

2.10.1. Databases and other sources of information

A large number of different databases is available on the internet with very diverse information on bacterial and fungal micro-organisms. None of the databases contains all information and every database contains different bits of information and in many cases the information from different sources needed to be combined.

A number of web sites and other sources of information on micro-organisms are listed below. Websites were all assessed between October 2014 and June 2015.

EPPO Global database: https://gd.eppo.int/

A database with basic information for more than 60.000 species of interest to agriculture, forestry and plant protection: plants (cultivated and wild) and pests (including pathogens). For each species: scientific names, common names in different languages, taxonomic position, and EPPO codes are given. It also contains more detailed information for more than 1600 pest species that are of regulatory interest (EPPO and EU listed pests, as well as pests regulated in other parts of the world). For each pest: geographical distribution (with a world map), host plants and categorization (quarantine status) are given. A large part of the functionalities of PQR (EPPO database on quarantine pests) has already been transferred to EPPO Global Database. Furthermore the database contains EPPO Datasheets, EPPO Standards as well as over 1800 pictures of pests (including invasive alien plants) and articles of the EPPO reporting service (since 2000).

Species Fungorum: (http://www.speciesfungorum.org/Names/Names.asp)

A RBG Kew coordinated initiative delivering the fungal component of the Species 2000 project. Different databases (The Dictionary of the Fungi), (Bibliography of Systematic Mycology) can be assessed.

Mycobank: http://www.mycobank.org

USDA ARS Fungal database: http://nt.ars-grin.gov/fungaldatabases/

A database with access to a lot of background information, including reported hosts and literature on a significant set of fungal species.

Animal and Plant health Inspection Service (APHIS)

Within the US Dept of Agriculture APHIS deals with plant- and animal health (http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth)

The APHIS Plant Protection and Quarataine program (PPQ) particularly focuses on the preventing entry of and regulation around harmful organisms.

APHIS has developed an information management system; the Integrated Plant Health Information System (IPHIS) that in the future will serve as the central information 'Portal'. This IPHIS system however has restricted access and is not publically accessible.

Within the USA the "National Clean Plant Network (NCPN)" (http://nationalcleanplantnetwork.org/) exists. This network is a collaboration between different parties and aims at promoting the use of certified and healthy planting material. The NCPN also uses a list of definitions: http://nationalcleanplantnetwork.org/Glossary/

International Collection of Microorganisms from Plants (ICMP) | Collections | Landcare Research

http://www.landcareresearch.co.nz/resources/collections/icmp

American Phytopathological Society (APS): database of common names of Plant diseases.

Lists names of reported plant diseases sorted by crop.

http://www.apsnet.org/publications/commonnames/Pages/default.aspx

Straininfo: Info on bacteria
http://www.straininfo.net

LPSN: List of prokaryotic names with standing in Nomenclature
http://www.bacterio.net/index.html

The NIAS (National Institute of Agrobiological Sciences) Genebank
The central coordinating institute in Japan for conservation of plants, microorganisms, animals and DNA materials related to agriculture.The site contains links to various databases that can be searched.
http://www.gene.affrc.go.jp/databases_en.php

Encyclopedia of Life (EOL): www.eol.org

PHI-base is a web-accessible database that catalogues experimentally verified pathogenicity, virulence and effector genes from fungal, Oomycete and bacterial pathogens, which infect animal, plant, fungal and insect hosts.
http://www.phi-base.org/about.php

Postharvest Information Network Article Database
http://postharvest.tfrec.wsu.edu/pages/Article_Table/d/D/No

Canadian (British Colombia) Ministry of Agriculture. Pages on Plant Disease Management:
http://www.agf.gov.bc.ca/cropprot/pathology.htm
Background information on diverse plant pests and pathogens.

2.10.2. Literature

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3. Screening of CGM/141218-01 (list of non-pathogenic bacteria)

3.1. Introduction

Following the outcome of the first part of the project and the subsequent application of the definition of a "postharvest pathogen" that "*only in case the micro-organism which develops in the harvested plant product, can spread back to healthy, growing plants in which it is known to cause disease (symptoms), it should be considered a pathogen*", on the COGEM "Classificatielijsten", the procedure als listed earlier in paragraph 2.7 was followed to identify possibly 'miss-labelled" micro-organism on the list of non-pathogenic (Class 1) bacteria in CGM/141218-01.

3.2 Screening procedure

For COGEM list CGM/141208-01 of non-pathogenic bacteria the following procedure was applied:

1. Bacteriologist Dr. Jan van der Wolf (WU Biointeractions and Plant Health) was consulted on how to obtain a reliable and as complete as possible overview of all publically known plant pathogenic bacteria.
2. Dr. Van der Wolf advised to start with the overviews of plant pathogenic bacteria given in:
    a. Kado CI (2010) Plant bacteriology, APS Press, St. Paul U.S.A.
    b. Janse JD (2005) Phytobacteriology, principles and practice, CABI Publishing, Wallingford UK
3. These books do not cover the period after 2010. Therefore Dr. Van der Wolf advised to screen the Journals (1) Plant Disease (volume 95-99), (2) Australasian Plant Disease Notes (2010-2015) and (3) BSPP New Disease Reports (volumes 19-31) for all "first reports" of plant pathogenic bacteria.
4. From the sourced listed above a list of plant pathogenic bacteria was compiled. Subsequently the additional information from Bull *et a*l in *Journal of Plant Pathology* 2010, 2012 and 2014) was added to this list, thus generating a list of all currently known plant pathogenic bacteria (see Appendix 2).
5. All non-pathogenic bacteria (Class 1) on COGEM-list CGM/141218-01 were compared to the newly generated list of plant pathogenic bacteria for common genera and species.
6. This resulted in the identification of two species on the Class 1 COGEM-list that also occur on the newly generated list of plant pathogenic bacteria: *Acetobacter aceti* and *Pseudomonas fluorescens*.
7. For these two species literature searchers were performed to assess their possible plant pathogenicity.

3.2.1. Acetobacter aceti

Bull et al (2010) published a comprehensive list of names of plant pathogenic bacteria (2010). The authors state that "*This document lists the names of all plant pathogenic bacteria that have been effectively and validly published according to the terms of the International Code of Nomenclature of Prokaryotes.*" It should be noted that it is unclear on what basis or evidence the particular species are placed on this list of recognized plant pathogenic bacteria as this information is not provided by the authors.

Acetobacter aceti is listed by Bull et al (2010) and two references are provided for the first description of this species (Pasteur, 1864 and Beyerinck, 1898).

According to the United States Environmental protection agency *(EPA), Acetobacter aceti* is a benign microorganism that is ubiquitous in the environment, existing in alcoholic ecological niches such as flowers, fruits, honey bees, as well as in water and soil (http://www.epa.gov/biotech_rule/pubs/fra/fra001.htm). It has a long history of safe use in the fermentation industry for the production of acetic acid from alcohol. There are no reports in the literature suggesting that *A. aceti* is pathogenic for humans or animals. It also is not considered a plant pathogen.

A. aceti is considered a Class 1 Agent (for humans and animals) under the NIH Guidelines for Research Involving Recombinant DNA Molecules (U.S. Department of Health and Human Services, 1986). The NIH does not consider plant pathogens; however, the NIH site does mention that *A. aceti* is on the FDA's GRAS (Generally Recognized As Safe) list of microorganisms.

With respect to possible pathogenicity on plants, the web site of EPA states that although *A. aceti* has been reported as the causal agent of pink disease of pineapple (Kontaxis and Hayward, 1978; Cho et al., 1980), this is likely to be the result of an initial miss-identification. Following a re-classification of the genus *Acetobacter*, *A. aceti* was shown not to be able to produce 2,5-diketogluconic acid, the compound responsible for the disease. It is therefore likely that the bacterium now designated as *Acetobacter liquefaciens* (formerly *A. aceti* subsp. *liquefaciens*) was previously misidentified as *Acetobacter aceti*. A more recent study (Cha et al, 1997) identified *Pantoe citreae* and not *A. aceti* as the causal agent of pink disease of pineapple.

Another report in the literature (Van Keer et al., 1981) mentions a disease of stored fruit (apples and pears) presumably caused by *A. aceti*. This organism, as well as numerous acetic acid bacteria and other bacteria, were reported to cause rot in apples and pears, resulting in different degrees of browning. It is however questionable whether *A. aceti* is capable of causing this storage disease as the paper was published before the revision of the genus *Acetobacter*, therefore, it is difficult to tell if the strains used would meet the current designation of *A. aceti*.

The APS Common names of plant diseases (http://www.apsnet.org/publications/commonnames/Pages/default.aspx) lists A. aceti as a fruit disease of pineapple ('pink disease').

Additional literature searches in the Journals Plant Disease and BSPP New Disease reports returned no hits for *A. aceti* as a plant pathogen. A search in the Australasian Plant Disease Notes returned one paper (Cho et al, 1980) describing the identification of a strain (295) of *A. aceti* from pineapple. However as stated above it cannot be ruled out that this strain is actually a strain of *Acetobacter liquefaciens*.

Conclusion

Despite the listing as a plant pathogenic bacterium in Bull et al (2010) and on the APS list of Common names of Plant Diseases, there is no apparent evidence that *Acetobacter aceti* is able to cause a disease in healthy, growing plants. Reports mentioning this bacterium as the cause of diseases in pineapple or rot in harvested apples and pears are likely to be incorrect and based on miss-identifications. Based on the available information it can be concluded that *Acetobacter aceti* should not be considered a plant pathogenic bacterium.

3.2.2. Pseudomonas fluorescens

In 2007, COGEM classified the bacterial species P*seudomonas fluorescens* as an opportunistic pathogen in pathogenicity Class 1 and advised to include this bacterial in Annex 1 ("Bijlage 1"). Due to uncertainty on its (a)pathogenic character, *P. fluorescens* was not included in the revised classification lists with (a)pathogenic bacteria from 2011.
In 2014 the classification of the species *P. fluorescens* was re-investigated resulting in COGEM advice CGM/140527 (2014). COGEM concluded that particular strains of *P. fluorescens* occur as commensal in plants, it occurs in the soil and is omni-present in the environment.
Prof. dr. Paul de Vos (Univ. Gent) was consulted on the possible plant pathogenicity of *P. fluorescens*. Professor De Vos indicated that what is considered to be *P. fluorescens* is a complex of many different bacterial species rather than a clearly defined species. Many bacteria, including different plant related and even plant pathogenic species have been incorrectly identified as belonging to this species. Usually these belong to the Pseudomonas syringae complex. Prof. De Vos also commented that recently some *P. fluorescens* strains (in particular pf01 and Pf5 strains) have been, or are in the process of being renamed.

Much remains unclear with respect to the taxonomy of *P. fluorescens*. In some cases *P. fluorescens* is referred as a species while in fact the sub-group *P. fluorescens* is meant. In COGEM advice CGM/140527-02, COGEM classifies the species *P. fluorescens* in pathogenicity Class 1.

Additional literature searches were performed in the journals Plant Disease, BSPP New Disease Reports and Australasian Plant Disease Notes and on the APS website.

Plant Disease returned three reports of *P. fluorescens* as the causal agent, including proof of Koch's postulates, of head rot in broccoli in China (Li et al, 2009; head rot symptoms in commercial fields consisting of water-soaked lesions on the buds which progressed into a brown-black soft rot.), the cause of head rot in cauliflower in Italy (Lo Cantorre and Iacobellis, 2007; symptoms in commercial cauliflower fields in Apulia, southern Italy.) and the identification, including proof of Kochs postulates of 1 strain of *P. fluorescens* as the cause of tomato pith necrosis in Saudi Arabia (Molan and Ibrahim, 2007).

The search in BSPP New Disease Reports returned a report on the identification, including proof of Kochs postulates, of 1 strain of *P. fluorescens* (Biotype 1) as the cause of tomato pith necrosis in Turkey (Saygili et al, 2007).

The search in Australasian Plant Disease Notes returned no findings for *P. fluorescens* as a plant pathogen.

A search on the APS web site listed a paper (Cui and Harling, 2006) in which pectolytic strains of *P. fluorescens* are mentioned as opportunistic pathogens of broccoli.

Conclusion

Given the apparent diversity of *P. fluorescens* strains and the uncertainty on their correct taxonomic identification and classification it is impossible to generally classify this bacterial species as either pathogenic or non-pathogenic on plants.

3.3. Literature

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4. Screening of CGM/141218-03 (list of non-pathogenic fungi)

4.1. Introduction

Following the outcome of the first part of the project and the subsequent application of the definition of a "postharvest pathogen" that "*only in case the micro-organism which develops in the harvested plant product, can spread back to healthy, growing plants in which it is known to cause disease (symptoms), it should be considered a pathogen*", on the COGEM "Classificatielijsten", the procedure als listed earlier in paragraph 2.7 was followed to identify possibly 'miss-labelled" micro-organism on the list of non-pathogenic fungi (Class 1) in CGM/141218-03.
It should be noted that apart from the true fungi, the CGM/141218-03 also contains oomycetes and other fungal-like organisms (also called lower fungi). Fungi and fungal-like organisms are members of the Eukaryota (Agrios, 2005 pg 390). For sake of clarity all fungi and fungal-like organisms will be referred to in this report as 'fungi'.

4.2. Screening procedure

For the screening of COGEM list CGM/141218-03 of non-pathogenic fungi, three independent methods were applied:

A: Expert evaluation (see 4.3.):

1. Phytopathologist Dr. Jürgen Köhl (WU Biointeractions and Plant Health) reviewed the COGEM list of non-pathogenic fungi (COGEM CGM/141218-03) for any plant related species. He identified both plant pathogenic fungi as well as fungal species known to have an antagonistic effect on plant pathogens (see Table 1).
2. Phytopathologist Dr. Gerard van Leeuwen (Nederlandse Voedsel en Waren Autoriteit; NVWA) also identified the plant-associated genera and species from the Class1 list in the COGEM list CGM/141208-03 (see Table 1).
3. The possible plant pathogenicity of the fungal species identified by both experts was assessed through a number of different searches listed below (# 4-6):
4. An literature search using bibliographic database SCOPUS and Web of Science as well as the web sites of two Journals published by the American Phytopathological Society (APS); Plant Disease and Phytopathology.

B: Screeing of internationally recognized databases (see 4.4.):

5. A search on Mycobank (www.mycobank.org), an internationally acknowledged fungal and yeast database.
6. A search on the fungi section of Q-bank (www.q-bank.eu/fungi), a database of regulated plant pests and pathogens.

C: Screening of the lists of the APS lists of common names of plant diseases as published by the American Phytopathological Society (APS) (see 4.5.):

7. The website of the American Phytopathological Society (APS) contains lists of Common names of Plant Diseases for different crops (http://www.apsnet.org/publications/commonnames/Pages/default.aspx). After obtaining permission from the APS editorial office for the restricted use of these lists, the names of the fungal species were extracted from these lists and converted to Excel worksheets. The compiled list of over 8500 listed species, covering all crops listed on the APS website, was de-dubbed and cleaned and an alphabetical list containing 605 different fungal genera was generated (Appendix 2).
8. The full list of pathogenic fungi as extracted from the APS web site was compared to the non-pathogenic fungi (Class 1) on COGEM-list CGM/141218-03. Any match was indicated on the compiled alphabetical list of 605 genera that the APS mentions as a plant pathogen (see Appendix 3).
9. One particular group are the species that are mentioned both on the plant pathogen APS list and on the COGEM Class 1 list of non-pathogenic fungi (see Table 2).

10. Both the species identified earlier through expert evaluation (Table 1) and in species listed in Table 2 were further investigated for their possible plant pathogenic status.

4.3. Assessment of the possible plant pathogenic status of fungal species identified by experts

The fungal species listed as non-pathogenic on CGM/141218-03 were screened by phytopathologists Dr. J. Kohl and Dr. G. van Leeuwen for known plant associated fungi. Dr. Köhl screened for plant pathogens and antagonists while Dr. Van Leeuwen identified fungal species that had at some point been found associated with plant material submitted to by the Dutch National Plant Protection Organisation (NPPO) for investigation. The species they identified from the COGEM list are listed in Table 1. It should be explicitly noted that identification of particular fungal species as associated with plants does not imply any link with plant pathogenicity. Therefore for each of these species a literature search was performed (see paragraph 4.2.) for possible references associated with these names. If necessary (due to the number of hits) the query was refined (with terms mentioned when appropriate below).

Table 1. Expert identification of plant associated fungi from COGEM list (CGM/141218-03) of non-pathogenic fungi (Class 1).

Species	**Dr. J. Köhl**		**Dr. G. van Leeuwen**
	Pathogenic	**Antagonist**	**Plant associated**
Aspergillus niger var. niger	X		X
Aureobasidium pullulans		X	X
Cladosporium herbarum			X
Clonostachys rosea		X	
Coniothyrium minitans		X	
Dichotomophthora portulacae			X
Metarhizium anisoplae		X	
Microsphaeropsis olivacea			X
Nigrospora sphaerica			X
Phoma herbarum			X
Pseudozyma flocculosa		X	
Rhodotorula glutinis			X
Trichoderma viride		X	

In addition the names were used to search the web sites of APS journals Plant Disease and Phytopathology for any references regarding these fungi. The results of these screenings are listed and discussed below for each of the individual species.

4.3.1. Aspergillus niger var. niger

Scopus search

A Scopus search for A. niger AND pathogen yielded 327 documents. Gajera et al (2014) describe *A niger* as a plant pathogen, causing collar rot in groundnut and Vitale et al (2012) as a plant pathogen causing Aspergillus vine canker in table grapes in Italy. 21 isolates of 37 isolated from infected plants, belonged to *A. niger var. awamori*. One isolate of *A. niger* was positively assessed for pathogenicity on mature canes of grape cv. Italia. Aigbe and Remison isolated *A. niger* from rotted cassava roots in the field.

Mirzaee (et al, 2013) isolated *Aspergillus niger* frequently from lint parts of cotton grown in Iran, showing symptoms of lint and boll rot prior to harvesting. Guerrero et al (2014) describe the presence of *A. niger* on empty or abnormal shaped hazelnuts from Chile. Pozzo-Ardizzi et al (2012) describe *A niger* as a post-harvest pathogen on onion in Argentina.

Web of Science search

A search in Web of Science for A. niger and limiting the search to plant sciences yielded 770 hits on a variety of subject. Coutinho et al (2006) report on *A. niger* as a plant pathogen (2006) as they identified *A. niger* as the causal agent of bol rot in Sisal (*Agave sisalana*) in Brazil.

Plant Disease search

A search in Plant Disease on *A. niger* yielded 44 references. A number describe *A. niger* as a plant pathogen (Xu et al, 2015; Vitale et al, 2008; Pawar et al, 2008) while two references describe *A.*

niger as the cause of rot in harvested products (Thomidis and Exadaltylou, 2012; Latorre et al, 2002).

Phytopathology search
A search in Phytopathology on *A. niger* yielded 37 references. None of these describe *A. niger* as a plant pathogen.

Conclusion
There are a number of papers reporting on the plant pathogenicity of *Aspergillus niger* on a variety of plant species. These result confirm the earlier findings in this report (paragraph 2.8.1. and references therein; Michailides and Morgan, 1991, Doster and Michailides, 1994, Doster *et al*, 1996) *A. niger* can be regarded as a plant pathogenic fungus as it is capable of causing symptoms on various plants before harvest.

Selected references
Doster *et al* (1996) Aspergillus Species and Mycotoxins in Figs from California Orchards. *Plant Disease* 80: 484

Michailides TJ and Morgan DP (1991) Positive correlation of fig smut in Calimyrna fruit with amounts of dust and propagules of Aspergillus niger accumulated on the trees (Abstr) Phytopathology 81: 1234

Xu ML., J. G. Yang, J. X. Wu and Y. C. Chi L. H. Xie (2015). First Report of Aspergillus niger Causing Root Rot of Peanut in China. Plant Disease 99 (2): 284.

Thomidis T. and E. Exadaktylou (2012). First Report of Aspergillus niger Causing Postharvest Fruit Rot of Cherry in the Prefectures of Imathia and Pella, Northern Greece. Plant Disease 96 (3): 458.

A. Vitale, I. Castello, and G. Polizzi (2008). First Report of Aspergillus Vine Canker on Table Grapes Caused by Aspergillus niger in Europe. Plant Disease 92 (10): 1471.

N. V. Pawar, V. B. Patil, S. S. Kamble, and G. B. Dixit (2008). First Report of Aspergillus niger as a Plant Pathogen on Zingiber officinale from India. Plant Disease 92 (9): 1368.

B. A. Latorre, S. C. Viertel, and I. Spadaro (2002). Severe Outbreaks of Bunch Rots Caused by Rhizopus stolonifer and Aspergillus niger on Table Grapes in Chile. Plant Disease 86 (7): 815.

H. P. Gajera, J. K. Jadav, S. V. Patel, B. A. Golakiya (2014). Trichoderma viride induces phenolics in groundnut (Arachis hypogaea L.) seedlings challenged with rot pathogen (Aspergillus niger Van Tieghem). Phytoparasitica 42 (5): 703-712.

J.C. Guerrero, S.F. Pérez, E.Q. Ferrada, L.Q. Cona , E.T. Bensch (2014). PHYTOPATHOGENS OF HAZELNUT (CORYLUS AVELLANA L.) IN SOUTHERN CHILE. ISHS Acta Horticulturae 1052: VIII International Congress on Hazelnut. Pages 269-274.

Mirzaee, M.R., Heydari, A., Zare, R., Sabzali, F., Hasheminasab, M. (2013). Fungi associated with boll and lint rot of cotton in Southern Khorasan province of Iran. Archives of Phytopathology and Plant Protection 46 (11): 1285-1294.

Pozzo-Ardizzi, C., Pellejero, G., Aschkar, G., Jiménez-Ballesta, R. (2012). Effects of Aspergillus niger in onion bulbs (Allium cepa L.) stored in the post-harvest phase. International Journal of Postharvest Technology and Innovation 2 (4): 414-425.

Vitale, A., Cirvilleri, G., Panebianco, A., (...), Perrone, G., Polizzi, G. (2012). Molecular characterisation and pathogenicity of Aspergillus Sect. Nigri causing Aspergillus vine canker of table grapes in Italy. European Journal of Plant Pathology 132 (4): 483-487.

Aigbe, S.O. and Remison, S.U. (2010). Minor root rot pathogens of cassava (Manihot esculenta Crantz) in Nigeria. Archives of Phytopathology and Plant Protection 43 (13): 1335-1341.

Coutinho WM, Suassuna ND, Luz CM, Suinaga FA, Silva ORRF (2006) Bole rot of sisal caused by Aspergillus niger in Brazil. Fitopatologia Brasileira 31: 605.

4.3.2. Aureobasidium pullulans

Search in Scopus
A Scopus search for *Aurobasidium pullulans* AND pistachio returned no hits. A Scopus search for *Aurobasidium pullulans* returned 45 hits, all related to the production of polygalacturnase enzymes.

Search in Web of Science
A Web of Science search for *Aurobasidium pullulans* returned over 1600 hits. Refining this search to Agriculture and Plant Sciences returned 54 references. Nearly all deal with use of *A. pullulans* as a biocontrol agent, particularly for post-harvest rots. None reports on *A. pullulans* as a plant pathogen. One paper (Yurlova et al, 1999) mentions the apparent pathogenicity of *A. pullulans* var *lini* on Russian flax. These authors state that his species falls withing the natural variabilty of *A. pullulans*, it remains unclear of the two species are identical (see also paragraph 4.6.6.).

Plant Disease search
A search in Plant Disease for *A. pullulans* yielded 27 hits. Most deals with antagonists however two papers refer to a pathogenic effect of *A. pullulans* on apples (Matteson Heidenreich et al, 1997) and pears (Spotts and Cervantes, 2002). From both papers it does not become clear if *A. pullulans* induces any significant symptoms on fruits developing on the trees. One paper (Kim, 2014) refers to post-harvest infections of sweet cherries in the US with *A. pullulans*.

Phytopathology search
A search in Phytopathology for *A. pullulans* yielded no hits relating to any plant pathogenic effect of this species.

Conclusion
There were no papers found reporting on an apparent plant pathogenicity of *Aurobasidium pullulans A. pullulans* might be related to postharvest diseases in pears and cherries.

Selected references

Matteson Heidenreich, M. C., Corral-Garcia, M. R., Momol, E. A., and Burr, T. J. 1997. Russet of apple fruit caused by Aureobasidium pullulans and Rhodotorula glutinis. Plant Disease 81:337-342.

Spotts, R. A., and Cervantes, L. A. (2002). Involvement of Aureobasidium pullulans and Rhodotorula glutinis in russet of d'Anjou pear fruit. Plant Disease 86:625-628.

Kim YK. (2014). First Report of a New Postharvest Rot in Sweet Cherries Caused by Aureobasidium pullulans. Plant Disease 98 (3): 424.

Yurlova N.A., De Hoog G.S. and van den Ende A.H.G.G. (1999). Taxonomy of Aureobasidium and allied genera. Studies in Mycology 43: 63-69

4.3.3. Cladosporium herbarum

Search in Scopus
A Scopus search for *C. herbarum* returned 426 hits and limiting these to Agricultural and Biological Sciences still gave 224 hits.
One paper (Latorre et al, 2011) describes the practice of leaf removal to control Cladosporium rot (caused by *C. herbarum* and *C. cladosporioides*). The authors do describe infection of developing grapes by these Cladosporium species. Abdel-Motaal (2009) report leaf spot disease caused by *C. herbarum* on *Hyoscyamus muticus* (Egyptian henbane).
Other papers report the presence *of C. herbarum* from healthly leaves of Amaranthus (Pusz et al, 2015) and on seedlings of Scots pine in Belarus (Baranov et al, 2010) with no indication for plant pathogencity.

Search in Web of Science
A Web of Science search for *C. herbarum* returned over 457 hits. Refining this search to Plant Sciences returned 63 references. Perello et al (2003) report *C. herbarum* as the causal agent of a disease on wheat leaves in Argentina.

Plant Disease search
A search in Plant Disease for *C. herbarum* yielded 22 hits. Three papers refer to a pathogenic effect on plants. Berner et al (2007) report it as a pathogen on *Centaurea solstitialis* in Greece, Briceño, and Latorre (2007 and 2008) report it on grapes in Chile. The latter two papers suggest a pathogenic effect on grapes when these are still attached to the vines although this does not become full clear. Benbow and Sugar (1999) report on *C. herbarum* as a post-harvest disease of pear.

Phytopathology search
A search in Phytopathology yielded 8 references none of which deals with plant pathogenicity of *C. herbarum*.

Conclusion
There are a number of papers reporting on the plant pathogenicity of *Cladosporium herbarum* on a variety of plant species.

Selected references

Hewitt W.. Compendium of Grape Diseases. R. Pearson and A. Goheen, eds. The American Phytopathological Society, St. Paul, MN, 1988.

Baranov, O.Y., Oszako, T., Nowakowska, J.A., Panteleev, S.V. (2010). Genetic identification of fungi colonising seedlings of the Scots pine (Pinus sylvestris L.) in the forest nursery in Korenevka (Belarus). Folia Forestalia Polonica, Series A 52 (1), pp. 61-64

Benbow, J. M., and Sugar, D. 1999. Fruit surface colonization and biological control of postharvest diseases of pear by preharvest yeast applications. Plant Dis. 83:839-844.

Pusz, W., Pląskowska, E., Yildirim, İ., Weber, R. (2015). Fungi occurring on the plants of the genus Amaranthus L. Turkish Journal of Botany 39 (1): 147-161

Berner DK, E. L. Smallwood, M. B. McMahon, D. G. Luster and J. Kashefi (2007). First Report of Leaf Spot Caused by Cladosporium herbarum on Centaurea solstitialis in Greece. Plant Disease 91 (4): 463

Abdel-Motaal F.F., Magdi A. El-Sayed, Soad A. El-Zayat, Mortada S. M. Nassar, and Shin-ichi Ito (2009). Leaf spot disease of Hyoscyamus muticus (Egyptian henbane) caused by Cladosporium herbarum. Journal of General Plant Pathology 75: 437-439

Briceño, E.X. and B. A. Latorre (2007). Outbreaks of Cladosporium Rot Associated with Delayed Harvest Wine Grapes in Chile. Plant Disease 91 (8): 1060

Briceño, E. X., and Latorre, B. A. (2008). Characterization of Cladosporium rot in grapevines, a problem of growing importance in Chile. Plant Disease 92:1635-1642.

Latorre, B.A., Briceño, E.X., Torres, R. (2011). Increase in Cladosporium spp. populations and rot of wine grapes associated with leaf removal. Crop Protection 30 (1), pp. 52-56

Perello, AE; Sisterna, MN; Moreno, MV (2003). Occurrence of Cladosporium herbarum on wheat leaves (Triticum aestivum) in Argentina. Australasian Plant Pathology 32 (2): 327-328   Published: 2003

4.3.4. Clonostachys rosea

Scopus search
A search in Scopus of *Clonostachy rosea* AND pathogen yielded 400 hits. Limiting this selection to Agriculture yielded 158 records. The majority describe the use of *C. rosea* as a biocontrol agent i.e. a fungal antagonist but also with nematopathogenic activity (Ahmed et al, 2014a and 2014b; Baloyi et al, 2012) and entopathogenic activity (Hamiduzzaman et al, 2012; Vega et al, 2008)). There was one record of *C. rosea* as a plant pathogen on soybean in the USA (Bienapfl et al, 2012).

Web of Science search
A search in Web of Science for *C. rosea* and limiting the search to Plant Sciences yielded 42 hits. Nearly all deal with use of *C. rosea* as a biocontrol agent. One record (Bienapfl et al, 2012) reports *C. rosea* as a pathogen on soybean.

Plant Disease search
A search in Plant Disease for C. rosea yielded 6 records. Five deal with biocontrol and one decribes C. rosea as a pathogen on soybean (Bienapfl et al, 2012; plants lacking foliar symptoms, but exhibiting taproot and lateral root necrosis were observed in 15 fields from nine counties in MN (USA) during 2007 and 2008).

Phytopathology search
A search in Phytopathology for *C. rosea* yielded 7 records all dealing with biocontrol.

APS search
The list of common names of diseases of soybeans on the APS web site does not list *Clonostachys rosea.*

Conclusion
One paper was found (Bienapfl et al, 2012) reporting on the plant pathogenicity of on soybean plants. There are a few papers reporting on the nematopathogenic and entopathogenic nature of *Clonostachys rosea.*

Selected references

Ahmed, M., Laing, M.D. and Nsahlai, I.V. (2014a). Use of Clonostachys rosea against sheep nematodes developing in pastures. Biocontrol Science and Technology 24 (4): 389-398.

Ahmed, M., Laing, M.D. and Nsahlai, I.V. (2014b). A new control strategy for nematodes of sheep using chlamydospores of a fungus, Clonostachys rosea f. rosea, and an ethanolic extract of a plant, Ananas comosus. Biocontrol Science and Technology 24 (8): 860-871.

Baloyi, M.A., Laing, M.D. and Yobo, K.S. (2012). Use of mixed cultures of biocontrol agents to control sheep nematodes. Veterinary Parasitology 184 (2-4): 367-370.

Bienapfl, J.C., Floyd, C.M., Percich, J.A., Malvick, D.K. (2012). First report of Clonostachys rosea causing root rot of soybean in the United States. Plant Disease 96 (11): 1700

Hamiduzzaman, M.M., Sinia, A., Guzman-Novoa, E. and Goodwin, P.H. (2012). Entomopathogenic fungi as potential biocontrol agents of the ecto-parasitic mite, Varroa destructor, and their effect on the immune response of honey bees (Apis mellifera L.). Journal of Invertebrate Pathology 111 (3): 237-243.

Lahlali, R. and Peng, G. (2014). Suppression of clubroot by Clonostachys rosea via antibiosis and induced host resistance. Plant Pathology 63 (2): 447-455

Vega, F.E., Posada, F., Catherine Aime, M., Pava-Ripoll, M., Infante, F. and Rehner, S.A.(2008). Entomopathogenic fungal endophytes. Biological Control 46 (1): 72-82.

Zhang, L., Guan, X., Chen, X., Chen, H., Zhang, J., Zhang, J., Li, J., Yang, Y., Wang, A., Mouekouba, L.D.O. (2014). Analysis of Clonostachys rosea-induced resistance to tomato gray mold disease in tomato leaves. PLoS ONE 9 (7): e102690

4.3.5. Coniothyrium minitans

Scopus search
A search in Scopus for *C. minitans* and restricting the output to Agricultural and Biological Science yielded 120 records, all dealing with biocontrol and none describing this microorganism as a plant pathogen.

Web of Science search
A search in Web of Science for *C. minitans* and limiting the search to Plant sciences yielded 91 hits. Nearly all deal with use of *C. minitans* as a biocontrol agent. None reports on *C.minitans* as a plant pathogen.

Plant Disease search
A search in Plant Disease for *C. minitans* yielded 13 records, most dealing with biocontrol and none describing this microorganism as a plant pathogen.

Phytopathology search
A search in Phytopathology for *C. minitans* yielded 9 records, most dealing with biocontrol and none describing this microorganism as a plant pathogen.

Conclusion
There were no papers found reporting on the plant pathogenic nature of *Coniothyrium minitans.*

Selected references
Jones, E.E., Rabeendran, N., Stewart, A. (2014) Biocontrol of Sclerotinia sclerotiorum infection of cabbage by Coniothyrium minitans and Trichoderma spp. Biocontrol Science and Technology 24 (12): 1363-1382

4.3.6. Dichotomophthora portulacae

Scopus search
A search in Scopus for *D. portulacae* yielded only one record (Eken, 1987) describing this fungus as a pathogen on purslane (*Portulaca oleracae*) in Turkey.

Web of Science search
A search in Web of Science for *D. portulacae* and limiting the search to Plant sciences yielded 4 hits (Eken, 1987; Mitchell, 1986; Klisiewicz 1985a, 1985b). All four papers report on the pathogenicity of this species on purslane while Mitchell (1986) also reports on its pathogenicity on carpetweed *(Mollugo verticillata L.).*

Plant Disease and Phytopathology search
Searches in Plant Disease and Phytopathology did not yield any new references with respect to plant pathogenicity.

Conclusion
There were several papers found reporting on the plant pathogenicity of *Dichotomophthora portulacae* on purslane (*Portulaca oleracae*).

Selected references
Eken, C (2003). Dichotomophthora portulacae on Portulaca oleracea in Turkey. MYCOTAXON 87 : 153-156.

Mitchell, JK (1986). Dichotomophthora portulacae causing black stem rot on common purslane in Texas. Plant Disease 70 (6): 603-603.

Klisiewicz, JM (1985a). Growth and reproduction of Dichotomophthora portulacae and its biological activity on purslane. Plant Disease SE 69 (9): 761-762 (DOI: 10.1094/PD-69-761)

Klisiewicz, JM, (1985b). Potential of Dichotomophthora portulacae for biological control of common purslane. Phytopathology 75 (11): 1328-1328

4.3.7. Metarhizium anisoplae

Scopus search
A search in Scopus for *M. anisoplae* yielded 9 records. Most dealing with the use of *M. anisoplae* as an entomopathogenic fungus (i.e. David et al, 2013; Iwase and Shimizu, 2004) and none indicating it as a plant pathogen.

Web of Science search
A search in Web of Science for *M. anisoplae* yielded 6 records. Most dealing with the use of *M. anisoplae* as an entomopathogenic fungus (i.e. Suyn et al, 2008; Iwase and Shimizu, 2004) and none indicating it as a plant pathogen.

Plant Disease and Phytopathology search
A search in these two journals yielded two references (Larena and Melgarejo, 2009; Weiland and Sundsbak, 2000). Both however merely mention the name as an organism used to verify the specificity of PCR-primers designed for the detection of other fungi.

Conclusion
There were no papers found reporting on the plant pathogenic nature of *Metarhizium anisoplae* however a number of papers report on its pathogenicity to insects.

Selected references
David, D., Simon, S., Kumar, A. (2013). Efficacy of biopesticides and chemical insecticide to control Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) fed on chickpea (Cicer arietinum lin.) in in vitro condition. Pestology 37 (8): 32-36

Iwase, R., Shimizu, S. (2004). Adhesion and virulence of conidia of Metarhizium anisopliae to Thrips palmi (Thysanoptera: Thripidae). Japanese Journal of Applied Entomology and Zoology 48 (4): 275-280.

Jian-Zhong Sun, James R. Fuxa, Arthur Richter, and Dennis Ring. (2008). Interactions of Metarhizium anisoplae and tree-based mulches in repellence and mycoses against Coptotermes formosanus (Isoptera : Rhinotermitidae). Environmental Entomology 37(3):755-763.

Larena I. and P. Melgarejo (2009). Development of a Method for Detection of the Biocontrol Agent Penicillium oxalicum Strain 212 by Combining PCR and a Selective Medium. Plant Disease 93 (9): 919-928.

John J. Weiland and Jamie L. Sundsbak (2000). Differentiation and Detection of Sugar Beet Fungal Pathogens Using PCR Amplification of Actin Coding Sequences and the ITS Region of the rRNA Gene. Plant Disease 84 (4): 475-482.

4.3.8. Microsphaeropsis olivacea

Web of Science search
Web of Science yielded 10 references for *M. olivacae*. None mention it as a plant pathogen but interestingly one paper describes this microorganism as a skin pathogen in a healthy human (Guarro et al, 1999). One other paper (Shah et al, 2001) describes *M. olivacae* as the causal agent of an eye infction in a 51-year aol male who suffered a penetratinginjury tothe right eye.

Scopus search
A Scopus search yielded 5 references which were also already included in the Web of Science search, including the paper by Guarro et al (1999).

Plant Disease and Phytopathology search
A search in these two journals yielded one references (Carisse et al, 2000) describing the use of an (further unidentified) *Microsphaeropsis* sp as a biocontrol agent for *Venturia inaequalis*.

Conclusion
There were no papers found reporting on the plant pathogenic nature of *Microsphaeropsis olivacea* however two papers report on its pathogenicity for humans and animals.

Selected references
Carisse, O., Philion, V., Rolland, D., and Bernier, J. (2000). Effect of fall application of fungal antagonists on spring ascospore production of the apple scab pathogen, Venturia inaequalis. Phytopathology 90:31-37.

Guarro, J; Mayayo, E; Tapiol, J; et al (1999). Microsphaeropsis olivacea as an etiological agent of human skin infection. Medical Mycology 37 (2): 133-137.

Shah, C.V., Jones, D.B. and Holz, E.R. (2001) Microsphaeropsis olivacea Keratitis and consectutive Endophthalmitis. American Journal of Ophthalmology 131 (1): 142-143.

4.3.9. Nigrospora sphaerica

Scopus search
A search in Scopus for *N. sphaerica* and restricting the output to Agricultural and Biological Science yielded 26 records. A number of references describe this micro-organism as a plant pathogen on different plant species; Dutta et al (2015) on tea in India; blight symptoms on leaves in commercial tea estates of the Darjeeling district reducing yield and quality of the leaves, Zao et al (2014) on sesame in China; leaf blight in sesame fields in Anhui, Hubei, and Henan provinces with approximately 30 to 40% of the plants symptomatic in the affected fields, Abassa et al (2013) on date palm in Iraq and Soylu et al (2011) with distinct leaf spots on Chinese wisteria in several gardens, retail nurseries, and parks located in Hatay Province in Turkey.

Web of Science search
A search in Web of Science for *N. sphaerica* and limiting the search to Plant sciences yielded 21 hits. Two references describe *N. sphaerica* as a plant pathogen: Zhang et al (2011) on Curcuma in China; early symptoms of yellow-to-brown, irregular-shaped lesions on the leaf margin or tip followed by severe leaf blight in fields located in Ruian, China with disease incidence approximately 90% of plants observed in affected fields, Verma and Gupta (2008) on *Glycyrrhiza glabra* in India with symptoms of the disease appearing in the form of small (2–5 mm), circular to irregular, red coloured spots on leaflets, covering major area of the leaf. Occasionally, the spots are seen delineated by the midrib. In advanced stages of the disease, some spots cracked at the centre. Eventually, leaves dry and the plant defoliates, Wright et al (2008) on blueberry in Argentina with leaf spots and twig and shoot blight observed on plants cultivated in Arrecifes, Mercedes, and San Pedro (provinces of Buenos Aires) and Concordia (province of Entre Ríos) since July 2004.

Plant Disease and Phytopathology search
A search in these two journals yielded seven references, identical to the five already identified in Scopus and Web of Science. The other two references, dealing with other pathogens of banana, only mentioned the name but not in the context of pathogens on banana.

Conclusion
There are a number of papers reporting on the plant pathogenicity of *Nigrospora sphaerica* on different plant species.

Selected references

Dutta, J., Gupta, S., Thakur, D., Handique, P.J. (2015). First report of nigrospora leaf blight on tea caused by nigrospora sphaerica in India. Plant Disease 99 (3): 417.

Abassa M.H., Muhammed A. Hameeda & Alaa Naser Ahmeda (2013). First report of Nigrospora sphaerica (Sacc.) Mason as a potential pathogen on date palm (Phoenix dactylifera L.). Canadian Journal of Plant Pathology35 (1): 75-80. http://dx.doi.org.ezproxy.library.wur.nl/10.1094/PDIS-10-10-0770

Soylu S., Dervis S. and Soylu E.M. (2011). First Report of Nigrospora sphaerica Causing Leaf Spots on Chinese Wisteria: A New Host of the Pathogen. Plant Disease 95 (2): 219.

Zhang, L. X.; Song, J. H.; Tan, G. J. (2011). First Report of Leaf Blight Caused by Nigrospora sphaerica on Curcuma in China. Plant Disease 95 (9): 1190.

Verma, O. P.; Gupta, R. B. L. (2008). A new host for Nigrospora sphaerica causing leaf spots on Glycyrrhiza glabra. Plant Pathology 57 (4): 782.

Wright, E. R.; Folgado, M.; Rivera, M. C.; et al. (2008). Nigrospora sphaerica causing leaf spot and twig and shoot blight on blueberry: A new host of the pathogen. Plant Disease 92 (1): 171.

Zhao, H., Liu, H.Y., Yang, X.S., Liu, Y.X., Ni, Y.X., Wang, F. and Tang, L (2014). First report of Nigrospora leaf blight on sesame caused by Nigrospora sphaerica in China. Plant Disease 98 (6): 842.

4.3.10. Phoma herbarum

Scopus search
A search in Scopus for *P. herbarum* AND pathogen yielded 141 references. Limiting these to Agricultural and Biological Sciences yielded 28 hits.
Ray and Vijayachandran (2013) isolated and identified pathogenic *P. herbarum* from naturally infected horse purslane (*Trianthema portulacastrum* L.) in India and evaluated its potential as a bioherbicide.
In addition to these reports as a plant pathogen, P. herbarum was also reported as a fish pathogen on Chinook salmon (Faisal et al, 2007) and Nile tilapia (Ali et al, 2011).

Web of Science search
A search in Web of Science for *P. herbarum* yielded 141 references. Limiting these to Plant Sciences yielded 33 hits.
Li et al (2012) described a disease consisting of a leaf spot symptom involving pale brown lesions with distinct dark brown margins on Tedera (*Bituminaria bituminosa* (L.) C.H. Stirton var. *albomarginata*). The causal agent was identified as *P. herbarum* and Koch's postulates were fulfilled. Li et al (2011) identified *P. herbarum* as the causal agent of black spot disease on field pea (*Pisum sativum*) in Australia.

Plant disease search
A search in Plant disease yielded 3 hits. Apart from Li et al (2011, 2012) Neumann-Bernbaum and Boland (1999) describe *P. herbarum* as a pathogen on dandelion in Canada and proof pathogenicity through Koch's postulates.

Phytopathology search
A search in Phytopathology for *P. herbarum* yielded no relevant hits.

Conclusion
There are a number of papers reporting on the plant pathogenicity of *Phoma herbarum* on a variety of plant species. In addition *P. herbarum* is reported as a fish pathogen.

Selected references

Li, Y. P., Wright, D. G. and Lanoiselet, V. (2012). First Report of Phoma herbarum on Tedera (Bittuminaria bituminosa var. albomarginata) in Australia. PLANT DISEASE 96 (5): 769-769.

Li Y.P., M. P. You, T. N. Khan, P. M. Finnegan, and M. J. Barbetti (2011). First Report of Phoma herbarum on Field Pea (Pisum sativum) in Australia. Plant Disease 95 (12): 1590.

Neumann Brebaum S. and G. J. Boland (1999). First Report of Phoma herbarum and Phoma exigua as Pathogens of Dandelion in Southern Ontario. Plant Disease 83 (2): 200.

Ray, P. and Vijayachandran, L.S. (2013). Evaluation of indigenous fungal pathogens from horse purslane (trianthema portulacastrum) for their relative virulence and host range assessments to select a potential mycoherbicidal agent. Weed Science 61 (4): 580-585

Faisal, M., Elsayed, E., Fitzgerald, S.D., Silva, V., Mendoza, L. (2007). Outbreaks of phaeohyphomycosis in the chinook salmon (Oncorhynchus tshawytscha) caused by Phoma herbarum. Mycopathologia 163 (1): 41-48.

Ali, E.H., Hashem, M., Al-Salahy, M.B. (2011). Pathogenicity and oxidative stress in Nile tilapia caused by Aphanomyces laevis and Phoma herbarum isolated from farmed fish. Diseases of Aquatic Organisms 94 (1): 17-28.

4.3.11. Pseudozyma flocculosa

Scopus search
A search in Scopus for *P. flocculosa* yielded 30 references with most referring to its use as an antagonist and biocontrol agent against powdery mildew. None related to any plant pathogenic effect.

Web of Science search
A search in Web of Science for *P. flocculosa* yielded 50 references. Many referred to its use as an antagonist and biocontrol agent against powdery mildew. None related to any plant pathogenic effect

Phytopathology search
A search in Phytopathology for *P. flocculosa* yielded two hits referring to its use as a biocontrol agent and no hits relating to any plant pathogenic effect.

Plant Disease search
A search in Plant Disease *P. flocculosa* yielded two hits referring to its use as a biocontrol agent and it commercialization through Sporodex, a wettable powder of this fungus, formulated to control powdery mildew greenhouse crops (Paulitz and Belanger, 2001). No hits were found relating to any plant pathogenic effect.

Conclusion
There were no papers found reporting on the plant pathogenic nature of *Pseudozyma flocculosa.*

Selected references
Paulitz, T. C., and Belanger, R. R. (2001). Biological control in greenhouse systems. Annual Rev. Phytopathology 39: 103-133.

4.3.12. Rhodotorula glutinis

Scopus search
A search in Scopus for *R. glutinis* AND pathogen yielded 116 references. Limiting these to Agricultural and Biological Sciences yielded 69 hits. A large number deal with the antagonistic effect of *R. glutinis* and its use as a biocontrol agents to other plant pathogenic fungi. No references were found indicating any plant pathogenic effect of *R. glutinis* itself.

Web of Science search
A search in Web of Science for *R. glutinis* yielded 150 references. Limiting these to Plant Sciences yielded 42 hits, most referring to its use as a biocontrol agent.

Plant Disease search
A search in Plant Disease for *R. glutinis* yielded 9 hits. Two papers refer to its pathogenic effect on apples (Matteson Heidenreich et al, 1997) and pears (Spotts and Cervantes, 2002). From both papers it does not become clear if *R. glutinis* induces any significant symptoms on fruits developing on the trees.

Phytopathology search
A search in Phytopathology for *R. glutinis* yielded one hits referring to its use as a biocontrol agent in stored apples and no hits relating to any plant pathogenic effect.

Conclusion
There were no papers found reporting on an apparent plant pathogenic nature of *Rhodotorula glutinis.*

Selected references
Matteson Heidenreich, M. C., Corral-Garcia, M. R., Momol, E. A., and Burr, T. J. 1997. Russet of apple fruit caused by Aureobasidium pullulans and Rhodotorula glutinis. Plant Disease 81:337-342.

Spotts, R. A., and Cervantes, L. A. (2002). Involvement of Aureobasidium pullulans and Rhodotorula glutinis in russet of d'Anjou pear fruit. Plant Disease 86:625-628.

4.3.13. Trichoderma viride

Scopus search
A search in Scopus for *T. viride* AND pathogen yielded 593 references. Limiting these to Agricultural and Biological Sciences yielded 432 hits. A large number deal with the antagonistic effect of *T. viride.*
Only one paper (Destri Nicosia,et al, 2014) describes the pathogenic effect of inoculated *T. viride* on 2-year old pine seedlings (*Pinus nigra*) in Italy. The authors conclude that the pathogenic isolates of T. viride clustered in a very uniform group containing strains from different geographic origin and hosts, but none was previously reported as a biocontrol agent.
One other paper (Cutler and Lefiles, 1978) describe the apparent phytotoxic effects of Trichodermin (4β-acetoxy-12,13-epoxy-Δ 9 –trichothecene) a fungal metabolite from *T. viride* as a potent inhibitor of plant growth and producing other phytotoxic effects. It inhibits wheat coleoptile growth, is phytotoxic to tobacco at high concentrations and inhibits growth at lower concentrations. Bean and corn plants are also affected by the metabolite.

Web of Science search
A search in Web of Science for *T. viride* yielded 1954 references. Limiting these to Plant Sciences yielded 285 hits, most referring to its use as a biocontrol agent and none.

Plant Disease search
A search in Plant Disease for *T. viride* yielded 26 hits. Most refer to its use as biocontrol agent and antagonist. The same paper as found earlier through Scopus (Destri Nicosia,et al, 2014) reports its pathogenic effect on pine.

Phytopathology search
A search in Phytopathology for *T. viride* yielded 23 hits with most referring to its use as a biocontrol agent and no hits relating to any plant pathogenic effect.

Conclusion
In addition to the earlier findings of *T. viridi* as a pathogen on onions (Schwartz and Krishna, 2008) as well as on cultivated mushrooms (see parapraph 2.8.2.) one additional paper was identified reporting on the plant pathogenicity of *Trichoderma viride* on pine seedlings.

Selected references
Li Destri Nicosia, M.G., Mosca, S., Mercurio, R., Schena, L. (2014). Dieback of Pinus Nigra seedlings caused by a strain of trichoderma viride. Plant Disease 99 (1): 44-49

Cutler, H.G., Lefiles, J.H.(1978). Trichodermin: Effects on plants. Plant and Cell Physiology 19 (1): 177-182.

Schwartz HF and Krishna M (2008). Compendium of onion and garlic diseases and pests. The American Phytopathological Society. APS Press, St. Paul MN

4.4. Assessment of Mycobank for plant pathogenic fungi

Mycobank (www.mycobank.org) is an internationally recognised database of fungi and yeasts which is hosted by CBS in Utrecht. The database contains basic information on taxonomy and characteristics as well as various tools to aid in (molecular) identification of species.
To investigate if Mycobank could aid in identifying plant pathogenic fungi the curators were contacted directly and asked if a selection based on plant pathogenicity would be possible.
Dr. G. Verkley (curator of filamentous fungi) replied to our request and explained that at this moment approximately 46 species were labelled with Plant pathogenicity code P2 (pathogenic) and 141 are labelled with Plant pathogenicity code P3 (strongly pathogenic).
Dr Verkleij explained that Mycobank is not intended to include information on plant pathogenicity. The current information in Mycobank is incomplete and is not actively maintained and it is not possible to extract a reliable list of plant pathogenic fungi from Mycobank.
For this reason Mycobank was not queried further for plant pathogenic fungi.

4.5. Assessment of Q-bank for plant pathogenic fungi

Q-bank (www.q-bank-eu) is an international database aimed at collecting information as well as the physical specimen of (quarantine) plant pests and pathogens and making these specimens and their accompanying information available.
The fungi section (www.q-bank-eu/fungi) was queried using the General search for all fungal species earlier identified from the Class 1 fungi by expert evaluation as plant associated (see Table 1). Three species gave a positive result in Q-bank (see Table 2).
The information on these three species as supplied by Q-bank is listed below in paragraphs 4.5.1 to 4.5.3

Table 2: Search result for species name in the fungi section of Q-bank

Species	**Q-bank result**
Aspergillus niger var. Niger	No record corresponding to your conditions
Aureobasidium pullulans	No record corresponding to your conditions
Cladosporium herbarum	No record corresponding to your conditions
Clonostachys rosea	No record corresponding to your conditions
Coniothyrium minitans	Paraconiothyrium minitans MycoBank# 500085
Dichotomophthora portulacae	No record corresponding to your conditions
Discosphaerina fulvida	No record corresponding to your conditions
Metarhizium anisoplae	No record corresponding to your conditions
Microsphaeropsis olivacea	Microsphaeropsis olivacea MycoBank# 438686
Nigrospora sphaerica	No record corresponding to your conditions
Phoma herbarum	Phoma herbarum MycoBank# 171008
Pseudozyma flocculosa	No record corresponding to your conditions
Rhodotorula glutinis	No record corresponding to your conditions
Trichoderma viride	No record corresponding to your conditions

4.5.1. Coniothyrium minitans

Q-bank lists two representative strains of *C. minitans*; CBS122786 and CBS122788. Strain CBS122786 was isolated from Clematis from Boskoop, The Netherlands. Strain CBS122788 was isolated from an unknown location in the United Kingdom. No information on a possible plant pathogenic status for these two strains is provided on Q-bank.
The information on this fungus at Mycobank also does not list any plant pathogenicity.

Conclusion
Although limited and not conclusive, the information from Q-bank does point towards an association of *Coniothyrium minitans* with plants however no information is provided on its possible pathogenicity. Previous literature searches also gave no indications for plant pathogenicity (see paragraph 4.3.5.).

4.5.2. Microsphaeropsis olivacea

Q-bank lists four representative strains of *M. olivacae;* CBS 116669, CBS 233.77, CBS 432.71 and CBS 442.83.
CBS 116669 was collected near Malden, The Netherlands from twigs of *Sarothamnus scoparius* showing lesions. No further information on possible additional plant pathogenicity is provided.
CBS 233.77 was collected near Nancy, France from needles of *Pinus laricio*. No further information on possible plant pathogenicity is provided.
CBS 432.71 was collected near Valkenswaard, The Netherlands from a dead twig and pod of a *Sarothamnus spp*. No further information on possible plant pathogenicity is provided.
CBS 442.83 CBS 233.77 was collected near Baarn, The Netherlands from a withering needle of *Taxus baccata*. No further information on possible plant pathogenicity is provided.
Mycobank classifies this species as plant pathogenic as well a skin pathogen in an otherwise healthy human. No further information to support its apparent plant pathogenicity is provided.

Conclusion
Although not conclusive, the information from Q-bank does point towards an association of *Microsphaeropsis olivacea* with plants however no information is provided on its possible plant pathogenicity. Previous literature searches also gave no indications for plant pathogenicity (see paragraph 4.3.5.). Mycobank however mentions *Microsphaeropsis olivacea* as a human pathogen.

4.5.3. Phoma herbarum

Q-bank lists five representative strains of *P. herbarum*; ATCC 12569, CBS 276.37, CBS 502.91, CBS 615.75, CBS 618.75.
ATCC 12569 was isolated from white lead paint in the United Kingdom.
CBS 276.37 was isolated from wood pulp in Sweden.
CBS 502.91 CBS 432.71 was collected in Waalwijk, The Netherlands from the stem base of a *Nerium* spp. No further information on possible plant pathogenicity is provided.
CBS 615.75 was collected in Emmeloord, The Netherlands from a dead stem base of *Rosa multiflora*, cv. 'Cathayensis'. No further information on possible plant pathogenicity is provided.
CBS 618.75 was collected near in Monterosso al Mare, Liguria, Italy from *Hedera helix* showing leaf spot. No further information on possible plant pathogenicity is provided.
Mycobank classifies this species as pathogenic BSL-1, implicated in human skin lesions in Canada (Bakerspigel 1970). No further information on its possible plant pathogenicity is provided.

Conclusion
Although not conclusive, the information from Q-bank does point towards possible plant pathogenicity for *Phoma herbarum*. This is in accordance with previous results obtained from literature searches (see paragraph 4.3.10) identifying *P. herbarum* as a plant pathogen. Mycobank however mentions *P. herbarum* as a human pathogen and it was also reported as a fish pathogen (see paragraph 4.3.10).

4.6. Assessment of APS common names of plant diseases

The American Phytopathological Society (APS) is an internationally well recognized, scientific organisation that publishes a number of highly ranked journals dealing with plant pathology and plant pathogens (Phytopathology, Plant Disease, Molecular Plant Microbe Interactions). In addition the APS provides general information on plant pathogens and plant pathology through specific publications and its website, including lists of common names of plant diseases indexed by crop (http://www.apsnet.org/publications/commonnames/Pages/default.aspx). These lists mention the common names of micro-organisms that were identified by experts as associated with diseases on particular crops.
In consultation with the project advisory committee it was decided to also use the APS lists of common names of plant diseases as a starting point to screen Class 1 listed microorganisms on COGEM CGM/141218-03 for possible plant pathogens according to the procedure described in paragraph 4.2.

4.6.1. COGEM Class 1 listed species present on APS lists

A direct comparison was made between the list of pathogenic fungi as extracted from the APS web site and the non-pathogenic fungi (Class 1) on COGEM-list CGM/141218-03. This resulted in a group of species that are mentioned as plant pathogens on the APS list and on the COGEM Class 1 list of non-pathogenic fungi (see Table 3) indicating a discrepancy between APS and the COGEM list with respect to their plant pathogen classification, which warranted further investigation.

Table 3: Fungal species listed by COGEM as non-pathogenic (Class 1) but listed by APS as plant pathogenic fungi on specific crops.

Genus	Species	APS listed crop
Acremonium	strictum	corn or maize, sorghum
Aspergillus	fischerianus	geranium
Aspergillus	glaucus	corn or maize
Aspergillus	niger	corn or maize
Aureobasidium	pullulans	pistachio
Bipolaris	spicifera (t.n. = Cochliobolus spiciferus)	cotton, peanut
Bjerkandra	adust	sweetgum
Cladosporium	herbarum (teleomorph = Mycosphaerella tassiana)	pear, rye, sweet cherry, date palm, grape, lentil
Graphium	ulmi (=Ophiostoma ulmi)	elm
Monascus	ruber (= Basipetospora rubra)	corn or maize
Nigrospora	sphaerica	turf grass, banana and plantain
Penicillium	aurantiogriseum	onion, strawberry, asparagus
Penicillium	chrysogenum	corn or maize
Penicillium	funiculosum	onion
Penicillium	purpurogenum	strawberry
Phaeotrichoconis	crotalariae	Pipiraceae (potting plants)
Phoma	herbarum	hemp, hop
Plectosporium	tabacinum	bean, cucurbits
Pleurotus spp.	ostreatus	sweet gum
Saccharomyces	cerevisiae	strawberry
Saccharomyces	kluyveri	strawberry
Trametes	versicolor	black walnut, elm, pear, sweet gum
Trichoderma	koningii	sweet potato
Trichoderma	viride	citrus, corn or maize
Zygosaccharomyces	bailii	strawberry

The APS editorial office was approached to gain more insight in the criteria which APS uses to list particular organisms as plant pathogens. Dr. Tim Paulitz, editor in chief of APS PRESS, kindly explained that up to a few years ago the lists were actively maintained by a standing committee of experts. Many of the lists were derived from the Compendia series, published by APS PRESS, which cover the diseases of most of the major crops. The Compendia series are edited, refereed books that gather experts on the different crop diseases and the book editor compiles the pathogen list for a particular crop. The main criterion for the organisms mentioned in the Compendia series is that the pathogen listed has to cause disease, at least some members of that taxon (*although disease was not further defined; RvdV*). Dr. Paulitz also explained that APS realizes that many organisms '*contain pathogenic and non-pathogenic isolates and some that are considered weak pathogens*'.

For each of the fungal species listed in Table 2, the corresponding crops that APS lists on their web site as a susceptible host were identified from the APS list of pathogenic fungi (Appendix 3 and Table 2). Since APS indicated that many of the lists of Common names of Plant Diseases are derived from the Compendia series, those Compendia which were available from the Wageningen University library were screened for any reference to the species linked to this crop (Table 2). It should be noted that not all APS published Compendia were available.
During this screening it became apparent that not all species listed by APS on their web site were traceable in the Compendia. An inquiry with the APS PRESS editor in chief revealed that indeed the list of Common names contains more species then mentioned in the Compendia because species were also included in the various lists by expert judgement and it is not always clear on what criteria the inclusion of particular species on the various list of Common names was based.
For these species and the species for which the Compendia were not available, additional literature searches in SCOPUS, Web of Science, Plant Disease and Phytopathology were conducted to investigate their possible plant pathogenicity.

4.6.2. Acremonium strictum

APS lists this species as a pathogen on maize, corn or sorghum. *A. strictum* is not mentioned in the Compendium of Corn Diseases. The Compendium for Sorghum diseases was not available. A Scopus, Web of Science, Plant Disease and Phytopathology search for *A. strictum* yielded different records reporting findings of this fungus on seeds of maize (corn) and sorghum, including reports of *A strictum* as an endophyte (Srivastava et al, 2014; Orole, 2009) or mycoparasite (Rivera-Varas et al, 2007). Youssef (2009) reported the production of four mycotoxins by *A. strictum*.
Different papers reports *A. strictum* as a plant pathogen on different crops and plants. Tagne et al (2002) describe *A. strictum* from Cameroon as a pathogen with clear pathogenic effects on different maize cultivars. The fungus was re-isolated from the infected plants.
Somda et al (2008) describe *A. strictum* on maize seeds and its transmission to maize seedlings. Elizabeth et al (2008) reported that seeds inoculated with *Acremonium strictum*, *Curvularia oryzae*, *F. equiseti*, *F. moniliforme* and *F. subglutinans* and sown in sterilized soil, showed considerable mortality of the seedlings. Anjum and Akram (2014) describe *A. strictum* as a pathogen on tomato in Pakistan. Racedo et al. (2013) reported the identification of *A. strictum* as a pathogen on strawberry plants in Argentina; Kang et al (2004) reported *A. strictum* as a pathogen on cultivated mushrooms (*Agaricus bisporus*)in China. Gonzalez-Perez (2008) report *A. strictum* as the cause of basal stem and corm rot on *Gladiolus grandiflorus* in Mexico. Lebeda et al (1987) report *A strictum* as a potential pathogen in carrot, Bandyopadhyay et al (1987) report it as a seed-transmitted pathogen of sorghum and Chase et al. report it as the causal agent of vascular wilt in Shasta daisy.

In addition to its plant pathogenic nature a number of references were also found that refer to its apparent pathogenic effect on humans and animals (Sharma et al, 2005; Sener et al., 2008; Pusterla et al, 2005)

Conclusion
There are a significant number of papers reporting on the plant pathogenicity of *Acremonium strictum* on a variety of plant species as well as on its pathogenicity for humans and animals.

Selected references

Anjum T. & W. Akram (2014). First Record of Acremonium Wilt in Tomato from Pakistan. Plant Disease 98 (1): 155.

Bandyopadhyay, R; Mughogho, LK; Satyanarayana, MV (1987). Systemic infection of sorghum by acremonium-strictum and its transmission through seed. Plant Disease 71 (7): 647-650.

Bruton B.D.,, R. M. Davis and T. R. Gordon (1995) Occurrence of Acremonium sp. and Monosporascus cannonballus in the Major Cantaloupe and Watermelon Growing Areas of California. Plant Disease 79: 754.

Chase, AR; Munnecke, de (1980). Shasta daisy vascular wilt incited by acremonium-strictum. Phytopathology 70 (8): 834-838.

Coutinho, W.M., Silva-Mann, R., Vieira, M.D.G.G.C., Machado, C.F., Machado, J.C. (2007) Health and physiological quality of maize seeds submitted to thermotherapy and physiological preconditioning [Qualidade sanitária e fisiológica de sementes de milho submetidas a termoterapia e condicionamento fisiológico]. Fitopatologia Brasileira, 32 (6), pp. 458-464.

Compendium of corn diseases [Monograph] - 3rd ed. White, D.G. \ NCR-25 Committee on Corn and Sorghum Diseases \ University of Illonois at Urbana-Champaign \ 1999.

Elisabeth, Z.P., Paco, S., Vibeke, L., Philippe, S., Irénée, S., Adama, N. (2008). Importance of seed-borne fungi of sorghum and pearl millet in Burkina Faso and their control using plant extracts. Pakistan Journal of Biological Sciences, 11 (3), pp. 321-331. DOI: 10.3923/pjbs.2008.321.331

Gonzalez-Perez, E., Yanez-Morales, MJ., Ortega-Escobar, HM., Velazquez-Mendoza, J. (2008). First report of acremonium strictum and gliocladium roseum causing basal stem and corm rot of gladiolus grandiflorus in mexico. Journal of Plant Pathology 90 (3): 586.

Kang XiaoHui; He XinSheng; Guoji Shudian (2004).Biological features of disease of Agaricus bisporus caused by Acremonium strictum and screening of fungicides. Plant Protection 30 (1): 28-31

Lebeda, A; Marvanova, L; Buczkowski, J. (1987). Acremonium-strictum, a new potential pathogen in carrot flower stems. Zeitschrift fur pflanzenkrankheiten und pflanzenschutz-Journal of Plant Diseases and Protection 95 (3): 314-321

Pusterla, N., Holmberg, TA., Lorenzo-Figueras, M., Wong, A., Wilson, WD (2005). Acremonium strictum pulmonary infection in a horse. Veterinay Clinical Pathology 34 (4): 413-416.

Sener, AG., Yucesoy, M., Senturkun, S., Afsar, I., Yurtsever, SG., Turk, M. (2008). A case of Acremonium strictum peritonitis. Medical Mycology 46 (5): 495-497. DOI 10.1080/13693780701851729

Sharma, A., Hazarika, NK., Barua, P., Shivaprakash, MR., Chakrabarti, A (2013). Acremonium strictum: Report of a Rare Emerging Agent of Cutaneous Hyalohyphomycosis with Review of Literatures. Mycopathologia 176 (5-6): 435-441. DOI 10.1007/s11046-013-9709-1

Racedo, J.; Salazar, S. M.; Castagnaro, A. P.; Díaz Ricci, J. C. (2013). A strawberry disease caused by Acremonium strictum. European Journal of Plant Pathology 137 (4): 649-654.

Rivera-Varas, VV., Freeman, TA., Gudmestad, NC., Secor, GA. (2007). Mycoparasitism of Helminthosporium solani by Acremonium strictum. Phytopathology 97; 1331-1337. DOI 10.1094/PHYTO-97-10-1331

Summerbell, R.C., Gueidan, C., Schroers, H.-J., de Hoog, G.S., Starink, M., Rosete, Y.A., Guarro, J., Scott, J.A. Acremonium phylogenetic overview and revision of Gliomastix, Sarocladium, and Trichothecium (2011) Studies in Mycology 68: 139-162.

Orole, O.O., Adejumo, T.O. (2009) Activity of fungal endophytes against four maize wilt pathogens. African Journal of Microbiology Research, 3 (12): 969-973.

Somda, I., Sanou, J., Sanon, P. (2008) Seed-borne infection of farmer-saved maize seeds by pathogenic fungi and their transmission to seedlings. Plant Pathology Journal, 7 (1):98-103.

Tagne, A., Neergaard, E., Hansen, H.J., The, C. (2002) Studies of host-pathogen interaction between maize and Acremonium strictum from Cameroon. European Journal of Plant Pathology, 108 (2): 93-102.

Youssef, M.S. (2009) Natural occurrence of mycotoxins and mycotoxigenic fungi on Libyan corn with special reference to mycotoxin control. Research Journal of Toxins 1 (1): 8-22

4.6.3. Aspergillus fischerianus

APS lists it as a pathogen on geranium. There is no Compendium for Geranium (or Pelargonium) Diseases. A literature search in Scopus and Web of Science revealed a limited number of references of which some describe *A. fischerianus* as a human pathogen (Gori et al, 1998; Manikandan et al., 2008). Plant Disease lists no references for this species while Phytopathology lists one reference in which a sequence of *A. fischerianus* is used in a phylogenetic comparison (de Sá et al, 2010).

Conclusion
No references were found describing *Aspergillus fischerianus* as a plant pathogen however two references reports on *A. fischerianus* as a human pathogen.

Selected references

de Sá, P. B., Havens, W. M., and Ghabrial, S. A. (2010). Characterization of a novel broad-spectrum antifungal protein from virus-infected Helminthosporium (Cochliobolus) victoriae. Phytopathology 100:880-889.

Gori, S., Pellegrini, G., Filipponi, F., Mosca, F., Lofaro, A. (1998). Pulmonary aspergillosis caused by Neosartorya fischeri (Aspergillus fischerianus) in a liver transplant recipient. Journal de Mycologie Medicale 8 (2): 105-107.

Manikandan, P., Dóczi, I., Kocsubé, S., Bhaskar, M., Kredics, L. (2008). Aspergillus species in human keratomycosis (Book Chapter). In "Aspergillus in the Genomic Era" pp. 293-328.

4.6.4. Aspergillus glaucus

APS lists this species as a pathogen on maize, corn or sorghum. In the Compendium of Corn Diseases (1999) this species is mentioned as a storage diseases on harvested kernels.
A Scopus, Web of Science, Plant Disease and Phytopathology search only returned references of *A. glaucus* as a postharvest or storage disease in sorghum (Dejene et al, 1999), wheat (Tuite and Christensen, 1957), alfalfa (Wittenberg et al, 1998), groundnut (Lisker and Joffe, 1970) and soybeans (Dhingra et al,2009).

Conclusion
Both the APS compendium as well as a significant number of papers report on *Aspergillus glaucus* only as a disease in harvested products (postharvest disease).

Selected references

Dhingra, O.D., Jham, G.N., Rodrigues, F.A., Silva, G.J., Costa, M.L.N. (2009). Retardation of fungal deterioration of stored soybeans by fumigation with mustard essential oil. Australasian Plant Pathology 38 (5), pp. 540-545

Wittenberg, K.M., Smith, S.R., Katepa-Mupondwa, F., Yang, J.F. (1998). Screening methodology for post-harvest fungal resistance in alfalfa. Canadian Journal of Plant Science 78 (3), pp. 481-488

Dejene, M; Yuen, J; Sigvald, R (1999). The impact of storage methods on storage environment and sorghum grain quality. Canadian Journal of Plant Science 79 (4): 475-482.

Lisker, N. and Joffe, A.Z. (1970). Relationships between fungi of aspergillus-glaucus group and a-niger in groundnut kernels. Israel Journal of Botany 19 (4): 620.

Tuite, JF., CM Christensen (1957). Grain storage studies: XXIV. Moisture content of wheat seed in relation to invasion of the seed by species of the Aspergillus glaucus group, and effect of invasion upon… Phytopathology, 19

Compendium of corn diseases [Monograph] - 3rd ed. (1999). White, D.G. \ NCR-25 Committee on Corn and Sorghum Diseases \ University of Illonois at Urbana-Champaign

4.6.5. Aspergillus niger var. niger

This species was identified earlier (see Table 1) by Dr Kohl as an known plant pathogen and by Dr. Van Leeuwen as a fungal species that had at some point been found associated with plant material by the Dutch National Plant Protection Organisation (NPPO). The investigation into its possible plant pathogenicity was described earlier in paragraph 4.3.1.
In addition the APS Compendia lists *A. niger* in the common names of diseases of maize and corn.

Scopus search
A Scopus search for A. niger AND pathogen yielded 327 documents. Gajera et al (2014) describe *A niger* as a plant pathogen, causing collar rot in groundnut and Vitale et al (2012) as a plant pathogen causing Aspergillus vine canker in table grapes in Italy. 21 isolates of 37 isolated from infected plants, belonged to *A. niger var. awamori*. One isolate of *A. niger* was positively assessed for pathogenicity on mature canes of grape cv. Italia. Aigbe and Remison isolated *A. niger* from rotted cassava roots in the field.
Mirzaee (et al, 2013) isolated *Aspergillus niger* frequently from lint parts of cotton grown in Iran, showing symptoms of lint and boll rot prior to harvesting. Guerrero et al (2014) describe the presence of *A. niger* on empty or abnormal shaped hazelnuts from Chile. Pozzo-Ardizzi et al (2012) describe *A niger* as a postharvest pathogen on onion in Argentina.

Web of Science search
A search in Web of Science for A. niger and limiting the search to plant sciences yielded 770 hits on a variety of subject. Coutinho et al (2006) report on *A. niger* as a plant pathogen (2006) as they identified *A. niger* as the causal agent of bol rot in Sisal (*Agave sisalana*) in Brazil.

Plant Disease search
A search in Plant Disease on *A. niger* yielded 44 references. A number describe A. niger as a plant pathogen (Xu et al, 2015; Vitale et al, 2008; Pawar et al, 2008) while two references describe *A. niger* as the cause of rot in harvested products (Thomidis and Exadaltylou, 2012; Latorre et al, 2002).

Phytopathology search
A search in Phytopathology on *A. niger* yielded 37 references. None of these describe *A. niger* as a plant pathogen.

Conclusion
There are a number of papers reporting on the plant pathogenic nature of *Aspergillus niger* on a variety of plant species. These results confirm the earlier findings in this report (paragraphs 2.8.1. and 4.3.1).

Selected references

Doster *et al* (1996) Aspergillus Species and Mycotoxins in Figs from California Orchards. *Plant Disease* 80: 484

Michailides TJ and Morgan DP (1991) Positive correlation of fig smut in Calimyrna fruit with amounts of dust and propagules of Aspergillus niger accumulated on the trees (Abstr) Phytopathology 81: 1234

Xu ML., J. G. Yang, J. X. Wu and Y. C. Chi L. H. Xie (2015). First Report of Aspergillus niger Causing Root Rot of Peanut in China. Plant Disease 99 (2): 284.

Thomidis T. and E. Exadaktylou (2012). First Report of Aspergillus niger Causing Postharvest Fruit Rot of Cherry in the Prefectures of Imathia and Pella, Northern Greece. Plant Disease 96 (3): 458.

A. Vitale, I. Castello, and G. Polizzi (2008). First Report of Aspergillus Vine Canker on Table Grapes Caused by Aspergillus niger in Europe. Plant Disease 92 (10): 1471.

N. V. Pawar, V. B. Patil, S. S. Kamble, and G. B. Dixit (2008). First Report of Aspergillus niger as a Plant Pathogen on Zingiber officinale from India. Plant Disease 92 (9): 1368.

B. A. Latorre, S. C. Viertel, and I. Spadaro (2002). Severe Outbreaks of Bunch Rots Caused by Rhizopus stolonifer and Aspergillus niger on Table Grapes in Chile. Plant Disease 86 (7): 815.

H. P. Gajera, J. K. Jadav, S. V. Patel, B. A. Golakiya (2014). Trichoderma viride induces phenolics in groundnut (Arachis hypogaea L.) seedlings challenged with rot pathogen (Aspergillus niger Van Tieghem). Phytoparasitica 42 (5): 703-712.

J.C. Guerrero, S.F. Pérez, E.Q. Ferrada, L.Q. Cona , E.T. Bensch (2014). PHYTOPATHOGENS OF HAZELNUT (CORYLUS AVELLANA L.) IN SOUTHERN CHILE. ISHS Acta Horticulturae 1052: VIII International Congress on Hazelnut. Pages 269-274.

Mirzaee, M.R., Heydari, A., Zare, R., Sabzali, F., Hasheminasab, M. (2013). Fungi associated with boll and lint rot of cotton in Southern Khorasan province of Iran. Archives of Phytopathology and Plant Protection 46 (11): 1285-1294.

Pozzo-Ardizzi, C., Pellejero, G., Aschkar, G., Jiménez-Ballesta, R. (2012). Effects of Aspergillus niger in onion bulbs (Allium cepa L.) stored in the post-harvest phase. International Journal of Postharvest Technology and Innovation 2 (4): 414-425.

Vitale, A., Cirvilleri, G., Panebianco, A., (...), Perrone, G., Polizzi, G. (2012). Molecular characterisation and pathogenicity of Aspergillus Sect. Nigri causing Aspergillus vine canker of table grapes in Italy. European Journal of Plant Pathology 132 (4): 483-487.

Aigbe, S.O. and Remison, S.U. (2010). Minor root rot pathogens of cassava (Manihot esculenta Crantz) in Nigeria. Archives of Phytopathology and Plant Protection 43 (13): 1335-1341.

Coutinho WM, Suassuna ND, Luz CM, Suinaga FA, Silva ORRF (2006) Bole rot of sisal caused by Aspergillus niger in Brazil. Fitopatologia Brasileira 31: 605.

4.6.6. Aureobasidium pullulans

This species was identified earlier (see Table 1) by Dr Kohl as an antagonist and by Dr. Van Leeuwen as a fungal species that had at some point been found associated with plant material by the Dutch National Plant Protection Organisation (NPPO). The investigation into its possible plant pathogenicity was described earlier in paragraph 4.3.2.
In addition the APS Compendia lists *A. pullulans* in the common names of diseases of Pistachio. This Compendium was not available so it is unclear if this listing means *A. pullulans* is associated with the growing pistachio plant or the harvested nuts.

Search in Scopus
A Scopus search for *Aurobasidium pullulans* AND pistachio returned no hits. A Scopus search for *Aurobasidium pullulans* returned 45 hits, all related to the production of polygalacturnase enzymes.

Search in Web of Science
A Web of Science search for *Aurobasidium pullulans* returned over 1600 hits. Refining this search to Agriculture and Plant Sciences returned 54 references. Nearly all deal with use of *A. pullulans* as a biocontrol agent, particularly for postharvest rots. None reports on *A. pullulans* as a plant pathogen.

Plant Disease search
A search in Plant Disease for *A. pullulans* yielded 27 hits. Most deals with antagonists however two papers refer to a pathogenic effect ('russet symptoms') of *A. pullulans* growing on and collected from apples and pears from orchard trees from different location over 2 consecutive years (Matteson Heidenreich et al, 1997). One paper (Kim, 2014) refers to post-harvest infections of sweet cherries in the US with *A. pullulans*.

Phytopathology search
A search in Phytopathology for *A. pullulans* yielded no hits relating to any plant pathogenic effect of this species.

A. pullulans is also listed on the COGEM list as *Discosphaerina fulvida*. A search for the latter name on the APS website resulted in one reference (Sivanesan, 1990) in which *D. fulvida* is morphologically described. This description lists a number of different synonymes for this name including *Aerobasodium lini* (Lafferty) as its anamorph and *A. pullulans* (de Bary) Arnaud var. *lini* (Lafferty). This reference also describes this fungus as a pathogen causing stem break and browning of linseed or polysporosis of flax in Russia, which is confirmed by the listing of *Aureobasidium lini* (Lafferty) Hermanides-Nijhof (teleomorph: *Guignardia fulvida* F.R. Sanderson) on the common names of diseases of flax as the causal agent of browning (and) stem break of flax. Based on the comparison of ITS1 and ITS 2 sequences Yurlova et al (1999) describe *Kabatiella lini*, the purported anamorph of *Discosphaerina fulvida* as falling within the range of variability of *A. pullulans.*
Nor *A. pullulans* , *A. lini* nor *D. fulvida* are listed in the APS Common diseases of apple or sweet and sour cherries.

Conclusion
There was one paper found reporting on an apparent plant pathogenic nature of *Aurobasidium pullulans* on apple and pears developing on trees. It is unclear whther the listing of A. pullulans in the common names of diseases of Pistachio is based on symptoms on growing plants or only on harvested nuts. The variety *A. pullulans* var. *lin*i is reported by APS as a plant pathogen on flax and linseed. From the available data it remains unclear whether *A. pullulans* can be regarded a plant pathogen or a postharvest disease.

Selected references
Sivanesan, A (1990). Discosphaerina fulvida. In: CMI Descriptions of pathognenic fungi and bacteria no. 982. (1990). Mycopathologia 109: 54-44.

Matteson Heidenreich, M. C., Corral-Garcia, M. R., Momol, E. A., and Burr, T. J. (1997). Russet of apple fruit caused by Aureobasidium pullulans and Rhodotorula glutinis. Plant Disease 81:337-342.

Kim YK. (2014). First Report of a New Postharvest Rot in Sweet Cherries Caused by Aureobasidium pullulans. Plant Disease 98 (3): 424.

Yurlova N.A., De Hoog G.S. and van den Ende A.H.G.G. (1999). Taxonomy of Aureobasidium and allied genera. Studies in Mycology 43: 63-69

4.6.7. Bjerkandera adusta

The APS site list a species named *Bjerkandra adust* in combination with the crop Sweet gum. The COGEM list contains the species *Bjerkandera adusta*. A search in Scopus resulted in 392 hits when searching for *Bjerkandera adusta*. Searching for *Bjerkandra adust*, as named on the APS list did not lead to any matches, therefore the search was continued using the name *Bjerkandera adusta*.

Most reports found in Scopus are on wood decay and on the degrading properties of this fungus, which is used in various industries.
B. adusta is reported to be pathogenic in *Ailanthus excelsa* Roxb. ('tree of heaven') (Pramod et al, 2015). These authors report it to be an aggressive pathogenic fungus which is said to be dangerous to urban trees (Del Rio et al., 2002; Robles et al., 2011). It was also identified as involved in a disease in red-flowering horse chestnut (Müller-Navarra, 2014).
B. adusta is also reported as an human pathogen, causing lung inflammation (Liu et al, 2014) and Asthma-like diseases (Chowdhary, 2014, Ogawa et al, 2014).
Searches on *B. adusta* AND sweet gum or Liquidambar (the scientific name of sweet gum) did not result in any hits.

Web of Science search
A search for *B. adusta* alone yielded 328 matches, but a search on *B. adusta* AND sweet gum yielded 0 matches. B. adusta AND Liquidambar also yielded no matches. No additional information was found in comparison to the search in Scopus.

Plant Disease search
One hit was found searching for *B. adusta* in Plant Disease, but in this reference only information on other fungi was reported.

Phytopathology search
No hits were found when searching for B. adusta in Phytopathology.

Conclusion
There are a number of references describing *Bjerkandera adusta* as a pathogen on different species of trees. In addition this species is reported as a human pathogen.

Selected references

Del Rio, J.C., Speranza, M., Gutierrez, A., Martinez, M.J., Martinez, A.T. (2002). Lignin attack during eucalypt wood decay by selected basidiomycetes: a Py-GC/MS study. J. Anal. Appl. Pyrol. 64, 421e431.

Jang, Y., Jang, S., Min, M., Hong, J.-H., Lee, H., Lee, H., Lim, Y.W., Kim, J.-J. (2015). Comparison of the Diversity of Basidiomycetes from Dead Wood of the Manchurian fir (Abies holophylla) as Evaluated by Fruiting Body Collection, Mycelial Isolation, and 454 Sequencing. Microbial Ecology, 12 p. Article in Press.

Pramod, S., Koyani, R.D., Bhatt, I., Vasava, A.M., Rao, K.S., Rajput, K.S. (2015). Histological and ultrastructural alterations in the Ailanthus excelsa wood cell walls by Bjerkandera adusta (Willd.) P. Karst. International Biodeterioration and Biodegradation 100: 124-132.

Robles, C.A., Carmaran, C.C., Lopez, S.L. (2011). Screening of xylaphagous fungi associated with Platanus acerifoila in urban landscapes: biodiversity and potential Biodeterioration. Landsc. Urban Plan. 100, 129e135.

Robles, C.A., Castro, M.A., Lopez, S.E. (2014). Wood decay by inonotus rickii and bjerkandera adusta: A micro-and ultra-structural approach. IAWA Journal, 35 (1): 51-60.

Liu, B., Ichinose, T., He, M., Kobayashi, F., Maki, T., Yoshida, S., Yoshida, Y., Arashidani, K., Takano, H., Nishikawa, M., Sun, G., Shibamoto, T. (2014). Lung inflammation by fungus, Bjerkandera adusta isolated from Asian sand dust (ASD) aerosol and enhancement of ovalbumin-induced lung eosinophilia by ASD and the fungus in mice. Allergy, Asthma and Clinical Immunology, 10 (1): art. no. 10.

Müller-Navarra, A., Gaiser, O., Moreth, U., Dujesiefken, D., Magel, E.A. (2014). New disease on red flowering horse chestnut (Aesculus × carnea Hayne) and the molecular identification of the involved pathogens [Neue Krankheit der Rotblühenden Rosskastanie (Aesculus × carnea Hayne) und molekulare identifizierung der beteiligten Schadorganismen]. Journal fur Kulturpflanzen, 66 (12): 417-423.

Ogawa, H., Fujimura, M., Ohkura, N., Satoh, K., Makimura, K. (2014). Fungus-associated asthma: Overcoming challenges in diagnosis and treatment. Expert Review of Clinical Immunology, 10 (5): 647-656.

Chowdhary, A., Kathuria, S., Agarwal, K., Meis, J.F. (2014). Recognizing filamentous basidiomycetes as agents of human disease: A review. Medical Mycology, 52 (8), pp. 782-797.

4.6.8. Bipolaris spicifera (teleomorph =Cochliobolus spiciferus)

On the APS website this species is listed as a pathogen on peanut and cotton however in the Compendium of cotton diseases (2001) this species is not mentioned. The Compendium of peanut diseases was not available.

A Scopus, Web of Science, Plant Disease and Phytopathology search returned different references of *B. spicifera* as a plant pathogen on different crops; Watermelon in Morocco (El Mhadri et al, 2009), buffalograss in Nebraska (Amarandasa and Amundsen, 2014), switchgrass in the US (Vu et al, 2011), sorghum in Turkey (Ünal et al, 2011), Eucalyptus from India (Mohanan and Sharma, 1986).

In addition to these there were also a number of references found for *B. spicifera* as a human pathogen; Patil et al (2011), Taguchi et al (2007), McGinnis et al, 1992) and Dixon and Polakwyss (1991).

Conclusion

There are a significant number of papers reporting on the plant pathogenicity of *Bipolaris spicifera* on a variety of plant species. In addition this species is reported as a human pathogen.

Selected references

M. El Mhadri, R. Benkirane, A. Ouazzani Touhami, A. Douira (2009) Citrullus lanatus, a new host of *Bipolaris spicifera* in Morocco. Phytopathologia Mediterranea 48 (2): 291-293.

Amaradasa BS, K Amundsen (2014). First report of Curvularia inaequalis and Bipolaris spicifera causing leaf blight of buffalograss in Nebraska. Plant Disease

Vu AL, MM Dee, RJ Gualandi Jr, S Huff, J Zale (2011). First report of leaf spot caused by Bipolaris spicifera on switchgrass in the United States. Plant Disease, 2011

Ünal F., EB Turgay, AF Yildirim, C Yüksel (2001). First report of leaf blotch on sorghum caused by Bipolaris spicifera in Turkey. Plant Disease

Mohanan C., JK Sharma (1986). Bipolaris-spicifera and exserohilum-rostratum causing leaf spots of eucalyptus-tereticornis-new record from india. Current science

Patil S., S Kulkarni, S Gadgil, A Joshi (2011) Corneal abscess caused by Bipolaris spicifera .- Indian Journal of Pathology 54: 408

Taguchi, Katsuji; Oharaseki, Toshiaki; Yokouchi, Yuki; et al.(2007). Allergic fungal sinusitis caused by Bipolaris spicifera and Schizophyllum commune. Medical Mycology 45 (6): 559-564.

McGinnis MR, G Campbell, WK Gourley (1992). Phaeohyphomycosis caused by Bipolaris spicifera: an informative case. European journal of Epidemiology 8:383

Dixon, DM and Polakwyss, A (1991) The medically important dematiaceous fungi and their identification. Mycoses 34 (1-2): 1-18

4.6.9. Cladosporium herbarum

This species was identified earlier by Dr. Van Leeuwen as a fungal species that had at some point been found associated with plant material by the Dutch National Plant Protection Organisation (NPPO). The investigation into its possible plant pathogenicity was described earlier in paragraph 4.3.
In addition the APS Compendia lists *C. herbarum* in the common diseases of Grape, Lentil, Pear, Rye, Sweet Cherry and Sour Cherry.

Conclusion
In addition to the earlier findings of papers reporting on the plant pathogenicity of *Cladosporium herbarum* on a variety of plant species (see below) this species is also mentioned as a plant pathogen in various APS compendia.

Selected references
Hewitt W. (1988) Compendium of Grape Diseases. R. Pearson and A. Goheen, eds. The American Phytopathological Society, St. Paul, MN.

Baranov, O.Y., Oszako, T., Nowakowska, J.A., Panteleev, S.V. (2010). Genetic identification of fungi colonising seedlings of the Scots pine (Pinus sylvestris L.) in the forest nursery in Korenevka (Belarus). Folia Forestalia Polonica, Series A 52 (1), pp. 61-64

Benbow, J. M., and Sugar, D. 1999. Fruit surface colonization and biological control of postharvest diseases of pear by preharvest yeast applications. Plant Dis. 83:839-844.

Pusz, W., Pląskowska, E., Yildirim, İ., Weber, R. (2015). Fungi occurring on the plants of the genus Amaranthus L. Turkish Journal of Botany 39 (1): 147-161

Berner DK, E. L. Smallwood, M. B. McMahon, D. G. Luster and J. Kashefi (2007). First Report of Leaf Spot Caused by Cladosporium herbarum on Centaurea solstitialis in Greece. Plant Disease 91 (4): 463

Abdel-Motaal F.F., Magdi A. El-Sayed, Soad A. El-Zayat, Mortada S. M. Nassar, and Shin-ichi Ito (2009). Leaf spot disease of Hyoscyamus muticus (Egyptian henbane) caused by Cladosporium herbarum. Journal of General Plant Pathology 75: 437-439

Briceño, E.X. and B. A. Latorre (2007). Outbreaks of Cladosporium Rot Associated with Delayed Harvest Wine Grapes in Chile. Plant Disease 91 (8): 1060

Briceño, E. X., and Latorre, B. A. (2008). Characterization of Cladosporium rot in grapevines, a problem of growing importance in Chile. Plant Disease 92:1635-1642.

Latorre, B.A., Briceño, E.X., Torres, R. (2011). Increase in Cladosporium spp. populations and rot of wine grapes associated with leaf removal. Crop Protection 30 (1), pp. 52-56

Perello, AE; Sisterna, MN; Moreno, MV (2003). Occurrence of Cladosporium herbarum on wheat leaves (Triticum aestivum) in Argentina. Australasian Plant Pathology 32 (2): 327-328.

4.6.10. Graphium ulmi (= Ophiostoma ulmi)

The COGEM lists Graphium sp. As non-pathogenic. APS lists *G. ulmi* as a pathogen on Elm and Graphium sp. as pathogens on Coconut palm.
G. ulmi is also known as *Ophiostoma ulmi* which is a well known pathogen on trees and the causal agent of the Dutch Elm disease. In the APS compendium of Elm diseases it is listed a pathogen and in Sinclair and Lyon (2005) and in references theirin, it is also listed as a pathogen of elm trees.

Conclusion
Different references report *Graphium ulmi* (= *Ophiostoma ulmi*) as a plant pathogen on elm trees.

Selected references

Sinclair W.A. and Howard H. Lyon Diseases of Trees and Shrubs page 240

Temple, B. and Horgen, P.A. (2000). Biological roles for cerato-ulmi a hydrophobin secreted by the elm pathogens *Ophiostoma ulmi* and *O. novo-ulmi.* Mycologia 92: 1-9

Stipes, R.J. and Campana, R.J. eds 1981. Compendium of elm diseases Am. Phytopathol. Soc. St Paul MN 96 pp

Smalley, E.B. and Guries, R.P. (1993) Breeding Elms for resistance to Dutch elm disease. Ann. Rev. Phytopathol. 31 325-352

Cannon, W.N.J. and Worley, D.P. (1980). Dutch elm disease control: performance and costs. USDA For. Sev. Res. Pap NE-457 8 pp

4.6.11. Monascus ruber

APS lists this species as a pathogen on maize and corn however in the Compendium of Corn diseases (1999) this species is not mentioned.

A Scopus search yielded 100 references and refining the search to Agricultural and Biological Sciences 43 papers. Most dealt with the production of pigments by various *Monascus* species or their use as antimicrobials. No papers were found referring to *M. ruber* as a plant pathogen.

Web of Science search
A Web of Science search for *M. ruber* yielded 167 references with many referring to the production of pigments by various *Monascus* species. Limiting the search to Plant sciences yielded 7 papers with none referring to plant pathogenicity.

Plant Disease and Phytopathology search
A search in these two journals yielded no references for *M. ruber*.

Conclusion
No references were found describing *Monascus ruber* as a plant pathogen.

Selected references
Compendium of corn diseases [Monograph] - 3rd ed. White, D.G. \ NCR-25 Committee on Corn and Sorghum Diseases \ University of Illonois at Urbana-Champaign \ 1999

4.6.12. Nigrospora sphaerica

APS lists *Nigrospora sphaerica* as a pathogen on turf grass and on banana and plantain. The Compedium for banana and plantian Diseases is not available but the Compendium of Turfgrass Diseases mentions *N. sphaerica* as the causal agent of Nigrospora blight in different grass species.

Scopus search
A search in Scopus for *N. sphaerica* and restricting the output to Agricultural and Biological Science yielded 26 records. A number of references describe this micro-organism as a plant pathogen on different plant species; Dutta et al (2015) on tea in India; blight symptoms on leaves in commercial tea estates of the Darjeeling district reducing yield and quality of the leaves, Zao et al (2014) on sesame in China; leaf blight in sesame fields in Anhui, Hubei, and Henan provinces with approximately 30 to 40% of the plants symptomatic in the affected fields, Abassa et al (2013) on date palm in Iraq and Soylu et al (2011) with distinct leaf spots on Chinese wisteria in several gardens, retail nurseries, and parks located in Hatay Province in Turkey.

Web of Science search
A search in Web of Science for *N. sphaerica* and limiting the search to Plant sciences yielded 21 hits. Two references describe *N. sphaerica* as a plant pathogen: Zhang et al (2011) on Curcuma in China; early symptoms of yellow-to-brown, irregular-shaped lesions on the leaf margin or tip followed by severe leaf blight in fields located in Ruian, China with disease incidence approximately 90% of plants observed in affected fields, Verma and Gupta (2008) on *Glycyrrhiza glabra* in India with symptoms of the disease appearing in the form of small (2–5 mm), circular to irregular, red coloured spots on leaflets, covering major area of the leaf. Occasionally, the spots are seen delineated by the midrib. In advanced stages of the disease, some spots cracked at the centre. Eventually, leaves dry and the plant defoliates, Wright et al (2008) on blueberry in Argentina with leaf spots and twig and shoot blight observed on plants cultivated in Arrecifes, Mercedes, and San Pedro (provinces of Buenos Aires) and Concordia (province of Entre Ríos) since July 2004.

Plant Disease and Phytopathology search
A search in these two journals yielded seven references, identical to the five already identified in Scopus and Web of Science. The other two references, dealing with other pathogens of banana, only mentioned the name but not in the context of pathogens on banana.

Conclusion
There are a number of papers reporting on the plant pathogenicity of *Nigrospora sphaerica* on different plant species.

Selected references
Compendium of turfgrass diseases [Monograph] - 3rd. ed. Smiley, R.W. \ Dernoeden, P.H. \ Clarke, B.B. \ 2005

Dutta, J., Gupta, S., Thakur, D., Handique, P.J. (2015). First report of nigrospora leaf blight on tea caused by nigrospora sphaerica in India. Plant Disease 99 (3): 417.

Zhao, H., Liu, H.Y., Yang, X.S., Liu, Y.X., Ni, Y.X., Wang, F., and Tang, L (2014). First report of Nigrospora leaf blight on sesame caused by Nigrospora sphaerica in China. Plant Disease 98 (6): 842.

Mohammed H. Abassa, Muhammed A. Hameeda & Alaa Naser Ahmeda (2013). First report of Nigrospora sphaerica (Sacc.) Mason as a potential pathogen on date palm (Phoenix dactylifera L.). Canadian Journal of Plant Pathology35 (1): 75-80. http://dx.doi.org.ezproxy.library.wur.nl/10.1094/PDIS-10-10-0770

S. Soylu, S. Dervis, and E. M. Soylu (2011). First Report of Nigrospora sphaerica Causing Leaf Spots on Chinese Wisteria: A New Host of the Pathogen. Plant Disease 95 (2): 219.

Zhang, L. X.; Song, J. H.; Tan, G. J. (2011). First Report of Leaf Blight Caused by Nigrospora sphaerica on Curcuma in China. Plant Disease 95 (9): 1190.

Verma, O. P.; Gupta, R. B. L. (2008). A new host for Nigrospora sphaerica causing leaf spots on Glycyrrhiza glabra. Plant Pathology 57 (4): 782-782.

Wright, E. R.; Folgado, M.; Rivera, M. C.; et al. (2008). Nigrospora sphaerica causing leaf spot and twig and shoot blight on blueberry: A new host of the pathogen. Plant Disease 92 (1): 171.

4.6.13. Penicillium aurantiogriseum

APS lists *P. aurantiogriseum* as a pathogen on onion, strawberry and asparagus. There is no Compendium for Asparagus Diseases. The Compendium for Onion and Garlic Diseases and Pests (2008) lists several Penicillium species including *P. aurantiogriseum* as causes of Blue mould, a disease of onion and garlic that occurs during harvest and storage.
The Compendium for Strawberry Diseases (1998) lists several Penicillium species including *P. aurantiogriseum* as nonselective pathogens of fruit and vegetable (including strawberries) in cold storage.

A search in Scopus resulted in 80 hits when searching for *Penicillium aurantiogriseum.* One hit describes *P. aurantiogriseum* as a postharvest disease (blue mold) of apple fruits (Moslem et al (2010)). A second hit describes the identification of *Penicillium* species on garlic affected by blue mold (postharvest disease). Among the *Penicillium* species identified *P. aurantiogriseum* occurred in a very low frequency (0.6 % of the tested garlic samples, Valdez et al 2009). A third publication mentions *P. aurantiogriseum* also as a postharvest disease of litchi (Lichter et al 2004).

Plant Disease search
Four hits were found searching for *P. aurantiogriseum* in Plant Disease, but in these references only information on other fungi was reported. One possibly interesting reference only gave reference to the publication of Moslem et al (2010) mentioned above.

Phytopathology search
Two hits were found searching for *P. aurantiogriseum* in Phytopathology, but in these references only information on other fungi was reported.

Conclusion
No publications were found with a clear indication of *P. aurantiogriseum* as a plant pathogen and generally this fungus is regarded as a postharvest disease.

Selected references
Compendium of onion and garlic diseases and pests [Monograph] - 2nd ed. Schwartz, H.F. \ Krishna Mohan, S. \ American Phytopathological Society \ 2008

Compendium of Strawberry D diseases [Monograph] - 2nd ed. Maas, J.L. \ 1998

Lichter, A., Dvir, O., Ackerman, M., Feygenberg, O., Pesis, E. Acidified peel of litchi fruits selects for postharvest Penicillium decay. 2004. Phytoparasitica 32 (3), pp. 226-236

Moslem, M., Abd-Elsalam, K., Yassin, M., and Bahkali, A. 2010. First morphomolecular identification of Penicillium griseofulvum and Penicillium aurantiogriseum toxicogenic isolates associated with blue mold on apple. Foodborne Pathog. Dis. 7:857-861.

Valdez, J.G., Makuch, M.A., Ordovini, A.F., Frisvad , J.C., Overy, D.P., Masuelli, R.W., Piccolo, R.J. Identification, pathogenicity and distribution of *Penicillium* spp. isolated from garlic in two regions in Argentina. 2009. Plant Pathology. 58 (2), pp. 352-361.

4.6.14. Penicillium chrysogenum

APS lists this species as a pathogen on maize or corn. In the Compendium of Corn Diseases (1999) this species is mentioned as a storage disease on harvested kernels.

Scopus search
A search in Scopus resulted in 493 hits when searching for *Penicillium chrysogenum*. One hit mentions *P. chrysogenum* as a postharvest disease in apples (Alwakeel. 2013).

Plant Disease search
Eight hits were found searching for *P. chrysogenum* in Plant Disease, but in these references only information on other fungi was reported.

Phytopathology search
Eleven hits were found searching for *P. chrysogenum* in Phytopathology, but in these references only information on other fungi was reported.

Conclusion
No publications were found with a clear indication of *P. chrysogenum* as a plant pathogen, only references indicating it as a storage or postharvest disease.

Selected references

Compendium of corn diseases [Monograph] - 3rd ed. (1999). White, D.G. \ NCR-25 Committee on Corn and Sorghum Diseases \ University of Illonois at Urbana-Champaign

Alwakeel, S.S. Molecular identification of isolated fungi from stored apples in Riyadh, Saudi Arabia 2013. Saudi Journal of Biological Sciences. 20 (4), pp. 311-317

4.6.15. Penicillium funiculosum

APS lists *P. funiculosum as* a pathogen on onion. The Compendium for Onion and Garlic Diseases and Pests (2008) lists several Penicillium species including *P. funiculosum* as causes of Blue mould, a disease of onion and garlic that occurs during harvest and storage.

Scopus search
A search in Scopus resulted in 118 hits when searching for *Penicillium funiculosum*. None of these hits mentions *P. funiculosum* as a plant pathogen or causal agent of a postharvest disease.

Plant Disease search
Three hits were found searching for *P. funiculosum* in Plant Disease. In two references only information on other fungi was reported. In one reference *P. funiculosum* was mentioned as one of the causal agents of postharvest wet core rot(WCR) in apples (Van der Walt et al, 2010).

Phytopathology search
Five hits were found searching for *P. funiculosum* in Phytopathology, but in these references only information on other fungi was reported.

Conclusion
No publications were found with a clear indication of *P. funiculosum* as a plant pathogen, only references indicating it as a storage or postharvest disease.

Selected references
Compendium of onion and garlic diseases and pests [Monograph] - 2nd ed. Schwartz, H.F. \ Krishna Mohan, S. \ American Phytopathological Society \ 2008

Van der Walt, L., Spotts, R. A., Visagie, C. M., Jacobs, K., Smit, F. J., and McLeod, A. 2010. Penicillium species associated with preharvest wet core rot in South Africa and their pathogenicity on apple. Plant Dis. 94:666-675.

4.6.16. Penicillium purpurogenum

APS lists *P. purpurogenum* as a pathogen on strawberry. The Compendium for Strawberry Diseases (1998) lists several Penicillium species including *P. purpurogenum* as nonselective pathogens of fruit and vegetable (including strawberries) in cold storage.

Scopus search
A search in Scopus resulted in 98 hits when searching for *Penicillium purpurogenum*. One hit mentions P. purpurogenum as a postharvest disease in apricots (Bhadwal et al. 2011).

Plant Disease search
Four hits were found searching for *P. purpurogenum* in Plant Disease, but in these references only information on other fungi was reported.

Phytopathology search
One hit was found searching for *P. purpurogenum* in Phytopathology, but in this reference only information on other fungi was reported.

Conclusion
No publications were found with a clear indication of *P. purpurogenum* as a plant pathogen, only references indicating it as a storage or postharvest disease.

Selected references
Compendium of Strawberry D diseases [Monograph] - 2nd ed. Maas, J.L. \ 1998

Bhadwal, J., Sharma, Y.P. Unrecorded post-harvest fungal rots of fresh apricots from India. 2011. Proceedings of the National Academy of Sciences India Section B - Biological Sciences 81 (PART3), pp. 288-290

4.6.17. Phaeotrichoconis crotalariae

APS mentions *P. crotalariae* as a pathogen on Pipieraceae (a group of potting plants). There is no Compendium for this group available.

A search in Scopus on *P. crotalariae* yielded two references. De Lima et al (20132) describe the isolation of *P. crotalariae* during studies with endophytic fungi on healthy leaves of *Vitis labrusca* in Pernambuco, Brazil. No reference to plant pathogenicity is made. The available abstract of the second paper (Jain et al, 1989) reports on a skin conditions caused by this fungus which was investigated in rabbits.

Plant Disease and Phytopathology search
A search in Plant disease and Phytopathology for *P. crotalariae* yielded no hits.

Conclusion
No references were found describing *Phaeotrichoconis crotalariae* as a plant pathogen.

Selected references

De Lima F., T.E., Bezerra, J.L., Queiroz Cavalcanti, M.A.D. (1012). Phaeotrichoconis crotalariae, endophytic on Vitis labrusca in Brazil. Mycotaxon 120, pp. 291-294

Jain P.K., M., Lal, B., Agrawal, P.K., Srivastava, O.P. (1989). Mycotic keratitis caused by Phaeotrichoconis crotalariae. New report. Mycoses 32 (5), pp. 230-232

4.6.18. Phoma herbarum

This species was identified earlier by Dr. Van Leeuwen as a fungal species that had at some point been found associated with plant material by the Dutch National Plant Protection Organisation (NPPO).
Literature searches for *P. herbarum* in Scopus, Web of Sciences, Plant Disease and Phytopathology are already reported before (see paragraph 4.3.10) with different references reporting on the plant pathogenicity of *P. herbarum* as well as reports on it pathogenicity on fish (Faisal et al, 2007; Ali et al, 2011).

APS lists *Phoma herbarum* as a pathogen on hemp and hop however in the Compendium of Hop Diseases and Pests (2009) this species is not mentioned. There is no Compedium for Hemp Diseases.

Conclusion
As already reported above (paragraph 4.5.3), information from Q-bank does point towards possible plant pathogenicity for *Phoma herbarum*. This is in accordance with previous results obtained from literature searches (see paragraph 4.3.10) which identified *P. herbarum* as a plant pathogen on a variety of plant species. In addition *P. herbarum* is reported as a human pathogen (Mycobank) as well as a fish pathogen.

Selected references

Compendium of hop diseases and pests [Monograph]. Mahaffee, W.F. \ Pethybridge, S.J. \ American Phytopathological Society \ cop. 2009

Li, Y. P., Wright, D. G. and Lanoiselet, V. (2012). First Report of Phoma herbarum on Tedera (Bittuminaria bituminosa var. albomarginata) in Australia. Plant Disease 96 (5): 769-769.

Li Y.P., M. P. You, T. N. Khan, P. M. Finnegan, and M. J. Barbetti (2011). First Report of Phoma herbarum on Field Pea (Pisum sativum) in Australia. Plant Disease 95 (12): 1590.

Neumann Brebaum S. and G. J. Boland (1999). First Report of Phoma herbarum and Phoma exigua as Pathogens of Dandelion in Southern Ontario. Plant Disease 83 (2): 200.

Ray, P. and Vijayachandran, L.S. (2013). Evaluation of indigenous fungal pathogens from horse purslane (trianthema portulacastrum) for their relative virulence and host range assessments to select a potential mycoherbicidal agent. Weed Science 61 (4): 580-585

Faisal, M., Elsayed, E., Fitzgerald, S.D., Silva, V., Mendoza, L. (2007). Outbreaks of phaeohyphomycosis in the chinook salmon (Oncorhynchus tshawytscha) caused by Phoma herbarum. Mycopathologia 163 (1): 41-48.

Ali, E.H., Hashem, M., Al-Salahy, M.B. (2011). Pathogenicity and oxidative stress in Nile tilapia caused by Aphanomyces laevis and Phoma herbarum isolated from farmed fish. Diseases of Aquatic Organisms 94 (1): 17-28.

4.6.19. Plectosporium tabacinum

APS lists this species as a pathogen on bean and cucurbits however in the Compendium of bean diseases (1999) and Compendium of Cucurbit Diseases this species is not mentioned.
A search in Scopus resulted in 32 hits when searching for *P. tabacinum* with several reports on pathogenicity on plants, but also humans (Keratitis, Kamada et al, 2012). *P. tabacinum* is pathogenic on melon plants (root rot and collapse), pumpkin, squash, beans, ranunculus etc. (Chilosi et al, 2008; Sato et al, 2005; Jimenez et al, 2005) The fungus is also reported as causing decay in fruits, and e.g. cutting rot in Chrysanthemum. There are several reports on the endofytic behaviour of *P. tabacinum*. This fungus can also be applied as biological control agent against false cleavers and other herbs, indicating its plant pathogenicity.
Web of Science yielded 43 hits when searching for *P. tabacinum* alone, with comparable results as the search in scopus. Additionally, a report on rot disease of lettuce, cilantro, and chervil caused by Plectosporium tabacinum was found (Usami et at, 2012).
A search for *Plectosporium tabacinum* in Plant Disease resulted in 24 hits. Additional information was found of *P. tabacinum* pathogenicity on basil, zucchini, pumpkin and squash.
A search for *P. tabacinum* in Phyopathology resulted in 4 hits. There were no reports on plant pathogenicity.

Conclusion
There are a significant number of papers reporting on the plant pathogenicity of *Plectosporium tabacinum* on a variety of plant species.

Selected references:

Compendium of bean diseases [Monograph]. Hall, R. \ 1991

Satou, M., Sumitomo, K., Chikuo, Y. (2013). Cultivar resistance, infection sources, and effective fungicides identified to control Chrysanthemum cutting rot caused by Plectosporium tabacinum. Journal of General Plant Pathology, 79 (3), pp. 168-174.

Kamada, R., Monden, Y., Uehara, K., Yamakawa, R., Nishimura, K. (2012). Rare case of fungal keratitis caused by Plectosporium tabacinum. Clinical Ophthalmology, 6 (1), pp. 1623-1627.

Satou, M., Chikuo, Y., Matsushita, Y., Sumitomo, K. (2010). Cutting rot of chrysanthemum (chrysanthemum morifolium) caused by plectosporium tabacinum. Journal of General Plant Pathology, 76 (3), pp. 225-228.

Chilosi, G., Reda, R., Aleandri, M.P., Camele, I., Altieri, L., Montuschi, C., Languasco, L., Rossi, V., Agosteo, G.E., MacRì, C., Carlucci, A., Lops, F., Mucci, M., Raimondo, M.L., Frisullo, S. (2008). Fungi associated with root rot and collapse of melon in Italy. EPPO Bulletin, 38 (1), pp. 147-154.

Götz, M., Nirenberg, H., Krause, S., Wolters, H., Draeger, S., Buchner, A., Lottmann, J., Berg, G., Smalla, K. (2006). Fungal endophytes in potato roots studied by traditional isolation and cultivation-independent DNA-based methods. FEMS Microbiology Ecology, 58 (3), pp. 404-413.

Dillard, H.R., Cobb, A.C., Shah, D.A., Straight, K.E. (2005). Identification and characterization of russet on snap beans caused by Plectosporium tabacinum. Plant Disease, 89 (7), pp. 700-704.

Sato, T., Inaba, T., Mori, M., Watanabe, K., Tomioka, K., Hamaya, E. (2005). Plectosporium blight of pumpkin and ranunculus caused by Plectosporium tabacinum. Journal of General Plant Pathology, 71 (2), pp. 127-132.

Jimenez, P., Zitter, T.A. (2005). First report of plectosporium blight on pumpkin and squash caused by Plectosporium tabacinum in New York. Plant Disease, 89 (4), p. 432.

Zhang, W.M., Mckee, K., Sulz, M., Mykietiak, T., Li, X., Cole, D.E., Bailey, K.L. (2003). Infection process of Plectosporium tabacinum on false cleavers (Galium spurium). Biocontrol Science and Technology, 13 (3), pp. 299-312.

Zhang, W., Sulz, M., Bailey, K.L. (202). Evaluation of Plectosporium tabacinum for control of herbicide-resistant and herbicide-susceptible false cleavers. Weed Science, 50 (1), pp. 79-85.

Zhang, W.M., Sulz, M., Bailey, K.L., Cole, D.E. (2002). Effect of epidemiological factors on the impact of the fungus Plectosporium tabacinum on false cleavers (Galium spurium). Biocontrol Science and Technology, 12 (2), pp. 183-194.

Youssef, Y.A., El-Tarabily, K.A., Hussein, A.M. (2001). Plectosporium tabacinum root rot disease of white lupine (Lupinus termis Forsk.) and its biological control by Streptomyces species. Journal of Phytopathology, 149 (1), pp. 29-33.

Chen, W., Gray, L.E., Kurle, J.E., Grau, C.R. (1999). Specific detection of Phialophora gregata and Plectosporium tabacinum in infected soybean plants using polymerase chain reaction. Molecular Ecology, 8 (5), pp. 871-877.

Smither-Kopperl, M.L., Charudattan, R., Berger, R.D. (1999). Plectosporium tabacinum, a pathogen of the invasive aquatic weed Hydrilla verticillata in Florida. Plant Disease, 83 (1), pp. 24-28.

Chung, Y.R., Koo, S.J., Kim, H.T., Cho, K.Y. (1998). Potential of an indigenous fungus, Plectosporium tabacinum, as a mycoherbicide for control of arrowhead (Sagittaria trifolia). Plant Disease, 82 (6), pp. 657-660.

Usami, T.; Morii, S.; Amemiya, Y. (1012). Rot disease of lettuce, cilantro, and chervil caused by Plectosporium tabacinum. Phytopathology 102 (7) Supplement: 4 Pages: 125-125.

4.6.20. Pleurotus ostreatus

APS lists this species as a pathogen on sweetgum and elm. There are no Compendia for sweetgum or elm.
A search in Scopus for *Pleurotus ostreatus* (Oyster mushroom) resulted in 2290 hits, most of them concerning the growth of this mushroom on different substrates and detoxification of components in the substrates. A search for P. *ostreatus* AND pathogen resulted in 43 hits, most of them about pathogens infecting the oyster mushroom. However, it was also reported that *P. ostreatus* itself is pathogenic to nematodes (Plotnikova et al., 2014), some bacteria and associated with a disease in red-flowering horse chestnut (Müller-Navarra, 2014).
Searches with Pleurotus AND 'elm' or 'gum' yielded 1 and 8 hits respectively, none of them reporting a pathogenic effect of the fungus to foresaid trees.
Web of Science yielded 2810 hits when searching for *P. ostreatus alone*, 46 records were found when searching for P. ostreatus AND pathogen. None of the 46 records described pathogenic effects of this fungus. Specific searches on *P. ostreatus* AND 'elm' or 'sweet gum' yielded 0 hits.
A search for *Pleurotus ostreatus* in Plant disease resulted in 3 matches, but none of them describes plant pathogenic properties of this mushroom.
A search for *Pleurotus ostreatus* in Phytopathology resulted in 8 matches, but none of them describes plant pathogenic properties of this mushroom.

As no Compendium for Elm was available, other books on diseases of trees were consulted. The book "Fungi on trees" (Watson and Green, 2011) mentions *P. ostreatus* as a fungus able to colonize a wide range of broadleaved trees. With respect to its impact the authors report the possibility of failure of a tree which may depend of the number or sizes of the wounds through which the fungus apparently is able to colonize the tree. This does indicate possible pathogenicity.

In the recent COGEM advice CGM/140227-03 two related species (*Pleurotes eryngii* and *P. pulmonarius*) were both classified (based on literature earches and expert judgement) as opportunistic parasites and placed on the Class 1 list of non-pathogenic fungi.

Conclusion
Although earlier classified by COGEM as non-pathogenic (CGM/140227-03), two references were found reporting on the apparent plant pathogenicity of *Pleurotus ostreatus* on trees as well as a reference showing its pathogenicity on nematodes.

Selected references:
CGM/140227-03. Advies classificatie basidiomycete witrotschimmels.

Müller-Navarra, A., Gaiser, O., Moreth, U., Dujesiefken, D., Magel, E.A. (2014). New disease on red flowering horse chestnut (Aesculus × carnea Hayne) and the molecular identification of the involved pathogens [Neue Krankheit der Rotblühenden Rosskastanie (Aesculus × carnea Hayne) und molekulare identifizierung der beteiligten Schadorganismen]. Journal fur Kulturpflanzen, 66 (12), pp. 417-423.

Plotnikova, J., Kamzolkina, O.V., Ausubel, F.M. (2014). A new model system for the study of the animal innate immune response to fungal infections. Moscow University Biological Sciences Bulletin, 69 (2), pp. 45-50.

Schillaci, D., Arizza, V., Gargano, M.L., Venturella, G. (2013). Antibacterial activity of mediterranean oyster mushrooms, species of genus Pleurotus (Higher Basidiomycetes). (2013) International Journal of Medicinal Mushrooms, 15 (6), pp. 591-594.

4.6.21. Saccharomyces cerevisiae

APS lists this species as a pathogen on strawberry however in the Compendium of Strawberry Diseases (1998) this species is not mentioned.
A search in Scopus resulted in 126,777 hits when searching for *S. cerevisiae*. 35 hits were received when searching for *S. cerevisiae* AND strawberry, the majority of the references describing fermentation-related topics regarding this yeast.
Web of Science yielded 129,303 hits when searching for *S. cerevisiae* alone, 44 records were found when searching for *S. cerevisiae* AND strawberry. None of the 44 records described pathogenic effects of this yeast in strawberry.
A Plant Disease search for *Saccharomyces cerevisiae* in strawberry resulted in 4 hits. None of them describes plant pathogenic properties of this yeast on strawberry.
A search in Phytopathology for *Saccharomyces cerevisiae* in strawberry resulted in 14 hits. None of them describes plant pathogenic properties of this yeast on strawberry.

Conclusion
No references were found describing *Saccharomyces cerevisiae* as a plant pathogen.

Selected refrences
Compendium of Strawberry D diseases [Monograph] - 2nd ed. Maas, J.L. \ 1998

4.6.22. Saccharomyces kluyveri

APS lists this species as a pathogen on strawberry however in the Compendium of Strawberry diseases (1998) this species is not mentioned.
A search in Scopus resulted in 227 hits when searching for *S. kluyveri*, the majority of the references describing fermentation-related topics regarding this yeast. Zero hits were received when searching for *S. kluyveri* AND strawberry.

Web of Science yielded 213 hits when searching for S. kluyveri alone, 0 records were found when searching for *S. kluyveri* AND strawberry.
Searches in Plant Disease and Phytopathology resulted in 0 hits.

Conclusion
No references were found describing *Saccharomyces kluyveri* as a plant pathogen.

4.6.23. Trametes versicolor

This fungus is listed by APS as a pathogen on Elm trees. There is no Compendium for Elm available so other books on diseases of trees were consulted. In Sinclaer and Lyon (2005) *T. versicolor* is listed as a pathogen of a large number of tree species, able to invade trough wounds, broken limbs etc. and killing sapwood. This book also contains additional references, listed below.

Trametes versicolor is listed by APS as a pathogen on the lists of names of common diseases of Black Walnut, Elm, Pear and Sweet Gum.

T. versicolor (*syn. Coriolus versicolor, Microporus versicolor, Boletus versicolor, Bjerkandera versicolor, Poria versicolor*) is a common fungus growing on dead wood and in COGEM advice CGM/140227-03 this fungus was classified (based on literature earches and expert judgement) as an opportunistic parasite of weakend trees and placed on the Class 1 list of non-pathogenic fungi.

However, searches employing SCOPUS and Web of Sciences identified a number of papers which describe this fungus as a plant pathogen capable of infecting healthy trees and inciting diseases symptoms. Bergdahl and French (1985) described the results of inoculations of several wood-decaying fungi (including *T. versicolor*) on healthy apple trees and they conclude that their inoculations and those of others indicate that *T. versicolor* is pathogenic.
Dilley and Covey (1981) describe the association of T versicolor with dieback symptoms on apple trees in Washington State (USA). Earlier reports from Australia suggest that *T. versicolor* (*C.versicolor*) is also capapble of acting as an aggressive parasite that kills sapwood and cambial tissues of apple trees. Symptoms caused by this fungus included white rot of wood, blistering and peeling of bark (papery bark) and dieback. These symptoms were caused by artificial inoculation of healthy apple trees with *C. versicolor* in the greenhouse (Darbyshire et al., 1969) and field (Wade, 1968) but it was also mentioned that not all trees were susceptible.

Conclusion
Although earlier classified by COGEM as non-pathogenic, there are a number of references describing *Trametes versicolor* as a pathogen on apple and other trees.

Selected references

Bergdahl, D. R. and French, D.W. (1985). Association of wood decay fungi with decline and mortality of apple trees in Minnesota. Plant Disease 69:887-890

Darbyshire B., Wade GC. And Marshall KC (1969). In vitro studies of the role of nitrogen and sugars on the susceptibility of apple wood to decay by Trametes versicolor. Phytopathology 59: 98-102.

Dilley MA and Covey R.P.Jr. (1981) Association of Coriolus versicolor with a dieback disease of apple trees in Washington State. Plant Disease 65: 77-78.

Kile, G.A. (1976). The effect of seasonal pruning and time since pruning upon changes in apple sapwood and its suseptibility to invasion bij *Trametes versicolor.* Phytopathol. Z 87: 231-240

Kile, G.A. and Wade, G.C. (1974). *Trametes versicola* on apple. Host-pathogen relationship. Phytopathologisches. Zeitschrift 81:328-338.

Sinclaer WA and Howard H. Lyon (2005). In: Diseases of Trees and Shrubs page 310

Schrenk, H. von (1914) A trunk disease of the lilac. An. Mo. Bot. Gard. 1: 253-262

Wade GC (1968). The influence of mineral nutrition on the suswceptibility of apple trees to infection by Trametes versocolor. Aust. J Exp. Agric. Anim. Husb 8: 436-439.

4.6.24. Trichoderma koningii

APS lists this species as a pathogen on sweet potato. The Compendium of Sweet potato Diseases was not available.
A search in Scopus for *T. koningii* resulted in 375 results, however a search for *T. koningii* AND sweet potato / ipomoea resulted in 0 hits. The majority of the results contained literature regarding the antagonistic properties of *T. koningii*. Four references were describing the pathogenic effects of *T. koningii* on mushrooms. No references were found indicating plant pathogenic effects of *T. koningii*.
Web of Science yielded 377 results on *T. koningii* and 0 results on *T. koningii* AND sweet potato.
A search in Plant Disease search resulted in 7 hits, only describing T. *koningii* as a biocontrol agent for the control of fungal plant diseases and a search in Phyopathology resulted in 22 matches, only describing *T. koningii* as a biocontrol agent for fungal plant diseases

Conclusion
No references were found describing *Trichoderma koningii* as a plant pathogen however it was reported as a fungal pathogen on mushrooms.

Selected references:

Zarger, S.A., Rizvi, G., Parashar, R. (2015). Studies on leaf spot disease of mango and its management. International Journal of Pharma and Bio Sciences, 6 (1), pp. B769-B776.

Ahluwalia, V., Walia, S., Sati, O.P., Kumar, J., Kundu, A., Shankar, J., Paul, Y.S. (2014). Isolation, characterisation of major secondary metabolites of the Himalayan Trichoderma koningii and their antifungal activity. (2014) Archives of Phytopathology and Plant Protection, 47 (9), pp. 1063-1071.

Strakowska, J., Błaszczyk, L., Chełkowski, J. (2014). The significance of cellulolytic enzymes produced by Trichoderma in opportunistic lifestyle of this fungus. Journal of Basic Microbiology, 54 (SUPPL.1), pp. S2-S13.

Khan, M.R., Ashraf, S., Rasool, F., Salati, K.M., Mohiddin, F.A., Haque, Z. (2014). Field performance of Trichoderma species against wilt disease complex of chickpea caused by Fusarium oxysporum f. sp. ciceri and Rhizoctonia solani. Turkish Journal of Agriculture and Forestry, 38 (4), pp. 447-454.

Górski, R., Sobieralski, K., Siwulski, M., Fraszczak, B., Sas-Golak, I. (2014). The effect of trichoderma isolates, from family mushroom growing farms, on the yield of four agaricus bisporus (lange) imbach strains. Journal of Plant Protection Research, 54 (1), pp. 102-105.

Nagendra Prasad, B., Reddi Kumar, M. (2013). Scanning electron microscopic studies on mycoparasitic activity of Trichoderma spp. against Rhizoctonia solani, incitant of sheath blight of rice. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 4 (3), pp. 88-96.

Alexandru, M., Lazăr, D., Ene, M., Şesan, T.E. (2013). Influence of some trichoderma species on photosyntesis intensity and pigments in tomatoes. Romanian Biotechnological Letters, 18 (4), pp. 8499-8510.

4.6.25. Trichoderma viride

This species was identified earlier (see Table 1) by Dr Kohl as an antagonist. The investigation into its possible plant pathogenicity was described earlier in paragraphs 2.8.2. and 4.3.13.
APS lists this species as a pathogen on citrus and on corn and maize. In the Compendium of Citrus Diseases (2000) *T. viride* is mentioned as ubiquitous soil saprophyte which also grows readily on wood products because of its strong cellulytic enzyme activities. No reference to plant pathogenicity is made.
In the Compendium of Corn Diseases (1999) *T. viride* is mentioned (pg 45) as Trichoderma ear rot which is associated with injury to the developing ear and is usually found on broadly distributed plants.

Literature searches in Scopus, Web of Science, Plant Disease and Phytopathology yielded references for *T. viride* as a storage disease in citrus, a biocontrol agent against nematodes in citrus (Montasser et al, 2012) and antagonistic activity against *Penicillium digitatum* (Borrás and Aguilar, 1990).
As reported before (paragraph 4.3.6.; Destri Nicosia,et al, 2014) describes the pathogenic effect of inoculated *T. viride* on 2-year old pine seedlings (*Pinus nigra*) in Italy and Cutler and Lefiles (1978) describe its apparent phytotoxic effects of through the production of a fungal metabolite (Trichodermin; 4β-acetoxy-12,13-epoxy-Δ 9 –trichothecene).

Conclusion
In addition to the earlier findings of *T. viridi* as a pathogen on onions (Schwartz and Krishna, 2008) as well as on cultivated mushrooms (see parapraphs 2.8.2. and 4.3.13) one additional paper was identified reporting on the plant pathogenic nature of *Trichoderma viride* on pine seedlings. One paper alos lists *T. viridi* as pathogenic to a particular nematode species.

Selected references:
Li Destri Nicosia, M.G., Mosca, S., Mercurio, R., Schena, L. (2014). Dieback of Pinus Nigra seedlings caused by a strain of trichoderma viride. Plant Disease 99 (1): 44-49

Cutler, H.G., Lefiles, J.H.(1978). Trichodermin: Effects on plants. Plant and Cell Physiology 19 (1): 177-182.

Compendium of corn diseases [Monograph] - 3rd ed. (1999). White, D.G. \ NCR-25 Committee on Corn and Sorghum Diseases \ University of Illonois at Urbana-Champaign.

Compendium of Citrus diseases [Monograph] - 2nd ed. (2000). Timmer, L.W. \ Garnsey, S.M. \Graham, J.H.

Montasser, S.A., Abd El-Wahab, A.E., Abd-Elgawad, M.M.M., Abd-El-Khair, H., Faika, F.H.K., Hammam, M.M.A. (2012). Effects of some fungi and bacteria as bio-control agents against citrus nematode tylenchulus semipenetrans cobb. Journal of Applied Sciences Research, 8 (11), pp. 5436-5444.

Borrás, A.D., Aguilar, R.V. (1990). Biological control of Penicillium digitatum by Trichoderma viride on postharvest citrus fruits. International Journal of Food Microbiology, 11 (2), pp. 179-183.

Schwartz HF and Krishna M (2008). Compendium of onion and garlic diseases and pests. The American Phytopathological Society. APS Press, St. Paul MN

4.6.26. Zygosaccharomyces bailii

APS lists this species as a pathogen on strawberry however in the Compendium of strawberry diseases (1998) this species is not mentioned.
A search in Scopus resulted in 312 hits when searching only for *Z. bailii*, but only 3 hits for *Z. bailii* AND strawberry (including one hit for 'strawberry tree'). No evidence was found for pathogenicity of *Z. bailii* on strawberry, only the role of the yeast *Z. bailii* in the decay of wine (but also a co-starter in the fermentation of wine), smoothies, etc. (Scolari et al, 2015; Bağder Elmacı et al, 2015; Fitzgerald et al, 2003, Roller and Covlin, 2000, 1999).
Web of Science yielded 359 hits for Z. bailii. Searching for Z. bailii AND strawberry resulted in 2 hits (again including a hit for the fermentation of fruit of the 'strawberry tree' (*Arbutus unedo* L.; Santo et al, 2012). No references for plant pathogenicity were found.
Searches for *Z. bailii* AND strawberry in Plant Disease and in Phytopathology resulted in 0 hits.

Conclusion
No references were found describing *Zygosaccharomyces bailii* as a plant pathogen.

Selected references:

Scolari, G., Zacconi, C., Busconi, M., Lambri, M. (2015). Effect of the combined treatments of high hydrostatic pressure and temperature on Zygosaccharomyces bailii and Listeria monocytogenes in smoothies. (2015) Food Control, 47, pp. 166-174.

Bağder Elmacı, S., Gülgör, G., Tokatlı, M., Erten, H., İşci, A., Özçelik, F. (2015). Effectiveness of chitosan against wine-related microorganisms. Antonie van Leeuwenhoek, International Journal of General and Molecular Microbiology, 107 (3), pp. 675-686.

Fitzgerald, D.J., Stratford, M., Narbad, A. (2003). Analysis of the inhibition of food spoilage yeasts by vanillin.. International Journal of Food Microbiology, 86 (1-2), pp. 113-122.

Roller, S. and Covill, N. (2000). The antimicrobial properties of chitosan in mayonnaise and mayonnaise-based shrimp salads. Journal of Food Protection, 63 (2): 202-209.

Roller, S., Covill, N. (1999). The antifungal properties of chitosan in laboratory media and apple juice. International Journal of Food Microbiology, 47 (1-2): 67-77.

Alonso, A, Belda, I , Santos, A , Navascues, E , Marquina, D , AF (2015). Advances in the control of the spoilage caused by Zygosaccharomyces species on sweet wines and concentrated grape musts. Food Control 51: 129-134.

Rojo, MC, Lopez, FNA , Lerena, MC, Mercado, L, Torres, A, Combina, M. (2015). Evaluation of different chemical preservatives to control Zygosaccharomyces rouxii growth in high sugar culture media. Food Control 50: 349-355.

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5. Summary of results

This chapter summarizes the results for the investigations into the possible plant pathogenicity of the different bacteria and fungi identified earlier in this report.

5.1. Bacteria

5.1.1. Acetobacter aceti

Despite the listing as a plant pathogenic bacterium in Bull et al (2010) and on the APS list of common names of plant diseases, there is no apparent evidence that *Acetobacter aceti* is able to cause a disease in healthy, growing plants.

5.1.2. Pseudomonas fluorescens

Given the apparent diversity of *P. fluorescens* strains and the uncertainty on their correct taxonomic identification and classification it is impossible to generally classify this bacterial species as either pathogenic or non-pathogenic on plants.

5.1.3. Xanthobacter autotrophicus

No literature was found indicating that *X. autotrophicus* is a plant pathogen. It is also not mentioned on the APS lists of common diseases of plants. It is therefore unlikely that *Xantobacter autotrophicus* is plant pathogenic.

5.2 Fungi

5.2.1. Acremonium strictum

There are a significant number of papers reporting on the plant pathogenicity of *Acremonium strictum* on a variety of plant species as well as on its pathogenicity for humans and animals.

5.2.2. Aspergillus fischerianus

No references were found describing *Aspergillus fischerianus* as a plant pathogen however two references reports on *A. fischerianus* as a human pathogen.

5.2.3. Aspergillus glaucus

Both the APS compendium as well as a significant number of papers report on *Aspergillus glaucus* only as a disease in harvested products (postharvest disease).

5.2.4. Aspergillus niger

There are a number of papers reporting on the plant pathogenicity of *Aspergillus niger* on a variety of plant species.

5.2.5. Aureobasidium pullulans

From the available data it remains unclear whether *A. pullulans* can be regarded a plant pathogen or a postharvest disease.

5.2.6. Bjerkandera adusta

There are a number of references describing *Bjerkandera adusta* as a pathogen on different species of trees. In addition this species is reported as a human pathogen.

5.2.7. Bipolaris spicifera

There are a significant number of papers reporting on the plant pathogenicity of *Bipolaris spicifera* on a variety of plant species. In addition this species is reported as a human pathogen.

5.2.8. Cladosporium herbarum

There are a significant number of references reporting on the plant pathogenicity of *Cladosporium herbarum* on a variety of plant species.

5.2.9. Clonostachys rosea

One paper was found reporting on the plant pathogenicity of *Clonostachys rosea* on soybean. There are a few papers reporting on the nematopathogenic and entopathogenic nature of *Clonostachys rosea.*

5.2.10. Coniothyrium minitans

No references were found reporting on the plant pathogenic nature of *Coniothyrium minitans.*

5.2.11. Dichotomophthora portulacae

There were several papers found reporting on the plant pathogenicity of *Dichotomophthora portulacae* on purslane (*Portulaca oleracae*).

5.2.12. Graphium ulmi (= Ophiostoma ulmi)

Different references report *Graphium ulmi* (= *Ophiostoma ulmi*) as a plant pathogen on elm trees.

5.2.13. Metarhizium anisoplae

There were no papers found reporting on a plant pathogenici nature of *Metarhizium anisoplae* however a number of papers report on its pathogenicity to insects.

5.2.14. Microsphaeropsis olivacea

There were no papers found reporting on the plant pathogenic nature of *Microsphaeropsis olivacea* however a number of papers report on its pathogenicity for humans and animals.

5.2.15. Monascus ruber

No references were found describing *Monascus ruber* as a plant pathogen.

5.2.16. Nigrospora sphaerica

There are a number of papers reporting on the plant pathogenicity of *Nigrospora sphaerica* on different plant species.

5.2.17. Penicillium aurantiogriseum

No publications were found with a clear indication of *P. aurantiogriseum* as a plant pathogen and generally this fungus is regarded as a post-harvest disease.

5.2.18. Penicillium chrysogenum

No publications were found with a clear indication of *P. chrysogenum* as a plant pathogen only references indicating it as a storage or post-harvest disease.

5.2.19. Penicillium funiculosum

No publications were found with a clear indication of *P. funilosum* as a plant pathogen, only references indicating it as a storage or post-harvest disease.

5.2.20. Penicillium purpurogenum

No publications were found with a clear indication of *P. funilosum* as a plant pathogen, only references indicating it as a storage or post-harvest disease.

5.2.21. Phaeotrichoconis crotalariae

No references were found describing *Phaeotrichoconis crotalariae* as a plant pathogen.

5.2.22. Phoma herbarum

Different references identify *P. herbarum* as a plant pathogen on a variety of plant species. In addition *P. herbarum* is reported as a human pathogen as well as a fish pathogen.

5.2.23. Plectosporium tabacinum

There are a significant number of papers reporting on the plant pathogenicity of *Plectosporium tabacinum* on a variety of plant species.

5.2.24. Pleurotus ostreatus

Although earlier classified by COGEM as non-pathogenic (CGM/140227-03), two references were found reporting on the apparent plant pathogenicity of *Pleurotus ostreatus* on trees as well as a reference showing its pathogenicity on nematodes.

5.2.25. Pseudozyma flocculosa

There were no papers found reporting on the plant pathogenic nature of *Pseudozyma flocculosa.*

5.2.26. Rhodotorula glutinis

There were no papers found reporting on an apparent plant pathogenic nature of *Rhodotorula glutinis.*

5.2.27. Saccharomyces cerevisiae

No references were found describing *Saccharomyces cerevisiae* as a plant pathogen.

5.2.28. Saccharomyces kluyveri

No references were found describing *Saccharomyces kluyveri* as a plant pathogen.

5.2.29. Trametes versicolor

Although earlier classified by COGEM as non-pathogenic, there are a number of references describing *Trametes versicolor* as a pathogen on apple and other trees.

5.2.30. Trichoderma koningii

No references were found describing *Trichoderma koningii* as a plant pathogen however it was reported as a fungal pathogen on mushrooms.

5.2.31. Trichoderma viride

A limited number of papers report on *T. viridi* as a pathogen on plants as well as on cultivated mushrooms. One paper also lists *T. viridi* as pathogenic to a particular nematode species.

5.2.32. Zygosaccharomyces bailii

No references were found describing *Zygosaccharomyces bailii* as a plant pathogen.

6. Concluding remarks

The COGEM lists of non-pathogenic bacteria and fungi as published in CGM/141218-01 and CGM/141218-03 respectively, were screened for microorganisms that were possibly incorrectly classified as non-pathogenic on plants. In the context of GMO-risk assessment a distinction is made between the micro-organisms that are 'true' plant pathogens and those that can only cause diseases in harvested products ('bewaarziekten' or postharvest diseases). This distinction is not always clear and the first part of this report focusses on formulating a definition of a 'postharvest disease' that can be used to identify postharvest pathogens on the above mentioned lists of non-pathogenic micro-organisms and to distinguish them from true plant pathogens and the non-plant pathogens.

Based on comparisons with expert lists the screening of the COGEM non-pathogens lists actually identified 35 plant related micro-organisms (32 fungi and 3 bacteria; see Table 4) which could possibly have been incorrectly placed on the list of non-pathogens. Five of these (all fungi) could indeed be classified as postharvest pathogens. As such these are correctly placed on the list of non-pathogens. However, the screening also revealed fourteen fungi for which scientific evidence was found for their pathogenicity on plants (and for ten of the species also indications for pathogenicity for humans, animals or insects). As such these appear to be incorrectly placed on the list of non-pathogens. For twelve fungi and two bacteria no scientific evidence could be found for their possible pathogenicity on plants and these appear to be correctly classified as non-pathogenic. For one fungus and one bacterium the scientific literature did not provide sufficient data to allow a decision on their possible plant pathogenicity.

When evaluating any list it should be noted that any list is intrinsically a snapshot of the information that is available, and accessible, up to its point of publication. The amount of new information published nowadays is enormous and any future information could warrant a change in the current classification of a particular microorganism on the COGEM lists. In addition older information can contain very valuable information but may be hard to find or to access.

Another important point to consider when evaluating information on the possible plant pathogenicity of a particular microorganism is that it is not always clear on the basis of what information the microorganism was identified as such. Sometimes proof of identification is missing or based on morphological characteristics, sometimes on molecular data e.g. ITS sequences. Not always Koch's postulates are fulfilled, leaving questions on the actual causal relationship between the presence of a particular microorganism and the disease symptoms on a plant. In addition to this, taxonomic classifications may change over time, which especially when dealing with older literature, may lead to confusion on the correct naming of a particular organism. In some cases the taxonomy of a particular organism (or group of organisms) may be so complex that it is impossible to actually distinguish the pathogenic from the non-pathogenic organisms, especially when no scientific information on pathogenicity determinants is available.

Table 4. Micro-organisms identified as possibly mislabelled as non-pathogenic in CGM/141218-01 and CGM/141218-03 and their pathogenicity classification according to this report.

Species	Post harvest pathogen	Non-plant pathogen	Plant pathogen	Possible human/animal/ insect pathogen
Bacteria				
Acetobacter aceti		x		
Pseudomonas fluorescens		?	?	
Xanthobacter autotrophicus		x		
		2		
Fungi				
Acremonium strictum			x	x
Aspergillus fischerianus		x		x
Aspergillus glaucus	x			
Aspergillus niger			x	
Aureobasidium pullulans	?	?	?	
Bipolaris spicifera			x	x
Bjerkandra adusta			x	x
Cladosporium herbarum			x	
Clonostachys rosea			x	x
Coniothyrium minitans		x		
Dichotomophthora portulacae			x	
Graphium ulmi			x	
Metarhizium anisoplae		x		x
Microsphaeropsis olivacea		x		x
Monascus ruber		x		
Nigrospora sphaerica			x	
Penicillium aurantiogriseum	x			
Penicillium chrysogenum	x			
Penicillium funiculosum	x			
Penicillium purpurogenum	x			
Phaeotrichoconis crotalariae		x		
Phoma herbarum			x	x
Plectosporium tabacinum			x	
Pleurotus ostreatus			x	x
Pseudozyma flocculosa		x		
Rhodotorula glutinis		x		
Saccharomyces cerevisiae		x		
Saccharomyces kluyveri		x		
Trametes versicolor			x	
Trichoderma koningii		x		
Trichoderma viride			x	x
Zygosaccharomyces bailii		x		
	5	12	14	10

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Appendix 1. Possible Database search terms

The following search terms were used for the initial search employed in Part 1 of this report on the above mentioned websites as well as for a general Google search:

- Plant health
- Plant disease(s)
- Plant pathogen(s)
- Storage disease
- Risk assessment
- Biosafety
- Post harvest disease

Nearly all information in relation to these terms applies to micro-organisms that are clearly categorised as (plant) pathogens and cause disease. Virtually no information relates to non-pathogenic micro-organisms.

Appendix 2. List of plant pathogenic bacteria

List of plant pathogenic bacteria as extracted from Bull (2010, 2012 and 2014), Kado (2010) and Janse (2005).

(yellow)	= other species within the genus are mentioned on COGEM-list
(orange)	= species mentioned on COGEM-list of non-pathogenic bacteria

information from Bull et al (2010)
information from Bull et al (2012)
information from Bull et al (2014)

No	Genus	Species	Pathovar
	Acetobacter	aceti	
	Acetobacter	pasteurianus	
1	Acidovorax/Pseudomonas	anthurii	
2	Acidovorax/Pseudomonas	avenae subsp avenae	
3	Acidovorax/Pseudomonas	avenae subsp cattleyae	
4	Acidovorax/Pseudomonas	avenae subsp citrulli	
	Acidovorax	cattleyae	
	Acidovorax	citrulli	
5	Acidovorax/Pseudomonas	konjaci	
	Acidovorax	oryzae	
6	Acidovorax/Pseudomonas	valerianellae	
	Agrobacterium: zie Rhizobium		
	Arthrobacter		
	Arthrobacter ilicis => Curtobacterium flaccumfacien pv. Ilicis		
	Bacillus		
	Bacillus megaterium		
	Bacillus megaterium pv. cerealis		
	Bacillus pumilus		
7	Brenneria/Erwinia	alni	
	Brenneria	goodwinii	
8	Brenneria/Erwinia	nigrifluens	
9	Brenneria/Dickeya	paradisiaca	
10	Brenneria/Erwinia	quercina	quercina
	Brenneria/Erwinia	quercina	lupinicola
11	Brenneria/Erwinia	rubrifaciens	
12	Brenneria/Erwinia	salicis	
13	Burkholderia/Pseudomonas	andropogonis	= Pseudomonas woodsii
14	Burkholderia/Pseudomonas	caryophylli	
15	Burkholderia/Pseudomonas	cepacia	
16	Burkholderia/Pseudomonas	gladioli pv. agaricicola	
17	Burkholderia/Pseudomonas	gladioli pv. alliicola	
18	Burkholderia/Pseudomonas	gladioli pv. gladioli	
19	Burkholderia/Pseudomonas	glumae	
20	Burkholderia/Pseudomonas	plantarii	
	Burkholderia solanacearum: see Ralstonia solanacearum		
21	Candidatus Liberibacter	africanus	
22	Candidatus Liberibacter	amaricanus	

23	Candidatus Liberibacter	asiaticus	
24	Candidatus Liberibacter	crescens	
25	Candidatus Liberibacter	europaeus	
26	Candidatus Liberibacter	psyllaurous	
27	Candidatus Liberibacter	solanacearum	
28	Candidatus Phlomobacter	fragariae	
29	Candidatus Phytoplasma	allocasuarinae	
30	Candidatus Phytoplasma	americanum	
31	Candidatus Phytoplasma	asteris	
32	Candidatus Phytoplasma	aurantifolia	
33	Candidatus Phytoplasma	australasia	
34	Candidatus Phytoplasma	australiense	
35	Candidatus Phytoplasma	brasiliense	
36	Candidatus Phytoplasma	caricae	
37	Candidatus Phytoplasma	castaneae	
38	Candidatus Phytoplasma	cynodontis	
39	Candidatus Phytoplasma	fragariae	
40	Candidatus Phytoplasma	fraxini	
41	Candidatus Phytoplasma	graminis	
42	Candidatus Phytoplasma	japonicum	
43	Candidatus Phytoplasma	mali	
44	Candidatus Phytoplasma	oryzae	
45	Candidatus Phytoplasma	phoenicium	
46	Candidatus Phytoplasma	pini	
47	Candidatus Phytoplasma	prunorum	
48	Candidatus Phytoplasma	pyri	
49	Candidatus Phytoplasma	rhamni	
50	Candidatus Phytoplasma	spartii	
51	Candidatus Phytoplasma	trifolii	
52	Candidatus Phytoplasma	ulmi	
53	Candidatus Phytoplasma	ziziphi	
54	Clavibacter	michiganensis subsp. insidiosus	
55	Clavibacter	michiganensis subsp. michiganensis	
56	Clavibacter	michiganensis subsp. nebraskensis	
57	Clavibacter	michiganensis subsp. sepedonicus	
58	Clavibacter	michiganensis subsp. tessellarius	
59	Clavibacter	toxicus	
	Clostridium		
	Clostridium puniceum		
	Corynebacterium species: zie Pantoea, Curtobacterium, Rhodococcus, Clavibacter, Rhathayibacter species/pv		
60	Curtobacterium	flaccumfaciens	betae
61	Curtobacterium	flaccumfaciens	beticola
62	Curtobacterium	flaccumfaciens	flaccumfaciens
63	Curtobacterium	flaccumfaciens	oortii
64	Curtobacterium	flaccumfaciens	poinsettiae
65	Curtobacterium/Arthrobacter	flaccumfaciens	ilicis
66	Dickeya/Erwinia/Pectobacterium	chrysanthemi	chrysanthemi
67	Dickeya/Erwinia/Pectobacterium	chrysanthemi	parthenii

68	Dickeya	dadantii		see: Dickeya dadantii subsp. Dasantii
	Dickeya	dadantii subsp. dasantii		
	Dickeya	dadantii subsp. dieffenbachiae		
69	Dickeya/Erwinia/Pectobacterium	dianthicola		
70	Dickeya/Erwinia/Pectobacterium	dieffenbachiae		see: Dickeya dadantii subsp. dieffenbachiae
71	Dickeya/Erwinia/Pectobacterium	zeae		
72	Dickeya/Brenneria/Erwinia	paradisiaca		
73	Enterobacter	cancerogenus		
74	Enterobacter	cloacae subsp. dissolvens		
75	Enterobacter	nimipressuralis		
	Enterobacter	mori		
76	Enterobacter	pyrinus		
77	Enterobacter/Erwinia	dissolvens		
78	Erwinia	amylovora		
79	Erwinia/Pectobacterium	brasiliensis		
80	Erwinia/Pectobacterium	cacticida		
81	Erwinia	carnegieana		
82	Erwinia	herbicola		
83	Erwinia	mallotivora		
84	Erwinia	milltiae		
85	Erwinia	papayae		
86	Erwinia	persicina/persicinus		
	Erwinia	pirifloringrans		
87	Erwinia	psidii		
88	Erwinia	pyrifolii		
89	Erwinia	rhapontici		
90	Erwinia	tracheiphila		
	Erwinia	uzenensis		
	Ewingella			
	Ewingella americana			
	Gibbsiella	quercinecans		
	Gluconobacter			
	Gluconobacter	oxydans		
	Herbaspirillum			
	Herbaspirillum	rubrisubalbicans		
91	Janthinobacterium	agaricidamnosum		
	Leifsonia	cynodontis		
92	Leifsonia	xyli subsp. cynodontis		
93	Leifsonia/Clavibacter	xyli subsp. xyli		
	Lonsdalea			
	Lonsdalea	quercina		
	Lonsdalea	quercina subsp. quercina		
	Lonsdalea	quercina subsp. Iberica		
	Lonsdalea	quercina subsp. Britannica		
94	Nocardia	vaccinii		
	Pantoea	agglomerans		
95	Pantoea	agglomerans	betae	
96	Pantoea	agglomerans	gypsophilae	
97	Pantoea	agglomerans	millettiae	
98	Pantoea	agglomerans		
	Pantoea	alii		

99	Pantoea	ananas		
100	Pantoea	ananatis	ananatis	
101	Pantoea	ananatis	uredovora	
102	Pantoea	ananatis		
	Pantoea	citrea		
	Pantoea	cypripedii		
103	Pantoea	dispersa		
	Pantoea	stewartii		
104	Pantoea	stewartii subsp. indologenes		
105	Pantoea	stewartii subsp. stewartii		
106	Pectobacterium	atrosepticum		
107	Pectobacterium	betavasculorum		
108	Pectobacterium/Erwinia	cacticida		
	Pectobacterium	carotovorum		
109	Pectobacterium	carotovorum subsp. betavasculorem		
110	Pectobacterium	carotovorum subsp. carotovorum		
111	Pectobacterium	carotovorum subsp. odoriferum		
112	Pectobacterium	cypripedii		
113	Pectobacterium	rhapontici		
114	Pectobacterium	wasabiae		
	Pseudomonas			
115	Pseudomonas	aeruginosa		human pathogenic
116	Pseudomonas	agarici		
117	Pseudomonas	amygdali		
118	Pseudomonas	asplenii		
119	Pseudomonas	avellanae		
	Pseudomonas	beteli		
120	Pseudomonas	cannabina		
	Pseudomonas	cannabina	alisalensis	
	Pseudomonas	cannabina	cannabina	
121	Pseudomonas	caricapapayae		
122	Pseudomonas	cichorii		
123	Pseudomonas	cissicola		
124	Pseudomonas	coronofaciens		
125	Pseudomonas	corrugata		
126	Pseudomonas	costantinii		
127	Pseudomonas	ficuserectae		
128	Pseudomonas	flectens		
129	Pseudomonas	fluorescens		**NB missing from Bull et al (2010)**
130	Pseudomonas	fuscovaginae		
	Pseudomonas	hibiscicola		
	Pseudomonas	marginalis		
131	Pseudomonas	marginalis	alfalfae	
132	Pseudomonas	marginalis	marginalis	
133	Pseudomonas	marginalis	pastinacae	
134	Pseudomonas	marginalis (syn. P. fluorescens group)		
135	Pseudomonas	mediterranea		
136	Pseudomonas	meliae		
137	Pseudomonas	palleroniana		
138	Pseudomonas	rubrilineans		
139	Pseudomonas	salominii		

	Pseudomonas	savastanoi		
140	Pseudomonas	savastanoi	fraxini	
	Pseudomonas	savastanoi	glycinea	
141	Pseudomonas	savastanoi	nerii	
	Pseudomonas	savastanoi	phaseolicola	
142	Pseudomonas	savastanoi	retacarpa	
143	Pseudomonas	savastanoi	savastanoi	
	Pseudomonas	syringae		
144	Pseudomonas	syringae	aceris	
145	Pseudomonas	syringae	actinidiae	
146	Pseudomonas	syringae	aesculi	
147	Pseudomonas	syringae	alisalensis	
148	Pseudomonas	syringae	antirrhini	
149	Pseudomonas	syringae	apii	
150	Pseudomonas	syringae	aptata	
151	Pseudomonas	syringae	atrofaciens	
152	Pseudomonas	syringae	atropurpurae	
153	Pseudomonas	syringae	avellanae	
154	Pseudomonas	syringae	avii	
155	Pseudomonas	syringae	berberidis	
156	Pseudomonas	syringae	bhibisci	
157	Pseudomonas	syringae	broussonetiae	
158	Pseudomonas	syringae	cannabina	see P. canabina
159	Pseudomonas	syringae	castaneae	
160	Pseudomonas	syringae	cerasicola	
161	Pseudomonas	syringae	ciccaronei	
162	Pseudomonas	syringae	coriandricola	
163	Pseudomonas	syringae	coronofaciens	
164	Pseudomonas	syringae	coryli	
165	Pseudomonas	syringae	cunninghamiae	
166	Pseudomonas	syringae	daphniphylii	
167	Pseudomonas	syringae	delphinii	
168	Pseudomonas	syringae	dendropanacis	
169	Pseudomonas	syringae	dysoxyli	
170	Pseudomonas	syringae	eriobotryae	
171	Pseudomonas	syringae	garcae	
172	Pseudomonas	syringae	glycinea	
173	Pseudomonas	syringae	helianthi	
	Pseudomonas	syringae	hibisci	
174	Pseudomonas	syringae	japonica:zie syringae	
175	Pseudomonas	syringae	lachrymans	
176	Pseudomonas	syringae	lapsa	
177	Pseudomonas	syringae	maculicola	
178	Pseudomonas	syringae	mellea	
179	Pseudomonas	syringae	mori	
180	Pseudomonas	syringae	morsprunorum	
181	Pseudomonas	syringae	myricae	
182	Pseudomonas	syringae	oryzae	
183	Pseudomonas	syringae	panici	see: P. syringae
184	Pseudomonas	syringae	papulans	
185	Pseudomonas	syringae	passiflorae	
186	Pseudomonas	syringae	persicae	
187	Pseudomonas	syringae	phaseolicola	
188	Pseudomonas	syringae	philadelphi	
189	Pseudomonas	syringae	photoniae	
190	Pseudomonas	syringae	pisi	

191	Pseudomonas	syringae	porri	
192	Pseudomonas	syringae	primulae	
	Pseudomonas	syringae	rhaphiolepidis	
193	Pseudomonas	syringae	ribicola	
194	Pseudomonas	syringae	sesami	
	Pseudomonas	syringae	solidagae	
	Pseudomonas	syringae	spinaceae	
195	Pseudomonas	syringae	striafaciens	
196	Pseudomonas	syringae	syringae	
197	Pseudomonas	syringae	tabaci	
198	Pseudomonas	syringae	tagetis	
199	Pseudomonas	syringae	theae	
200	Pseudomonas	syringae	tomato	
201	Pseudomonas	syringae	tremae	
202	Pseudomonas	syringae	ulmi	
203	Pseudomonas	syringae	viburni	
204	Pseudomonas	syringae	zizaniae	
205	Pseudomonas	tolaasii		
206	Pseudomonas	tremae		
207	Pseudomonas	viridiflava		
208	Pseudomonas/Herbaspirillum	rubrisubalbicans		
209	Pseudomonas/Ralstonia	syzygii		
	Pseudomonas woodsii: see Burkholderia andropogonis			
	Ralstonia			
210	Ralstonia	solanacearum		
	Ralstonia	syzygii		
	Ratayibacter			
211	Ratayibacter	iranicus		
212	Ratayibacter	rathayi		
213	Ratayibacter	toxicus		
214	Ratayibacter	tritici		
	Rhizobacter			
215	Rhizobacter	dauci		
216	Rhizobium/Agrobacterium	larrymoorei		
	Rhizobium	nepotum		
217	Rhizobium/Agrobacterium	radiobacter		
218	Rhizobium/Agrobacterium	rhizogenes		
219	Rhizobium/Agrobacterium	rubi		
	Rhizobium	skierniewicense		
220	Rhizobium/Agrobacterium	tumefaciens		**NB missing from Bull et al (2010)**
221	Rhizobium/Agrobacterium	vitis		
222	Rhodococcus	fascians		
223	Salmonella	enterica		**NB missing from Bull et al (2010)**
	Samsonia			
224	Samsonia	erythtinae		
225	Serratia	marcescens		human pathogenic
226	Serratia	proteamaculans		
	Sphingomonas			
227	Sphingomonas	asaccharolytica		**NB missing from Bull et al (2010)**
228	Sphingomonas	mali		**NB missing from Bull et al (2010)**
229	Sphingomonas	melonis		

230	Sphingomonas	pruni		NB missing from Bull et al (2010)
231	Sphingomonas	rosa		NB missing from Bull et al (2010)
232	Sphingomonas/Rhizomonas	suberifaciens		
233	Spiroplasma	citri		
234	Spiroplasma	kunkelii		
235	Spiroplasma	phoeniceum		
	Streptomyces			
236	Streptomyces	acidiscabies		
	Streptomyces	albidoflavus		
237	Streptomyces	aureofaciens		NB missing from Bull et al (2010)
	Streptomyces	candidus		
238	Streptomyces	caviscabies		
	Streptomyces	collinus		
239	Streptomyces	europaeiscabiei		
	Streptomyces	intermedius		
240	Streptomyces	ipomoea		
	Streptomyces	luridiscabiei		
	Streptomyces	niveiscabiei		
	Streptomyces	punciiscabiei		
241	Streptomyces	reticuliscabiei		
242	Streptomyces	scabiei		
243	Streptomyces	setonii		
244	Streptomyces	steliiscabiei		
245	Streptomyces	turgidiscabies		
	Streptomyces	wedmorensis		
246	Tatumella	citrea		NB missing from Bull et al (2010)
	Tatumella	morbirosei		
	Tatumella	ptyseos		
	Xanthomonas			
247	Xanthomonas	albilineans		
	Xanthomonas	alfalfae		
	Xanthomonas	alfalfae subsp. alfalfae		
	Xanthomonas	alfalfae subsp. citrumelonis		
	Xanthomonas	arboricola		
248	Xanthomonas	arboricola	celebensis	
249	Xanthomonas	arboricola	corylina	
	Xanthomonas	arboricola	fragariae	
250	Xanthomonas	arboricola	juglandis	
251	Xanthomonas	arboricola	populi	
252	Xanthomonas	arboricola	pruni	
	Xanthomonas	axanopodis		
253	Xanthomonas	axanopodis	alfalfae	see X. alfalfae
254	Xanthomonas	axanopodis	alli	
	Xanthomonas	axanopodis	anacardii	
255	Xanthomonas	axanopodis	aurantifolii	see X. fuscans subsp. aurantifolii
256	Xanthomonas	axanopodis	axonopodis	
257	Xanthomonas	axanopodis	bauhiniae	
258	Xanthomonas	axanopodis	begoniae	
259	Xanthomonas	axanopodis	betlicola	
260	Xanthomonas	axanopodis	biophyti	

	Xanthomonas	axanopodis	bauhiniae	
261	Xanthomonas	axanopodis	cajani	
262	Xanthomonas	axanopodis	cassavae	see X. casavae
263	Xanthomonas	axanopodis	cassiae	
264	Xanthomonas	axanopodis	citri	
265	Xanthomonas	axanopodis	citrumelo	see X. alfalfae subsp. citrumelonis
266	Xanthomonas	axanopodis	clitoriae	
267	Xanthomonas	axanopodis	coracanae	
268	Xanthomonas	axanopodis	cyamopsidis	
269	Xanthomonas	axanopodis	desmodii	
270	Xanthomonas	axanopodis	desmodiigangetici	
271	Xanthomonas	axanopodis	desmodiilaxiflori	
272	Xanthomonas	axanopodis	desmodiirotundifolii	
273	Xanthomonas	axanopodis	dieffenbachiae	
274	Xanthomonas	axanopodis	erythrinae	
275	Xanthomonas	axanopodis	fascicularis	
276	Xanthomonas	axanopodis	glycines	
277	Xanthomonas	axanopodis	khayae	
278	Xanthomonas	axanopodis	lespedezae	
279	Xanthomonas	axanopodis	maculifolliigardeniae	
280	Xanthomonas	axanopodis	malvacearum	see X. citri subsp. malvacearum
281	Xanthomonas	axanopodis	manihotis	
	Xanthomonas	axanopodis	mangiferaeindicae	
282	Xanthomonas	axanopodis	martyniicola	
283	Xanthomonas	axanopodis	melhusii	
284	Xanthomonas	axanopodis	nakataecorchori	
285	Xanthomonas	axanopodis	patelii	
286	Xanthomonas	axanopodis	pedalii	
287	Xanthomonas	axanopodis	phaseoli	
288	Xanthomonas	axanopodis	phaseoli var. fuscans	see X. fuscans
289	Xanthomonas	axanopodis	phyllanthi	
290	Xanthomonas	axanopodis	physalidicola	
291	Xanthomonas	axanopodis	poinsettiicola	
292	Xanthomonas	axanopodis	punicae	
293	Xanthomonas	axanopodis	rhynchosiae	
294	Xanthomonas	axanopodis	ricini	
295	Xanthomonas	axanopodis	sesbaniae	
	Xanthomonas	axanopodis	spondiae	
296	Xanthomonas	axanopodis	tamarindi	
297	Xanthomonas	axanopodis	vasculorum	
298	Xanthomonas	axanopodis	vesicatoria	see X. vesicatoria
299	Xanthomonas	axanopodis	vignaeradiatae	
300	Xanthomonas	axanopodis	vignicola	
301	Xanthomonas	axanopodis	vitians	
302	Xanthomonas	bromi		
	Xanthomonas	campestris		
303	Xanthomonas	campestris	diverse pathovars	
304	Xanthomonas	campestris	aberrans	
305	Xanthomonas	campestris	alangii	
306	Xanthomonas	campestris	amaranthicola	
307	Xanthomonas	campestris	amorphophalii	
308	Xanthomonas	campestris	aracearum	
309	Xanthomonas	campestris	arecae	
310	Xanthomonas	campestris	argemones	

311	Xanthomonas	campestris	armoraciae	
312	Xanthomonas	campestris	arracaciae	
313	Xanthomonas	campestris	asclepiadis	
314	Xanthomonas	campestris	azadirachtae	
315	Xanthomonas	campestris	badrii	
316	Xanthomonas	campestris	barbareae	
317	Xanthomonas	campestris	betae	
318	Xanthomonas	campestris	bilvae	
319	Xanthomonas	campestris	blepharidis	
320	Xanthomonas	campestris	boerhaaviae	
321	Xanthomonas	campestris	brunneivaginae	
322	Xanthomonas	campestris	campestris	
323	Xanthomonas	campestris	cannabis	
324	Xanthomonas	campestris	cannae	
325	Xanthomonas	campestris	carissae	
326	Xanthomonas	campestris	centellae	
327	Xanthomonas	campestris	citrumelo	see: X. alfalfae subsp. citrumelonis
328	Xanthomonas	campestris	clerodendri	
329	Xanthomonas	campestris	convolvuli	
330	Xanthomonas	campestris	coriandri	
331	Xanthomonas	campestris	daturae	
332	Xanthomonas	campestris	durantae	
333	Xanthomonas	campestris	esculenti	
334	Xanthomonas	campestris	eucalypti	
335	Xanthomonas	campestris	euphorbiae	
336	Xanthomonas	campestris	fici	
337	Xanthomonas	campestris	guizotiae	
338	Xanthomonas	campestris	gummisudans	
	Xanthomonas	campestris	heliotropii	
339	Xanthomonas	campestris	incanae	
340	Xanthomonas	campestris	ionidii	
341	Xanthomonas	campestris	lantanae	
342	Xanthomonas	campestris	laureliae	
343	Xanthomonas	campestris	lawsoniae	
344	Xanthomonas	campestris	leeana	
345	Xanthomonas	campestris	leersiae	
346	Xanthomonas	campestris	leiotropii	**NB missing from Bull et al (2010)**
347	Xanthomonas	campestris	malloti	
348	Xanthomonas	campestris	mangiferaeindicae	see X. axonopodis anacardii
349	Xanthomonas	campestris	merrmiae	
350	Xanthomonas	campestris	mirabilis	
	Xanthomonas	campestris	mori	
351	Xanthomonas	campestris	musacearum	
352	Xanthomonas	campestris	nigromaculans	
353	Xanthomonas	campestris	obscurae	
354	Xanthomonas	campestris	olitorii	
355	Xanthomonas	campestris	papavericola	
356	Xanthomonas	campestris	parthenii	
357	Xanthomonas	campestris	passiflorae	
358	Xanthomonas	campestris	paulliniae	
359	Xanthomonas	campestris	pennamericanum	
360	Xanthomonas	campestris	phormiicola	
361	Xanthomonas	campestris	physalidis	

362	Xanthomonas	campestris	plantaginis	**NB missing from Bull et al (2010)**
363	Xanthomonas	campestris	raphani	**NB missing from Bull et al (2010)**
364	Xanthomonas	campestris	sesami	
365	Xanthomonas	campestris	spermacoces	
366	Xanthomonas	campestris	syngonii	
367	Xanthomonas	campestris	tardicrescens	
368	Xanthomonas	campestris	thespesiae	
369	Xanthomonas	campestris	thirumalacharii	
370	Xanthomonas	campestris	tribuli	
371	Xanthomonas	campestris	trichodesmae	
372	Xanthomonas	campestris	uppalii	
373	Xanthomonas	campestris	vernoniae	
374	Xanthomonas	campestris	viegasii	
375	Xanthomonas	campestris	viticola	
376	Xanthomonas	campestris	vitiscarnosae	
377	Xanthomonas	campestris	vitistrifoliae	
378	Xanthomonas	campestris	vitiswoodrowii	
379	Xanthomonas	campestris	zantedeschiae	
380	Xanthomonas	campestris	zingibericola	
381	Xanthomonas	campestris	zinniae	
382	Xanthomonas	cassavae		
	Xanthomonas	citri		
383	Xanthomonas	citri	aurantifolii	**NB missing from Bull et al (2010)**
384	Xanthomonas	citri subsp. citri		= X. citri pv. citri
	Xanthomonas	citri subsp. malvacearum		
385	Xanthomonas	codiaei		
386	Xanthomonas	cucurbitae		
387	Xanthomonas	cynarae		
	Xanthomonas	dyei		
	Xanthomonas	dyei	dysoxyli	
	Xanthomonas	dyei	eucalypti	
	Xanthomonas	dyei	laureliae	
	Xanthomonas	euvesicatoria		
388	Xanthomonas	fragariae		
	Xanthomonas	fuscans		
	Xanthomonas	fuscans subsp. aurantifolii		
	Xanthomonas	fuscans subsp. Fuscans		
	Xanthomonas	gardneri		
	Xanthomonas	hortorum		
389	Xanthomonas	hortorum	carotae	
390	Xanthomonas	hortorum	hederae	
391	Xanthomonas	hortorum	palargonii	
392	Xanthomonas	hortorum	taraxaci	
393	Xanthomonas	hyacynthi		
394	Xanthomonas	melonis		
	Xanthomonas	oryzae		
395	Xanthomonas	oryzae	oryzae	
396	Xanthomonas	oryzae	oryzicola	
397	Xanthomonas	pisi		
398	Xanthomonas	populi		
399	Xanthomonas	sacchari		
400	Xanthomonas	theicola		

	Xanthomonas	translucens		
401	Xanthomonas	translucens	arrhenatheri	
402	Xanthomonas	translucens	cerealis	
403	Xanthomonas	translucens	graminis	
404	Xanthomonas	translucens	phlei	
405	Xanthomonas	translucens	phleipratensis	
	Xanthomonas	translucens	pistaciae	
406	Xanthomonas	translucens	poae	
407	Xanthomonas	translucens	secalis	
408	Xanthomonas	translucens	translucens	
409	Xanthomonas	translucens	undulosa	
410	Xanthomonas	vasicola	-	
411	Xanthomonas	vasicola	holcicola	
412	Xanthomonas	vasicola	vasculorum	see: X. axonopodis pv. vasculorum
413	Xanthomonas	vesicatoria		
	Xylella			
	Xylella	fastidiosa		
	Xylella	fastidiosa subsp. fastidiosa		
414	Xylella	fastidiosa	multiplex	**NB missing from Bull et al (2010)**
415	Xylella	fastidiosa	pauca	**NB missing from Bull et al (2010)**
416	Xylella	fastidiosa	piercei	**NB missing from Bull et al (2010)**
417	Xylella	fastidiosa subsp. agglomerii		
418	Xylella	fastidiosa subsp. idiaotraposa		
	Xylella	fastidiosa subsp. pauca		
419	Xylella	fastidiosa subsp. piercei		see: X.fastidiosa subsp. fastidiosa
420	Xylophilus	ampelinus		

Appendix 3 List of plant pathogenic fungi

List of plant related fungi as compiled from COGEM Class 1 list of non-pathogenic fungi and the APS listed Common names of Plant Diseases (http://www.apsnet.org/publications/commonnames/Pages/default.aspx).

[yellow] = Fungal species listed by COGEM as non-pathogenic but listed on the APS Common names of Plant Diseases

		GENUS	SPECIES
A	1	Acanthorhynchus	
	2	Achlya	
	3	Acremonium	strictum
	4	Acrocalymma	
	5	Acrocylindrium	
	6	Acrodontium	
	7	Acrophialophora	
	8	Acrosporium	
	9	Aecidium	
	10	Agaricus	-
	11	Akaropeltopsis	
	12	Albugo	
	13	Allantophomopsis	
	14	Alternaria	
	15	Amphobotrys	
	16	Angiopsora	
	17	Angiosorus	
	18	Anguillosporella	
	19	Anisogramma	
	20	Anthostomella	
	21	Antrodia	
	22	Aphanomyces	
	23	Apiognomonia	
	24	Apiospora	
	25	Apostrasseria	
	26	Arkoola	
	27	Armillaria	
	28	Armillariella	
	29	Arthrinium	
	30	Arthuriomyces	
	31	Ascochta	
	32	Ascochyta	
	33	Ascospora	
	34	Ashbya	
	35	Aspergillus	fischerianus; glaucus; niger
	36	Asperisporium	
	37	Asteridiella	
	38	Asteroma	
	39	Asteromella	
	40	Athelia	
	41	Aureobasidium	pullulans
B	42	Beniowskia	
	43	Bipolaris	spicifera(= Cochliobolus spiciferus)

	44	Biscogniauxia	
	45	Bitrimonospora	
	46	Bjerkandra	adusta
	47	Blumeria	
	48	Blumeriella	
	49	Botryodiplodia	
	50	Botryosphaeria	-
	51	Botryosporium	
	52	Botryotinia	
	53	Botrytis	
	54	Botrytiscinerea	
	55	Bremia	
	56	Briosia	
	57	Bursaphelenchus	
	58	Butlerelfia	
	59	Byssochlamys	
C	60	Calonectria	
	61	Calvatia	
	62	Camarosporium	
	63	Candelobrochaete	
	64	Candida	-
	65	Capitorostrum	
	66	Capnodium	
	67	Catacauma	
	68	Cavalconti	
	69	Centrospora	
	70	Cephaleuros	
	71	Cephalosporium	
	72	Ceratobasidium	
	73	Ceratocystis	
	74	Ceratorhiza	
	75	Cercoseptoria	
	76	Cercospora	
	77	Cercosporella	
	78	Cercosporidium	
	79	Cercosporina	
	80	Ceriospora	
	81	Ceriporia	
	82	Cerrena	
	83	Ceuthospora	
	84	Chaetodiplodia	
	85	Chaetoseptoria	
	86	Chaetosphaeropsis	
	87	Chalara	
	88	Chalaropsis	
	89	Chlorophyllum	
	90	Choanephora	
	91	Chondrostereum	
	92	Chrysomyxa	
	93	Cladosporium	herbarum
	94	Clathrospora	
	95	Claviceps	
	96	Clethridium	
	97	Climacodon	
	98	Clitocybe	

	99	Clitocybe	
	100	Clypeoporthe	
	101	Cochiobolus	
	102	Cochliobolus	spiciferus (= Bipolaris spicifera)
	103	Coleophoma	
	104	Coleosporium	
	105	Colletotrichum	
	106	Collybia	
	107	Coniella	
	108	Coniothyrium	
	109	Coprinus	
	110	Cordana	
	111	Coriolopsis	
	112	Coriolus	versicolor (= Trametes versicolor)
	113	Corticium	
	114	Corynespora	
	115	Coryneum	
	116	Crinipellis	
	117	Cristulariella	
	118	Cryptocline	
	119	Cryptoporus	
	120	Cryptosporella	
	121	Cryptosporiopsis	
	122	Cryptosporium	
	123	Cryptostistis	
	124	Cunninghamella	
	125	Curvularia	
	126	Cylindrocarpon	
	127	Cylindrocladiella	
	128	Cylindrocladium	
	129	Cylindrosporium	
	130	Cymadothea	
	131	Cystopus	
	132	Cytospora	
	133	Cytosporina	
D	134	Dactuliochaeta	
	135	Dactuliophora	
	136	Dactylaria	
	137	Daedaleopsis	
	138	Datronia	
	139	Deightoniella	
	140	Dematophora	
	141	Dendrophoma	
	142	Dendrophora	
	143	Dermea	
	144	Deuteromycetes	
	145	Deuterophoma	
	146	Diapleella	
	147	Diaporthe	
	148	Dicarpella	
	149	Dichotomophthora	
	150	Dictochaeta	
	151	Didymella	
	152	Didymosphaeria	
	153	Dilophospora	

	154	Dimeriella	
	155	Diplocarpon	
	156	Diplocarponmespili	
	157	Diplodia	
	158	Diplodina	
	159	Discochora	
	160	Discohainesia	
	161	Discosia	
	162	Discostroma	
	163	Discula	
	164	Doratomyces	
	165	Dothidella	
	166	Drechslera	-
	167	Durandiella	
E	168	Echinodontium	
	169	Elsinoe	
	170	Embellisia	
	171	Endothia	
	172	Entomosporium	
	173	Entyloma	
	174	Epichloe	
	175	Epicoccum	
	176	Eremothecium	
	177	Erysiphe	
	178	Erythricium	
	179	Eupropolella	
	180	Eutypa	
	181	Eutypella	
	182	Exobasidium	
	183	Exserohilum	
F	184	Fabraea	
	185	Flammulina	
	186	Fomes spp.	
	187	Fomitella	
	188	Fomitopsis	
	189	Frommea	
	190	Fulvia	
	191	Fusarium	-
	192	Fusicladium	
	193	Fusicoccum	
G	194	Gaeumannomyces	
	195	Galactomyces	
	196	Ganoderma	
	197	Ganodermazonatum	
	198	Geastrumia	
	199	Geotrichium	
	200	Gerlachia	
	201	Germano	
	202	Gibbera	
	203	Gibberella	
	204	Gibellina	
	205	Gilbertella	
	206	Gleocercospora	
	207	Gliocladium	
	208	Globiformes	

	209	Gloeocystidiellum	
	210	Gloeodes	
	211	Gloeophyllum	
	212	Gloeoporus	
	213	Gloeosporium	
	214	Glomerella	
	215	Gnomonia	
	216	Godronia	
	217	Gonatobotrys	
	218	Grandinia	
	219	Graphiola	
	220	Graphium	NB. COGEM-lists only the genus
	221	Greeneria	
	222	Grovesinia	
	223	Guignardia	
	224	Gymnoconia	
	225	Gymnosporangium	
H	226	Hainesia	
	227	Hansenula	
	228	Hapalosphaeria	
	229	Haplobasidion	
	230	Helicobasidium	
	231	Helicoma	
	232	Helminthosporium	
	233	Hemileia	
	234	Hendersonia	
	235	Hendersonula	
	236	Hericium	
	237	Heterobasidion	
	238	Hexagonia	
	239	Hormodendrum	
	240	Hyalothyridium	
	241	Hymenochaete	
	242	Hymenula	
	243	Hyphodermella	
	244	Hypochnicium	
	245	Hypochnus	
	246	Hypocrea	-
	247	Hypoxylon	
	248	Hysizygus	
I	249	Idriella	
	250	Iononotus	
	251	Irpex	-
	252	Isaria	
	253	Isariopsis	
	254	Itersonilia	
J	255	Johncouchia	
	256	Junghuhnia	
K	257	Kabatiella	
	258	Khuskia	
	259	Kuehneola	
	260	Kutilakesa	
L	261	Labrella	
	262	Labyrinthula	
	263	Laetiporus	

	264	Laetisaria	
	265	Lagena	
	266	Lasiodiplodia	
	267	Laxitectum	
	268	Leandria	
	269	Lentinus	
	270	Lenzites	
	271	Lepiota	
	272	Lepteutypa	
	273	Leptodiscus	
	274	Leptodontium	
	275	Leptographium	
	276	Leptosphaeria	
	277	Leptosphaerulina	
	278	Leptothyrium	
	279	Leptotrochila	
	280	Leucocytospora	
	281	Leucostoma	
	282	Leveillula	
	283	Libertella	
	284	Ligniera	
	285	Limacinula	
	286	Limonomyces	
	287	Linochora	
	288	Lophodermium	
	289	Lycoperdon	
M	290	Macrophoma	
	291	Macrophomina	
	292	Macrosporium	
	293	Magnaporthe	
	294	Mamianiella	
	295	Marasmiellus	
	296	Marasmius	
	297	Mariannaea	
	298	Marielliottia	
	299	Marssonina	
	300	Massarina	-
	301	Mastigosporium	
	302	Mauginiella	
	303	Melampsora	
	304	Melanconis	
	305	Melanconium	
	306	Melanospora	
	307	Melanotus	
	308	Meliola	
	309	Meruliopsis	
	310	Microdochium	
	311	Micronectriella	
	312	Microsphaera	
	313	Microstroma	
	314	Moesziomyces	
	315	Monascus	ruber
	316	Monilia	
	317	Monilochaetes	
	318	Monochaetia	

	319	Monographella	
	320	Monosporascus	
	321	Monostichella	
	322	Mucor	-
	323	Mycena	
	324	Mycocentrospora	
	325	Mycoleptodiscus	-
	326	Mycosphaerella	tassiana (= Cladosporium herbarum)
	327	Mycovellosiella	
	328	Myriogenospora	
	329	Myriosclerotinia	
	330	Myrothecium	
	331	Mystrosporium	
N	332	Naevia	
	333	Nattrassia	-
	334	Necator	
	335	Nectria	
	336	Nectriella	
	337	Nematospora	
	338	Neocosmospora	
	339	Neofabrae	
	340	Neotyphodium	
	341	Neovossia	
	342	Nigrospora	sphaerica
	343	Nodulisporium	
O	344	Oidiopsis	
	345	Oidium	
	346	Olpidium	
	347	Omphalia	
	348	Oncobasidium	
	349	Operculella	
	350	Ophiobolus	
	351	Ophiosphaerella	
	352	Ophiostoma	ulmi
	353	Orobanche	
	354	Ovularia	
	355	Ovulariopsis	
	356	Ovulinia	
	357	Ovulitis	
	358	Oxyporus	
	359	Ozonium	
P	360	Paecilomyces	-
	361	Paracercospora	
	362	Paraphaeosphaeria	
	363	Patellaria	
	364	Patellina	
	365	Pellicularia	
	366	Peltaster	
	367	Peltella	
	368	Penicillium	aurantiogriseum; chrysogenum; funiculosum; purpurogenum
	369	Peniophora	
	370	Perenniporia	
	371	Periconia	

	372	Periconiella	
	373	Peridermium	
	374	Perisporiaceae	
	375	Peronoplasmopara	
	376	Peronosclerospora	
	377	Peronospora	
	378	Pesotum	
	379	Pestalosphaeria	
	380	Pestalotia	
	381	Pestalotiopsis	
	382	Pezicula	
	383	Phacidiopycnis	
	384	Phacidium	
	385	Phaeocryptopus	
	386	Phaeocytosporella	
	387	Phaeocytostroma	
	388	Phaeoisariopsis	
	389	Phaeolus	
	390	Phaeoramularia	
	391	Phaeoseptoria	
	392	Phaeosphaerella	
	393	Phaeosphaeria	
	394	Phaeotrichoconis	crotalariae
	395	Phakopsora	
	396	Phanaerochaeta	-
	397	Phellinus	
	398	Phialophora	-
	399	Phlebia	-
	400	Phloeospora	
	401	Pholiota	
	402	Phoma	herbarum
	403	Phomopsis	
	404	Phoradendron	
	405	Phragmidium	
	406	Phyllachora	
	407	Phyllactinia	
	408	Phyllosticta	
	409	Phymatotrichopsis	
	410	Phymatotrichum	
	411	Phyophthora	
	412	Physalospora	
	413	Physarum	
	414	Physoderma	
	415	Phytophthora	
	416	Pichia	-
	417	Piggotia	
	418	Pileolaria	
	419	Pilidiella	
	420	Pithomyces	
	421	Plasmodiophora	
	422	Plasmopara	
	423	Platyspora	
	424	Plectosporium	tabacinum
	425	Plenodomus	
	426	Pleocyta	

	427	Pleosphaerulina	
	428	Pleospora	
	429	Pleurotus	ostreatus
	430	Podosphaera	
	431	Polyporus	-
	432	Polyscytalum	
	433	Polystigma	
	434	Polythrincium	
	435	Poria	-
	436	Postia	
	437	Protoventuria	
	438	Pseudocercospora	
	439	Pseudocercosporella	
	440	Pseudoepicoccum	
	441	Pseudoperonospora	
	442	Pseudopezicula	
	443	Pseudopeziza	
	444	Pseudophaeolus	
	445	Pseudoseptoria	
	446	Psilocybe	
	447	Puccinia	
	448	Pucciniacoronata	
	449	Pucciniahelianthi	
	450	Pucciniastrum	
	451	Pycnoporus	
	452	Pycnostysanus	
	453	Pyrenobotrys	
	454	Pyrenochaeta	
	455	Pyrenopeziza	
	456	Pyrenophora	
	457	Pyricularia	
	458	Pythium	
R	459	Ramichloridium	-
	460	Ramularia	
	461	Ramulariabeticola	
	462	Ramulispora	
	463	Resinicium	
	464	Rhabdocline	
	465	Rhabdospora	
	466	Rhinocladium	
	467	Rhizina	
	468	Rhizoctonia	
	469	Rhizomorpha	
	470	Rhizophydium	
	471	Rhizopus	
	472	Rhopographus	
	473	Rhynchosporium	
	474	Rhytidhysteron	
	475	Rhytisma	
	476	Rigidoporus	
	477	Roesleria	
	478	Rosellinia	
S	479	Saccharomyces	cerevisiae; kluyveri
	480	Salmonia	
	481	Sarocladium	

	482	Schiffnerula	
	483	Schizoparme	
	484	Schizophyllum	
	485	Schizopora	
	486	Schizothyrium	
	487	Schizoxylon	
	488	Scleroderma	
	489	Sclerophoma	
	490	Sclerophthora	
	491	Sclerospora	
	492	Sclerotinia	
	493	Sclerotium	
	494	Scolecosporiella	
	495	Scolicotrichum	
	496	Scopulariopsis	-
	497	Scytalidium	-
	498	Scytinostroma	
	499	Seimatosporium	
	500	Seiridium	
	501	Selenophoma	
	502	Septobasidium	
	503	Septocyta	
	504	Septogloeum	
	505	Septoria	
	506	Septoriamenthae	
	507	Septoriatritici	
	508	Setosphaeria	
	509	Sirosporium	
	510	Spaceloma	
	511	Sparrasis	
	512	Spermospora	
	513	Sphacelia	
	514	Sphaceloma	
	515	Sphacelotheca	
	516	Sphaerella	
	517	Sphaeria	
	518	Sphaeropsis	
	519	Sphaerostilbe	
	520	Sphaerotheca	
	521	Sphaerulina	
	522	Sphenospora	
	523	Spicaria	
	524	Spilocaea	
	525	Spiniger	
	526	Splanchonema	
	527	Spongipellis	
	528	Spongospora	
	529	Sporisorium	
	530	Sporobolomyces	-
	531	Sporonema	
	532	Sporotrichum	-
	533	Stagonospora	
	534	Stagonosporopsis	
	535	Steccherinum	
	536	Stegophora	

	537	Stemphylium	
	538	Stenella	
	539	Stereum	
	540	Stigmella	
	541	Stigmina	
	542	Strasseria	
	543	Streptomyces	
	544	Sydowia	
	545	Sydowiella	
	546	Synchronoblastia	
	547	Synchytrium	
	548	Syspastospora	
T	549	Tapesia	
	550	Taphrina	
	551	Taphrinaulmi	
	552	Thanetophorus	
	553	Thecaphora	
	554	Thekopsora	
	555	Thielaviopsis	
	556	Thyrostroma	
	557	Tilletia	
	558	Tilletiacaries	
	559	Torula	
	560	Trachysphaera	
	561	Trames	
	562	Trametes	versicolor (= Coriolus versicolor)
	563	Tranzschelia	
	564	Trechispora	
	565	Trichaptum	
	566	Trichoderma	koningii; viride
	567	Tricholoma	
	568	Trichothecium	-
	569	Tripospermum	
	570	Trochila	
	571	Tubakia	
	572	Tubercularia	
	573	Tubeufia	
	574	Tunstallia	
	575	Typhula	
	576	Tyromyces	
U	577	Ulocladium	-
	578	Uncinula	
	579	Uncinulanecator	
	580	Uncinuliella	
	581	Uredo	
	582	Urocystis	
	583	Uromyces	
	584	Uromycesbetae	
	585	Urophlyctis	
	586	Ustilaginoidea	
	587	Ustilago	
	588	Ustulina	
V	589	Valsa	
	590	Vararia	
	591	Venturia	

	592	Vermicularia	
	593	Verticllium	
	594	Viscum	
	595	Volutella	-
W	596	Waitea	
	597	Whetzelinia	
	598	Wilsonomyces	
X	599	Xeromphalina	
	600	Xylaria	
Z	601	Zimmermaniella	
	602	Zopfia	
	603	Zygophiala	
	604	Zygosaccharomyces	bailii
	605	Zythia	